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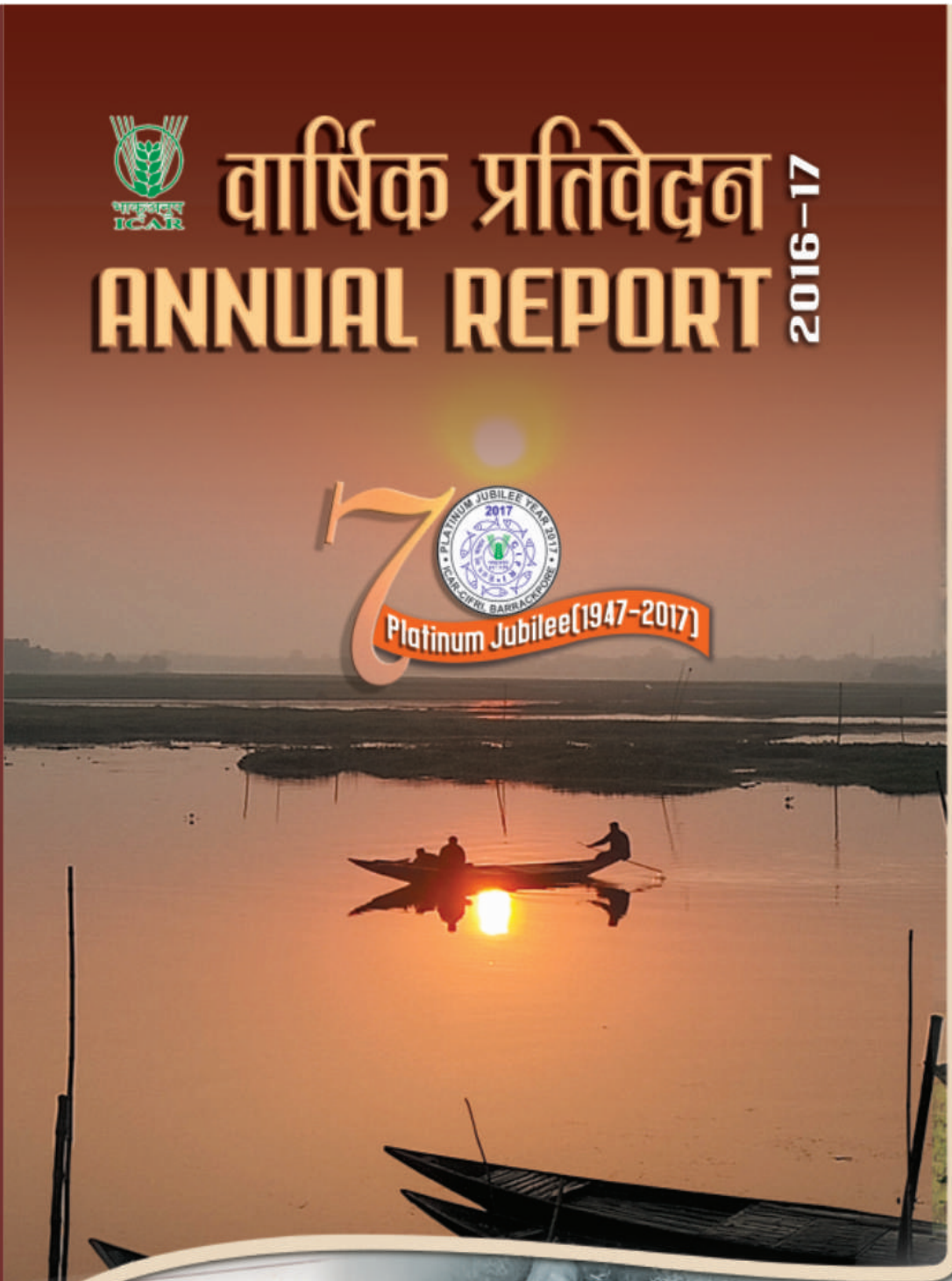
ANNUAL REPORT 2016–17



भा.कृ.अनु.प.— केन्द्रीय अंतर्स्थलीय मात्स्यिकी अनुसंधान संस्थान
बैरकपुर, कोलकाता— 700120

ICAR-Central Inland Fisheries Research Institute
Barrackpore, Kolkata-700120

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भाकृअनुप
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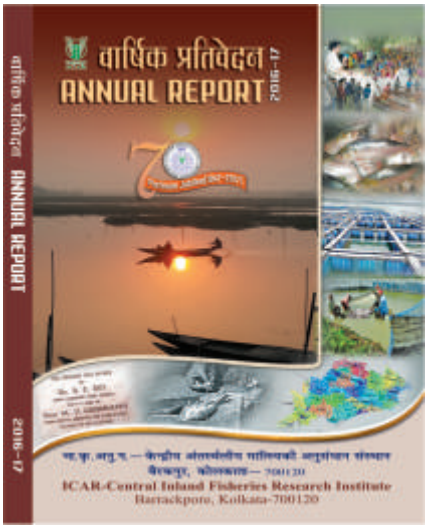
ICAR-Central Inland Fisheries Research Institute
Barrackpore, Kolkata - 700120, West Bengal
www.cifri.res.in
(ISO 9001:2008 certified Institution)



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Compilation & Editing :
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Atanu Das, Debasis Singha

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PREFACE

Inland open water resources in the form of rivers, estuaries, floodplain wetlands, reservoirs, backwaters and lagoons are invaluable aquatic resources of the country offering tremendous scope for fisheries development through knowledge based scientific management. India is blessed with vast area of inland open waters in terms of 45,000 km of rivers, 0.3 million ha of estuaries, 0.19 million ha of backwaters and lagoons, 3.51 million ha of reservoirs, 0.354 million ha of floodplain wetlands and 0.72 million ha of upland lakes. The present contribution from inland open water resources is 1.3 million tonnes with a percentage contribution of around 21% to the total inland fish production. The estimated demand of fish by 2025 in the Indian domestic market would be around 16 million tonnes (MT) against the present production of 9.58 MT coming from inland (65%) and marine (35%) sectors. In this context, the projected second blue revolution of the country demands fish production from inland open water bodies as a promising option for providing high quality protein food, livelihood to the rural populace and doubling the fisher's income. However, most of these waters are in a process of degradation due to increasing anthropogenic activities and have lost their pristine characteristics, which in turn affected the ecological services and ultimately natural fish stocks and biodiversity. This necessitates proper resource management, based on sound and informed decision making and location specific technological interventions for protecting the goods and ecological services to sustain the fisheries. In this context, ICAR-CIFRI has considerably accomplished significant scientific and technological milestones towards generating current knowledge base through interdisciplinary research for enabling sustainability of their ecosystem services and fisheries.

The Institute executed a number of programmes and activities resulting in significant scientific and technical achievements in the year 2016-17. The commercialization of ICAR-CIFRI Model cage was a great success. Further, the Institute successfully implemented and considerably extended cage culture programme in the reservoirs for production of table size fish and provided technical advisory to the different state fisheries departments. The Institute will be continuing its efforts to expand enclosure culture technology alongwith species diversification at national level for increasing the productivity. Updation of data base on ecology and fisheries of major inland open water resources is one such major mandated activity. Preparation of E-atlas of Odisha and Himachal Pradesh, designing and testing of e-DAS mobile application; successful demonstration of cage culture in reservoirs in a number of states; cost effective brewery waste-based fish feed development for enclosure culture; stock assessment of Hilsa as well as fishes of Chilika lake, Sundarbans and other open water resources; assessment of

impact of multiple habitat alterations on fisheries and ecology of river Ganges; e-flow estimation and recommendations for a number of rivers; assessment of impact of climate change on inland fisheries and development of adaptation strategies; valuation of ecosystem goods and services; ecosystem modeling; nutrient profiling of fishes; disease surveillance and fish genetic stock characterization; identification of novel genes and bacteria; pollution biomarkers and ecosystem health assessment are some of the major areas where the Institute has made measurable strides.

The Institute could bring new projects on fish health, National Mission for Clean Ganga, bioinformatics and computational biology, remote sensing, impact of coal transportation along water ways. During the year, the Institute conducted about 30 training programmes, benefitting more than 500 farmers and other stakeholders from various States. The Institute organized a number of important meetings, consultations and training programmes of national and regional significance. Our massive drive on Swachh Bharat Abhiyaan and coverage under Mera Gaon Mera Gaurav received wide appreciation.

The Institute has executed activities under Tribal Sub Plan and North Eastern Hill Region components, benefitting tribal fisher community through canal fisheries development, integrated farming and distribution of inputs for fish culture and fishing implements and pen culture and wetland fisheries development in North Eastern States. The staff of the Institute attended a number of capacity building programmes, overseas trainings, workshops, brain storming sessions, international and national seminars and symposia, meetings, etc.

I am confident that our hard work and commitment to research programmes will continue to provide significant outputs and decision making tools for making effective strategies for sustainable management of the vast inland open water resources.

I have the privilege of acknowledging the constant support and guidance received from Dr. T. Mahapatra, Secretary, DARE and Director General, ICAR. I am also grateful to Dr. J. K. Jena, Deputy Director General (Fisheries Science), Dr. S. Raizada, Assistant Director General (Inland Fisheries), Dr. Pravin Puthra, Assistant Director General (Marine Fisheries) and other staff members of the Fisheries Division of ICAR for their cooperation and help in our endeavors. All activities furnished in this report have been carried out by the Scientists and other staff members of the Institute. I put on record my profound thanks and gratitude to all of them. I also take this opportunity to thank all the members of Editorial team for their sincere effort, dedication and commitment in timely publication of the annual report.

Barrackpore
Dated 15th July, 2017

B. K. Das
Director

EXECUTIVE SUMMARY

ICAR-Central Inland Fisheries Research Institute (ICAR-CIFRI) is a premier research organization and has developed state of the art facilities and expertise in several areas including reservoir and wetland ecology and fisheries, riverine and estuarine fisheries, ecosystem and fish health, climate resilient inland fisheries, resource assessment modelling and fisheries socioeconomics.

The Institute has accomplished significant scientific and technological progress towards generating current knowledge base for ensuring sustainability of inland open water ecology, biodiversity and fisheries. At present, the institute has 83 scientists, 51 technical staff, 37 administrative and 46 supporting personnel posted at Head Quarter Barrackpore and Regional Centres/Stations at Allahabad, Guwahati, Bangalore, Vadodara, Kochi and Kolkata.

During the year 2016-17, the Institute conducted research activities under 4 major institute based research programmes implemented through Riverine Ecology and Fisheries, Reservoir and Wetlands Fisheries, Fisheries Resource and Environmental Management Divisions and Fisheries Socio-Economics Section. Besides those, 3 outreach activities, a number of externally funded research and consultancy projects, training and extension programmes were also executed successfully. The major research findings of these projects are summarized below:

Riverine and Estuarine Fisheries

Population characteristics of small indigenous fish (SIFs) and ecology of rivers namely River Torsa (North Bengal) in Brahamputra Basin and River Gandak (Bihar) in Ganga Basin and associated ecosystems in relation to rural livelihood and nutritional security were studied. Out of 65 recorded species of fish, 45 SIFs and 20 Non-SIFs were documented from River Gandak in Bihar, and out of 53 recorded fish species from River Torsa of North Bengal, 37 species belong to SIFs. A documentary on traditional methods to catch SIFs in River Torsa was prepared.

Assessment of environmental variability, nutrient dynamics, biodiversity, fish stock of selected estuarine and mangrove ecosystems were completed. Sediment carbon sequestration in Sundarbans was significantly influenced by mangrove litter falls. *Excoecaria agallocha* leaf litter was the most susceptible to decomposition due to low C: N ratio of leaves. Estimation of fish landings from winter bag net fisheries along the lower Sundarbans revealed a major shift in the fish catch composition with dominance of trash fishes and sardines. *Harpadon nehereus*, a dominant species in winter bag net fishery, showed a reduction from 18.34 % (1362.92 tonnes) in 2009-10 to 12.33 % in 2015-16 (1475.29 tonnes). *Sartoriana spinigera* was the only freshwater crab found from selected stretches of Sundarbans. Highest landing of commercially important mud crab (*Scylla olivacea*) was recorded in December 2016 (289.6 tonnes). A total of 84 finfish and shellfish species belonging to 38

families and 11 orders were identified from Narmada estuary and from Korapuzha estuary : a total of 59 species belonging to 27 families and 11 orders were recorded. Quantification of environmental flow requirements for ecosystem functions, including biodiversity and fisheries of selected rivers were carried out. E-flow study in River Mahanadi estimated water flow requirements of 424.56 – 566.09 m^3/sec and 1415.22 – 1556.75 m^3/sec for breeding of *Rita rita* and *Tor putitora*, respectively. In Hirakud to Satkosia stretch of River Mahanadi monthly discharges of 24.284 MCM and 331.953 MCM for lean and monsoon season are required for breeding and sustenance of *Tor mahanadicus*. Zone of distribution of adult and fingerlings of Mahaseer (*Tor mahanadicus*) in River Mahanadi was delineated for future conservation of the species. Damming and water abstraction deprive the river of water, which in turn badly impacts river ecosystem functioning. In River Ganga, the catch per unit effort (kg/day/fishermen) above and below the barrages at Kanpur, Narora and Bijnor were estimated at 3.2, 5.1, 5.6, and 2.7, 3.1 and 3.6 respectively.

Under the Hilsa flagship programme, catch structure, Maximum Sustainable Yield (MSY), Spawning Stock Biomass, reproductive characters, sex ratio and size at first maturity of *Tenualosa ilisha* in Hooghly estuary have been estimated. The hilsa catch from Hooghly-Bhagirathi system for 2016-17 was 48922 t, 99.4% of which was realized from marine sector. The mean annual catch of hilsa in the last fifteen years from Hooghly-Bhagirathi system has been 30537 t; the average catch for the last four years (study period) was 30762 t. The MSY for the species was estimated at 32953 t, which is very close to present average catch from the Hooghly-Bhagirathi system: further increase in effort might affect the sustainability of the stock. Hilsa of 341-360 mm size group had maximum reproductive potential in terms of fecundity, higher gonado somatic index, sex ratio. The minimum mesh size of gill nets to avoid catch of specimens up to this size group was estimated to be 110 mm. Two major breeding zones of hilsa have been identified, viz., Godakhali on main stream Hooghly and Kolaghat on Rupnarayan tributary of Hooghly.

Post restoration assessment of the ecology and fisheries diversity of Chilika lake indicated that catch of *Mugil cephalus*, *Daysciaena albida* and *Eleutheronema tetradactylum* are seriously declining, while that of *Chelon macrolepis* and *Etroplus suratensis* maintain stable catch pattern. All these commercially important species are being seriously growth-overfished, as 65.7 to 88.0% of the catches constitute immature size of fishes. Stock assessment was conducted comprehensively for these species and fishery management guidelines have been provided. *Labeo gonius* haplotypes of River Narmada was found to be genetically different from other haplotypes of the River Ganga, Mahanadi and Brahmaputra.

Reservoir Ecology and Fisheries

Habitat characteristics, fish diversity, assemblage and catch dynamics of 11 reservoirs in South India (Mallaghatta, Tunga, Jambadahalla, Thippagondanahalli Nagavara, Krishnaiahnakatte in Karnataka; Wyra and Paleru in Telangana; Pothundi, Peechi and Malankara in Kerala), 3 reservoirs in Eastern India (Kangsabati in West Bengal; Chandil and Panchet in Jharkhand), 2 from western part of India (Bhatghar and Dhom in Maharashtra) were investigated. Habitat quality of three Eastern India reservoirs, based on limnological parameters, was

found to be in favorable range for fisheries enhancement. Morpho Edaphic Index suggested higher fish yield potential of Panchet (148 kg/ha/yr), followed by Kangsabati (93 kg/ha/yr) and Chandil reservoir (55 kg/ha/yr). Reservoirs of Eastern India supported higher diversity of fishes compared to peninsular reservoirs and spatial analysis revealed more fish diversity in the lotic zone of the reservoir.

The technology for enhancement of fisheries productivity in reservoirs was developed and disseminated by ICAR-CIFRI. A remarkable increase in fish productivity was achieved in small reservoirs of Odisha, Karnataka and Chattisgarh during the period from 2010 to 2016 due to carp seed stocking. Fish productivity of the Govind Sagar reservoir, Himachal Pradesh has increased from 16 kg/ha/yr to 149 kg/ha/yr through regular stocking of fingerlings. Fish production level of 125 kg/ha/yr has been achieved in the selected reservoirs of Chattisgarh, MP, Jharkhand, Karnataka and Tamil Nadu through culture based fisheries. Fish yield of 58 small reservoirs of Odisha has increased by 158% through adoption of culture based fisheries. Stocking of fish seed in small reservoirs of Kerala has resulted in increase in productivity of *Labeo rohita, Catla catla* and *Cirrhinus mrigala* indicating the positive impact of stocking.

Hydro-acoustic surveys were conducted in Karapuzha Reservoir and depth profiling was done in lotic, intermediate and lentic zones. Using acoustics the potential fishery zones (PFZs) of Karapuzha Reservoir were identified: the lotic zone showed high concentration of fishes, followed by intermediate (medium concentration) and lentic zones (low concentration). This will help fishermen to udentify the potential fishery zone. Aquastics target strengths for seven fish species, viz., *Catla catla, Labeo rohita, Cirrhinus mrigala, Oreochromis mossambicus, O. niloticus, Channa marulius* and *Cyprinus carpio* were estimated. An assembly for converting portable echo-sounder into portable sonar has been developed and the prototype has been tested successfully for counting the fishes in Banasurasagar reservoir.

The Manchanbele reservoir was modelled to study the impact of Nile Tilapia population on major carps and other native fishes of the reservoir. The study showed that changes in ecosystem stability can be caused by trophic interactions due to stocking of major carps. However, the process does not cause any adverse impact in the reservoir ecosystem with Nile Tilapia and Indian Major Carps growing together.

Using agro-industry co-products, a highly stable floating feed with FCR 1.3 has been developed and released for *Pangasianodon hypophthalmus*. It saves feed cost by `10-12/kg compared to commercial feed with similar protein content for *Pangasianodon hypophthalmus*. Similarly, sinking feed with high water stability has been developed. National guidelines for cage culture in open water has been developed by ICAR-CIFRI and published by Department of Animal Husbandry, Dairying and Fisheries, Government of India

Wetland Ecology and Fisheries

Impact of fish stock enhancement on fisheries and ecology was assessed in unstocked and open Sukdol-Sarubori beel, and in stocked, seasonally open Mer and Damal beels of Assam. Limno-chemical parameters indicated productive

environment of the beels. Macrophyte coverage, macrophyte-associated fauna as well as the macro-benthos population were higher in the unstocked beels than in the stocked beels. Plankton population was inversely related to fish yield rates in the selected beels. Fish diversity consisted of a total of 28 species belonging to 10 orders, 12 families and 23 genera. Studies conducted in wetlands of Meghalaya (Boro, Katuli and Kumligaon beel) indicated moderate productive environment. Fish diversity studies recorded a total of 54 fish species from Katuli and 57 fish species from Kumligaon beel.

Study on ecological status and fisheries in 8 unexplored wetlands (four from Teesta-Torsa basin and four from Bhagirathi-Hooghly stretch of lower Gangetic basin) of West Bengal indicated that majority of the wetlands in lower Gangetic basin are more productive. Most of the wetlands were eutrophic in nature and fish yield varied from 175 to 3482 kg/ha/yr. In Uttar Pradesh, the fish productivity in Gujwartal (closed, stocked wetland) was comparatively higher than in Ajjeypur jheel (open, unstocked wetland), while fish diversity was higher in Ajjeypur (45 fish species) than in Gujwar tal (26 fish species).

The impact of enhanced temperature and altered precipitation regime on inland open water fisheries were studied for predicting spawning and reproductive traits of targeted fishes under changing climatic scenario. The potential of primary carbon capture and ultimate carbon accumulation in sediments of different wetlands of West Bengal and Assam were determined. The impact of climate change and climate induced threats on wetland fisheries were also studied using stakeholder driven approach and effective mitigation strategies suggested.

Growth performance of IMC in cages is not satisfactory. To examine influence of flow on fish growth, fishes in cages were put in flowing water. Feeding trials conducted in cages showed 2.7 times higher growth of the genetically improved Jayanti rohu in cages installed in lotic environment as compared to that installed in lentic environment. Also the growth (% weight gain) of normal rohu was 2.15 times higher in lotic environment as compared to lentic environment. Proximate biochemical analysis of flesh revealed more lipid accumulation in lentic water compared to that in lotic water while in case of normal rohu, the corresponding value was 9%.

Ecology and fisheries status have been assessed in three unexplored wetlands floodplain wetlands of Meghalaya viz., Boro beel in West Garo Hill district and Katuli and Kumligaon beel in South West Garo Hill district. Limnological parameters indicated moderate productive environment for fish production except for slightly acidic pH and low total alkalinity. A total of 65 species of fishes were recorded from Boro beel, 54 from Katuli beel and 57 from Kumligaon beel belonging to 41 genera, 20 families and 8 orders. Exotic carnivorous catfish, *Clarias gariepinus* was also reported from both the beels.

Ecosystem and Fish Health

Fish based IBI study identified 70% sites of river Mahanadi and 85% sites of river Gomti as Moderately Impaired. In another study, ICAR-CIFRI recommended, to MoEF&CC, for transportation of maximum 1.5 Million MT per annum of coal from Sagar to Farakka Super Thermal Power Plant through the National Water Way # 1.

Potential biomarkers for inland aquatic health assessment has been identified, few of which are under validation (hsp27 for coliform contamination and hsp47 for organic pollution). Dietary supplementation of curcumin has been found to augment heat stress tolerance through upregulation of nrf-2-mediated antioxidative enzymes and hsps in *Puntius sophore*.

Viral disease viz. WSSV and parasitic disease EHP have been reported from shrimp (*P. monodon, L. vanammei*) farming systems of West Bengal. About 30% and 60% of *Litopenaeus vannamei* samples collected from Midnapore districts, West Bengal were positive for WSSV and EHP respectively, and none were positive for IHHNV. Incidence of *Enterocytozoon hepatopenaei* infection has been confirmed in *Litopenaeus vannamei* from all three shrimp producing districts of West Bengal. Parasitic diseases like Argulus, Myxobolus, Dactylogyrus, Larnaea and Diplostomum etc. were reported from the finfish farms of West Bengal and Assam. In Nagaon district of Assam average biomass loss from fish mortality were estimated to be 5.03% per farm and 13.46% of total production per wetland respectively.

Surveys conducted in Assam and Karnataka listed more than 110 drug formulations in use. In Assam, fish farmers often use nutritional supplements and probiotics for enhancing fish growth. Sanitizers, water quality enhancers etc. are also used in the state, but at lesser extent. The surveys also revealed presence of many dubious drugs, including those lacking detailed composition, in the market. In Karnataka majority of farmers are using pesticides like dichlorvos, deltamethrin, quinolphos, cypermethrin, antibiotics and water sanitizers like enrofloxin, glutaraldehyde, formaldehyde, potassium permanganate, calcium peroxide are also used.

Health problems and diseases of *Pangasionodon hypophthalmus* in cages were investigated towards BMP development. Study revealed that mortality was high in fry and fingerlings stages of Pangasius in cages, especially during winter months, which may even lead to total loss of the stock in some cases. Important diseases identified were: superficial fungal infestation, bacterial septicaemia and Ich.

In vitro study showed that *Pseudomonas aeruginosa, Ps. putida, Ps. citronelllolis* and *Acinetobacter pitti* were more efficient in degrading phenol and chlorophenol compounds while *Chryseobacterium teanense*, *C. geocarposphaerae*, *Bacillus cereus, B. flexus* and *B. megaterium* efficiently degraded protein, lipid and starch. In microcosm experiment using sediment from highly polluted East Kolkata Wetlands, it was found that few strains were effective in reducing sediment organic matter level by up to 61% and might be useful in reducing pollution load in situ that would enhance water quality as well as water productivity.

Resource Assessment and Modeling

Monthly variations of water area in 20 reservoirs of Chattisgarh were delineated using LE8 images. A total of 1,28,738 water bodies with water spread area of about 5.80 lakh hectares were delineated in states of Andhra Pradesh and Telangana. In Assam water bodies of 7 districts (Hailakandi, Karimganj, Lakhimpur, Shibsagar, Goalpara, Dhemaji and Tinsukia) have been delineated. Lakhimpur district had the highest number of water bodies (13486) with total water spread area of 3219.79

hectares and Dhemaji had the least number of water bodies with total water spread area of 640.02 hectares. Enumeration of 933 large water bodies has been completed by collecting socio-economic data to assess the overall picture in these water bodies. Annual catch data of Hilsa, Bombay duck, Mullet, Prawn and *Wallago attu*, of Narmada river-estuary system were analysed by Dynamic Factor Model. Two common trends were identified. The trend 1 was the representative of Hilsa. It shows sharp decreasing trend over the period 1991 to 2008. The second trend reflected the aggregating contribution of the catch of prawn, mullet, *Wallago attu* and Bombay duck. This showed no particular trend. Annual catch variation of Hilsa was explained with the maximum observable flood at Bharuch and monsoon sediment load at Gurudeshwar. In addition, maximum observable flood at Bharuch has significant negative influence on the catch of prawn, Bombay duck and *Wallago attu*.

A forecasting model for finfish production in Chilika lagoon, Odisha has been developed and it predicted 10 percent increase in finfish production for the period 2017-18. A decision support tool using geo-spatial technology for reservoir stocking enhancement program has been developed based on seasonal water level variations in selected reservoirs of West Bengal, Uttar Pradesh and Chhattisgarh. Roadmap for inland open water fisheries has been developed for the states of West Bengal, Odisha, Jharkhand, Bihar and NE states for ushering in blue revolution.

Fisheries Socio-economics

The pattern of ownership and fisheries management rights of reservoirs in Gujarat state were documented. Survey revealed that revenue system of fisheries governance model operates in the distribution of fisheries management rights in the state of Gujarat. A database of livelihood assets (natural, physical, human, social and financial capital) of 450 fishers' households in Ganga basin, covering the states of Uttar Pradesh, Bihar, Jharkhand and West Bengal, has been developed in Microsoft Access platform.

Socio-economic study revealed that livelihood systems prevailing among the fishers in and around the Chilika lagoon are mainly related to fisheries, agriculture, petty business or employment in service sectors. Fisheries based livelihoods include fishers, small time fish traders and middlemen and commission agents. Around 70% of the fishermen owned boat, however, around 64% of them are non-motorized. Yearly income of the fishermen households of Chilika lagoon ranged from ` 70,000 in outer channel to ` 1,10,000 in southern sector for motorized boat owners. For the households which don't possess boats, the income is found to be much less. During 2011-12 to 2015-16 annual average total fish, shell fish and crab production of the Chilika lagoon was 12,781 MT and based on the fishers' price, the value of the fishery is estimated to be ` 234.5 crore. Defined property rights, optimum dependence on wetlands and adoption of alternate livelihood options like eco-tourism should be encouraged for sustainable management of Chilika lagoon.

The study carried out on 185 fishermen households from Kholshi and Akaipur wetlands of West Bengal and Deepor wetland of Assam found that the average economic vulnerability scores, on a scale of 0 to 1, were 0.21, 0.14 and 0.33 for

Kholshi, Akaipur and Deepor, respectively. The study suggested for creation of supplementary income generating opportunities and integrated agricultural activities in the vicinity of the wetlands by state government.

A multi-faceted road map was developed for Nutri-smart village through promotion of conservation, culture and consumption of SIFs in Madanganj, Namkhana area of Sundarbans where SIFs have traditionally been an integral part of rural community in term of livelihood and nutrition. The socio-economic profile, dietary pattern and morbidity pattern were studied to generate a proper understanding of the livelihood, current nutritional status, disease prevalence and treatment options of the fishermen community.

Experimental feeding trial to assess the beneficial effects of SIFs in improving the nutritional status of the women was undertaken on 30 women volunteers of Madanganj, Namkhana area of Sundarbans. The initial health check-up found that 20% of the women were suffering from anemia and 64% of the women have low calcium and 57% have low phosphorus in their blood.

Tribal Sub Plan Activities

To develop fisheries in the derelict water bodies and ponds of tribal in Khansahebabad village, Sagar Island, South 24 Parganas district of West Bengal CIFRI provided freshwater and brackish water fish seeds, fish feed and fertilizers initially in 10 ponds (0.91 ha) to benefit 40 tribal families.

Canals (4 no) of Sundarbans have been brought under culture-based fishery with significant improvement in fish production and livelihood of tribal fishers. The average fish yields from these canals were 800 kg/ha. A total 1200 tribal and scheduled caste fishermen and women benefitted from the canal fisheries development programme. By the technological intervention of ICAR-CIFRI during 2014-2016, fish production of farmers has increased from 800 kg/ha/yr to 1,700 kg/ha/yr in tribal area of Lakhimpur Kheri district of UP, which lead to increase in income from ` 2,500 to ` 6,000 per month under TSP Program.

NEH Activities

ICAR-CIFRI Regional Centre, Guwahati in collaboration with AFDC Ltd., Guwahati carried out supplementary stocking of Indian major carps in Sorbhog beel, Barpeta district of Assam. Fingerlings of IMCs were stocked @ 3,000 nos./ha and growth of fishes were monitored every 3 months. Catla attained the highest growth with specific growth rate (SGR) of 1.34, followed by rohu (SGR 1.3) and mrigal (SGR 0.99). Growth of the reared fishes is expected to accelerate during the second year after the earlier stocked carps were partially harvested in January, 2017.

The Regional Centre, in collaboration with AFDC Ltd., Guwahati carried out pen aquaculture demonstrations for fish stock enhancement in Merbeel, Nagaon district, Assam. The pens were stocked with six species of carps (4 indigenous and 2 exotic). The average weight of the stunted fingerlings was 150.9g with 86% survival. Stunted carp fingerlings raised in the pens were released to the beel proper

for stock enhancement @ 2000 nos./ ha towards partial restocking of the beel in January. The benefit-cost ratio was 1.92, indicating in-situ raising of stunted fingerlings of carps in pen enclosures is economically viable.

Mass Awareness and Human Resource Development

During the year, a total of nine mass awareness camps were organized on wide range of issues including fish health management, beel fisheries management, reservoir fisheries management in different parts of the country. The technologies of ICAR-CIFRI have been showcased in exhibitions organized in 20 different places of India. Three trainings for fisheries Officials, 9 trainings for students and 18 training programmes for fishers/fish farmers were organized covering 32 Officials, 210 students and 700 fish farmers/fishers. The Institute staff have also undergone capacity building trainings in their respective fields of specialization.

Fishing at Kanpur

ICAR-CIFRI

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 benefits 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

MAJOR RESEARCH ACHIEVEMENTS

- *Hilsa kelee* in Mahanadi Estuary near Paradip, *Bangana dero* in Deepor beel of Assam and *Trichogaster lalius* in River Cauvery were recorded for the first time.
- Sediment carbon sequestration in Sundarbans was significantly influenced by mangrove litter falls. *Excoecaria agallocha* leaf litter was most susceptible to decomposition due to low C: N ratio of leaves.
- Water flow of 424.56 – 566.09 m^3/sec and 1415.22 – 1556.75 m^3/sec for breeding of *Rita rita* and *Tor putitora* respectively are required in River Mahanadi. In Hirakud to Satkosia stretch of River Mahanadi monthly discharges of 24.284 MCM and 331.953 MCM for lean and monsoon season are required for breeding and sustenance of *Tor mahanadicus*.
- The MSY for hilsa was estimated at 32953 t in Hooghly-Bhagirathi system, which is very close to present average catch.
- *Labeo gonius* haplotypes of Narmada river was found to be genetically different from other haplotypes of River Ganga, Mahanadi and Brahmaputra.
- Morpho Edaphic Index suggested higher fish yield potential of the reservoirs Panchet (148 kg/ha/yr), followed by Kangsabati (93 kg/ha/yr) and Chandil reservoir (55 kg/ha/yr).
- Reservoirs of Eastern India supported higher diversity of fishes compared to peninsular reservoirs and spatial analysis revealed more fish diversity in the lotic zone of the reservoir. Similarly by using acoustics in Karapuzha Reservoir, it was found that the lotic zone possesses higher concentration of fishes, followed by intermediate (medium concentration) and lentic zones (low concentration).
- Higher fish production level of 125 kg/ha/yr has been achieved in the selected reservoirs of Chattisgarh, Madhya Pradesh, Jharkhand, Karnataka and Tamil Nadu through culture based fisheries. Fish yield of 58 small reservoirs of Odisha has increased by 158% through adoption of culture based fisheries.
- An assembly for converting portable echo-sounder into portable sonar has been developed for counting the fishes in Banasurasagar reservoir.
- Ecosystem stability can be disturbed by trophic interactions due to stocking of major carps. However, the process does not cause any adverse impact in the reservoir ecosystem with Nile Tilapia and Indian Major Carps growing together.
- Using agro-industry co-products, a highly stable and economical floating feed with FCR (1.3) has been developed and released for *Pangasianodon hypophthalmus* in cages. Similarly, sinking feed with high water stability has been developed.
- National guidelines for cage culture in open water has been developed which was published by Department of Animal Husbandry, Dairying and Fisheries, Govt. of India.
- Macrophyte coverage, macrophyte-associated fauna as well as the macro-benthos population were higher in the unstocked beels as compared to the stocked beels in Assam.
- Most of the unexplored wetlands in Teesta-Torsa basin and Bhagirathi-Hooghly stretch of lower Gangetic basin were eutrophic in nature.
- Jayanti rohu grows more faster with feed in cages (2.7 times higher growth) installed in lotic environment as compared to that installed in lentic environment.

- Fish based IBI study identified 70% sites of River Mahanadi and 85% sites of River Gomti as moderately impaired.
- Transportation of maximum of 1.5 million MT per annum of coal from Sagar to Farakka Super Thermal Power Plant through the National Water Way # 1 was recommended to MoEF&CC . Potential biomarkers for inland aquatic health assessment have been identified.
- Dietary supplementation of curcumin has been found to be augmenting heat stress tolerance through upregulation of nrf-2-mediated antioxidative enzymes and hsps in *Puntius sophore*.
- *Pseudomonas aeruginosa, Ps. putida, Ps. citronelllolis* and *Acinetobacter pitti* were more efficient in degrading phenol and chlorophenol compounds while *Chryseobacterium teanense, C. geocarposphaerae, Bacillus cereus, B. flexus* and *B. megaterium* efficiently degraded protein, lipid and starch.
- Monthly variations of water area in 20 reservoirs of Chattisgarh were delineated using LE8 images. A total of 1,28,738 water bodies with water spread area of about 5.80 lakh hectares were delineated in Telangana and Andhra Pradesh. In Assam water bodies of 7 districts have been delineated.
- Maximum observable flood at Bharuch has significant negative influence on the catch of prawn, Bombay duck and *Wallago attu* in Narmada estuary.
- A forecasting model for finfish production in Chilika lagoon, Odisha has been developed and it predicted 10 percent increase in finfish production for the period 2017-18.
- A decision support tool using geo-spatial technology for reservoir stocking enhancement program has been developed based on seasonal water level variations in selected reservoirs of West Bengal, Uttar Pradesh and Chattisgarh.
- Roadmap for inland open water fisheries has been developed for the states of West Bengal, Odisha, Jharkhand and Bihar and NE States for ushering in blue revolution.
- Revenue system of fisheries governance model is in vogue for the distribution of fisheries management rights in the state of Gujarat. A database of livelihood assets of 450 fishers' households in Ganga basin, covering the states of Uttar Pradesh, Bihar, Jharkhand and West-Bengal has been developed in Microsoft Access platform.
- Livelihood systems prevailing among the fishers in and around the Chilika lagoon were mainly related to fisheries, agriculture, petty business or employment in service sectors. Around 70% of the fishermen owned boat, however, around 64% of them are non-motorized. For the households which do not possess boats, the income was found to be much less.
- The average economic vulnerability scores, on a scale of 0 to 1, were 0.21, 0.14 and 0.33 for fishermen households of Kholshi, Akaipur and Deepor beels, respectively in West Bengal and Assam.
- Development of multi-faceted road map for Nutri-smart village was attempted through promotion of conservation, culture and consumption of SIFs in Madanganj, Namkhana area of Sundarbans.
- By the technological intervention of the institute under Tribal Sub Plan, production of fish farmers has increased from 800 kg/ha/yr to 1,700 kg/ha/yr in the tribal area of Lakhimpur Kheri district of UP.

INTRODUCTION

History

ICAR-Central Inland Fisheries Research Institute started its journey as Central Inland Fisheries Research Station from 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 elevated to Central Inland Fisheries Research Institute in 1959 and shifted to Barrackpore, West Bengal in its own building. The Institute came under the umbrella of Indian Council of Agricultural Research (ICAR), New Delhi in 1967. During the last seven decades, the Institute has grown from strength to strength and established itself as a pioneer inland fisheries research institute in India and abroad. The major responsibilities of the Institute were to assess inland fishery resources and to evolve strategies to obtain optimum fish production. 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 Brackish Water Fish Farming during 1971-1973. The combined success of Composite Fish Culture and Fish Seed Production projects initiated in 1974 brought blue revolution in the country and laid down a solid foundation for development of freshwater aquaculture.

Since 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 reservoirs and floodplain wetland fisheries, database on inland open water ecology and fisheries, conservation of rivers and lagoons. The focus of the Institute has recently been inclined towards Natural Resource Management mode and mandate has been modified.

Organizational Structure

To address the mandate, the Institute is organized in the following manner: the Headquarters of the Institute is located at Barrackpore, West Bengal; the Regional Research Centers are located at Allahabad, Guwahati, Bangalore and Vadodara, with Research stations at Kochi and Kolkata. In XI Plan, the research set up of the Institute has been re-structured in to three Research Divisions, viz.,

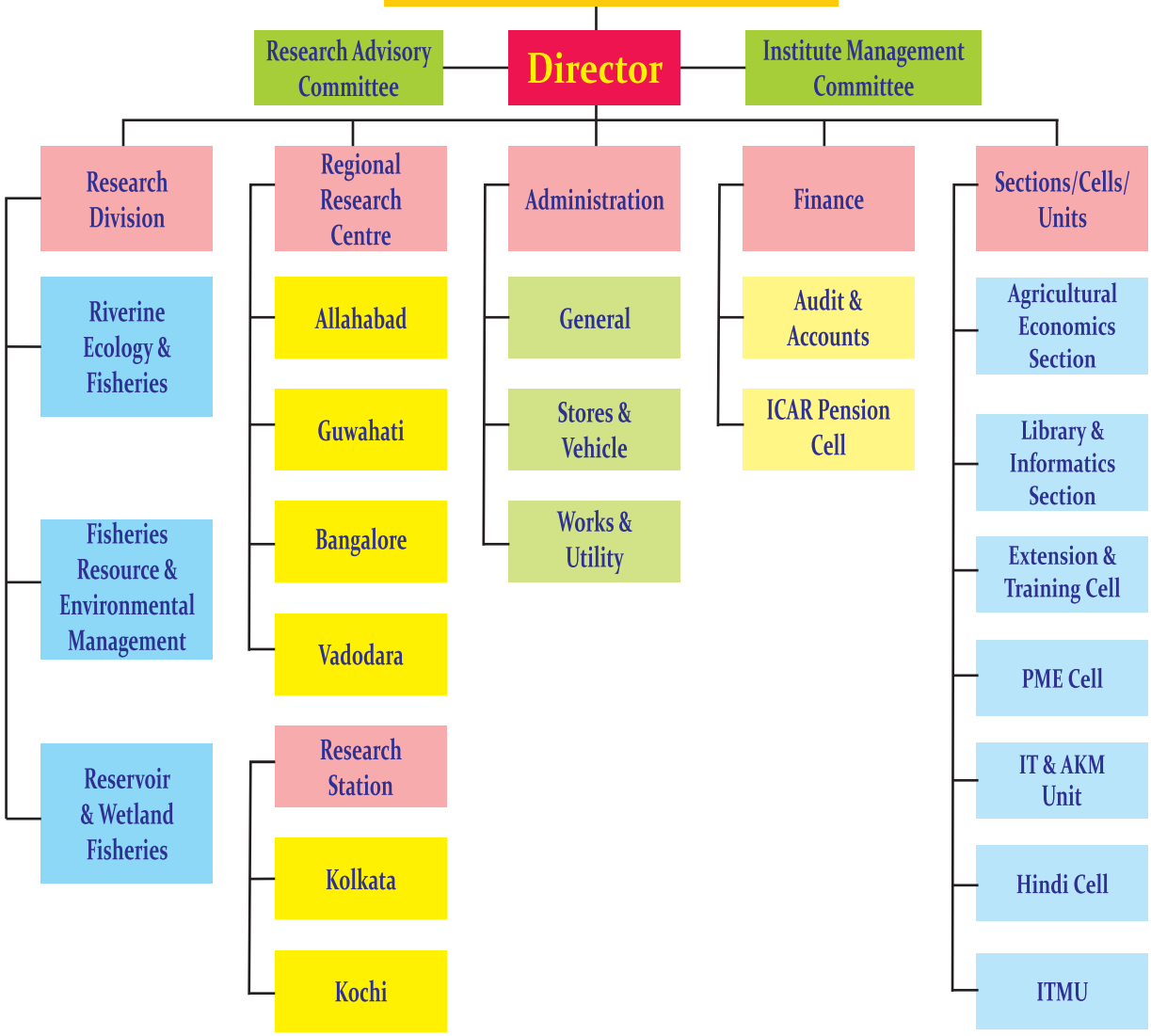
- Riverine Ecology and Fisheries Division
- Reservoir and Wetland Fisheries Division
- Fisheries Resource and Environment Management Division

Besides these, Socio-economic research, Extension and Training activities are carried out through the 'Agricultural Economics Section' and 'Extension and Training Cell', respectively. The research activities under each of these divisions are led by Heads of Divisions appointed by ICAR. While the Regional Centers at Allahabad and Guwahati are administered by Heads of Regional Centers appointed by ICAR, other research centres are administered by Officers-in-Charge. The Institute has cadre strength of 95 Scientists, 85 Technical Officers, 66 Administrative and 130 Supporting personnel.

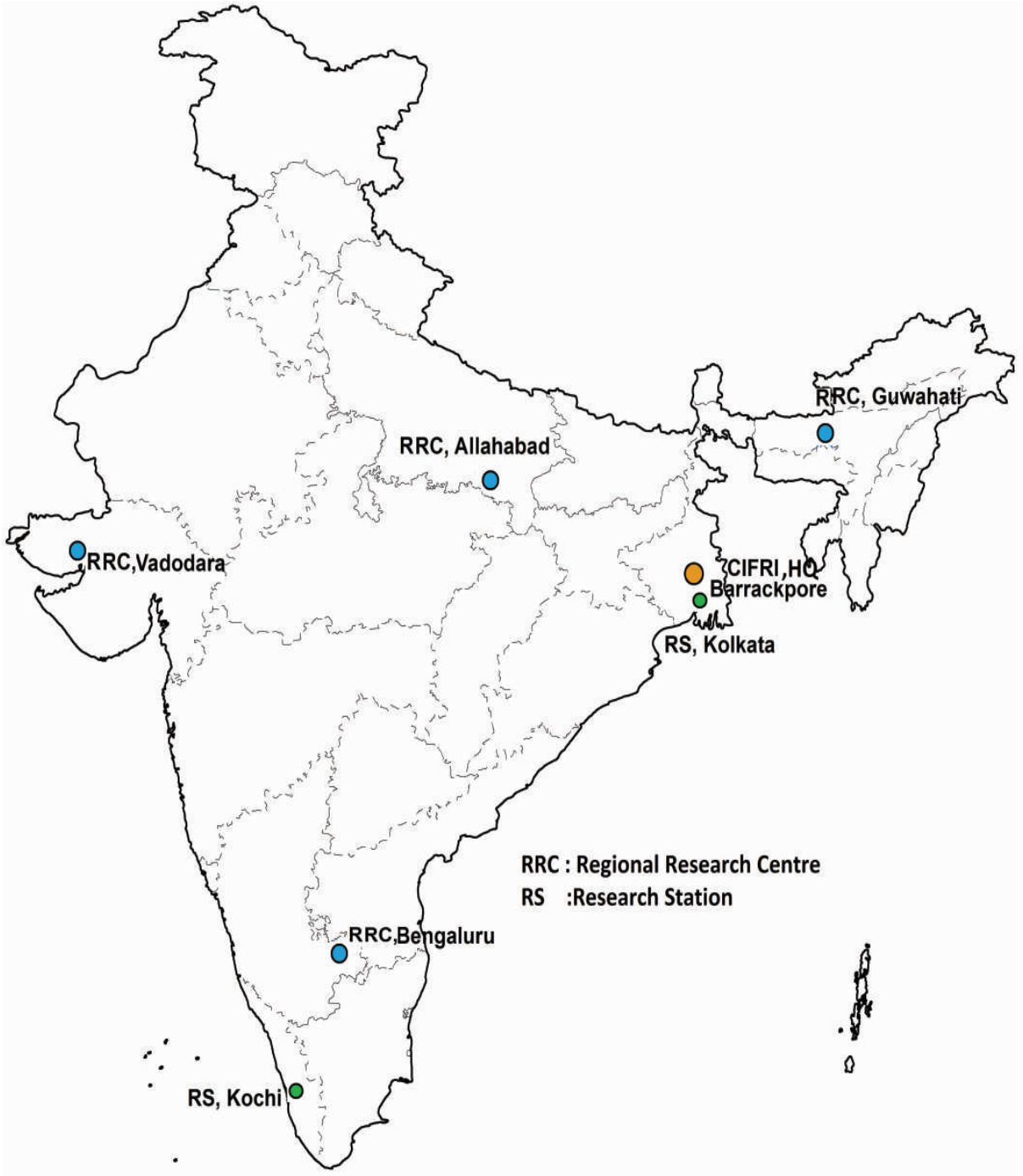
Head Quarter of the Institute has a number of support services, viz. Administration Section, Audit and Accounts Section, PME Cell, Hindi Cell, AKM Unit, Library and Informatics Section, Institute Technology Management Unit, Hindi Cell, Stores Section, Vehicle Section, and Nodal Officers for MGMG program, TSP program, RFD and HRD executing different functions of the Institute.

The Director leads the Institute and is responsible for overall research, administrative and financial management with support and guidelines from concerned Sections, Institute Management Committee, the Institute Research Committee and the Research Advisory Committee. The Institute is ISO 9001: 2008 certified and the new certification for ISO 9001:2015 series is under process.

Organogram of ICAR-CIFRI



LOCATION OF CIFRI HEAD QUARTER, REGIONAL RESEARCH CENTRES AND RESEARCH STATIONS



BUDGET DETAILS

Budget details for the Year 2016 – 17

(` in Lakh)

Head of Account	Budget (RE)		Expenditure	
	Plan	Non Plan	Plan	Non Plan
Pay and allowance including OTA*	-	2020.50	-	2020.38
TA	50.00	7.00	50.00	7.00
Other charges including equipment, Library books, IT and HRD	468.50	4219.50	468.48	4194.28
Works	5.00	-	4.49	-
Grand Total	**523.50**	**6247.00**	**523.47**	**6221.66**

The Budget & Expenditure under Non Plan and Plan for the Financial Year 2016 – 17

(` in Lakh)

Budget Head	Non Plan		Plan	
	Budget	Expenditure	Budget	Expenditure
Revenue				
Estt. charges	2020.00	2019.99	-	-
OTA	0.50	0.39	-	-
TA	7.00	7.00	50.00	50.00
Other charges	192.16	192.14	252.00	251.98
Office buildings	23.38	23.38	-	-
Residential buildings	4.96	4.96	-	-
Minor works	-	-	-	-
Misc expenses including HRD	3.00	3.00	13.00	12.99
TSP general	-	-	10.00	10.00
NEH general	-	-	54.00	54.00
Capital				
Equipment*	4.00	3.99	49.00	49.00
Information Technology	-	-	21.00	21.00
Library books	-	-	19.00	19.00
Vessel	-	-	-	-
Furniture & fixture	-	-	26.00	26.00
Works	-	-	-	-
Minor works	-	-	5.00	5.00
TSP capital	-	-	4.50	4.50
NEH general			25.00	25.00
Total	2255.00	2254.85	523.50	523.47
Pension	3992.00	3966.81	-	-
Loans & advances	15.00	5.54	-	-

Cont.....

Other projects

Projects/Schemes	Receipts (including opening balance)	Expenditure
NICRA	94.97	94.64
CABIN	20.78	20.76
NASF	53.10	40.74
ITMU	15.37	6.38
ICAR-Extra mural	13.60	13.60
Fish health	37.24	26.26
Deposit schemes (Externally funded)/consultancies	712.25	417.96

Revenue receipts

Head	Target	Achievement
Income from sales / services	6.24	7.23
Fee / subscription	-	0.84
Income from royalty, publication etc.	-	0.48
Other income	-	26.49
STD Interest	-	36.95
Sale of assets	-	0.08
Recoveries on loans and advances	-	16.14
CPWD / Grants refund	-	2.81

*Plan Equipment includes 'Other Equipment' of ` 5.00 lac

CERTIFICATE

TÜV NORD

Management system as per
ISO 9001 : 2008

In accordance with TÜV INDIA procedures, it is hereby certified that

ICAR-CENTRAL INLAND FISHERIES RESEARCH INSTITUTE
(INDIAN COUNCIL OF AGRICULTURAL RESEARCH)
Barrackpore, Kolkata - 700 120,
West Bengal,
India

applies a quality management system in line with the above standard for the following scope

Basic, Strategic and Applied Research on Sustainable Fisheries Management in Inland Waters

Certificate Registration No. **QM 05 00293**
Audit Report No. **Q 5533/2014**

Valid until **02.06.2017**
Initial Certification **03.06.2014**

S.K.Kulta

Certification Body
at TÜV INDIA PVT. LTD.

Issue **15.05.2015**
Place : **Mumbai**

This certification was conducted in accordance with the TÜV INDIA auditing and certification procedures and is subject to regular surveillance audits.

TUV India Pvt. Ltd., 801, Raheja Plaza – 1, L.B.S. Marg, Ghatkopar (W), Mumbai - 400 086, India www.tuvindia.co.in

TUV INDIA NABCB

IAF

RIVERINE AND ESTUARINE FISHERIES

Programme : Restoration of rivers and estuaries for ecosystem integrity and conservation of fish stocks

Programme Co-ordinator : Dr. V. R. Suresh

Project (REF/ER/12/01/02) : Population characteristics of small indigenous fishes (SIFs) in rivers and associated ecosystems in relation to rural livelihood and nutritional security

Project staff : A. Sinha, S. K. Das, A. Roy, S. Roy, Kavita Kumari, Raju Baitha, S. K. Koushlesh, Nirupada Chanu, P. Gogoi, Mitesh H. Ramteke, Arunava Mitra, C. N. Mukherjee, Deepak K. Biswas, Abhijita Sengupta, A. K. Barui, Sucheta Majumder and Debasis Saha

In the River Gandak of Bihar, a total of 75 fish species were recorded out of which 52 were Small Indigenous Fishes (SIFs). Similarly out of 53 fish species recorded, 34 SIFs were documented from River Torsa of North Bengal. The study found that SIFs significantly contribute to the income of fisher folk of Torsa River (31%) as well as in Sundarbans (17%). A conservation and demonstration site has been developed in Madanganj, Namkhana, Sundarbans for SIFs.

Small indigenous fishes diversity and physico-chemical parameters of rivers and associated wetlands

Two rivers (Gandak and Torsa), and two associated wetlands (Sarayaman and Balarampur) and coastal wetlands of Sundarbans have been selected for the study. A total of 66 SIFs have been recorded from these study areas.

The study recorded 75 species, of these 52 species were SIFs belonging to 18 families. Out of 52 SIFs, 13, 3 and 37 species have been categorized as food, ornamental and food-ornamental groups, respectively. Shannon's diversity index (H') indicated better SIFs diversity at Maheshwarighat (3.49) followed by Tengrahighat (3.23) and Rewaghat (3.01) of River Gandak. Cyprinids (38%) were most abundant in catch. The SIFs recorded are categorized as Least Concern (46), Near Threatened (2) and Not Evaluated (4) as per IUCN Red List.

Sarayaman, a floodplain wetland of River Gandak has been studied for SIFs diversity, which recorded 26 species, out of which 17 species were SIFs and 1 species was exotic carp (*Cyprinus carpio*). The catch composition of SIFs and non-SIFs was 88% and 12% respectively. Out of 17 SIFs, 1 species was ornamental and 16 species were food-ornamental. The highest number of species/taxa was represented under the family Cyprinidae (27%). The SIF species recorded were categorized as Least Concern (13), Near Threatened (2), Data Deficient (1) and Not Evaluated (1) as per IUCN Red List.

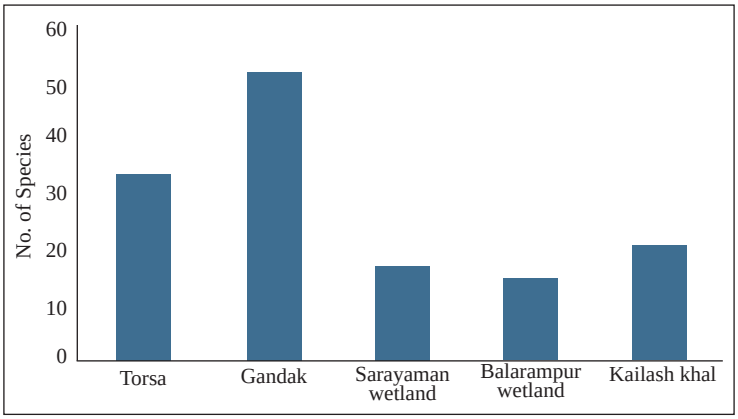


Fig. 1. SIFs diversity in different water bodies

The water of Gandak River was alkaline (with pH range of 8.4 to 9.4), having moderate transparency (25 to 35 cm), high dissolved oxygen (8.4 to 9.2 ppm) and specific conductance ranging from 267 to 287µScm^{-1} during the study period. The nitrate content in the water ranged from 0.51 to 0.76 ppm, phosphate varied from 0.012 to 0.018 ppm and silicate 8.7 – 9.6 ppm.

Fish diversity in Torsa River comprised of 53 species of which 34 were SIFs. Maximum number of taxa (23 species) of SIFs was recorded at Madarihat (upper stretch) and minimum (9 species) at Toofanganj (lower stretch) station. The Shannon diversity index ranged from 1.42 to 2.53 indicating moderate diversity in the river. Species richness varied from 1.40 to 3.12, evenness from 0.46 to 0.54 and dominance index from 0.11 to 0.33. Evenness index value was the highest at

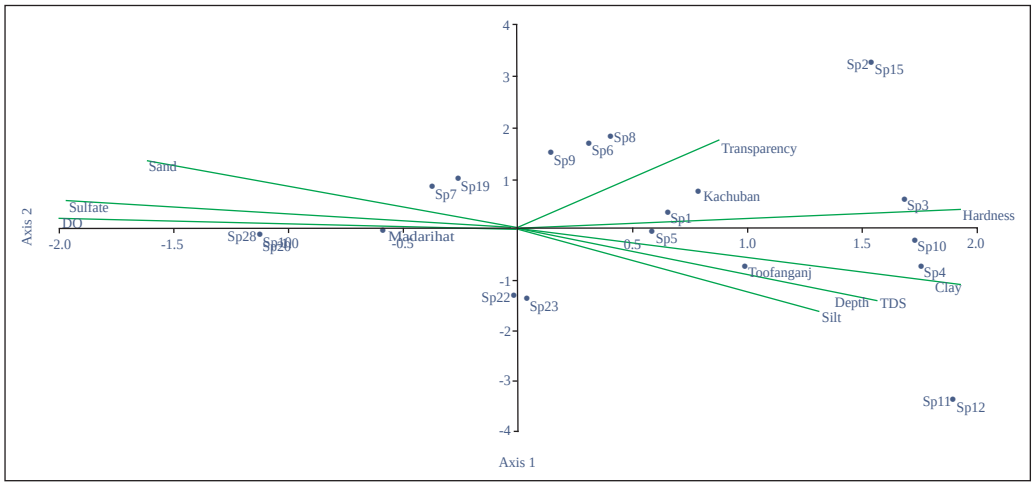


Fig. 2. CCA biplot between physico-chemical parameters and fish in River Torsa

Note : *Crossocheilus latius*:Sp1, *Mystus tengra* : Sp2, *Aspidoparia jaya* : Sp3, *Aspidoparia morar* : Sp4, *Puntius* Sp : Sp5, *Barilius barna* : Sp 6, *Barilius bendelisis* : Sp7, *Salmophasia boopis* : Sp8, *Devario devario* : Sp9,*Nandus nandus* : Sp10, *Chanda ranga* : Sp11, *Chanda nama* : Sp12, *Aborichthys* sp : Sp13, *Acanthocobitis botia* : Sp14, *Ailia coila* : Sp15, *Amblyceps mangois* : Sp16, *Batasio merianiensis* : Sp17, *Botia birdi* : Sp18, *Gagata cenia* : Sp19, *Garra* spp : Sp20, *Glyptothorax indicus* : Sp21, *Lepidocephalus guntea* : Sp22, *Macrognathus* spp. : Sp23, *Ompok pabda* : Sp24, *Orichthys crenuchoides* : Sp25, *Pseudochenensis sirenica* : Sp26, *Pseudolaguvia* spp : Sp27, *Schistura* spp. : Sp28, *Channa gachua* : Sp29

Madarihat whereas dominance was higher at Toofanganj. The SIFs recorded were categorised as Least concern (74.19%), Near Threatened (9.67%) and Not evaluated (16.12%) as per IUCN Red List.

The water of Torsa River was neutral to slightly alkaline with pH value 7.2 to 7.9 with sufficient dissolved oxygen (8 to 9.6 ppm). Madarihat (upper stretch) had highest dissolved oxygen and low temperature (18°C) of water compared to other sampling stations. Transparency was observed high to very high with a range of 61 to 159 cm, total hardness ranged from 62 to 96 ppm. Silicate content varied between 11.05 to 15.84 ppm, nitrate level varied less (0.9 to 1.1 ppm) in different stretches of the river; phosphate content was higher in Madarihat (upper stretch) and Kachuban (middle stretch) of the river (0.012 to 0.014 ppm) and least (0.009 ppm) in the lower most sampling point (Toofanganj).

Canonical Correspondence Analysis of species abundance and water quality parameter showed hardness, transparency at Kachuban, clay (%), depth, total dissolved solid at Toofanganj and sulphate (ppm). DO at Madarihat is more affecting the fish diversity at the respective sites. The dominant SIFs present at Kachuban were *Mystus tengara*, *Ailia coila*, *Crossocheilus latius*, *Aspidoparia jaya*, *Barilius barna* and *Salmophasia boopis*, whereas at Toofanganj were *Nandus nandus*, *Chanda ranga*, *Chanda nama* and at Madarihat were *Schistura* spp. and *Pseudolaguvia* spp.

The diversity and abundance of SIFs in a wetland seasonally connected with Torsa River situated at Balarampur, Cooch Behar district in monsoon and post monsoon season were assessed, and recorded a total of 15 SIFs. Majority (12) of SIFs were falling under IUCN category; Least Concern (LC) and one species each under Vulnerable (VU), Near threatened (NT) and Not Evaluated (NE). The SIFs fauna of the wetland was dominated by the family Cyprinidae (66.83%) followed by Ambassidae (11.24%), Bagridae (7.42%) and Channidae (5.86%). The flood pulse from main river channel Torsa was important in contributing to the fish diversity in the wetland as evident by higher value of Shanon-Weiner index (2.68) in monsoon as compared to post monsoon (1.90).

There was wide difference in transparencies between monsoon (30 cm) and post-monsoon season (210 cm) in the wetland. Amongst the parameters analysed, total alkalinity in post monsoon season (150 ppm) was double than that recorded in

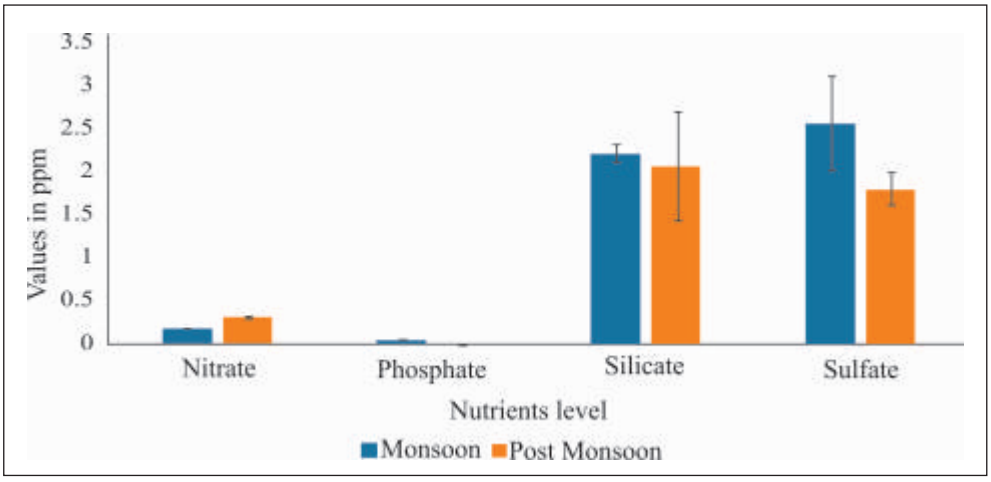


Fig. 3. Nitrate, Phosphate, Silicate and sulfate content in water of *Kailash Khal*

monsoon (74 ppm). Dissolved oxygen and other nutrients (nitrate, silicate, sulphate) were found slightly higher in monsoon season.

The water of the Kailash Khal (a wetland associated with Datta River in Anpur, Sundarban) was slightly brackish; the salinity ranging from 0.33 ppt to 4.54 ppt. The study recorded a total of 27 fish species of both freshwater and brackish water belonging to 8 orders, 15 families and 23 genera. Out of 27 species, 21 were SIFs having both ornamental and food value, 5 were non-SIFs and 1 species was exotic (*Oreochromis mossambicus*). Cyprinidae was the dominant family contributing 23% followed by Gobiidae (15%) and Ambassidae (11%); among the SIFs recorded, *Parambassis ranga* was the most abundant (in numbers) contributing about 19% of total catch. *Amblypharyngodon mola* was the most dominant during pre-monsoon sharing about 28% of the total catch, whereas, *Oryzias dancena* (21%) and *Parambassis ranga* (39%) was dominant during monsoon and post-monsoon respectively. Shannon-Weiner diversity ranged from 1.79 to 2.27 indicating moderate diversity in the wetland, with highest diversity (2.27) recorded during monsoon. The recorded SIF species are categorized as Least Concern (14 species), Near Threatened (1 species), Not Evaluated (3 species), Endangered (1 species) and Data Deficient (2 species) as per IUCN Red List.

A shift in salinity from monsoon (0.33 ppt) to post monsoon (4.54 ppt) was recorded as the wetland is associated with the river. A wide shift in Ca^{++} content (18.7 to 192.08 ppm) and also some increase in total alkalinity (from 48.67 to 76.7 ppm) was recorded in post monsoon season. Except nitrate, the other nutrient contents (phosphate, silicate, sulphate) were higher in monsoon season; a reason might be monsoon showers wash down nutrients to the wetland from adjacent agricultural fields.

Population characterization of important small indigenous fishes

The L-W relationship of four SIFs from Sarayaman (a floodplain wetland of River Gandak) has been studied. The 'b' value for all the species studied were within the reference range (*Nandus nandus*: 3.11; *Heteropneustes fossilis*: 2.64; *Puntius sophore:* 2.79; *Pethia conchonius*: 2.95). Condition factor (K) for *N. nandus, H. fossilis, P. sophore* and *P. conchonius* was 0.62-2.05, 0.39-0.69, 0.52-2.13 and 1.02-1.96, respectively.

Fecundity and GSI of *Amblypharyngodon mola* from Sundarbans of West Bengal was studied. Mature specimens of *A. mola* ranging from 2.13 g to 4.46 g and 59 mm to 78 mm were analysed. Fecundity varied from 940 to 7210 and the fecundity factor ranged from 429.65 to 2281.65. Relationships between fecundity and ovary weight was significant ($r=0.890$, $p<0.01$). *A. mola* is a highly fecund fish and reproductive cycle ranged from April to December with two peaks in June and in November. Fecundity highly correlated ($p<0.01$) with body length, body weight, ovary weight and ovary length. Lowest value of GSI was recorded in the month of January and reached first peak in June and second peak in November.

Plankton diversity and abundance in Torsa, Gandak Rivers and Kailash Khal Wetland

Twenty five genera of phytoplankton were recorded in Torsa River. Diatoms viz., *Fragilaria* spp., *Synedra* spp., *Cymbella* spp., *Nitzschia* spp., *Navicula* spp. and *Gomphonema* spp. have been recorded as dominant taxa from this River. Seasonal abundance was highest in post-monsoon (4.9×10^3 uL^1 at Kachubon) and lowest in

monsoon (0.5x 10^3 uL^{-1} at Jaldapara). Shannon-Weinner diversity index was highest at Kachubon (2.1) and lowest at Madarihat (1.2). In Gandak River, 19 genera of phytoplankton were recorded. The occurrences of pennate diatoms were predominant in summer and centric in winter. Bacillaryophyceae dominated in abundance and diversity in all seasons both in Gandak and Torsa River. Seasonal abundance of phytoplankton in Gandak River showed similar pattern with Torsa River, highest during post-monsoon ($2.8x10^3uL^{-1}$ at Tengrahi) and lowest during monsoon ($0.5x10^3uL^{-1}$ at Maheswarighat).

Six groups of zooplankton were recorded in Torsa River, comprising crustacean nauplii (36%), cyclopoida (35%), cladocera (11%), protozoa (8%), calanoida (6%) and rotifera (4%). Rotifera mainly dominated by two genera *Brachionus* and *Filinia*, while Protozoa consisted of only one genera (*Centropyxis*). The quantitative abundance of zooplankton was observed to be highest at station Kachubon (914 uL^{-1}) while lowest at Madarihat (19 uL^{-1}). However, cyclopoids, rotifers and crustacean nauplii dominated in sampling sites of Gandak River. The highest abundance was at Tengrahi ghat ($1.6x10^3uL^{-1}$) while lowest at Maheswari ghat (0.22 x 10 uL^{-1}) in Gandak River.

A total of 24 genera of phytoplankton was observed during the study period in Kailash Khal wetland, Sundarban. Bacillaryophyceae recorded highest dominance followed by Myxophyceaea and Chlorophyceae. The mean quantitative abundance of phytoplankton ranged from 0.7 $x10^3$ uL^{-1} to 7.2 x 10^3 uL^{-1}. Seven groups of zooplankton were recorded, comprising copepods (23%), crustacean nauplii (22%), rotifers (19%), cladocerons (17%), protozoans (7%), ostracods (7%) and mysis (5%). Significant increase in zooplankton abundance was observed in post-monsoon compared to pre-monsoon and monsoon.

Community knowledge on SIFs

Community's traditional knowledge and associated information were collected from the elders with Prior Informed Consent (PIC). A total of thirteen Indigenous Technical Knowledge (ITK) statements and fifteen traps and gears related to small indigenous fishes were documented and validated from Sunderban areas through Perceived Effective Index and QUIK method. A total of seven traps and gears including fish killing herbs (*Polygonum hydropiper, Zanthoxylum armatum)* were documented from Torsa River.

SIFs and livelihood of fishers

To assess the dependence of the community on SIFs, data were collected from three sites of Torsa River stretch viz. Balarampur, Kachubon and Hasimara and three sites of River Gandak viz. Rewa ghat, Maheshwari ghat and Tengrahi ghat and in Sundarbans two sites viz. Madanganj and Kakdwip. It was evident from the study that SIFs significantly contributed in the income of the fisher folk of Torsa river (31%) area as well as in Sundarbans (17%). But, in Gandak, SIFs did not contribute much in the income of the fisherfolks as the price of such fishes is less in the area. SIFs are also a source of livelihood of tribal women (particularly Rava, Toto, Rajbanshi and Oraon) in upper stretch of Torsa in Hasimara and Totopara region. In Sundarbans, 37% women of fisher's community were dependent on SIFs catching for their livelihood during monsoon.

A conservation and demonstration site has been developed in Madanganj, Namkhana for SIFs. An attempt was made to assess the effect of fishers' socio-

Polygonum hydropiper

economic characteristics and attitudes on participation in SIFs conservation in Sundarbans. Logistic regression analysis was done and it was found that the age of the respondents has negative and significant effect (estimate 0.0442) on willingness to participate in SIFs conservation. Young farmers are more likely to participate in the conservation programme. Gender (estimate 1.0947) is also an important factor. Male members are more willing to participate in SIFs conservation programme than females, as most of the females perceive that SIF is not economically important species. Farmers willing to pay for resource conservation also have positive attitude towards participation in SIF conservation.

Conservation site of SIFs at Sundarbans

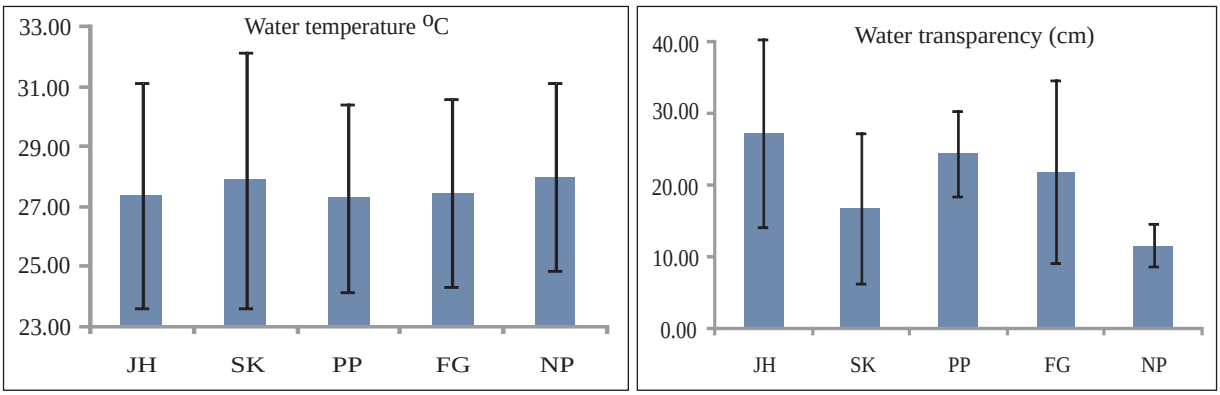
Project (REF/ER/12/01/03) : Assessment of environmental variability, nutrient dynamics, biodiversity, fish stock assessment of selected estuarine and mangrove ecosystems

Project staff : S. K. Das, R. K. Manna, Roshith C. M., D. Sudheesan, D. Bhakta, Manas H. M., S. Roy, W. A. Meetei, T. Nirupada Chanu, S. K. Koushlesh, Vaisakh G, V. L. Ramya, P. Gogoi, R. C. Mandi, C. N. Mukherjee, A. Mitra, A. Sengupta, D. Saha, A. Barui, A. Roychoudhury, S. Mandal, R. K. Sah and J. K. Solanki

Sediment carbon sequestration in Sundarbans was significantly influenced by mangrove litter fall. *Excoecaria agallocha* leaf litter was most susceptible to decomposition due to low C:N ratio in leaves. A total of 177 fish species belonging to 58 families were recorded from Sundarbans. A major shift in the fish catch composition with dominance in trash fishes and Sardines was recorded. *Fragilaria* sp., *Skeletonema* sp., *Triceratium* sp., *Asterionella* sp. and *Odontella* sp. showed positive correlation with salinity and total alkalinity. Transparency, total hardness, salinity and magnesium played important role in distribution and abundance of macrobenthos in selected sites of Sundarbans. A total of 84 finfish and shellfish species with 38 families and 11 orders were identified from Narmada estuary. *O. pama* was the dominant fish species in winter gill net and the fishes were mainly caught in maturing phases. A total of 59 fish species belonging to 27 families and 11 orders were recorded from Korapuzha estuary and prawn was an economically important fishery in this estuary.

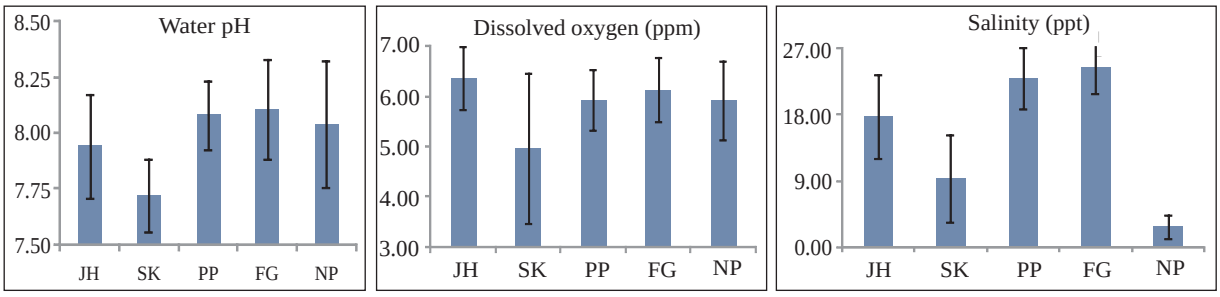
Variability of aquatic environmental parameters in Sundarbans

Examination of the river water, sediment and soil parameters of the mangrove ecosystems of Sandeskhali, Jharkhali, Patharpratima, Fraserganj and Nischintapur in Sundarbans revealed spatial and temporal variations, depending on seasons and locations of the sampling stations. Water temperature was influenced by turbidity; Nischintapur (28.00 ± 3.14°C) and Sandeshkhali (27.90 ± 4.24°C) being more turbid, recorded higher average temperature than other three sampling centres. Water was highly turbid at Nischintapur (transparency 11.63±3.02cm) followed by Sandeshkhali (transparency 16.83 ± 10.49cm) due to riverine discharge of suspended mater from upstream; Hooghly river at Nischintapur and Ichhamati river at Sandeshkhali as the rivers are connected with the Ganga and the Padma respectively.



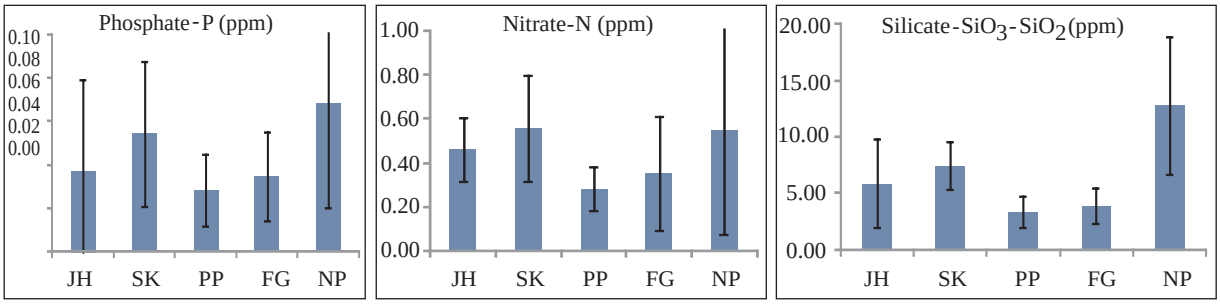
Note : JH = Jharkhali; SK = Sandeshkhali; PP= Patherpratima; FG = Frazerganj; NP = Nishchintapur

Fig. 4.Water temperature and transparency in Indian Sundarbans



Note : JH = Jharkhali; SK = Sandeshkhali; PP= Patherpratima; FG = Frazerganj; NP = Nishchintapur

Fig. 5. pH, dissolved oxygen and salinity of water in Indian Sundarbans



Note : JH = Jharkhali; SK = Sandeshkhali; PP= Patherpratima; FG = Frazerganj; NP = Nishchintapur

Fig. 6.Available nutrients (PO_4-P, NO_3-N and SiO_3-SiO_2) in Indian Sundarbans

Significantly lower water pH (7.72 ± 0.16) and lower dissolved oxygen (4.96 ±1.49) were recorded at Sandeshkhali as compared to other stations especially during monsoon months when low DO of 3.04 ppm was recorded. Polluted water from catchment areas and high turbidity, preventing photosynthesis has a role behind it. Other sampling centres have water pH (7.7 to 8.3) and dissolved oxygen (5 to 7 ppm) congenial for aquatic communities especially fishes. Salinity of Jharkhali station remained high in spite of longer distance from sea; the reason might be very less freshwater discharge from upstream.

Available nutrients

Nutrient parameters (PO_4-P, NO_3-N and SiO_3-SiO_2) followed similar pattern of spatial variation with higher values at Nischitapur and Sandeshkhali, the sampling centres with freshwater discharge from upstream.

Sediment properties

The sediment samples collected from Jharkhali area in February 2016 (post-monsoon) had more organic carbon (mean value 0.66%) as compared to the samples collected from the same area during August 2016 (monsoon) (mean value 0.57%). This was indicative of probable role of mangrove litter fall in sequestration of carbon in soil, as all the samples were taken from under mangrove plantations. Total nitrogen in Jharkhali soil was higher during February 2016 (mean value 0.071 %), but as temperature increased and monsoon set in, the N-mineralization rate increased; moreover, rain washed the forest floor along with the litters, etc. and thus chances of organic nitrogen accumulation was also reduced. Consequently, total nitrogen pool depleted as reflected from the analysis of soil samples collected in monsoon season of 2016 (mean total N = 0.032%). Higher carbon-nitrogen ratio (9.6) in the sediment of River Herobhanga adjacent to mangroves as compared to

nearby River Vidya (2.7) indicated importance of mangroves in maintaining the carbon reservoir in soil.

Leaf litter decomposition

Leaf litter decomposition rates were negatively correlated with initial C:N ratios as revealed from litter bag study at Jharkhali in Sundarbans with three important mangrove species, *viz. Avicennia officinalis, Avicennia alba and Excoecaria agallocha* (the initial C:N ratios were measured as 83.36, 51.34 and 55.94, respectively for those plant species). During decomposition the C:N ratio of *E. agallocha* reduced from 55.94 to 22.90 after 60 days of decomposition, whereas this value for *Bruguiera gymnorrhiza* was higher (60.11), indicating the presence of higher quantity of decomposition resistant carbon fibres (like lignocelluloses) in it .

Fish and shellfish diversity in Sundarbans

A total of 177 fish species belonging to 58 families were recorded. White sardine (*Escualosa thoracata*) has emerged as significant fishery resource along the Sundarbans and is contributing to the bag net catches in good numbers at Saptamukhi estuarine system with relative abundance of 44.16, 62.98 and 93.7%, respectively during pre-monsoon, monsoon and post-monsoon in bag net catches in 2015-16. Increase in the abundance of low value fishes and drastic reduction in catches of commercial fish species has been an established indicator of climate change related impacts in fish community structure. The estimation of fish catch and effort from winter bag net fisheries along the lower Sundarbans (Fraserganj) during 2015-16 and its comparison with the landing data of ICAR-CIFRI during 2009-10 revealed a major shift in the fish catch composition.

The percentage contribution of *Harpadon nehereus*, once considered to be the most dominant species in winter bag net fishery, has reduced from 18.34 % (1362.92 t) in

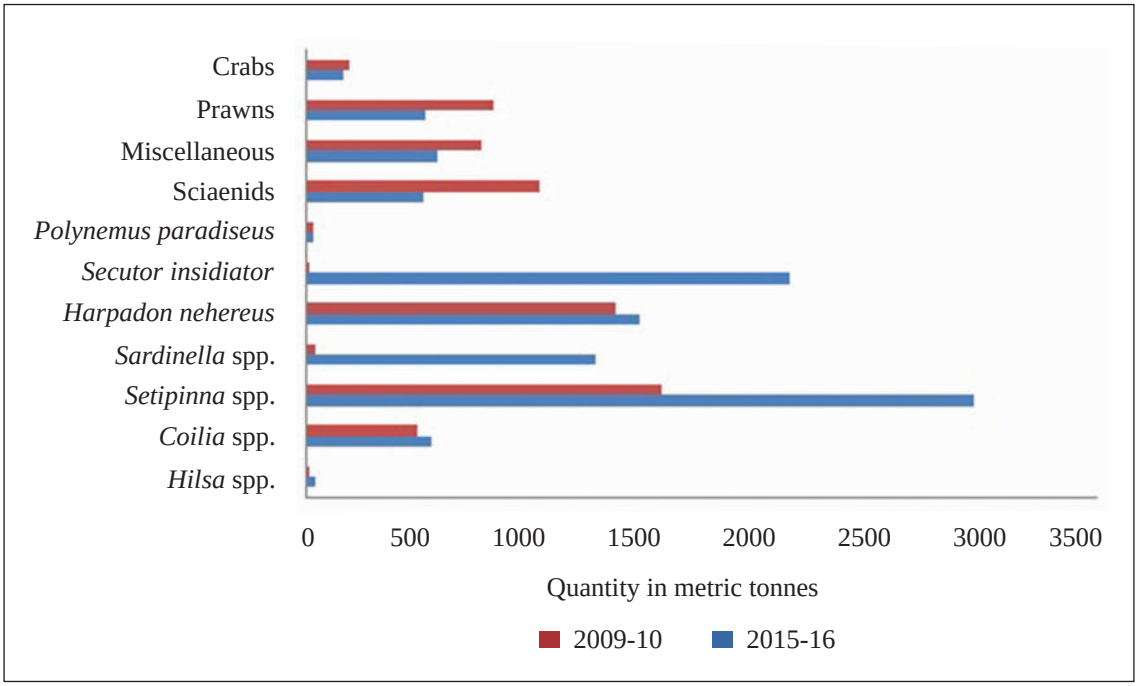


Fig. 7. Shift in the catch structure along lower Sundarbans during 2009-10 to 2015-16

2009-10 to 12.33 % in 2015-16 (1475.29 t). The winter fish catch was dominated by low value species, *Secutor insidiator*, which recorded a drastic increase in the landings from 0.09 % (1.37 t) in 2009-10 to 17.90 % during 2015-16 (2140.57 t). Similarly, there has been tremendous increase in the catches of sardines (*Sardinella gibbosa*, *S. longiceps* and *S. fimbriata*), which currently contribute to 10.66 % (1275.52 t) from 0.48 % (35.61 t) during 2009-10. Though there is overall increase in total fish landings from 7431.59 t (2009-10) to 11962.52 t (2015-16), the catch composition indicated gradual replacement of commercially important fish species by relatively low valued species.

A total of 19 species of marine, estuarine, brackish water and freshwater crabs belonging to 11 genera and 7 families were recorded from Sundarbans. The only freshwater crab species recorded was *Sartoriana spinigera*, from natural canals of Sundarbans. Crabs of the family Portunidae were most dominant (42%) followed by Ocypodidae (Fiddler crabs, about 27%), Varunidae (11%) and 5% each by Calappidae, Leucosidae, Gecarcinucidae and Dorippidae.

Catch of crabs was the highest during winter season; ranged from 200 to 400 kg/boat/month, which was about 600 kg/boat/month during 1986-87. The reduction in catch quantity may be due to overfishing. Landing of *Scylla olivacea* in middle Sundarbans during June 2016 to December, 2016 was 1496.86 t; maximum landing (289.6 t) was recorded during December 2016.

Freshwater crab, *Sartorina spinigera*

Mud crab, *Scylla olivacea*

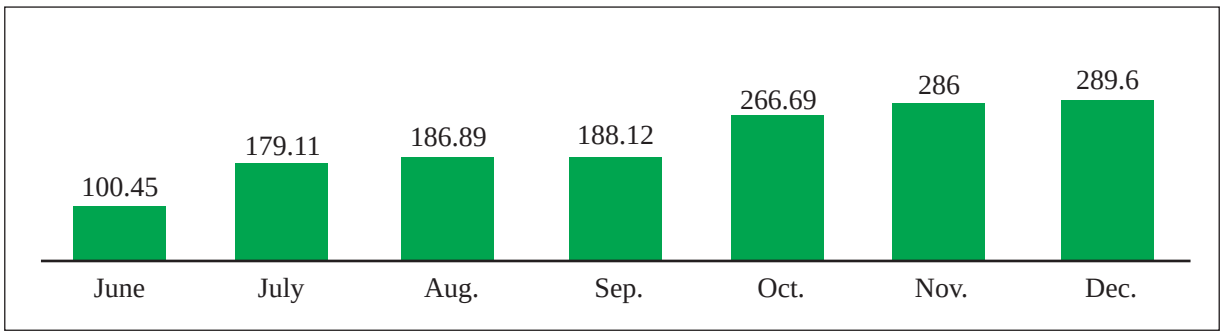


Fig. 7. Monthly landing (t) of mud crab in middle Sundarbans during 2016

The length-weight relationship of Bombay duck was estimated as log W= -6.171 + 3.353 log L, where W is weight of fish in g, L is length of fish in mm, log 'a' = -6.171 and b = 3.353. The total mortality coefficient (Z) obtained from length converted catch curve was 2.42 and the natural mortality (M) was 0.65 by Pauly's empirical formula. The fishing mortality (Z-M=F) was 1.77. The E_{max} (exploitation rate, which produces maximum yield) estimated from relative yield per recruit model was 0.439 while the present exploitation rate for the fishery was estimated at 0.67. This indicates the stock is over-exploited. Since, the length at capture (Lc) is 45mm and 95.7% of the catch was less than the length at first maturity of 260mm, the bag net fishery may lead to growth overfishing.

Plankton diversity in Sundarbans

Plankton analysis revealed the presence of 84 species of phytoplankton belonging to 62 genera Bacillaryophyceae shared maximum diversity (35 species) followed by Coscinodiscophyceae (22 species) and Chlorophyceae (9 species). Myxophyceae, Zygnematophyceae and Mediophyceae were represented by 5 species for each group. Lowest species diversity was recorded in Dinophyceae (3 species). Out of 62 phytoplankton genera identified, 40 were diatoms, 19 Centrals and 21 Pennales. Coscinodiscophyceae showed dominance in all seasons in terms of abundance while Bacillaryophyceae showed dominance in terms of diversity during the study period. The quantitative abundance of phytoplankton was found to be in peak in monsoon (3.74×10^3 uL^{-1} to 13.24×10^3 uL^{-1}) followed by pre-monsoon (1.03×10^3 uL^{-1} to 12.06×10^3 uL^{-1}) and post-monsoon (2.42×10^3 uL^{-1} to 7.83×10^3 uL^{-1}). Highest abundance of phytoplankton in monsoon season reflected the presence of more freshwater dominant euryhaline species of Chlorophyceae, Zygnematophyceae and Myxophyceae. Richness (Margalef, 1958) and Shannon diversity index (Shannon, 1949) found to be >1.6 indicated that all stations have moderate diversity in Sundarbans. Ten groups of zooplankton were recorded from lower, middle and upper Sundarbans. Compositions of zooplankton were represented by copepod

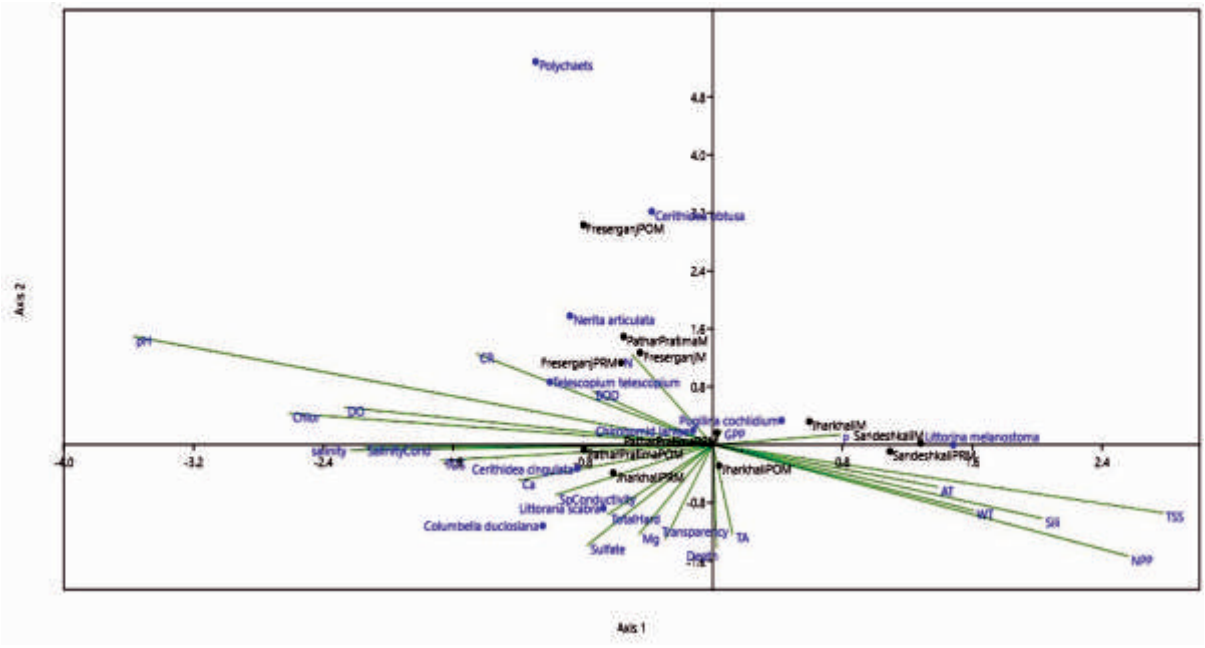


Fig. 9. CCA biplot of Sundarbans between physicochemical parameters and dominant phytoplankton genera

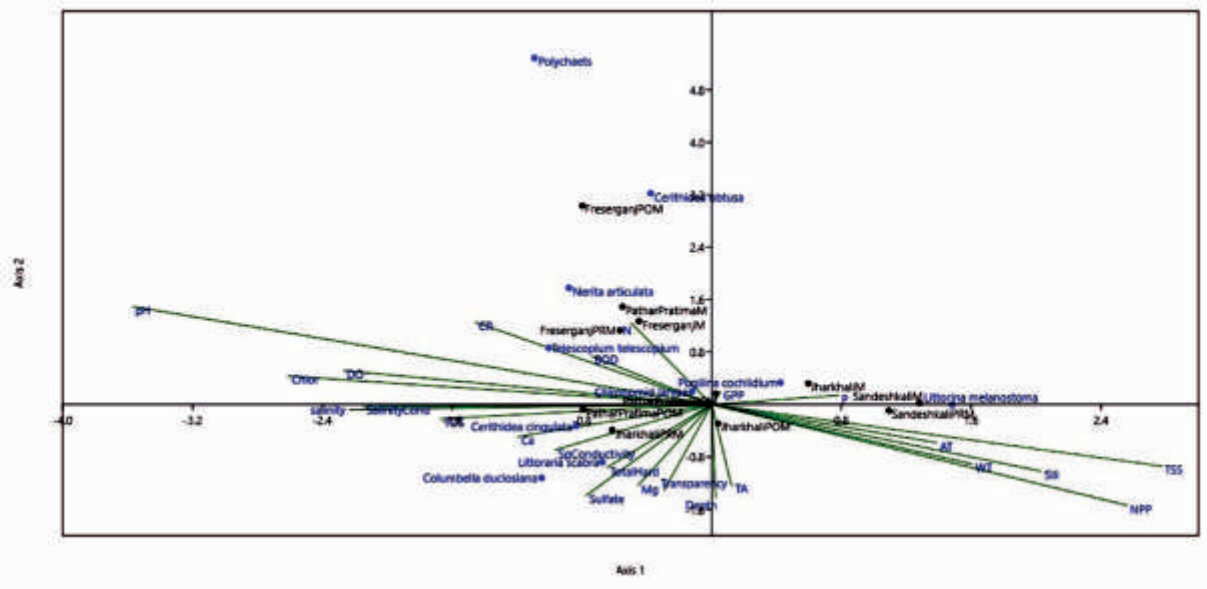


Fig. 10. CCA bioplot of benthos and water parameters

(44%), crustacean naupli (27%), copepod eggs (10%), mysis (4%), cladocerons (4%), rotifers (3%), bivalve larvae (3%), gastropod larvae (3%), tintinnids (2%) and nematodes (0.48%). Genus *Oithona* was common in all stations and mainly comprised of three species, *Oithona simplex, O. rigida* and *O. similis*, whereas Herpecticoida was chiefly dominated by *Microsetella norvegica*. The quantitative abundance of zooplankton ranged from 496 to 1,496 uL^{-1}, highest at Patharpratima (monsoon) and lowest at Nischintapur during post-monsoon season. Freshwater gastropod larvae, *Gangetia miliaceae*, primarily recorded during monsoon and observed lower abundance in post-monsoon and pre-monsoon season. Canonical Correspondence Analysis using nine physico-chemical parameters and 39 plankton genera revealed that *Fragilaria, Skeletonema, Triceratium, Asterionella, Chaetoceros* and *Odontella* are positively influenced by salinity and total alkalinity. *Pseudonitzschia, Tabellaria, Navicula, Ditylum, Ankistrodesmus* and *Oodogonium* showed positive correlation with pH, water temperature, phosphate and silicate whereas *Hemidiscus, Oscillatoria, Thalassiothrix* and *Melosira* revealed negative relationship with dissolved oxygen in the sampling sites.

Diversity of macro benthic fauna in Sundarbans

A total of 24 taxa were recorded. Phylum Mollusca was most dominant and represented 80-95% of total taxa of macrozoobenthos. Highest species richness and H' was recorded from Patherpratima and Fraserganj, during monsoon and pre-monsoon respectively. This richness in benthos diversity may be due to both sites being estuarine zone and getting nutrients from both land and sea origin. Cluster analysis of benthos abundance at different sites and seasons revealed that Nischintapur formed separate cluster with that of other sites in all seasons, which might be due to this site being predominantly freshwater zone with salinity varying between 2.7 to 5.4 ppt. Canonical correspondence analysis with water parameters and benthos abundance in different sites and seasons revealed that, transparency, total hardness, salinity and magnesium played important role in distribution and abundance of macrobenthos in selected sites of Sundarbans.

Fish and shell fish diversity in Narmada estuary

A total of 84 finfish and shell fish species under 38 families and 11 orders were recorded from Narmada estuary. The most commercially important fish species were *Tenualosa ilisha, Otolithoides pama, Macrobranchium rosenbergii, Rhinomugil corsula, Arius arius, Cynoglossus cynoglossus, Lates calcarifer, Wallago attu, Harpadon nehereus and Mugil cephalus.* Bag net (1.0 cm cod end) catch data showed that *Arius arius* contributed 37% of the total catch followed by *R. corsula, W. attu, O. pama, M. rosenbergii, C. cynoglossus, M. cavasius* with CPUE 8-14 kg/bag/tide (monsoon season).

Water quality parameters of Bharuch, Bhadbhut, Mehgam and Ambetha indicated that Narmada estuary was moderately productive with DO 6.08 to 7.76 ppm, pH 7.74 to 8.17, salinity 0.12 to 34.7 ppt and transparency 4 to 43 cm. Gross primary production rate ranged from 50 to 116.67 $mgCm^{-3}hr^{-1}$. The water quality of the Narmada estuary as evident from important attributes viz. water temperature, transparency, pH, dissolved oxygen, free CO_2, total alkalinity, specific conductivity, salinity and total dissolved solids, was conducive for biological production. Relationship between fish abundance and physicochemical parameters revealed that, five parameters were important in the abundance of the fish namely, water temperature, specific conductivity, dissolved oxygen, salinity and total dissolved solids. Sediment quality parameters such as pH, specific conductivity, organic carbon, available phosphorus, total nitrogen of the relevant stretch was found conducive for the metabolic activities of the estuary. However, the total nitrogen content was low.

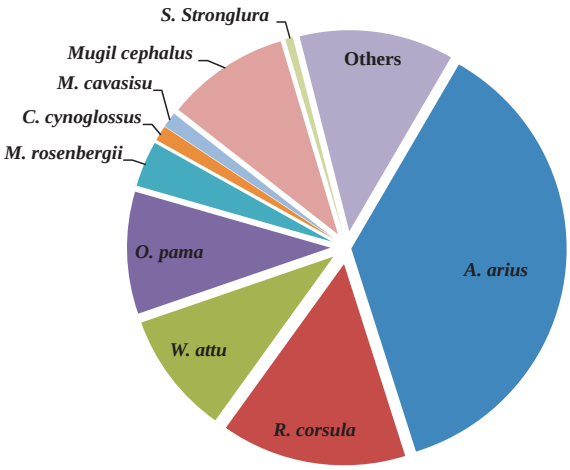


Fig. 11. Composition of bag net catch in Narmada estuary

Bag net catch from Narmada estuary

O. pama was the dominant fish species in winter gill net (60-80 mm mesh size). Catch showed specimens of TL ranging from 17 to 44.9 cm during winter season. The percentage composition of fishes in each length classes revealed that around 85% of the specimens fall under the length class of over 201-300 mm; which indicated that the fishes are mainly caught in their maturing phases. Length weight relationship of *O. pama* was found to be $W = 0.011791 \times L^{2.845103}$ ($r^2 = 0.8547$).

Fish and shell fish catch and diversity in Korapuzha estuary

A total of 59 species belonging to 27 families and 11 orders were recorded from Korapuzha estuary. Perciformes was the most dominant order, covering 12 families

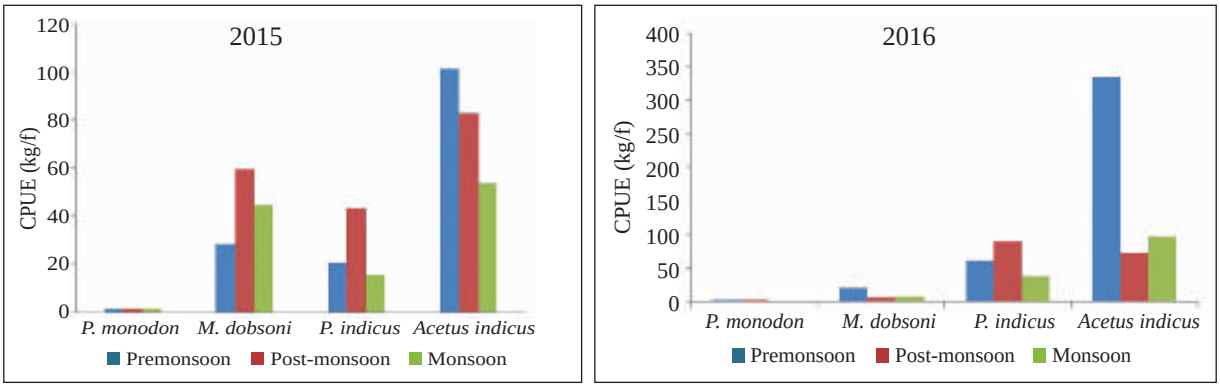


Fig. 12. CPUE in stake net in 2015 and 2016

and 30 species. Prawn fishery was economically important in this estuary. Major prawn catch of this estuary comprised of *Acetes indicus* (62%), *Penaeus indicus* (23%), *Metapenaeus dobsoni* (14%), and *Penaeus monodon* (1%) from stake net. *A. indicus* catch was high in pre-monsoon whereas *M. dobsoni* and *P. indicus* catches were high in monsoon season. Highest catch was recorded in post-monsoon in the year 2015; however it was shifted to pre-monsoon season in 2016. It was observed that CPUE of most of the species in stake net were significantly reduced in 2016 as compared to year 2015. Shannon diversity index of fish found to be 3.72-3.85 and taxonomic distinctness 2.33-2.42, in which highest diversity was reported in monsoon season. Crustacean and finfish catches showed positive and high correlation (0.7) with water quality parameters.

Project (REF/ER/12/01/05) : Quantification of environmental flow requirements for ecosystem functions, including biodiversity and fisheries of selected rivers

Project staff: A. K. Sahoo, Roshith C. M., S. Das Sarkar, Rohan K. Raman, Manas H. M., Kavita Kumari, Simanku Borah, Lianthuamluaia, Shravan K. Sharma, Abhijita Sengupta, Debasis Saha, A. Roychowdhury and Amoy Barui

The zone of adult fish of *Tor mahanadicus* was mostly characterized by rocky, transparent and fast water velocity. A minimum of 24.284 MCM and 331.953 MCM for lean and monsoon period, respectively are required for sustainable fisheries of this species in River Mahanadi. Depth and water temperature were significantly correlated with *C. chitala* distribution and it was found that biomass distribution was more in the deeper pools with an average depth of 12 feet.

Environmental flows (e-flows) describe the quantity, timing and quality of water flows required to sustain freshwater, estuarine ecosystems and fishers' livelihoods that depend on these ecosystems. Assuming hypothesis that estimation of e-flows for a key fish species would represent the e-flows requirement for sustainable river ecosystem in the selected river stretch, *Tor mahanadicus*, an endangered fish species as per IUCN Red list and the state fish of Odisha, was considered. The study recorded adult and juvenile *T. Mahanadicus* from Hirakud (21°32'00.11"N; 83°52'32.57"E) to Satkosia gorge (20°30'10.73"N; 84°52'14.40"E). The zone of adult fish was mostly characterized by rocky, transparent and high water velocity (0.5 to 1m/s).

In order to study the reproductive biology, a total of 24 adults were collected, of which 12 were male, 5 were female and 7 were unidentified. All 12 males were in the size range of 237 to 810 mm with oozing milt, while female size ranged from minimum 210 to 342mm. Histology of the female gonads during March-May representing pre-monsoon showed ova stage II to III with varying ova diameter from 0.03 to 0.11 mm with greater number of 0.05mm oocytes. While during September, representing monsoon, showed from ova stage IV to V with varying ova diameter from 0.7 to 0.15 mm with greater number of 0.11 mm, indicating late stage

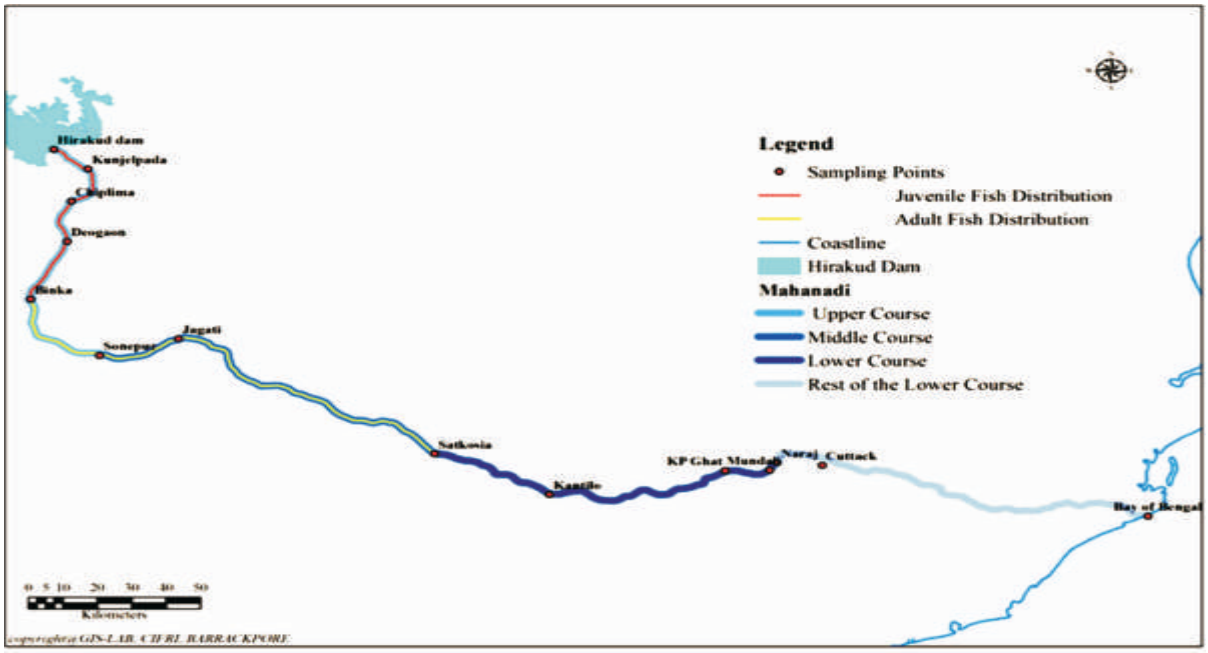


Fig. 13. Distribution of *Tor mahanadicus* in river Mahanadi, Odisha

Tor Mahanadicus

Female fish with maturing gonad

Male with oozing out milt

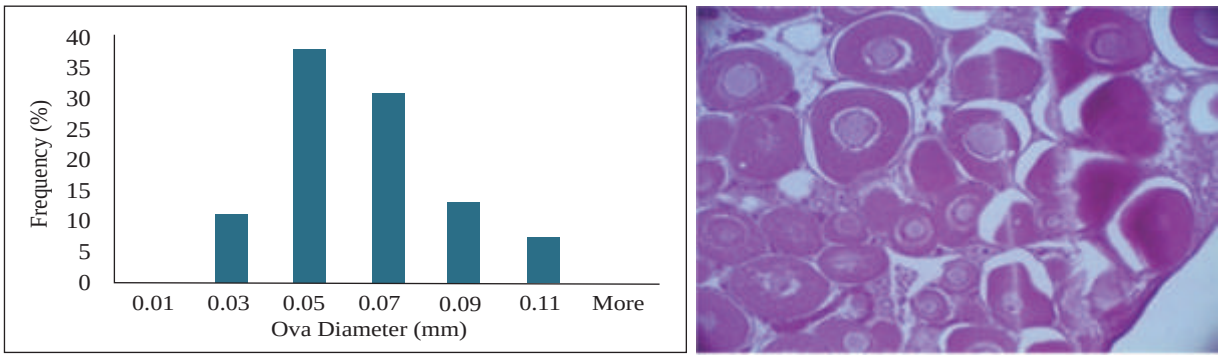


Fig. 14. Histology of female gonad showing matured eggs with egg diameter of maximum frequency of 0.05 during pre-monsoon (April-May)

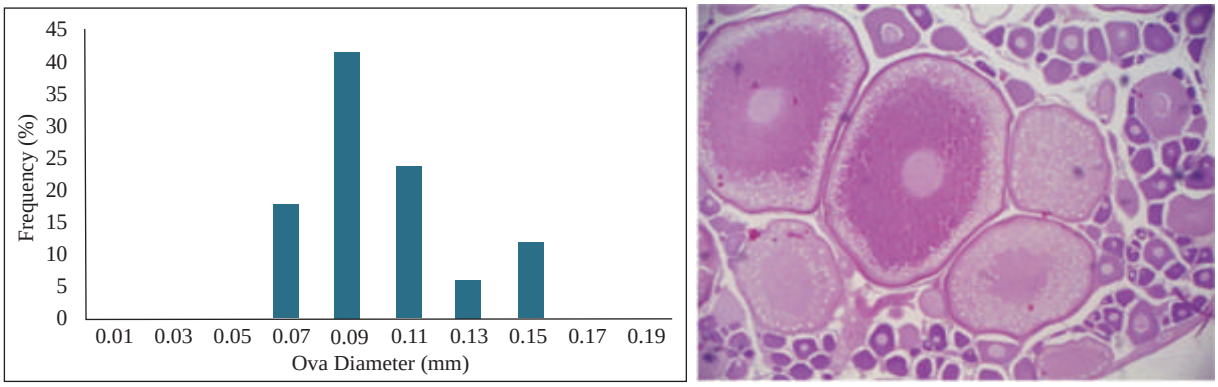


Fig. 15. Histology of female gonad showing matured eggs with egg diameter of maximum frequency of 0.08 during monsoon (Aug-Sep, 2016)

of maturity. During the same time, the river discharge showed 100% fall. While males showed oozing milt during August and December indicating gonadal maturation irrespective of sharp fall in river discharge. Based on the reproductive suitability, river flow requirements for sustainable recruitment of *T. mahanadicus* was that a river water temperature of 24.0±0.5^{0}C, pH 7.5±0.5, dissolve oxygen 7.4±1.0 ppm, and total alkalinity 85±1.5 ppm during August to September are conducive for the sustainable recruitment of the species.

Though more than 200 methods are being used for estimation of e-flows, we used hydrologic-wetted perimeter method for eflows requirement for *T. mahanadicus*. Daily discharge of river Mahanadi at Satkosia G/D site was used for estimation. Considering the water depth of 1m and velocity more than 0.5m/s, it was estimated that a minimum of 24.284 MCM and 331.953 MCM for lean and monsoon period, respectively are required for sustainable fisheries in river Mahanadi.

Distribution of *Chitala chitala* (Ham. 1822) *vis a vis* river habitat in Mahanadi

Chitala chitala is considered as near threatened fish species as per IUCN Red list. In order to understand the distribution of the species in association with river habitat, a study was carried out in River Mahanadi from Hirakud to Paradip in a stretch of 450 km representing both freshwater and brackish water. 17 physico-chemical parameters of water and soil were taken for generalised linear model (GLM) analysis. It was observed that depth ($P < 0.01$) and water temperature ($P < 0.05$) were significantly correlated with *C. chitala* distribution. *C. chitala* was caught with a

size range from 190mm (210g) to 810mm (932g). Further, it was observed that the distribution in terms of biomass was more in the deeper pools with an average depth of 12 feet. Hence, the study underlines the importance of water requirement for deep pools in the river ecosystem.

Chitala chitala caught from River Mahanadi

Deep pool in Mahanadi at Shankheswar

Project (REF/NR/12/01/06) : Impact assessment of multiple habitat alterations on ecosystem functions and fisheries in rivers

Project staff: K. D. Joshi (upto 30.11.2016), R. S. Srivastava, D. N. Jha, M. A. Alam, Vaishak G., J. Kumar, S. C. S. Das, A. K. Yadav, S. K. Srivastava, K. Srivastava and V. Kumar

Gangotri to Vindhyachal stretch of the River Ganga recorded a total of 127 fish species belonging to 78 genera, 31 families and 11 orders. The estimated fish landing at Vindhyachal, Kanpur, Narora and Bijnor was 2.85, 3.4, 4.0 and 3.1 quintals/day, respectively. *Catla catla* was not recorded in these centers. Contribution of other IMCs was 0.29-6.7%, large catfishes 13.75-27.1% and miscellaneous fishes 52.6-64.5%. Fifteen species were threatened as per IUCN category. 71% of the fishes were omnivorous. *Sicamugil cascasia* spawn year round except in December and January. The total plankton and periphyton abundance were higher in lower stretches. The nutrient level was low in the entire upper stretch. Following the GEFC model it was estimated that the requirement of discharge is higher in Nov – May as compared to actual discharge in Bhimgora barrage.

Fish diversity, composition and distribution patterns

A total of 127 fish species belonging to 78 genera 31 families and 11 orders were recorded from Gangotri to Vindhyachal stretch of the river Ganga. Of these, six were exotics viz. *Oreochromis niloticus*, *Cyprinus carpio*, *Clarias gariepinus*, *Hypophthalmichthys molitrix*, *H. nobilis*, *Ctenopharyngodon idella* and *Salmo trutta fario*. Number of species recorded from Haridwar, Bijnor, Narora, Farrukhabad, Kannauj, Kanpur, Allahabad and Vindhyachal were 59, 115, 110, 92, 89, 90, 94 and 93 respectively. Cypriniformes was the most dominant order with 62 species followed by Siluriformes (31) and Perciformes (17). Cyprinidae was the most dominated family represented by 54 species belonging to 26 genera, followed by Sisoridae (8 species from 5 genera) and Schilbeidae (7 species from 3 genera).

The estimated fish landing at Vindhyachal, Kanpur, Narora and Bijnor was 2.85, 3.4, 4.0 and 3.1 quintals/day, respectively. *Catla catla* was not recorded from these centers. Landing of other IMCs ranged from 0.29-6.7% of the total catch, being maximum at Bijnor and minimum at Vindhyachal. Contribution of large catfishes ranged from 13.75 to 27.1%, being maximum at Bijnor. *Wallago attu* dominated at

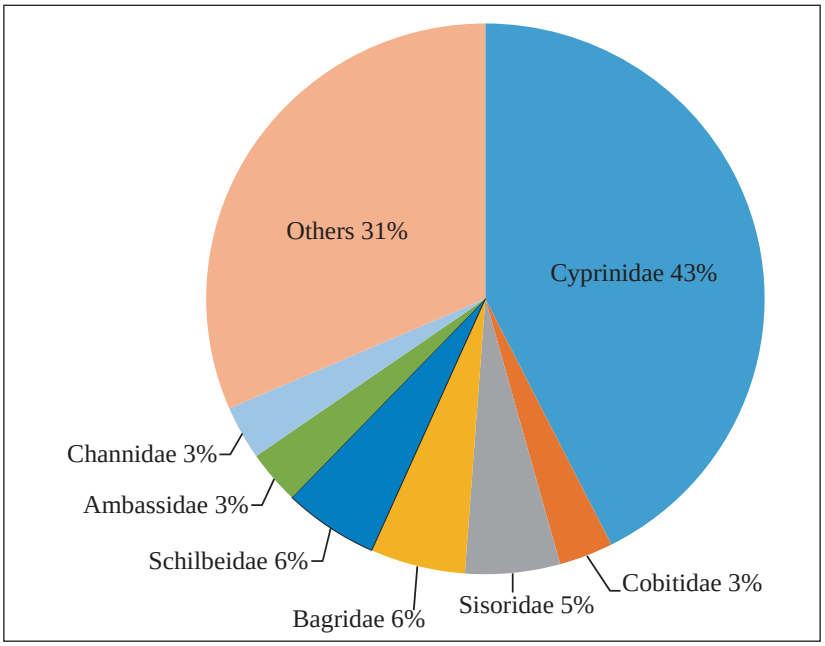


Fig. 16. Family-wise composition of fishes in Gangotri to Vindhyachal stretch of River Ganga

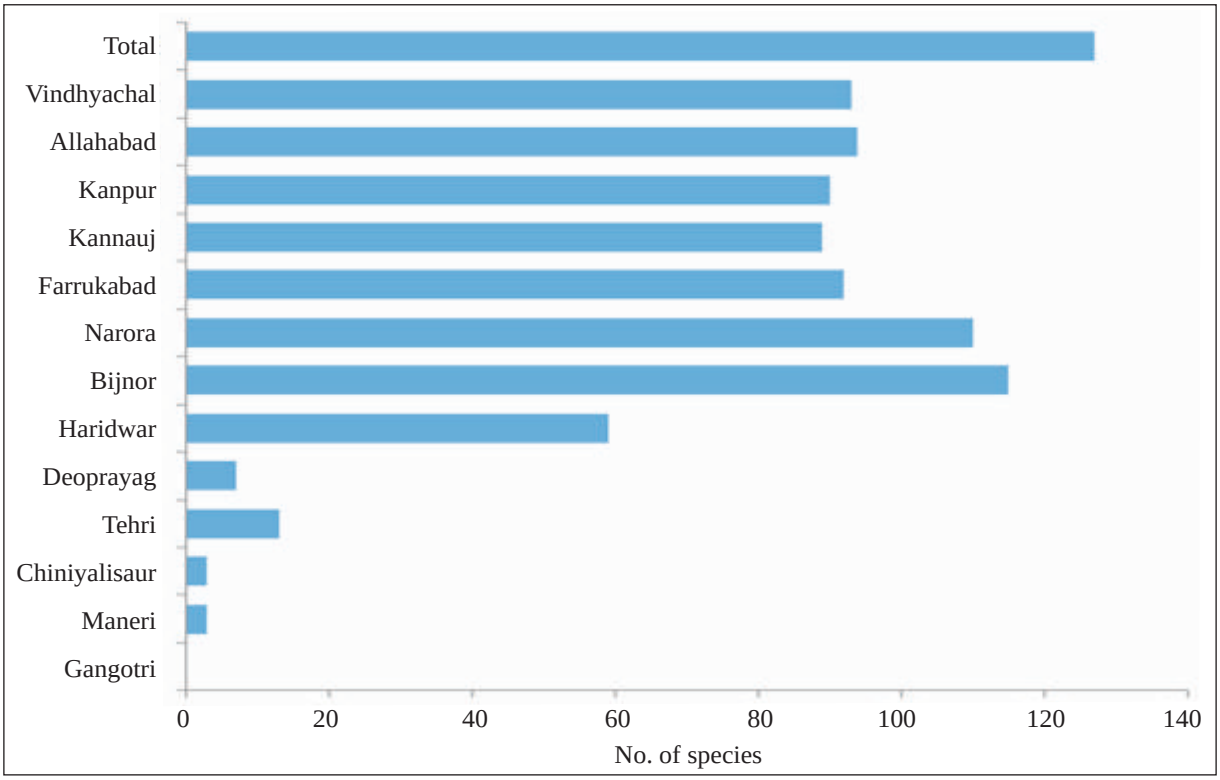


Fig. 17. Number of fish species in different sampling centres of River Ganga

all centers. Catch of exotic fishes was constituted by *Oreochromis niloticus* and *Cyprinus carpio*. Among exotics, *C. carpio* and *O. niloticus* at Kanpur, Allahabad and Vindhyachal was 26.5, 7.4 and 1.8 and 15.8% of catch respectively. *C. carpio*

contributed significantly at Narora while no exotic fish was recorded at Bijnor. Miscellaneous fishes dominated at all the centers (52.6-64.5%). *Cabdio morar, Barilius barila, Puntius* spp., *Channa* spp., *Xenantodon cancila, Gudusia chapra,* etc contributed mainly to the miscellaneous group of fishes.

The catch per unit effort (CUPE) in kg/day/fisher was higher above the barrage stretch and was estimated at 3.2, 5.1 and 5.6 as compared to 2.7, 3.1 and 3.6 below the barrage at Kanpur, Narora and Bijnor, respectively.

Conservation status

Following the IUCN criteria, 15 species were found to be threatened, 2 endangered (*Tor tor, Clarias magur*), 4 vulnerable (*Cirrhinus cirrhosis, C. mrigala, Schizothorax richardsoni* and *Tor chelynoides*) and 10 near threatened (*Anguilla bengalensis, Parambassis lala, Ailia coila, Wallago attu, Ompok pabda, Ompok bimaculatus, Chitala chitala, Bagarius bagarius, Tor tor* and *Labeo pangusia*), warranting conservation attention.

Trophic structure of fishes

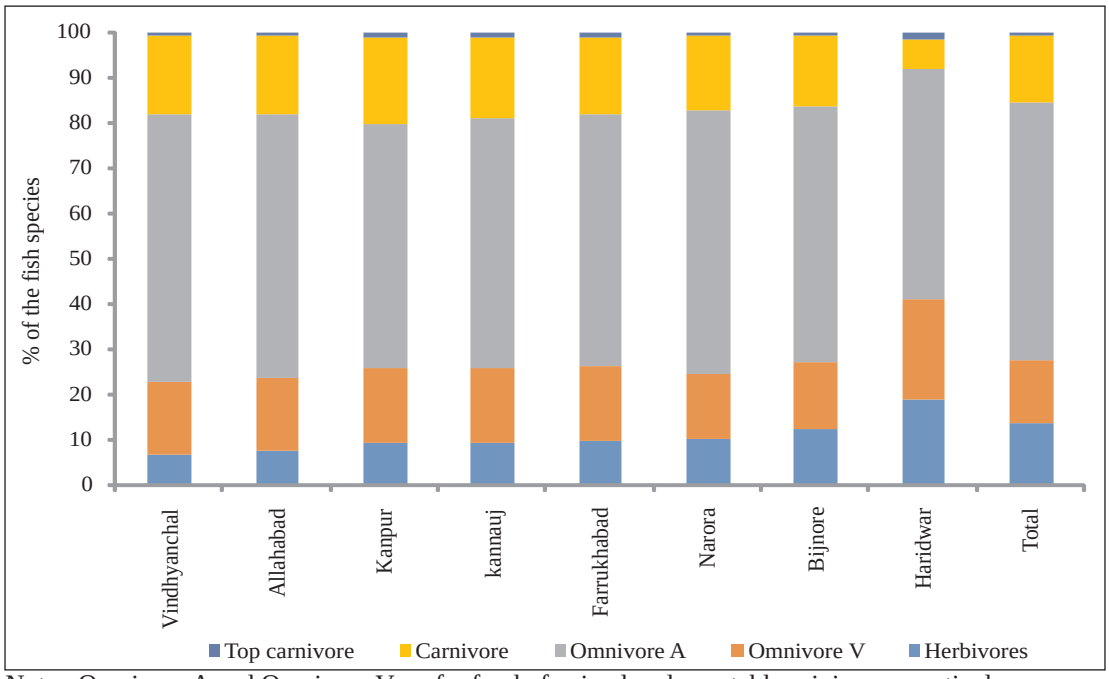
Analysis of the trophic structure of the fishes recorded from the River Ganga between Gangotri and Vindhyachal revealed that 71.1% of them were omnivorous. The share of carnivores was 14.8%, herbivorous 13.3% and top carnivorous 0.8%.

Biology of *Sicamugil cascasia*

Sicamugil cascasia was very common in the middle and the lower stretches of River Ganga. It is locally known as *Banna/Rudha* and the catch at Allahabad is significant among the miscellaneous group of fishes. Feeding and reproductive aspects of *S. cascasia* was studied at monthly intervals from River Ganga at Allahabad. Gut content analysis revealed that it feeds mainly on phytoplankton (Bacillariophyceae, Chlorophyceae and Myxophyceae), detritus and zooplankton. Relative Gut Length (RGL) indicated that the fish is omnivorous and values of RGL ranged between 1.67 and 2.26 with a mean of 2.02.

Mean monthly Gonadosomatic Index (GSI) ranged between 0.91 and 6.08 % and with mean of 3.04% in females. Maximum GSI value of 12.61% was found in the month of June. Matured and spent individuals were recorded in every month except December and January, which indicated year round spawning other than in

Anabas testudineus recorded from Bijnor



Note : Omnivore A and Omnivore V prefer food of animal and vegetable origins, respectively

Fig. 18. Trophic structure of the fish species along the Gangotri and Vindhyanchal stretch of river Ganga

December and January. Average monthly GSI ranged between 0.91 and 6.08 %, with a mean of 3.04% in females.

Gastro-somatic Index (GaSI) ranged from 2.96 to 9.66% and 2.25 to 9.64% with mean of 6.94% and 6.97% in males and females, respectively. GaSI values were higher in almost all months except June and December but the values did not show any significant variation (t test, p>.05) and indicated that both males and females feed in equal intensity. The condition factor was found to be in the range of 0.98 to 1.21 with mean of 1.11 in males while in females, it ranged from 0.99 to 1.24 with

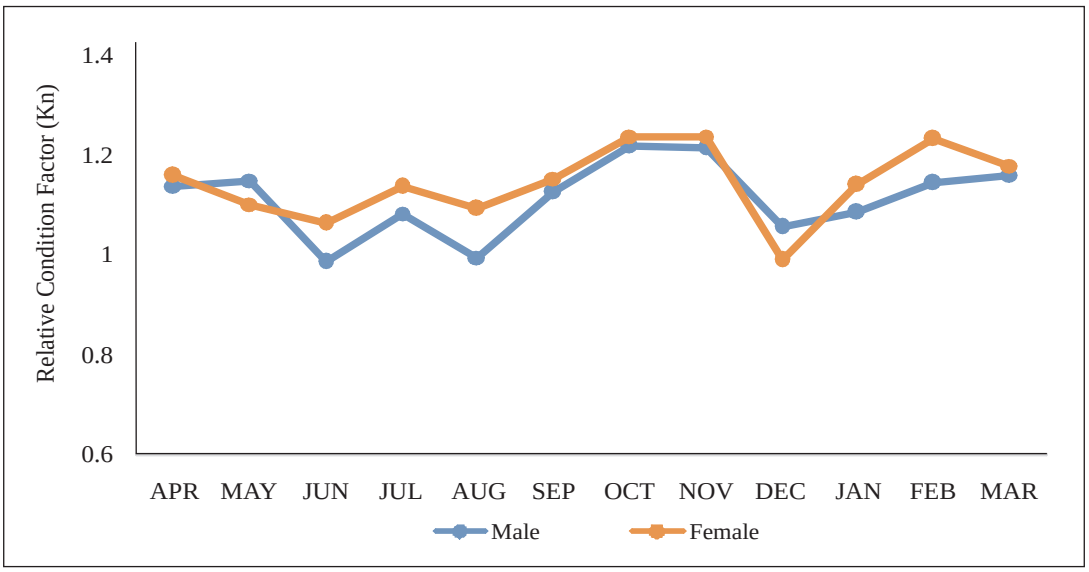


Fig. 19. Monthly mean variations in Relaive Condition factor (Kn) in male and female of *S. cascasia*

mean of 1.14, respectively. There was no significant differences in the condition factor in males and females, respectively (t test, $p>0.05$) except in the month of March which indicated better conditions throughout the year.

Environmental flow estimation

Based on hydrological data and following the methodology of Global Environmental Flow Calculator (GEFC), the monthly discharge from Bhimgoda barrage should be as per the data given in table. It will mark the river in 'Moderately Modified' class of environmental management.

Table 1. Requirement of discharge from Bhimgora barrage

Month	Current Discharge (cumecs)	Estimated Discharge required (cumecs)
January	63.94874	148.8694
February	69.65833	153.1917
March	61.84749	154.525
April	76.666	178.7194
May	204.214	239.3389
June	557.2039	331.0111
July	1498.46	522.6917
August	2165.257	840.5361
September	1216.92	475.5556
October	401.7447	259.6861
November	114.513	183.3556
December	64.25217	159.625

Fish landing

Fish landing from Allahabad stretch of the River Ganga was estimated at 174.46 t during 2016. Contribution of other group of fishes was maximum (41.33%) followed by exotic fishes (36.19%), while contribution of IMC and cat fishes were 12.88% and 9.6% respectively. Common carp dominated among exotic fishes. There has been a decrease of about 12.56% in fish catch as compared to the preceding year mainly due to difficulty in catching fishes owing to heavy rain and flood during mid-June to mid-October-2016.

Plankton

Abundance of total plankton in the lower stretch was higher in comparison to upper stretch. Total plankton ranged from 30uL^{-1} (Gangotri) to 4000 uL^{-1} (Kanpur, below barrage). Kannauj (2520 uL^{-1}) and Allahabad (3700 uL^{-1}) also depicted higher abundance. In the upper stretch it ranged from 30uL^{-1} (Gangotri) to 215 u/l (Srinager) and increase in abundance was noticed after Haridwar. In the upper stretch Bacillariophyceae was dominant but in lower stretch (below Haridwar) increase in Chlorophyceae and other groups such as Myxophyceae, Euglenophyceae, Rotifera, Protozoa and Crustacea was noticed. Bacillariophyceae ranged from 14.7% (Kannauj) to 83.8% (Haridwar), Chlorophyceae from 4% (Bijnore bb) to 66.5% (Kanpur ab), Myxophyceae from 7.5% (Haridwar bb) to 34.9% (Vindhyachal), Euglenophyceae from 0.9% (Allahabad) to 12.9% Farrukhabad). Zooplankton contributed 2.8% (Bijnore ab) to 8.9% - 10%

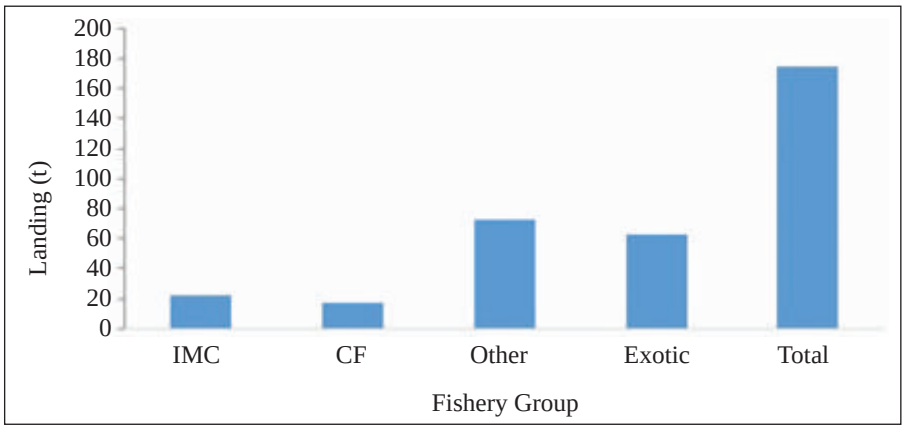
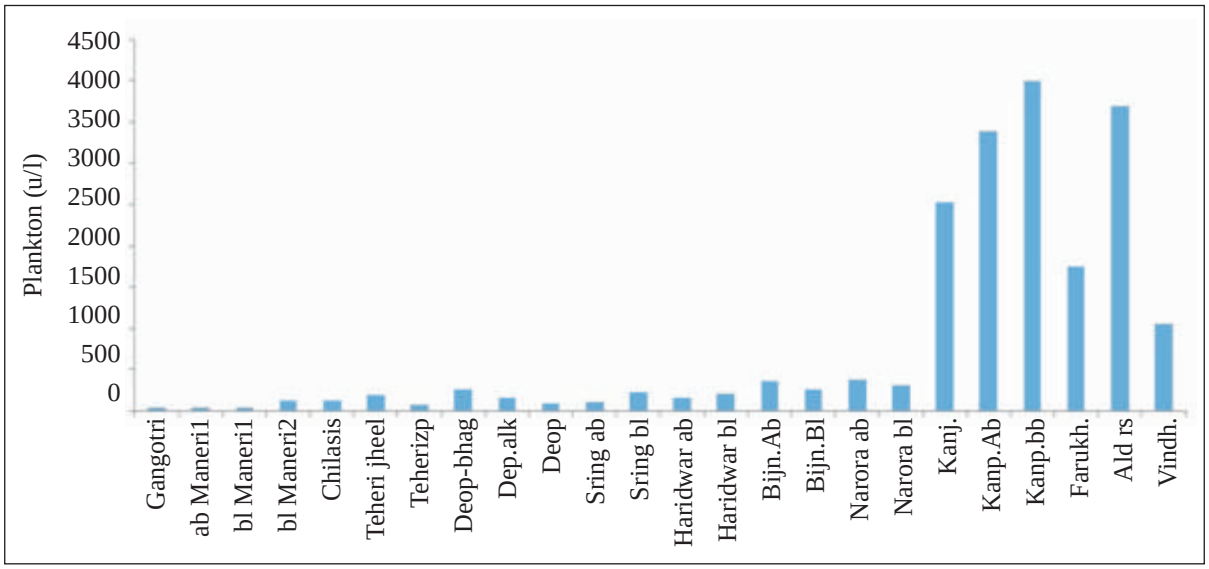


Fig. 20. Fish landing at Allahabad

(Farrukhabad). Rotifers were dominant and contributed 2 (Kanpur ab) to 6.2% (Kanpur bb). Crustaceans and Protozoans contributed maximum 1.5 % (Farrukhabad) to 4.4% (Narora bb). During the period of study, total of 102 taxa were recorded (32 Bacillariophyceae, 42 Chlorophyceae, 9 Myxophyceae, 3 Euglenophyceae, 5 Protozoa, 6 crustacea, 9 Rotifera). Dominant Bacillariophycean taxa were Synedra and Cyclotella in the upper stretch and Synedra and Melosira in lower stretch. Other abundant taxa in the plankton were Ankistrodesmus, Scnedesmus, Oocystis (Chlorophyceae) Microcystis, and Merismopedia (Myxophyceae), Euglena (Euglenophycae) Bosmina, Ceriodaphnia (Crustacea) and Variou species of Brachionus (Rotifera). Tryblionella and Eunotia were restricted to the upper stretch only. Lower stretch of the River Ganga (Bijnor to Allahabad) had higher density and diversity in comparison to upper stretch (Gangotri to Haridwar). In the above barrage areas, increase in Chlorophyceae was recorded, as compared to below barrage areas, as stagnation due to construction of dam favored growth of green algae.

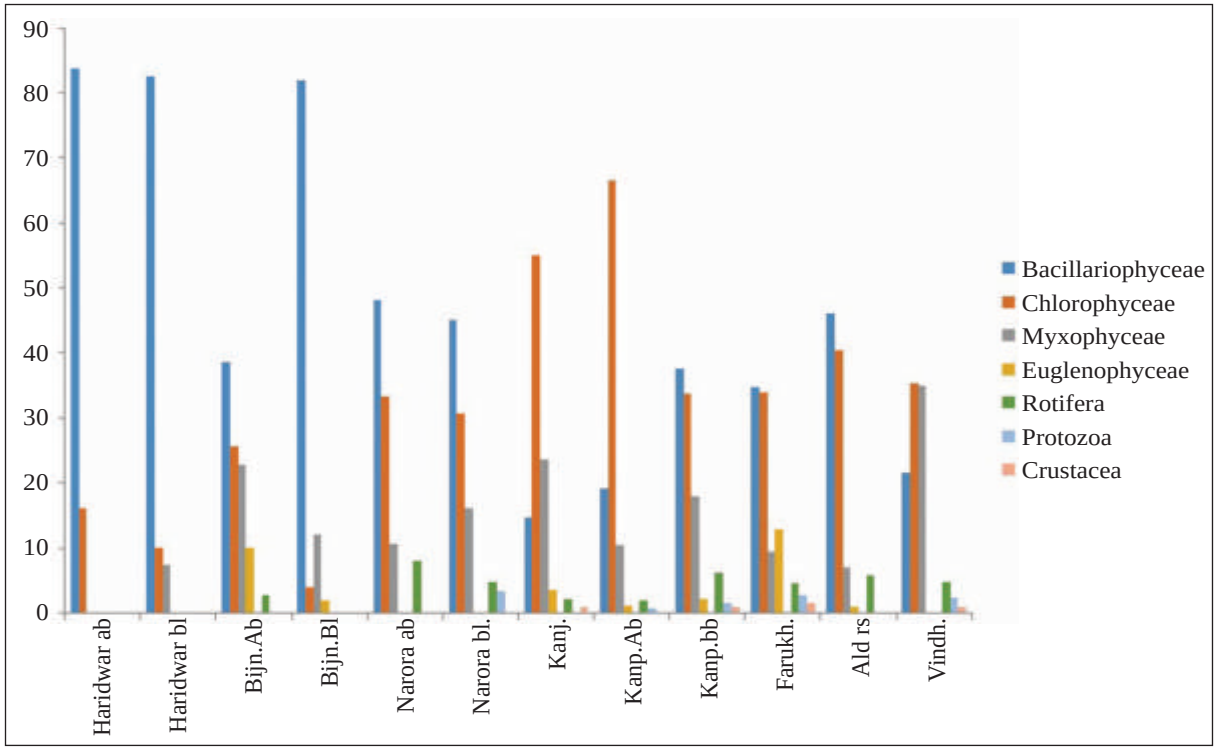


Note : See Acronyms for name of the sampling sites

Fig. 21. Plankton abundance in River Ganga

Periphyton

Periphyton population of the River Ganga ranged from160 ucm^{-2} (Gangotri) to 15130 ucm^{-2} (Farukhabad). In above barrage and below barrage areas, no definite trend in periphytic deposition was found. Periphytic population was higher in the whole stretch and was dominated by Bacillariophyceae. However its percentage contribution varied centre wise. Yet Myxophyceae exhibited its presence from Gangotri (80 ucm^{-2}), it reached 2630 ucm^{-2} at Srinager above barrage and 3100 ucm^{-2} (Farukhabad). Gradual increase in Chlorophyceae was recorded from Haridwar (40 ucm^{-2}) to Kannauj (1605 ucm^{-2}), Kanpur ab (1590 ucm^{-2}) and Allahabad (1085 ucm^{-2}). Deoprayag, Kanpur bb and Farukhabad were recorded as periphytic-diversity rich centers. In the upper stretch, dominant taxa were *Meridion* sp., *Synedra* sp., *Cyclotella* sp., *Gomphonema* sp., *Cymbella* sp. (Bacillariophyceae), *Ankistrodesmus* sp., *Staurastrum* sp. (Chlorophyceae), *Phormidium* sp. and *Anabaena* sp. (Myxophyceae). In the lower stretch dominant taxa were *Cyclotella* sp., *Synedra* sp., *Navicula* sp., *Nitzschia* sp., *Melosira* sp. (Bacillariophyceae), *Ankistrodesmus* sp., *Scenedesmus* sp. (Chlorophyceae), *Phormidium* sp. and *Merismopedia* sp.(Myxophyceae).

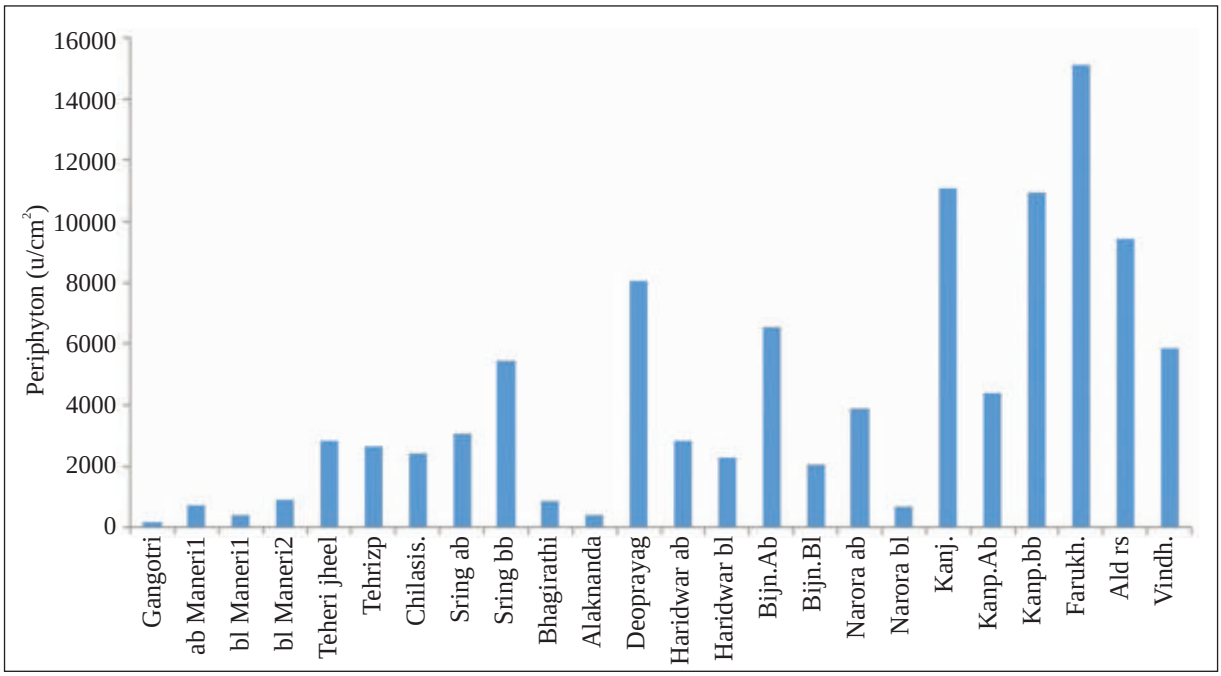


Note : See Acronyms for name of the sampling sites

Fig. 22. Distribution of planktons in River Ganga

Water quality

The water temperature varied from 2.85°C at Gangotri to 22.9°C at Haridwar. The water was alkaline in nature with maximum dissolved oxygen content varying from 8.80-10 mgL^{-1} in Gangotri to Haridwar. Biological oxygen demand (BOD) levels were 0.46-1.04 mgL^{-1} from Gangotri to Haridwar. In the present investigation, alkalinity was within the range limit. The observation of the total dissolved solids



Note : See Acronyms for name of the sampling sites

Fig. 23. Periphyton of river Ganga

revealed that the variation ranged from 60.26 to 131.7 mgL^{-1}. The value of conductivity varied from Gangotri to Haridwar in the range of 104.6-219.2 $\mu S/cm^{-1}$. Chloride is one of the major anions found in the water and were generally combined with calcium, magnesium or sodium. The chloride concentration ranged from 7.1 to 13.49 mgL^{-1}, which was lower than the accepted limit of 250 mgL^{-1} of upper stretch of River Ganga . Total hardness of water was found to be within the ideal range of 58 to 106 mgL^{-1} in upper stretch of Ganga. Calcium and magnesium increased from Gangotri to Haridwar Centre. Phosphorus and silicates were major nutrients in the water. In upper stretch phosphorus and silicate levels did not show much variation. The range of dissolved organic matter was 1.17 – 2.065 ppm from Gangotri to Haridwar.

Sediment quality

The soil texture of River Ganga between Gangotri to Haridwar stretch was mainly sandy (97.8- 98.5%) and alkaline (pH 7.7-8.3). The highest value of organic carbon was recorded in Tehri (0.06%). Specific conductance did not show increasing trend in the upper stretch and the maximum value was recorded at Gangotri (300.9 μScm^{-1}). The nutrients level was low in the entire upper stretch ranging from 0.84-3.48 mg P/100g and 2.94.68 to 8.26 mg N/100g Soil. Free calcium carbonate ($CaCO_3$) was low in the stretch Gangotri to Haridwar.

RESERVOIR AND WETLAND FISHERIES

Programme : Ecosystem based fisheries management in reservoirs and wetlands

Programme Co-ordinator : Dr. U. K. Sarkar

Project (RWF/NE/12/02/01) : Sustainable management of floodplain wetlands for enhanced fishery and livelihood

Project staff: B. K. Bhattacharjya, U. K. Sarkar, M. A. Hassan, Md. Aftabuddin, Arun Pandit, S. Yengkokpam, D. Debnath, A. K. Yadav, P. Das, D. K. Meena, K. M. Sandhya, Mishal P, Lianthuamluaia, Suman Kumari, A. Alam, S. C. S. Das, N. Sharma, Simanku Borah, N. Samarendra Singh, P. J. Majhi, K. K. Sarma, K. Srivastava, A. Kakati, V. Kumar, S. Das, S. Saha, Y. Ali and B. Naskar

The study revealed that productive environment exists in wetlands (beels) of Sukdol-Sarubori (unstocked, open), Mer and Damal (stocked, closed) of Assam and moderate productive environment in wetlands of Meghalaya (Boro, Katuli, Kumligaon). Macrophyte coverage, macrophyte-associated fauna as well as the macro-benthos population were higher in the unstocked beels than in the stocked beels. In unstocked beels moderate (25-50%) macrophyte coverage support fisheries, while in stocked beels, low macrophyte infestation together with supplementary stocking practices contribute to higher fish yield. Plankton population was inversely related to fish yield rates. Most of the wetlands in Bhagirathi-Hooghly stretch of lower Gangetic basin were more productive than Teesta-Torsa basin. However, most of these wetlands fall under eutrophic category based on the chlorophyll trophic state index. In Uttar Pradesh, fish productivity in Gujwar tal (closed, stocked) was better than Ajjeypur jheel (open, unstocked) whereas in terms of fish diversity, Ajjeypur (45 fish species recorded) was better than Gujwar (26 fish species).

Impact of fish stock enhancement on fisheries and ecology

Impact of fish stock enhancement on fisheries and ecology was assessed in three beels of Assam viz. Damal (closed, 15 ha) and Sukdol-Sarubari (open, 17 ha) in Morigaon district and Mer beel (seasonally open; 19 ha) located in Nagaon district. The selected beels represented three fish stock enhancement regimes: capture fisheries (Sukdol-Sarubari), supplementary stocking at moderate density @ 1500-2000 fingerlings (FL)/ ha (Damal) and supplementary stocking at high density @ 2500-3000 FL/ ha (Mer beel).

Limno-chemical parameters, biotic communities and species composition

Limno-chemical parameters in the beels indicated conducive environment for fish

production. Water had slightly alkaline pH (7.25-8.8), moderate to high DO (5.40-9.4 ppm), moderate alkalinity (28-60 ppm), low free CO_2 (2-8 ppm), moderate to high conductivity (95-310 µS/cm) and TDS (84-270 ppm), moderate chlorophyll (58-160 µg/l) and fluctuating secchi disc visibility (49-80 cm). The nature of soil was sandy loam in Damal, clayey in Mer and sandy-clayey in Sukdol-Sarubari beel.

Plankton population was moderate (72-215 u/l) and dominated by Bacillaryophyceae (65.3-87.2%), followed by Chlorophyceae (18.6-39.4%) and Cyanophyceae (5.2-8.1%). Plankton population was inversely related to fish yield rates in the selected beels although the relationship was not significant. Bacillariophyceae (61-79%) dominated the periphyton population in all the three beels followed by Chlorophyceae, Cyanophyceae, Chrysophyceae, Peridiniaceae and Euglenophyceae. Mostly observed periphyton associated groups were Diatoma, Synedra, Navicula, Nitzchia, Melosira, Microcystis, Chlorella, Pandorina and Closterium. Benthos population was higher in Sukdol-Sarubori (29 Nos./m^2) compared to Damal (15 Nos./m^2) beel. The mollusc dominated the benthos comprising of three species viz. *Bellamya bengalensis*, *Thiara scabra* (Gastropod) and *Lamellidens corrinus* (Bivalve) in Sukdol whereas four species were reported from Damal viz., *B. bengalensis*, *Pila globosa*, *G. convexiusculus* and *Melania* sp. (Gastropod). Overall, gastropods represented 93.2% of the total specimens reported with bivalves contributing the remaining 6.8%. Macrophyte coverage in the beels ranged from 1-30% with biomass of 11.6-23.2 kg/m^2 (in wet weight) comprising of 12 species, dominant being Eichhornia, Alternantheria, Hydrilla, Valisneria, Ipomea, Colocasia and *Christella* sp. The macrophyte-associated fauna consisted of small fishes (11 species), insects (3 species), molluscs (2 species), small prawns, frog and spider.

Fish diversity

Fish diversity of three selected wetlands of Assam consisted of a total of 28 species belonging to 10 orders, 12 families and 23 genera. The order Cypriniformes was dominant followed by Perciformes and Siluriformes. Most of the fish catch (65-

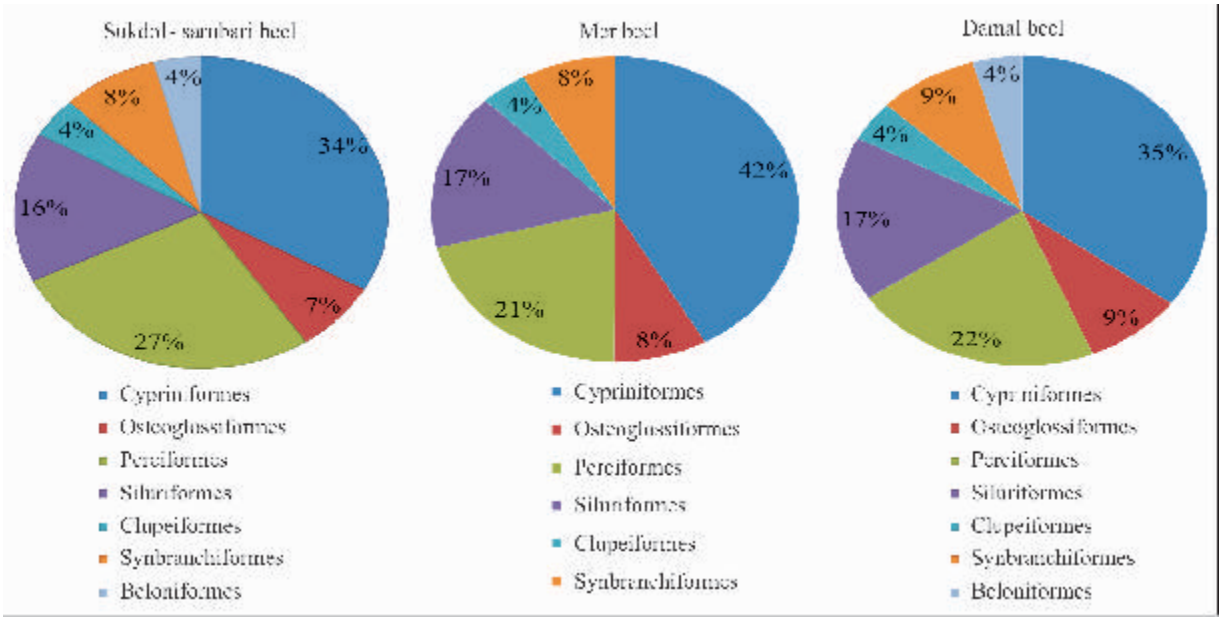


Fig. 24. Order-wise distribution of fishes in three beels of Assam

75%) was contributed by stocked fishes, mainly IMCs, Exotic carps, *Labeo gonius* and *Labeo bata*. Among the unstocked fishes the fish species mostly observed were *Puntius* spp., *Gudusia chapra*, *Amyblypharyngodon mola*, *Channa* spp, *Chanda nama*, *Mystus* spp, *Macrognathus* spp and *Mastacembalus armatus*.

Macrophyte infestation *vis-a-vis* fish yield

Twelve stocked (closed/ seasonally open) and twelve unstocked (open) beels of Assam were studied for the effect of macrophyte infestation (MI) level (low, medium and high) and stocking status (stocked and unstocked) on fish yield rates (kg ha^{-1} y^{-1}) by using two way ANOVA. Macrophyte infestation was measured based on visual estimation of area covered by macrophytes. Among the unstocked beels, the fish yield rate was the highest in the medium MI group, followed by those of low and high MI groups. Among the stocked beels, low MI group had significantly ($p<0.05$) higher fish yield rate than the other two groups. The results indicated that moderate (25-50%) macrophyte coverage might support fisheries in unstocked beels, while in stocked beels, low macrophyte infestation together with supplementary stocking practices contribute to higher fish yield.

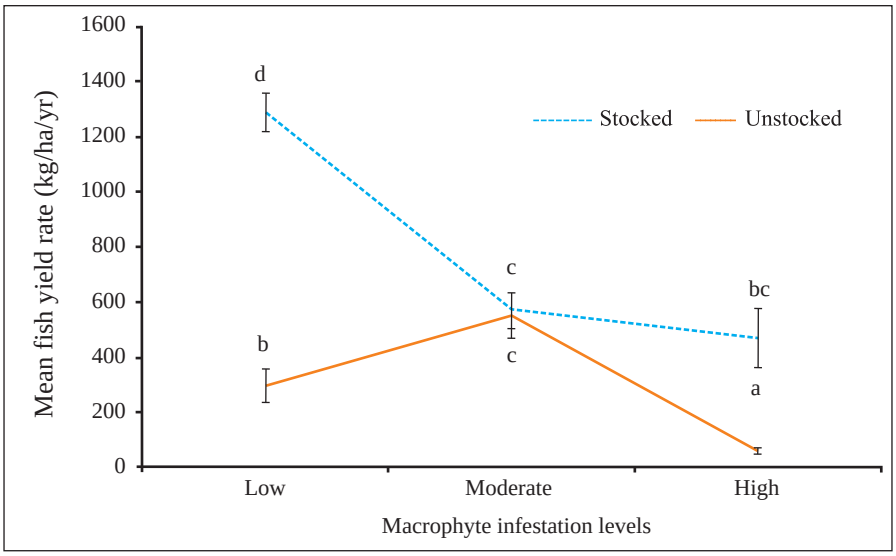


Fig. 25. Interaction plot of macrophyte infestation levels and fish yield rates of stocked and unstocked beels of Assam

Food and feeding habit and reproductive biology of floodplain wetland fishes

Macrognathus pancalus (n=261) specimens were collected from Deepor beel on a monthly basis from April, 2016 to March, 2017. The Deepor beel is a Ramsar site located in Assam, India. The sex ratio of the collected specimens was found to be 1.013:1 (M:F). Relative fecundity and absolute fecundity ranged from 22-648 ova /g body weight and 323 to 5562 ova, respectively. Length at first maturity (L_{50}) ranged between 10-14 cm (TL). Feeding intensity was determined by estimating the Gastro-somatic index (GaSI). GaSI values were found to be highest during the month of September for males and in the months of November-December for females. Feeding intensity was found to be highest during maturity stage V (Spent stage) and lowest during stage IV (Ripe stage). Analysis of the food and feeding habits showed that aquatic insects (insect larvae and body parts) dominate the food spectrum (46.85 %), followed by unidentified and semi-digested material (23.70%), crustaceans (15.12%), sand and mud particles (11.32%) and plant material (3.01%).

Length-weight relationship of indigenous fish species from Deepor beel

Length-weight relationship for nine small indigenous fish species, namely *Puntius sophore*, *Amblypharyngodon mola*, *Trichogaster chuna*, *Trichogaster lalius*, *Trichogaster fasciata*, *Chanda nama*, *Parambassis lala*, *Glossogobius giuris* and *Macrognathus aral* were studied for the first time from Deepor beel. A total of 911 fish specimens were collected on a monthly basis from February, 2016 to August, 2016 from landing centres adjoining the beel. In the present study, '*b*' value ranged from 2.77 (for *Trichogaster fasciata*) to 3.35 (for *Amblypharyngodon mola*). Among the selected fish species, 4 species (*T. fasciata*, *T. lalius*, *C. nama* and *M. aral*) showed negative allometric growth, 2 species (*P. lala* and *G. giuris*) showed isometric growth and 3 species (*T. chuna*, *P. sophore* and *A. mola*) showed positive allometric growth.

First report on the occurence of *Bangana dero* (Hamilton, 1822) from Deepor beel

Bangana dero, a cyprinid fish species, was collected for the first time from the Deepor beel. Twenty-eight specimens of *B. dero* (total length: 8.77–10.14 cm, live weight: 6.74 – 10.61 g) were collected and identified during October, 2016. Length-weight relationship of the species was worked out as $W = 0.074*L^{2.103}$.

B. dero recorded from Deepor beel, Assam

Assessment of impact of stocking on biochemical and microbial properties of water /sediment

Analysis of data collected during six seasons on sediment enzyme activity and physicochemical properties and nutrients in water and sediment revealed variation in type of correlation between the two wetlands Akaipur and Kholshi beels of West Bengal. All the four sediment enzymes varied distinctly with respect to type of correlation. Carbon mineralizing enzyme β glucosidase correlated positively with organic matter and electrical conductivity of sediment in Akaipur while negatively with specific conductivity in Kholshi. Alkaline phosphatase showed positive correlation with organic matter in Kholshi only. Acid phosphatase showed positive correlation with organic matter and negative correlation with dry matter content in Akaipur while negative correlation with organic carbon in Kholshi. Dehydrogenase was correlated negatively with organic matter and organic carbon in Khalsi. Among water parameters, in both the beels β glucosidase was negatively correlated with specific conductivity and nitrate while negatively with pH and positively with

phosphate in Akaipur. Alkaline phosphatase was correlated positively with specific conductivity in Akaipur and negatively in Khalsi while acid phophatse is correlated negatively in both the beel. Dehydrogenase showed negative correlation with turbidity in Akaipur and positive in Khalsi.

Regression equation of organic matter and organic carbon

The wetlands of closed and open nature with varied type of macrophytic vegetation and stocking management have bearing on organic matter content and type of organic matter present in wetland sediment. The sediment collected from two differently managed (stocking and macrophyte) wetland were analysed for organic matter and organic carbon content. The data revealed regression equations which varied between the wetlands and also with terrestrial agricultural soil. The findings have implication in using them as diagnostic for management intervention in terms of quality of organic matter.

Characterization of unexplored wetlands of Meghalaya

Three unexplored wetlands of Meghalaya viz., Boro beel in West Garo Hill district and Katuli and Kumligaon beel in South West Garo Hill district were studied. Limnological parameters assessed during the monsoon season in selected wetlands of Meghalaya indicated moderate productive environment for fish production. The parameters assessed were temperature (23-26^{0}C), DO (6.0-8.6 mg l^{-1}), free CO_2 (1-4 mg l^{-1}), specific conductivity (40.5-62.7 µS/cm), ammonia (0.011-0.018 mg l^{-1}), phosphate (0.01-0.07 mg l^{-1}) pH (6.8-7.5) and total alkalinity (22-40 mg l^{-1}). The soil was clayey-loam in nature.

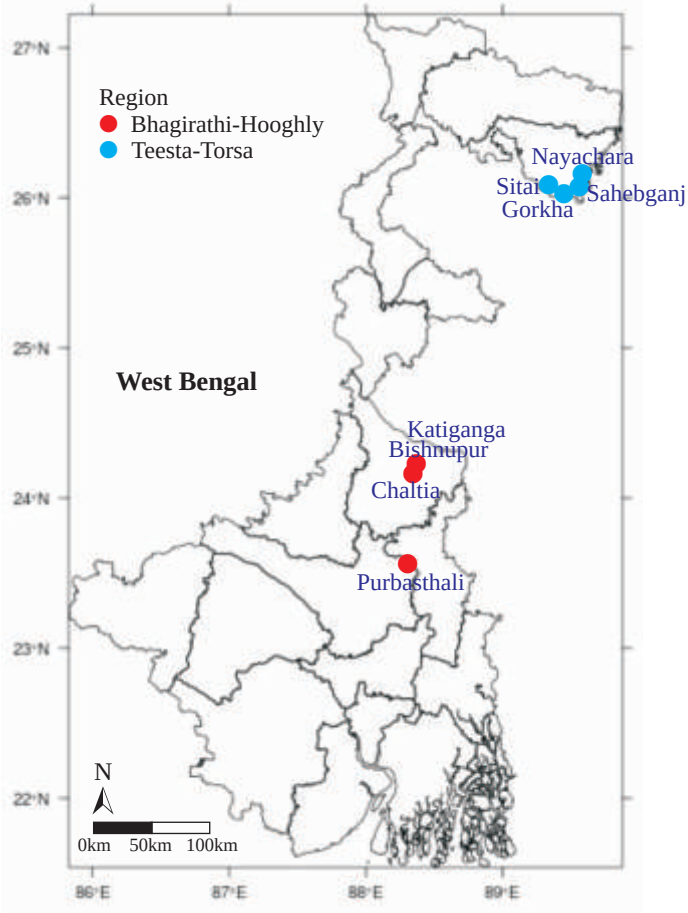
Bacillariophyceae (43-60%) dominated the plankton populations in all the beels, followed by Chlorophyceae (24-30%), Myxophyceae (11.3-22.3%) and Zygnemophyceae (3.5%). Periphyton population was similar with plankton population in all the beels with Bacillariophyceae being the dominant group. The density of macro-benthic organisms ranged between 25-42 Nos./m^2 in the beels. Macrophyte infestation was low to moderate (2-30%) in the beels. In this beel, submerged macrophytes covered most part of the bottom of the wetland. A total of 54 species of fish were recorded from the Katuli beel and 57 from Kumligaon beel belonging to 41genera, 20 families and 8 orders. A banned exotic carnivorous catfish, *Clarias gariepinus* was reported by the local people from both the beels.

Assessment of ecological and fisheries status of unexplored wetlands of West Bengal

A rapid survey was conducted to assess the ecological status and fisheries of 8 unexplored wetlands of West Bengal. Four wetlands (Nayachara, Gorkha, Sahebganj and Sitai) from Teesta-Torsa basin and four wetlands (Katiganga, Chaltia, Bishnupur and Purbasthali) from Bhagirathi-Hooghly stretch of lower Gangetic basin were selected for the study.

The selected wetlands were oxbow lakes originated from tributaries of river systems having functional/non-functional/feeble connectivity with the parent rivers for varying periods of time. Among the wetlands, Bishnupur and Chaltia were peri-urban and received city sewage affecting their water quality, ecology and fish diversity. Purbasthali wetland is the largest open access wetland providing roosting ground for 39 species of local and migratory birds. The remaining wetlands are mainly used for fisheries. The survey indicated that most of the wetlands from

Bhagirathi-Hooghly stretch of lower Gangetic basin of West Bengal were more productive (considering selected parameters like nitrate, phosphorus, total alkalinity, specific conductivity, pH and DO). Analyses of ecological parameters following Multidimensional Scaling (MDS) method indicated that wetlands located in the two different basins are distinct in terms of ecological characters. Chaltia wetland was found to be distinct from the other wetlands; it was the most productive wetland considering the nutrient profile (nitrate and phosphorus) and other productivity parameters including total alkalinity, conductivity, pH, DO and transparency.



Selected wetlands of West Bengal for rapid survey

The study indicated that most of the wetlands fall under eutrophic category based on the chlorophyll trophic state index (TSI-chl*a*) except Purbasthali and Sahebganj (mesotrophic state). Among the studied wetlands, Chaltia, Gorkha and Bishnupur had high NPP and GPP/PR ratio corroborating with the high fish yield. The phytoplankton abundance was also higher in Chaltia, Gorkha and Bishnupur welands indicating high productivity. Dominance of Cyanophycea in most of the wetlands indicated eutrophic nature. Lower abundance of phytoplankton was observed in macrophyte infested wetlands. Zooplankton abundance was higher in Nayachara and Bishnupur wetlands. The macrophyte coverage was more than 50% of the surface area in Sitai, Purbasthali and Sahebganj; the remaining wetlands had negligible macophyte coverage which may be due to fisheries management practices. Macro-zoobenthos abundance was higher in Nayachara and Gorkha of

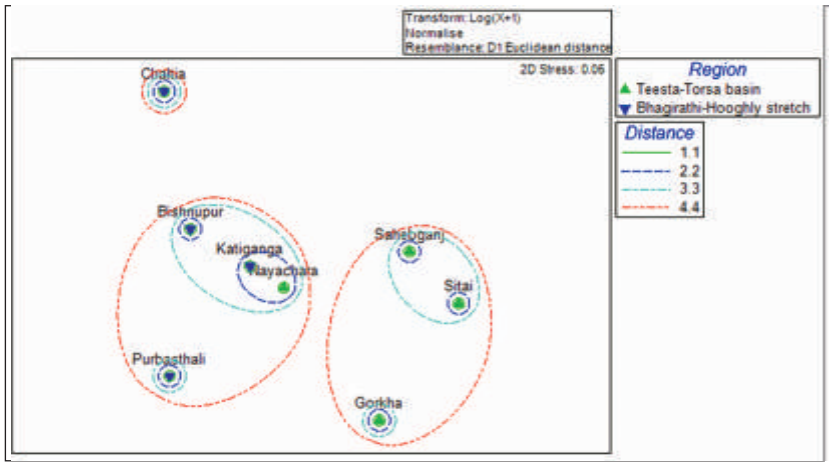


Fig. 26. Multidimensional Scaling (MDS) plot showing the wetlands located in the two different basins based on their ecological characters

Table 2. Trophic state index and fish production potential of eight wetlands of West Bengal

Wetland	GPP/PR	TSI (chl *a*)	Fish production potential (kg/ha/yr)*
Gorkha	13.3	74.2	1182
Nayarchara	3.0	56.4	511
Sitai	3.0	57.5	128
Sahebgangi	6.0	49.2	64
Chaltia	16.2	78.7	2922
Bishnupur	16.0	60.2	718
Katiganga	3.0	53.7	96
Purbasthali	4.9	40.9	52

*Based on NPP

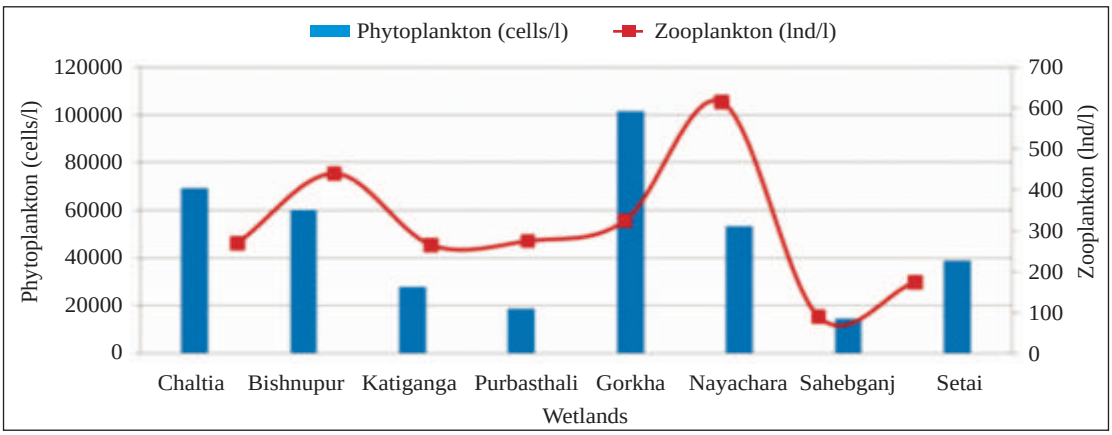


Fig. 27.Plankton abundance in wetlands of Bhagirathi-Hooghly and Teesta -Torsa basins

Teesta-Torsa basin than that in the other wetlands. Low species richness and dominance of *Chironomus* sp. observed in Chaltia wetland may be due to high organic pollution.

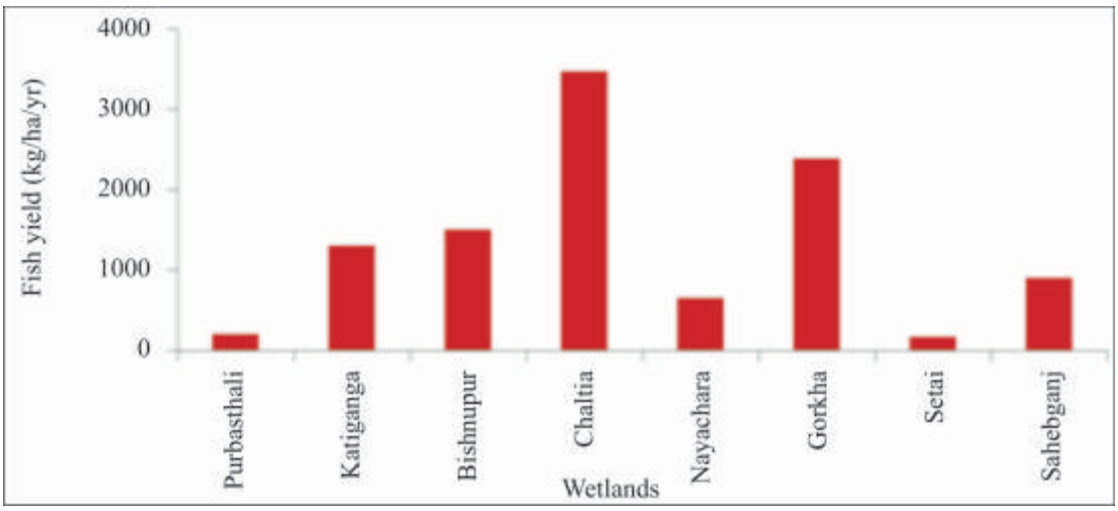


Fig. 28. Fish yields of wetlands of Bhagirathi-Hooghly and Teesta -Torsa basin

Most of the wetlands have adopted culture-based fisheries except in Purbasthali. Fish yield varied from 175 to 2400 kg $ha^{-1}yr^{-1}$ in 4 wetlands of Teesta-Torsa basin. Fish yield from the 4 wetlands of Bhagirathi-Hooghly stretch varied from 200 to 3482 kg $ha^{-1}yr^{-1}$. Fish diversity study showed maximum indigenous fin-fish diversity in Sahebganj (H?=1.75) followed by Gorkha (H?=1.73) even though the stocking density was comparatively higher in these well-managed beels.

Characterization of unexplored wetlands of Uttar Pradesh

Gujwar tal (40 ha, closed, stocked) in Pratapgarh district and Ajjeypur jheel (91.54 ha, seasonally open, unstocked) in Sitapur district of Uttar Pradesh were studied. A total of 45 fish species belonging to 7 orders, 16 families and 32 genera were recorded in Ajjeypur jheel. In Gujwar tal, only 26 fish species belonging to 4 orders 8 families and 20 genera were observed. The observation in Ajjeypur jheel depicted more of riverine trait in terms of fish species richness. Indian Major Carps dominated the fish catch in Gujwar tal whereas miscellaneous fish species dominated in Ajjeypur (on weight basis). The catch composition of fishes at Ajjeypur jheel was 27% major carps followed by 21% catfishes, 52 % miscellaneous group of fishes and exotics 1% while in Gujwar tal, it was 80% for major carps followed by exotic carps (13%) miscellaneous fishes (5%) and catfishes (2%).

A total of 45 species belonging to 5 groups of phytoplankton ($2.6x10^6$ cells/L density) was recorded in Ajjeypur jheel while only 18 species belonging to 5 groups of phytoplankton ($1.4x10^6$ cells/L density) was recorded in Gujwar tal. A total of 9 species of benthos were recorded in Gujwar tal (3 gastropods, 2 bivalves, 1 polychaete, 3 insects) while 7 macrobenthos was observed in Ajjeypur jheel (3 gastropods, 2 bivalves, 2 insects). Benthos abundance was 330 and 230 no/m^2 in Gujwar tal and Ajjeypur jheel, respectively.

The water quality parameters indicated that Ajjeypur jheel was moderately productive and Gujwar tal was highly productive. Gross Primary productivity (mgC/m^3/hr) and net primary productivity (mgC/m^3/hr) were estimated at 166.7 and

100 for Ajjeypur jheel and 383.33 and 233.3 for Gujwar tal, respectively. Positive NPP suggested that both the wetlands were not autotrophic and GPP/R>1 which is sufficient enough to support the planktivorous fishes in the food web. The soil was sandy in nature with alkaline pH in both the wetlands. Rich sediment quality with

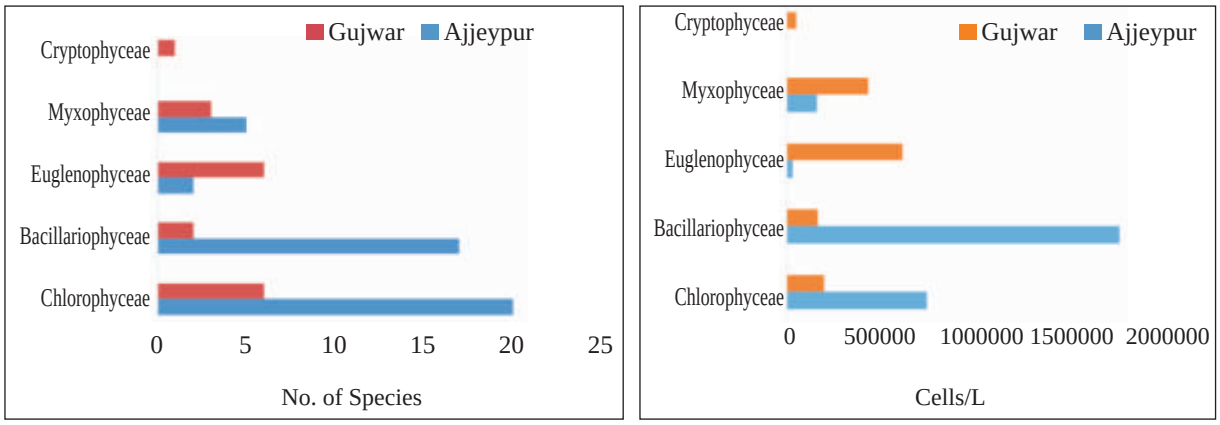


Fig. 29. Phytoplankton population and density (Cells/L) in Gujwar and Ajjeypur wetlands

Table 3. Water quality parameters of Ajjeypur and Gujwar wetland

Water quality parameters	Gujwar tal	Ajjeypur jheel
Transparency (cm)	39.3	30.8
Dissolved oxygen (mg l^{-1})	3.84	7.04
pH	7.5	7.85
Free CO_2 (mg l^{-1})	22	2
Alkalinity (mg l^{-1})	204	56
Hardness (mg l^{-1})	148	112
Total dissolved solids (mg l^{-1})	148	122.6
Chloride (mgl^{-1})	17.04	4.26
Dissolved organic matter (mg l^{-1})	4.8	2.93
Phosphate (mg l^{-1})	0.125	0.032
Silica (mg l^{-1})	0.6	0.2
Gross Primary Productivity (mgC/m^3/hr)	383.33	166.7
Net primary productivity (mgC/m^3/hr)	233.33	100
Respiration (mgC/m^3/hr)	180	80

Table 4. Sediment quality parameters of Ajjeypur and Gujwar wetland

Sediment quality parameters	Ajjeypur jheel	Gujwar tal
Sand (%)	83	60
Silt (%)	16.5	28
Clay (%)	0.5	12
pH	7.9	7.9
Conductance (µS/cm)	507.6	413.4
Free $CaCO_3$ (%)	3.5	4.63
Organic carbon (%)	2.16	3.5
Available nitrogen (ppm)	112	84
Available phosphorous (ppm)	47.6	13.5

high organic carbon (>1%) and nutrients, optimum water quality parameters reflect high production potential of these wetlands.

Project (RWF/SR/12/02/02) : Habitat characteristics, fish assemblage and stock dynamics and impact of stocking in selected reservoirs

Project staff: D. S. K. Rao (upto 31.10.2017), U. K. Sarkar, M. Karthikeyan, R. Palaniswamy, P. Panikkar, D. Bhakta, K. M. Sandhya, T. T. Paul, V. L. Ramya, Suman Kumari, Lianthuamluaia, Vikash Kumar, Gunjan Karnatak, Mishal P, Sibina Mol S., A. K. Bera, Himanshu S. Swain, Tasso Tayung, Priti J. Majhi, Manoharan, Usha Unnithan, Vijaykumar M. E., Subrata Das and Y. Ali

Habitat quality of Panchet, Chandil and Kangsabati reservoirs was found to be in the favorable range for fisheries enhancement. Morpho Edaphic Index (MEI) suggested higher fish yield potential of Panchet (148 kg/ha/yr) followed by Kangsabati (93 kg/ha/yr) and Chandil reservoir (55 kg/ha/yr). Spatial analysis revealed that the Eastern reservoirs have higher fish diversity compared to the peninsular reservoirs and more fish diversity in the lotic zone of the reservoir. Due to carp seed stocking a significant increase in fish productivity was achieved in small reservoirs of Odisha, Karnataka and Chhattisgarh in 2016 as compared to 2010 . Similarly stocking of fish in small reservoirs of Kerala resulted in the increase of the productivity of *Labeo rohita*, *Catla catla* and *Cirrhinus mrigala*. App based Android Application, eDAS was updated to eDAS+. eLDAS was developed to collect data on length-frequency also of fishes directly from reservoirs.

Habitat characteristics of reservoirs

Habitat quality of three Eastern reservoirs (Panchet, Chandil and Kangsabati) based

on limnological parameters was found to be in the favorable range for fish production. The parameters like pH, alkalinity, nitrate, phosphate, conductivity and temperature indicated that the three reservoirs to be graded as medium productive in nature. Morpho Edaphic Index (MEI) suggested higher fish yield potential of Panchet (148 kg/ha/yr) followed by Kangsabati (93 kg/ha/yr) and Chandil reservoir (55 kg/ha/yr). Based on the habitat parameters, Bhatgar and Dhom reservoirs were found to be mesotrophic whereas Thippagondanahalli and Nagawara were eutrophic in nature. Bhavanisagar dam (7,500 ha) in Tamil Nadu registered conducive water parameters indicating higher productivity status, ubiquitous presence of Myxophyceae and mesotrophy.

Study on 14 reservoirs in Kerala showed they were perennial, low in nutrient, acidic to low alkaline in nature and predominant of desmids, an indicator phytoplankton of oligotrophic nature of water body. During summer, the TSI value indicated an unusual moderate eutrophic state at hypolimnion in Pothundi.

Spatio temporal variation in habitat quality of eastern reservoirs

The habitat assessment of the three reservoirs, Panchet and Chandil from Jharkhand and Kangsabati from West Bengal showed significant difference ($p<0.05$) among the reservoirs as indicated by the PERMANOVA. The three reservoirs were observed to have a significant temporal (seasonal) variations ($p<0.05$). Multi Dimensional Scaling (MDS) indicated Panchet reservoir to have distinct pattern of habitat parameters as compared to Kangsabati and Chandil reservoirs.

Spatio-temporal dynamics of plankton

Cyanophyceae was dominant in all three reservoirs followed by Chlorophyceae among the phytoplankton, while rotifers among zooplankton. Panchet and Kangsabati reservoir had similar plankton density pattern in all seasons. In Chandil reservoir during postmonsoon, *Microcystis* sp. was observed in highest concentration at Lawa (Cage site). Panchet had higher zooplankton abundance compared to other reservoirs. Rotifer *Brachionus* sp. was found to be dominant among zooplankton. In Chandil reservoir, copepod nauplii was dominant during post monsoon.

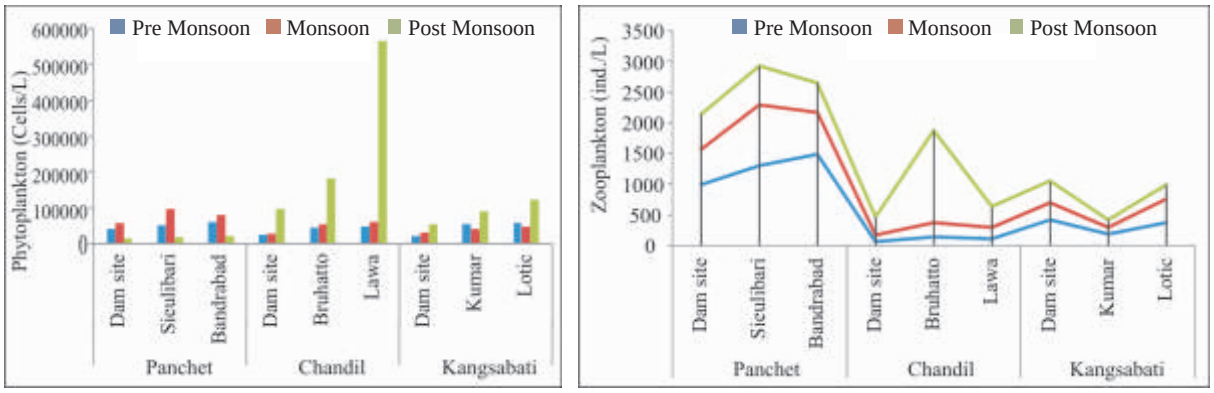


Fig. 30. Spatio-temporal abundance of plankton in reservoirs of eastern India

Fish assemblage structure

A total of 62 species was reported from Panchet reservoir. Exotic species namely

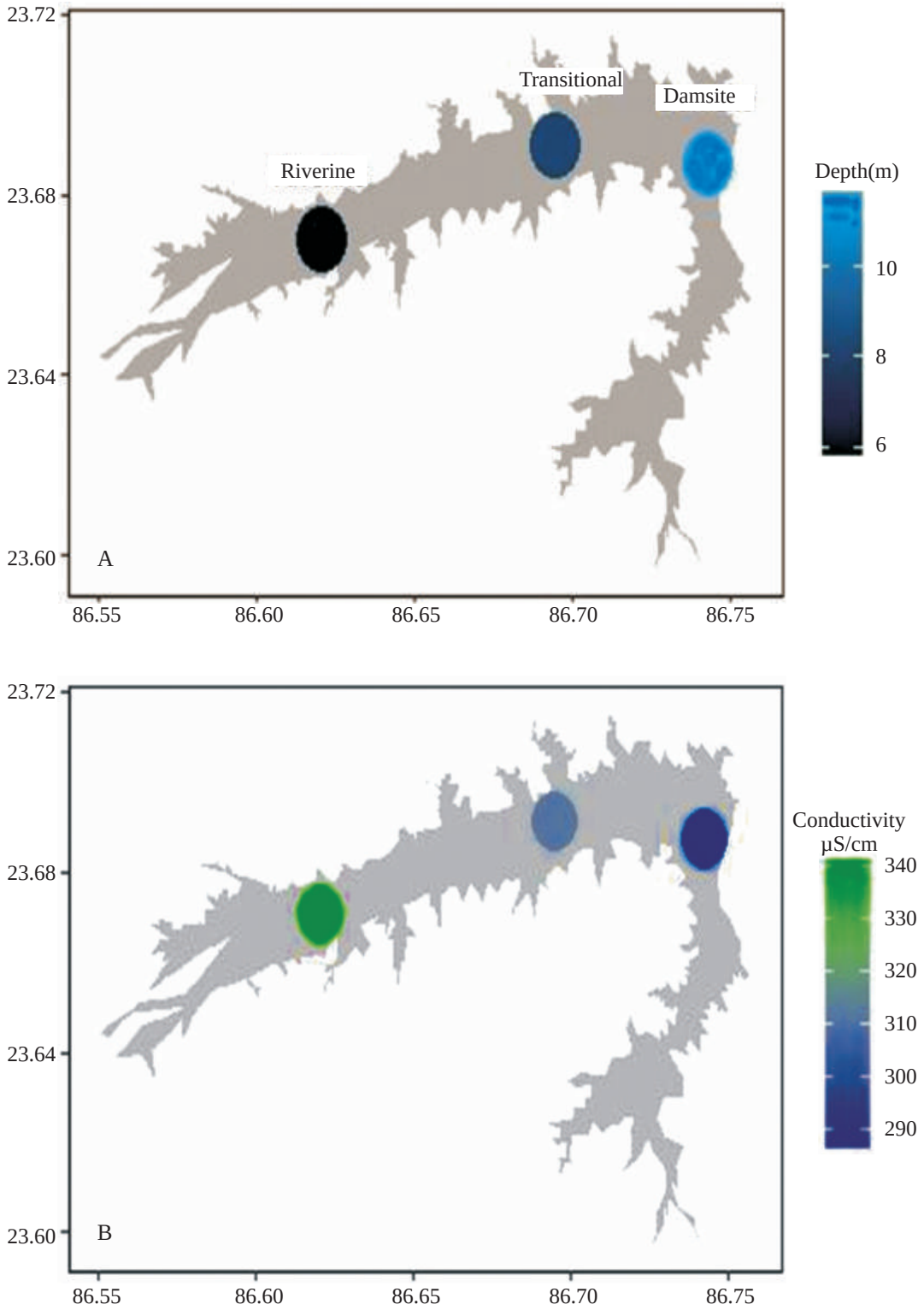


Fig. 31. GIS based mapping of habitat parameters of Panchet

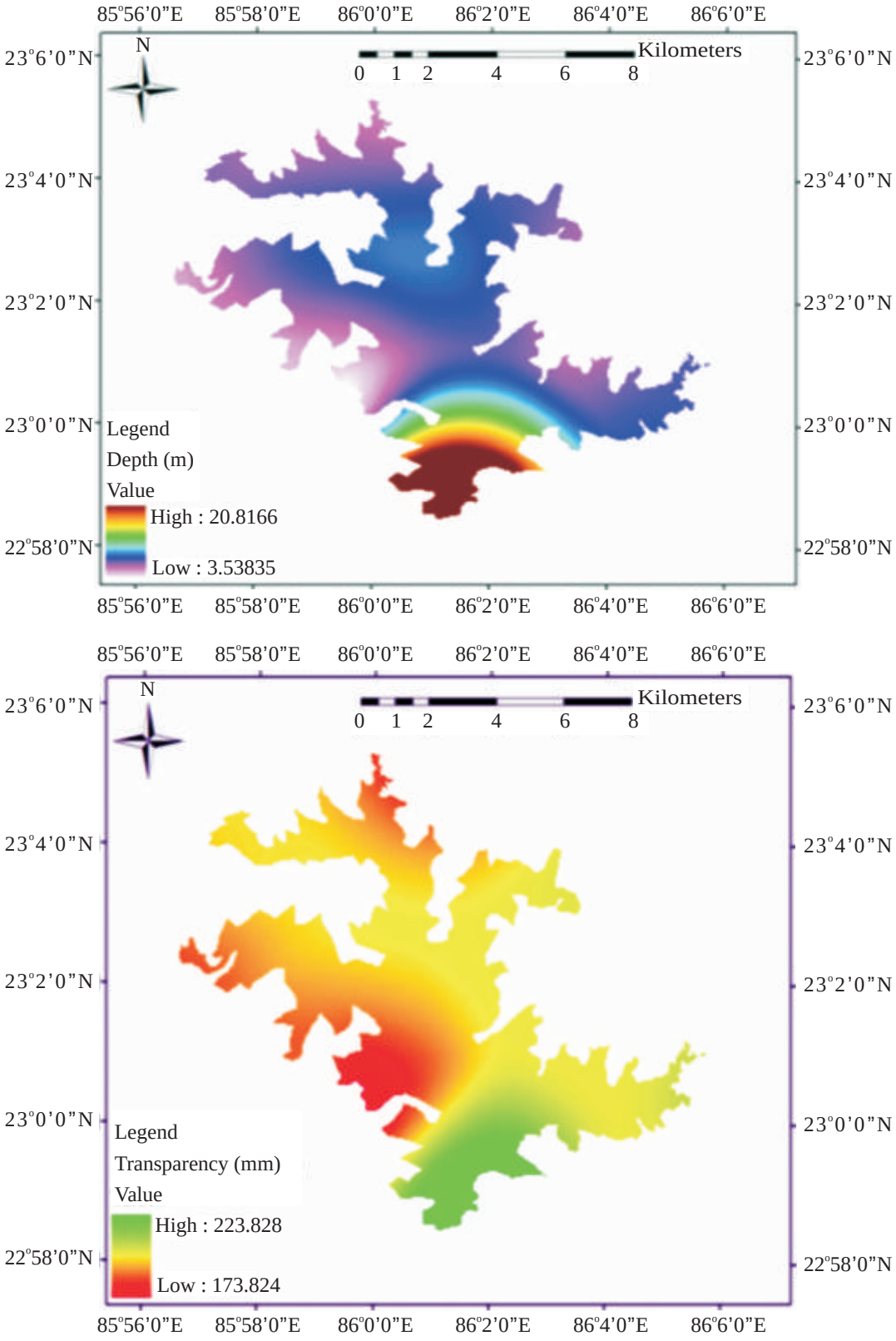


Fig. 32. GIS based mapping of habitat parameters of Chandil reservoir

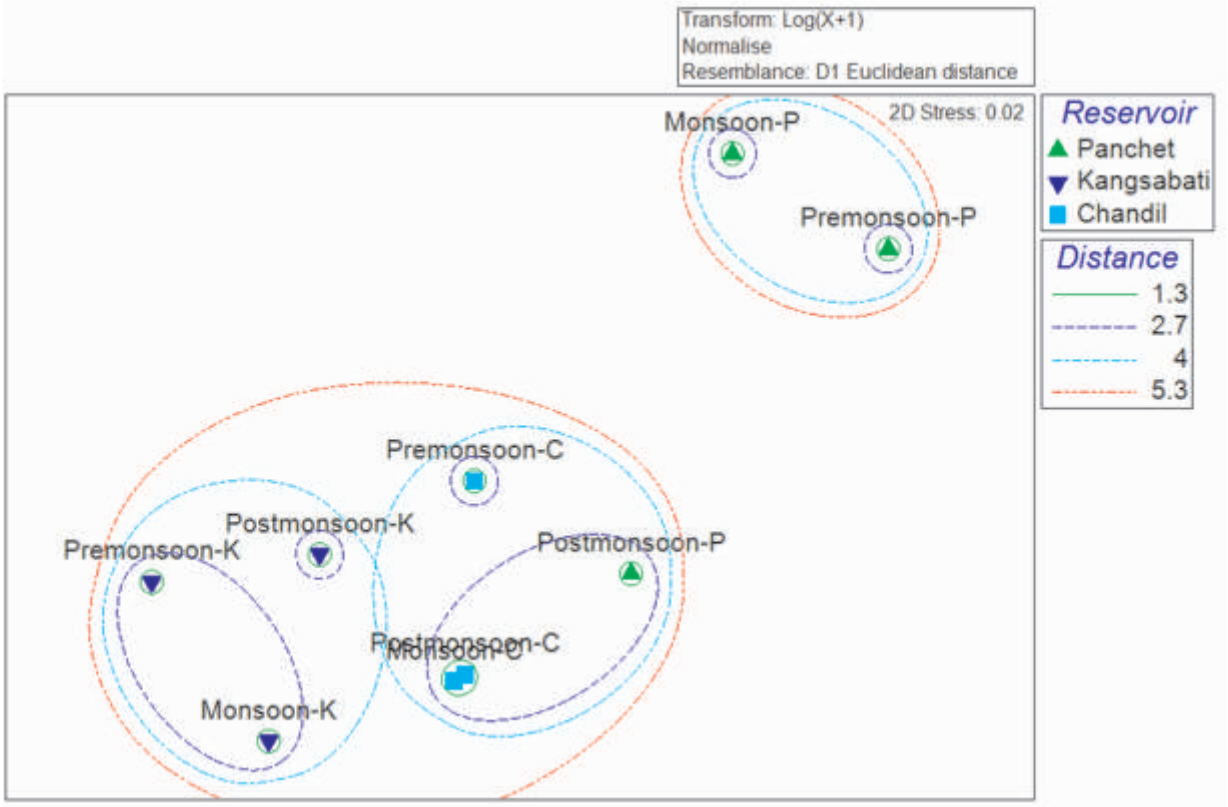


Fig. 33. MDS indicating pattern of habitat parameters in Eastern reservoirs

Ctenopharyngodon idella, *Hypophthalmichthys molitrix* and *Oreochromis niloticus* contributed 8% to total number of species. Cyprinidae was the most diverse family represented by 26 species followed by Bagridae with 5 species. Indian Major Carps accounted for 45.91%, among them *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala* contributed around 20.23%, 13.39% and 3.50% respectively. *Labeo calbasu* (10.83%) was the next most abundant species after IMCs. In Chandil reservoir, catch was mainly contributed by IMCs (23%) followed by *Labeo calbasu* (9%) and catfishes (9%). Exotic species were represented by *Oreochromis niloticus and Pangasianodon hypophthalmus*. Majority of the catch in Kangsabati reservoir was contributed by carps, catfishes and tilapia (*Oreochromis niloticus*). Fish Species inventory from this reservoir reported two new records of Indian hill trout *Barilius bendelisis* and *Chagunius chagunio*.

Among peninsular reservoirs, 21 species under 8 families were reported in Thippagondanahalli reservoir and 80% of fish catch was dominated by indigenous fishes such as *Puntius sophore* and *Chanda nama*. In Nagawara lake, 13 species belonging to 5 families were recorded during the study. Among these, *Oreochromis niloticus* contributed 60% of the catch followed by *Cirrhinus mrigala* (9%), *O. mossambicus* (8%) and *Hyophthalmichthys molitrix* (7%). Ichthyofaunal studies in Peechi reservoir showed that the reservoir was dominated by Cypriniformes (80%), Perciformes (17%) followed by Siluriformes in meagre percentage. Pothundi reservoir was dominated by Perciformes (83%) and lentic zone was inhabited mainly by*Ambassis ambassis*. Cypriniformes mainly represented the minor fishery of *Dawkensia filamentosus* in the reservoir.

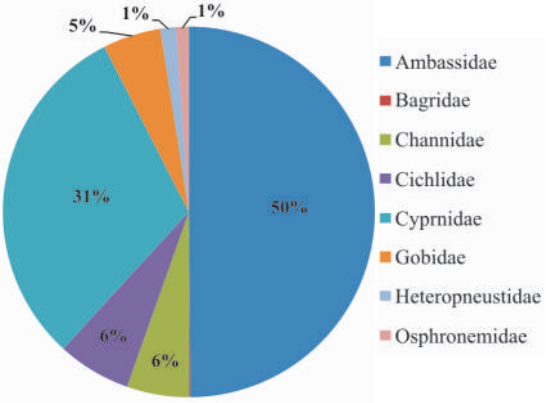


Fig. 34. Family-wise distribution of fishes in Thippagondanahalli reservoir

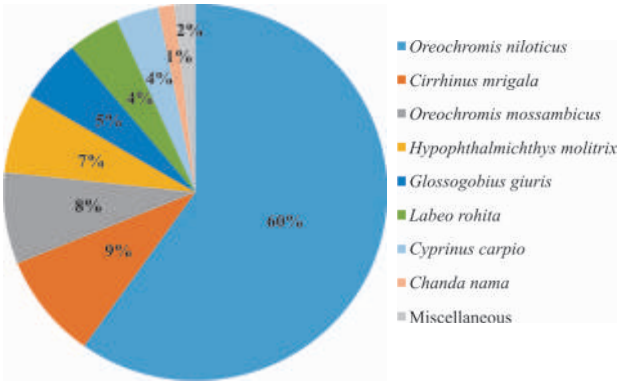


Fig. 35. Fish species composition in Nagawara lake

Habitat parameters and fish assemblage

Canonical Correspondence Analysis (CCA) indicated depth, dissolved oxygen, transparency and alkalinity to be the most important parameters influencing the fish abundance in Panchet reservoir while depth, conductivity, pH and depth, phosphate and nitrate were found to be important parameters influencing the fish abundance in Chandil and Kangsabati reservoir, respectively. CCA indicated the positive relationship of fish assemblages with conductivity and hardness in Walayar reservoir, Kerala.

Fish diversity pattern

Panchet reservoir supported maximum number of species (62) followed by Kangsabati (42) and Chandil (42). Species diversity indices showed diversity was highest in Panchet (H?=2.52) as compared to other two reservoirs. Species evenness pattern indicated even distribution and showed close values for Panchet (0.20) and Chandil (0.199). Lotic zone supported more species diversity in Panchet and Kangsabati where as in Chandil, maximum diversity was observed in the intermediate zone which may be attributed to the suitable habitat as evident from the large occurrence of aquatic macrophytes in this zone.

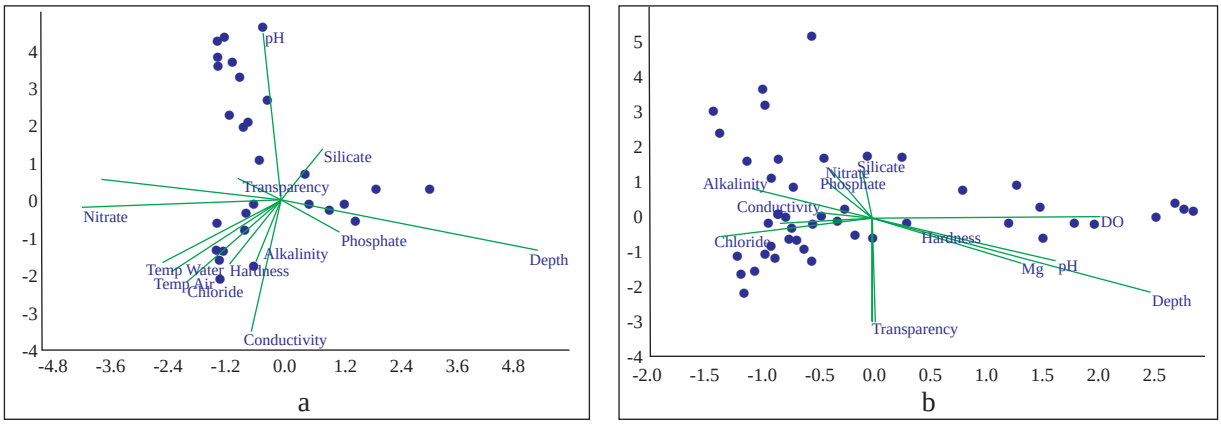


Fig. 36. CCA indicating relationship of habitat parameters with species assemblage in Chandil (a) and Panchet (b) reservoir, Jharkhand

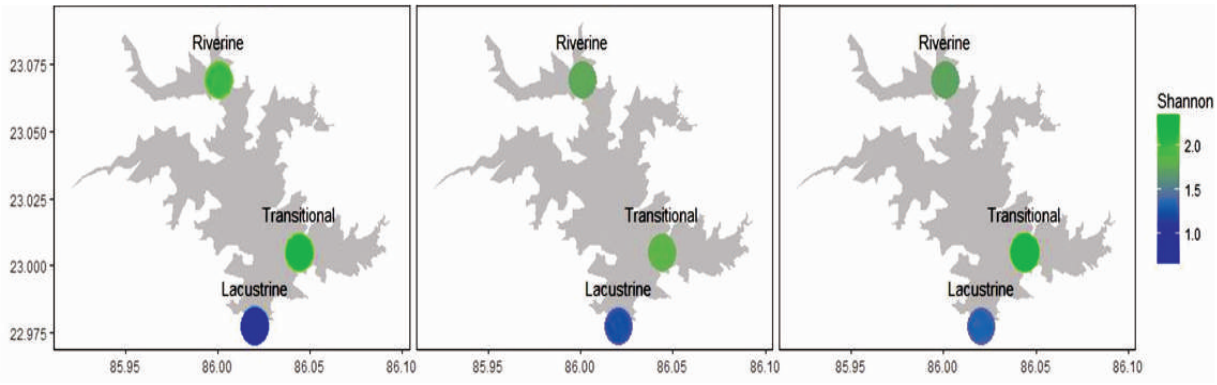


Fig. 37. Spatial fish diversity pattern in Chandil reservoir Jharkhand, during different seasons, (a: Monsoon, b: Pre-monsoon, c: Post-monsoon)

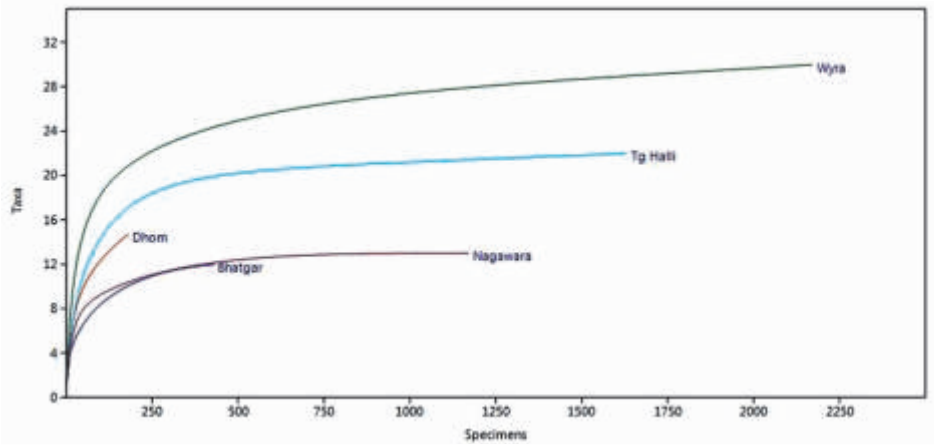


Fig. 38. Species accumulation curve for various reservoirs

During the study period, Wyra reservoir showed high diversity index with a Shannon-Weinner index of 2.57, while Thippagondanahalli, Dhom, Nagawara and Bhatgar reservoirs with Shannon-Weinner index of 1.775, 1.7, 1.478 and 1.4 respectively. The taxonomic distinctness was high in Wyra followed by Thippagondanahalli, Dhom, Nagawara and Bhatgar.

A total of 17 species of fishes were identified, and the Species Richness (13), Margalef index, (2.86), Evenness index (0.9975), Shannon index (2.16) and dominance (0.84) were high in the lotic zone during end of monsoon in Walayar reservoir. Pothundi reservoir recorded 13 species of fish fauna comprising native and stocked species and showed high diversity indices at lotic zone at monsoon season. The Shannon diversity index was found to be more in Pothundi (1.47) than in Peechi reservoir (1.14). Fish faunal diversity is comparatively higher in Bhavanisagar dam than Kerala reservoirs, recording nearly 23 species. Many indigenous fishes like *L. kontius*, *Cirrhinus cirrhosa* and *P. dubius* have disappeared in the landings of Bhavanisagar Dam.

Diet composition studies of selected species from reservoirs

Diet composition studies were carried out for *Gudusia chapra*, *Salmophasia*

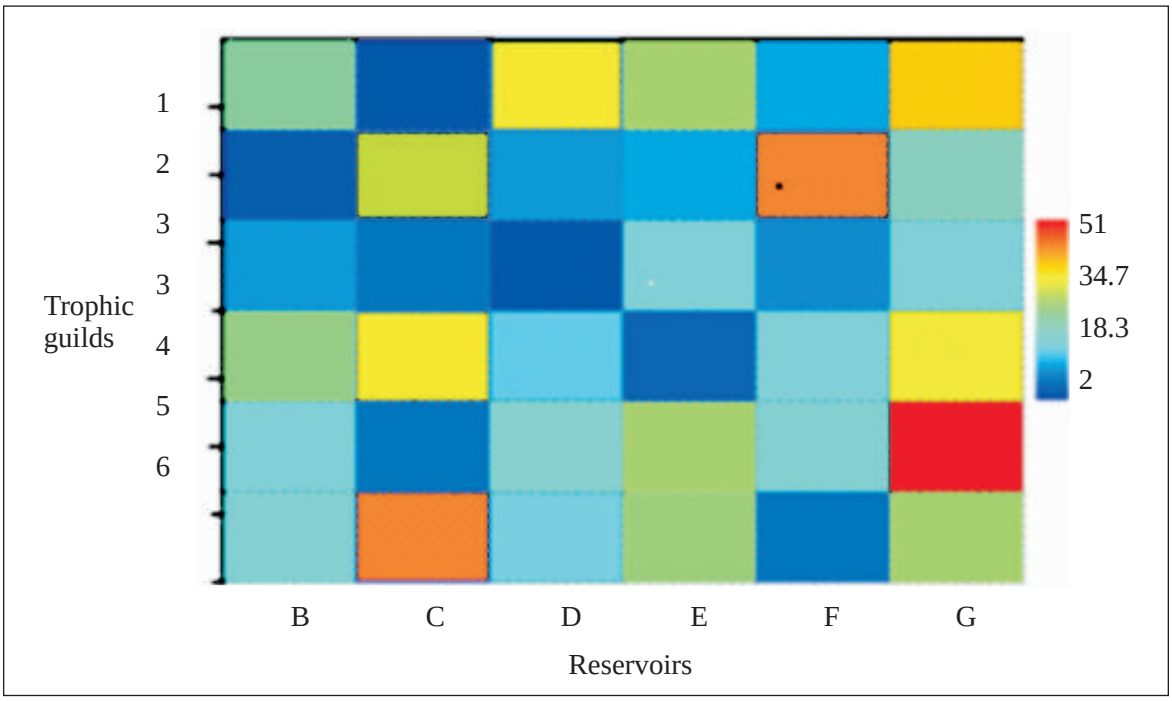


Fig. 39. Graphic model of feeding strategies of fishes from reservoirs of Peninsular India. B- Nagavara, C-Tunga, D-Thippagondanahalli, E-Wyra, F-Krishnarajasagar, G-Dhom

novacula, *Salmophasia boopsis*, *Amblypharyngodon mola*, *Parambassis ranga*, *Chanda nama*, *Labeo calbasu*, *Osteobrama cotio*, *Garra mullya*, *Cirhhinus reba*, *Cirrhinus kolus*, *Cirrhinus mrigala*, *Dawkensia filamentosus*, *Systomus sarana*, *Puntius sophore*, *Hypselobarbus kolus*, *Glossogobius giuris*, *Ompok bimaculatus*, *Channa striata*, *Sperata seenghala*, *Mystus seenghtii*, and *Xenentodon cancila*.

It was found that a range of food items were consumed by fish species, from detritus, algae and macrophytes, to aquatic invertebrates, molluscs, crustaceans and fish. Food consumption by the fish community reflected seasonal fluctuation in productivity and food supply: during the monsoon season, aerial and surface invertebrates, algae and some detritus appeared to be consumed more frequently, while macrophytes, micro-crustaceans and molluscs appeared more important in the mean diet during the pre-monsoon season. Using graphical models of feeding strategies based on the relative importance of food categories in the diet of the species, the fish assemblage showed food resource partitioning according to food habits and foraging habitats among the reservoirs.

Health assessment of fishes in reservoirs

Epizootic ulcerative syndrome was recorded in different types of fishes like *Puntius sophore*, *Cirrhinus mrigala*, *Labeo calbasu* and *Mastacembelus armatus* in Chandil and Panchet reservoir. Among parasites, metacercaria of *Isoparorchis hypselobagri* (Southwell, 1898) was recorded in *Sperata seenghala*, *M. armatus* and *Ompok bimaculatus*. The adult parasite was observed within the swim bladder of *Wallago attu* whereas the metacercaria was seen in body cavity of the same host. Conventional morphological identification of metacercaria using Semicon Carmine stain and molecular method using partial fragment of cytochrome oxidase subunit 1 (COX I) confirmed the parasitic trematode. *Alitropus typus* (H. Milne

a

b

c

d

a) Epizootic ulcerative syndrome in *Puntius sophore* of Chandil and Panchet reservoir, b) Metacercarial stage of trematode isolated from catfishes of Chandil and Panchet reservoir, c) Haematophagus ecto-parasite recorded from various fishes of Chandil reservoir, d) Nematohelminth in body cavity in Gobid fish of Nagawara lake.

Edwards, 1840), a blood feeder isopod was observed in *C. mrigala*, *L. calbasu* and *Oreochromis niloticus* in Chandil reservoir. In Nagawara lake, parasite larvae of nematodes belonging to the genus *Eustrongylides* of the family Dioctophymatidae were detected in freshwater teleost, *Glossogobius giuris* (Gobiidae).

Electronic Data Acquisition System plus (eDAS+)

Electronic Data Acquisition System plus (eDAS+) is a hybrid version of eDAS

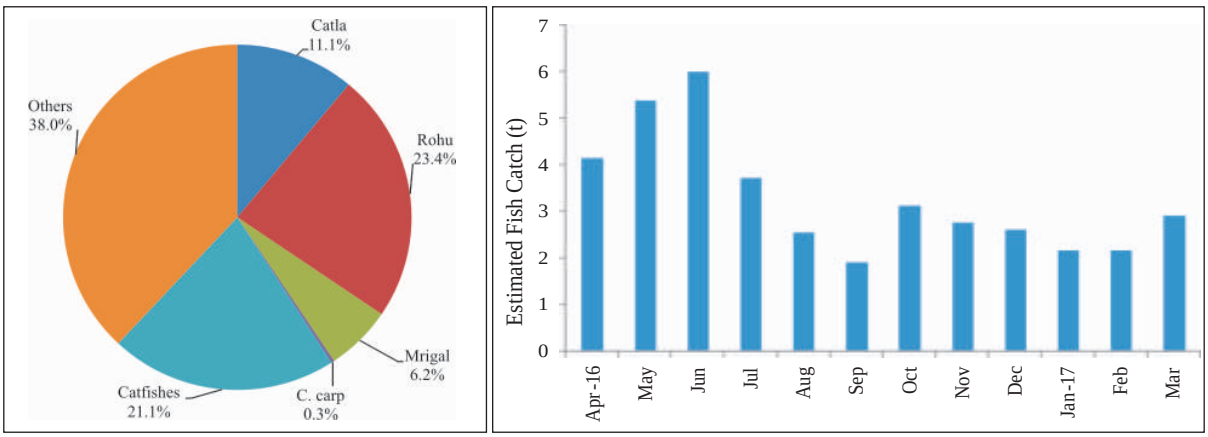


Fig. 40. Fish catch and composition from Tunga reservoir collected through eDAS

wherein the data acquisition, storage and retrieval are more efficient (than in eDAS) and also eDAS+ can be integrated with the sampling methodologies developed for the estimation of inland fish catch in India. Using eDAS, the daily fish catch data (species-wise) at Tunga reservoir were collected during April 2016 - March 2017. During this period, there was an estimated total fish catch of 39.4 tonnes from the reservoir and the fishery was dominated by rohu (23.4%) followed by catfishes (21.0%), catla (11.1%), mrigal (6.2%) and miscellaneous fishes (38.3%). Length-frequency data of fishes are essential for stock assessment studies. An Android Application (eLDAS) was developed to collect data on length-frequency of important species of fishes from reservoirs through fishery friends and the same is being tested with sample data.

Impact of stocking on reservoir productivity

For assessing the impact of fish seed stocking in reservoirs, secondary data on fish seed stocking and production were collected from state fisheries departments of Chhattisgarh, Karnataka, Kerala and Tamil Nadu. The analysis of data indicated that average productivity of selected reservoirs (34nos.) of Chhattisgarh has increased 3.3 folds from 48 kg/ha/yr to159 kg/ha/yr during 2010-2016 because of fish seed stocking.

Manchanbele reservoir (365ha), Karnataka was stocked with 167 lakh fingerlings of catla, rohu, mrigal, grass carp and common carp during 2012-17. The present fish yield is 65-140 kg/ha/yr and have registered an increase of 30-40% post stocking. The fish yield increased by 50% from 2014-15 to 2015-16 due to seed stocking in Tunga reservoir, Karnataka.

IMC seeds stocked in Malampuzha, Mangalam, Walayar and Kanjirapuzha reservoirs of Kerala during 2013-14 showed positive impact on fish production. The fish production increased by 3.5% and 0.6% of rohu and catla at Malampuzha during 2014-15. An increased productivity was recorded in rohu (9.6%) at Mangalam reservoir. At Walayar reservoir, the productivity of rohu, catla and mrigal increased by 2.2, 0.7 and 2.5% respectively during 2014-15. Kanjirampuzha reservoir recorded an increase in the productivity of mrigal (2.8%) during 2014-15.

Fish seed stocking is widely practiced in Tamil Nadu reservoirs. In Bhavanisagar it has resulted in fish yield of 750 kg per day. However, *L. calbasu* fishery has been

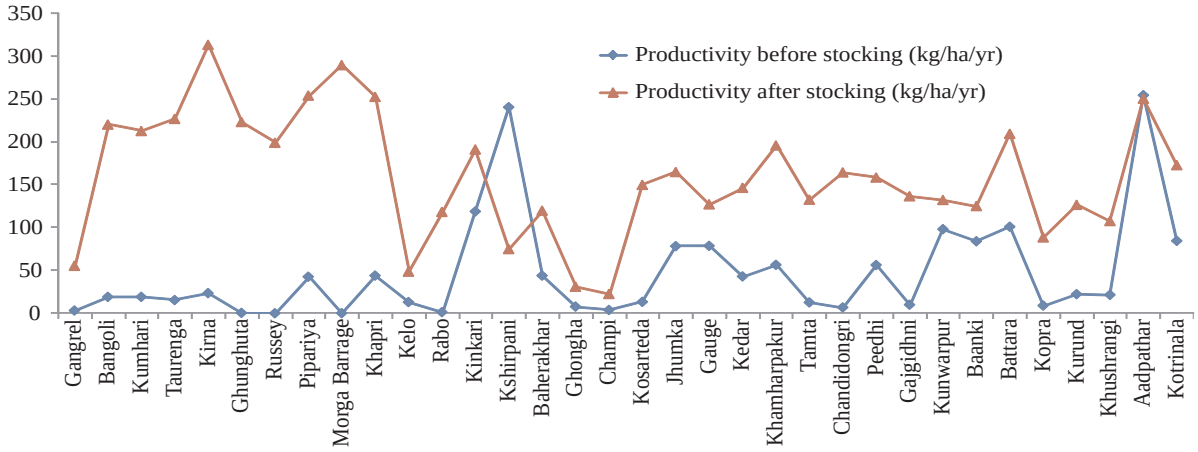


Fig. 41. Productivity, before and after fish seed stocking in reservoirs of Chhattisgarh

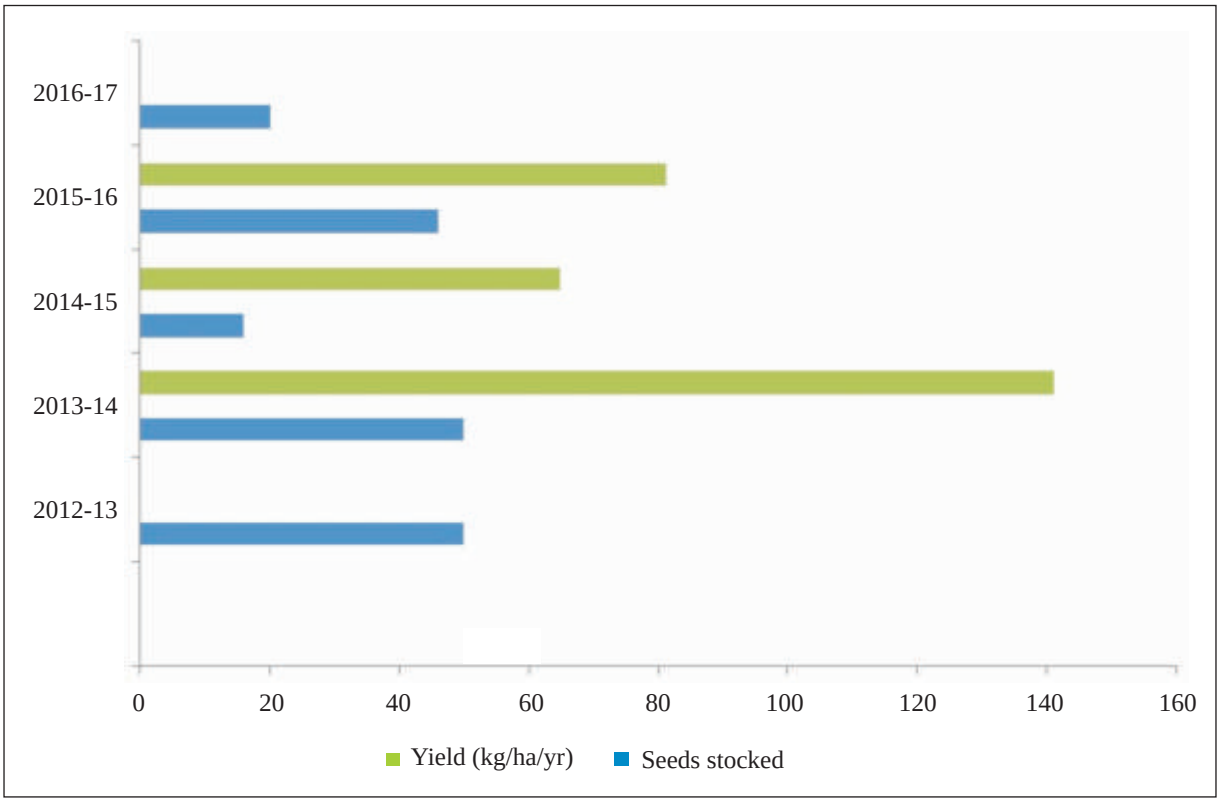


Fig. 42. Seeds stocked and yield in Manchanbele reservoir, Karnataka

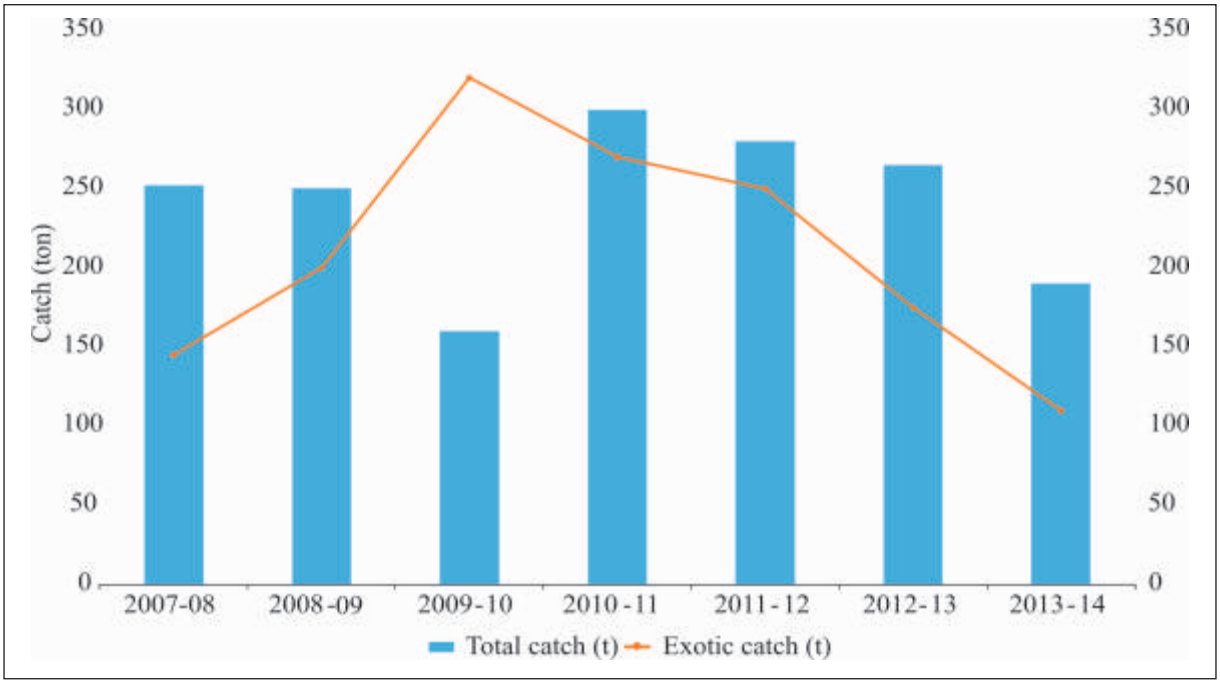


Fig. 43. Total fish catch vis-à-vis exotic fish catch of Mettur reservoir

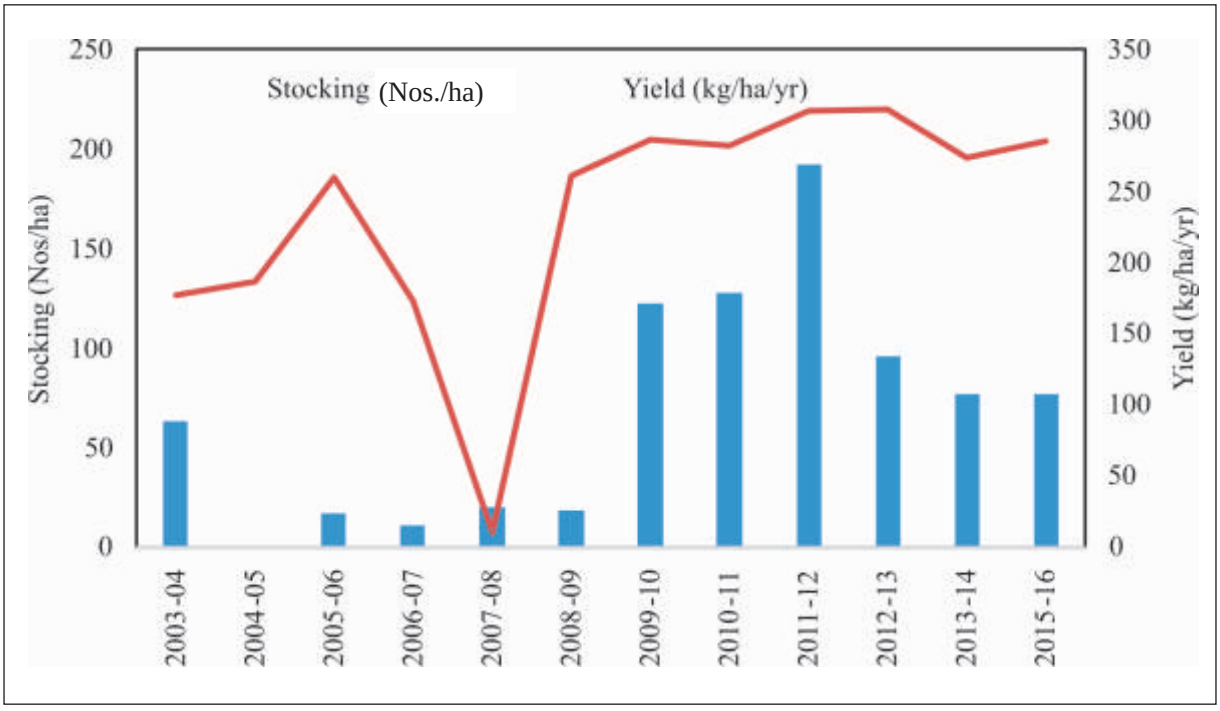


Fig. 44. Fish yield vis-à-vis fish stocking rate at Ukai reservoir

replaced by IMC. A significant decline has been observed in the landings of *P. dubius*, (15.3t), *L. bata* (10.1t), *W. attu (*64.6 t) and *S. aor* (29.1t) as compared to 1971-81. Heavy stocking by IMC fingerlings did not show proportionate yield in Bhavanisagar reservoir. Supplementary stocking of *L. fimbriatus* and exotic fish *C. carpio* did not reflect in the yield. In Mettur reservoir (15,346 ha), the annual exotic catch in the fishery increased from 1.6% in 2007-08 to 5.3% in 2009-10, then a steady decline to 1.6% in 2013-14. The annual exotic catch in the fishery increased from 1.6% in 2007-08 to 5.3% in 2009-10, then a steady decline to 1.6% in 2013-14.

Impact of stocking in Ukai reservoir was studied from2003-04 to 2015-16.The fish seed stocking rate varying from 10 to 192 Nos./ha with the fish production of 10-308 kg/ha/yr. A positive correlation (r = 0.57) was found between the fish stocking and the production from the reservoir as a whole. The fish production level is encouraging when compared with other larger reservoir of the country. The fish production data (2011-12) of the reservoir shows that carps contributed 64% of the total production, rest are catfishes 16%, eel 2%, prawn 1% and others 17%. The dominant species of carps are *Catla catla, Labeo rohita, Cirrhinus mrigala, L. calbasu*; among catfishes *Wallago attu, Notopterus notopterus, Sperata aor, Ompok bimaculatus* were predominant. Among others, *Tenualosa ilisha*, contributes less than one percent of the total catch of the reservoir.

Project (RWF/SR/12/02/03) : Application of acoustics and trophic models for ecosystem-based fisheries management in reservoir

Project staff : M. F. Khan, P. Panikkar, V. L. Ramya, Sibina S. Mol and Vijaykumar, M. E.

Using acoustics, Potential Fishery Zones (PFZs) of Karapuzha Reservoir were identified. The lotic zone showed high concentration of fishes followed by intermediate and lentic zone. Target strengths of seven species were estimated. An assembly for converting portable echo-sounder into portable sonar has been developed and the prototype is tested successfully on counting the fishes in Banasurasagar reservoir. The study showed that changes in ecosystem stability can be caused by trophic interactions due to stocking with major carps but the process does not interfere in both Nile Tilapia and Indian Major Carps growing together without causing any adverse impact to the reservoir ecosystem.

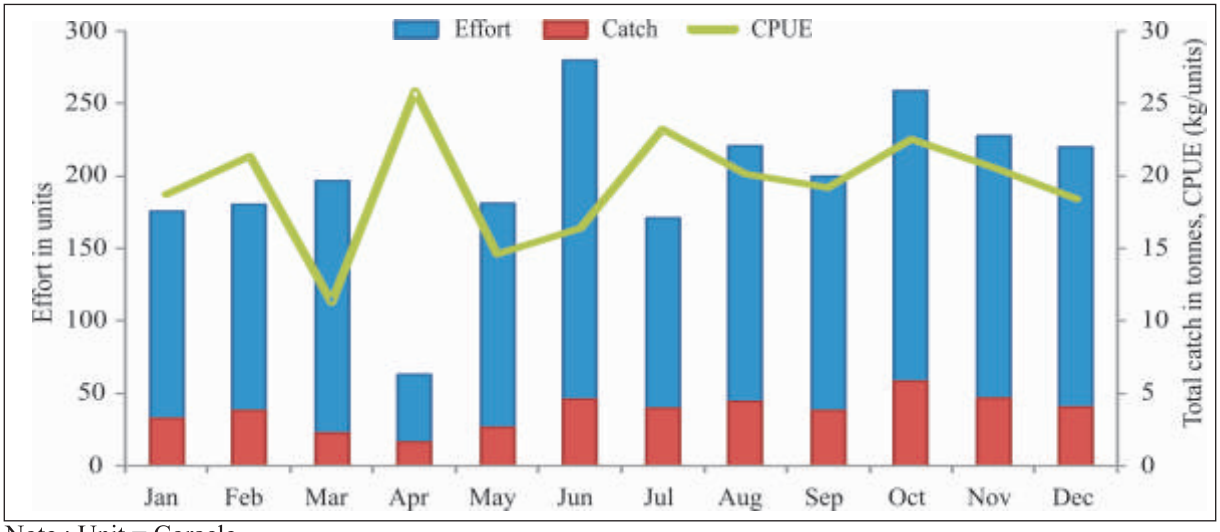
Manchanabele reservoir in Karnataka (12°53'55"N 77°19'37"E)

Catch composition

In 2016-17, the maximum fish catch was recorded in the month of October (5.83 t) and minimum in April (1.63 t). The maximum number of fishing days and fishing units operated were in June 2015, while the minimum was in April 22, 2016. Hence, the catch per unit effort (CPUE) recorded a maximum in April (25.8 kg/unit). The fishing activities in the reservoir are monitored by the Averahalli Fish Co-operative society.

Experimental fishing

It was revealed that *O. mossambicus* dominated the fish catch contributing 42% of the total catch, followed by *Channa marulius* (28%), *Labeo fimbriatus* (18%) and miscellaneous fishes (12 %).



Note : Unit = Coracle

Fig. 45. Estimated monthly fishing effort and catch (2016)

Important water quality parameters of the reservoir on monthly basis were collected and analysed. The plankton composition and feeding strategy of *Puntius ticto* and *Cyprinus carpio* were studied. Based on life history characteristics, feeding habitats and dominance of fish in the catch, ecological groupings were made. A diet matrix was prepared for the consumers in the reservoir.

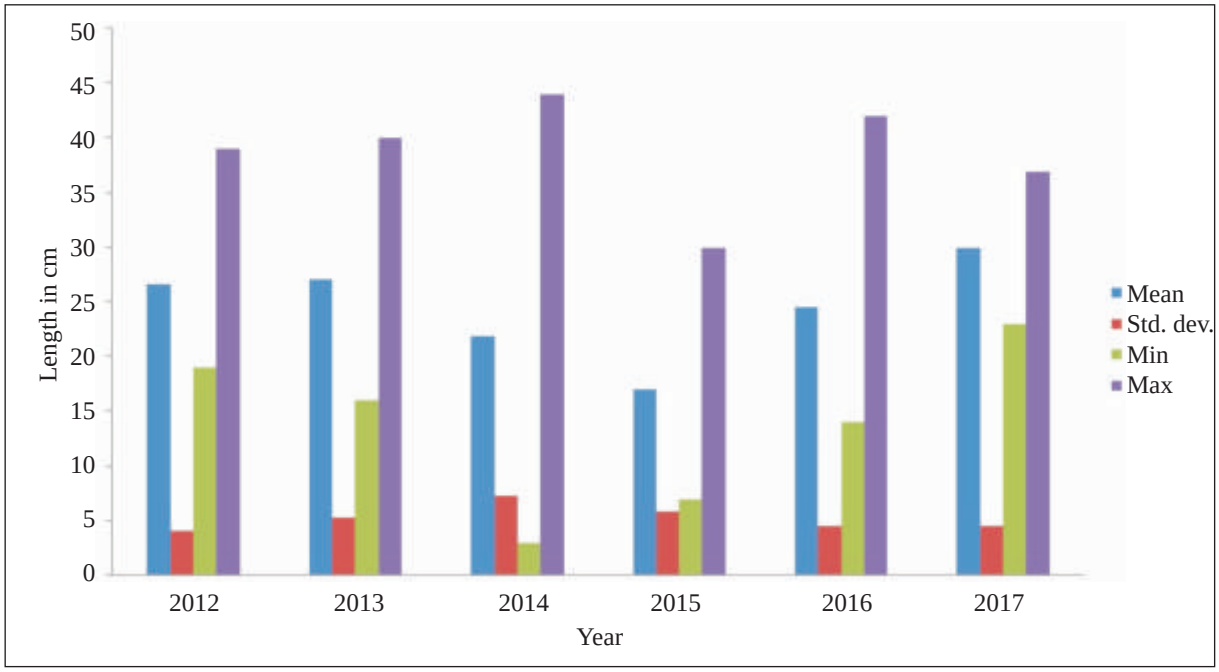


Fig. 46. Length distribution of *O. niloticus* in Manchanbele (2012-2015)

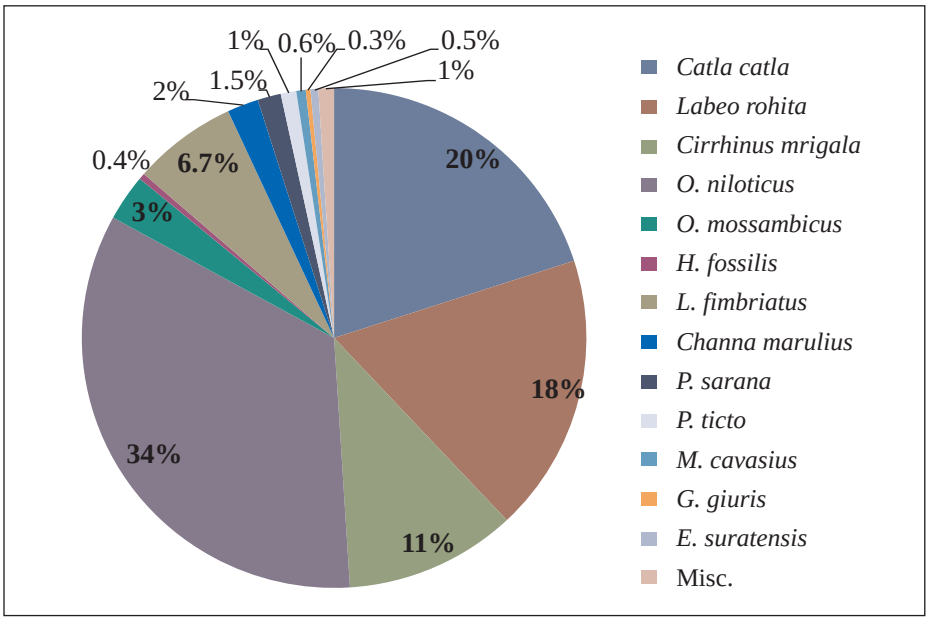


Fig. 47. Species wise fish catch composition of Manchanbele reservoir, Karnataka

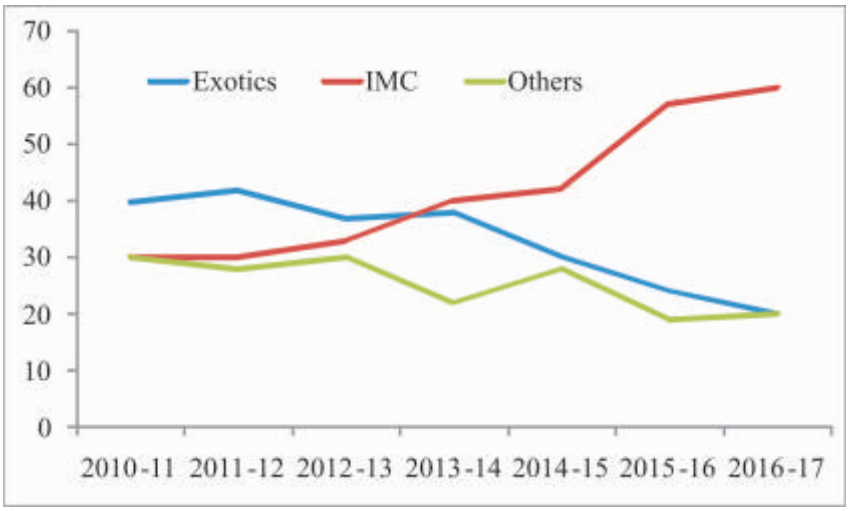


Fig. 48. Percentage contribution of IMC, Exotics and Others in total catch of Manchanbele reservoir

Plankton resources

The most dominant group was Chlorophyceae (14.8 – 32.4%) represented by *Spirogyra, Zygnema, Xanthidium, Ulothrix* spp., *Pediastrum* and *Scenedesmus* spp., Myxophyceae represented mainly by *Microcystis* dominated in July (28-52.7%). Bacillariophyceae (12.2-35.3%) were represented by *Cymbella*, *Navicula, Nitzschia, Surirella* spp., Zooplankton was predominated by copepods species, mainly calanoid in the monsoon (44.65% of the total zooplankton resources). Cladocerans and rotifers were observed in less quantity. The Dominance index in the diversity study showed its dominance in August (0.148) followed by July (0.13) month. As per the Simpson's index, species are not evenly distributed. The values range from 0.86 to 0.94.

Food and feeding habit

Food and feeding habits of dominant fin fishes from the reservoir were studied to investigate the trophic levels, prey-predator relationships, system omnivory indices for further development of food web dynamics which help in ecosystem resource management. In *Puntius ticto* three types of prey were considered of high importance with the phytoplankton being the most frequent (FO = 0.71). Diet composition of *Cyprinus carpio* consisted of detritus (34.2%), diatoms (18%), blue-green algae (17.8%), zooplankton (8.5%), insects (6.5%) and vegetal matter (15%).

Reproductive biology of *P. ticto*

The overall sex- ratio of *P. ticto* (M/F) was 1:1.2. Occurrence of males was relatively higher than females during post monsoon months (61.2%), while for females, sex ratio was higher in summer (65.7%). Chi square test (χ^2) showed insignificant seasonal differences between both sexes ($p< 0.05$). The maturity stages of *P. ticto* ranged from I (Immature) to ripe and oozing (V) and spent (VI). Fecundity ranged from 8136 to 11779 numbers for fishes ranging from 90 mm to 120 mm. In females 28% of the total fish were in mature stage (II); 39% were in mature stage (III) and 24% were in ripe stage (IV). In males 26% of the total fish were in mature stage (II); 48% were in mature stage (III) and 16% were in ripe stage (IV). About 75 % of the total fishes were in reproductive process. The mean ova diameter of the fishes ranged from 0.13 ±0.01 to 0.44 ±0.022 mm.

Food-web model of Manchanbele reservoir

The prey-predator analysis showed that *Channa* spp. preferred major carps and barbs for food. Zooplankton and macrophytes are least preferred food of *O. niloticus*. Detritus is preferred food item of many groups in lower trophic levels. The value of overhead was at 36.8. This reveals that the food web is less resistant to perturbations.

Acoustic survey

Hydroacoustic surveys were conducted in Karapuzha Reservoir. The Portable SIMRADEY60, split beam echo sounder with frequency 120 kHz and elliptical transducer (opening angles at -3dB were 4 and 10 degrees) were used. The water parameters, dissolved oxygen, temperature, conductivity was measured at surface using portable instrument and from conductivity salinity is estimated and incorporated in SIMRAD ER60 software. Using acoustics, Potential Fishery Zones (PFZs) of Karapuzha Reservoir were identified. The lotic zone showed high concentration of fishes followed by intermediate (medium concentration) and lentic zone (low concentration). This will help fishermen to realize where to fish for more catch.

Target strengths of seven species viz. *Catla catla, Labeo rohita, Cirrhinus mrigala, Oreochromis mossambicus, O. niloticus, Channa marulius* and *Cyprinus carpio* were estimated. An assembly for converting portable echosounder into portable sonar has been developed and the prototype is tested successfully on counting the fishes in Banasurasagar reservoir.

Project (RWF/ER/12/02/04) : Refinement of enclosure fish culture (pens & cages) in reservoirs and wetlands for production of stocking materials and table fish

Project staff : A. K. Das, B. K. Das, U. K. Sarkar, D. N. Jha, A. Alam, Suman Kumari, Vikash Kumar, Gunjan Karnatak, A. K. Bera, Himanshu S. Swain, Tasso Tayung, Subhra Saha, S. Das and B. Naskar

Demonstration of cage culture technology of *Pangasianodon hypophthalmus* was carried out in Govindsagar and Pong reservoirs of Himachal Pradesh. Experiments for diversification of species were carried out taking different candidate species viz. *Mystus cavasius*, *Oreochromis niloticus* and *Ompok bimaculatus* at Maithon reservoir. Limno-chemical parameters of water and sediment quality inside and outside cage were monitored. Patent has been filed for 'Model CIFRI-Cage' developed by the Institute.

Demonstration of cage culture technology

Demonstration of cage culture technology using *P. hypophthalmus* was carried out in Govindsagar and Pong reservoirs of Himachal Pradesh. The fish seed has been stocked @ 60/m^3 in 48 cages (size 6x4x4 m^3). The average length and weight of fish was 70.85mm and 2.63g, respectively at the time of stocking. Initially the fishes were fed with commercial diet of size 1.2 mm having 32% of protein and 5% of fat @ 8% of body weight.

Institute has initiated studies on species diversification to evaluate the culture potential of commercially important fish species (*M. cavasius*, *O. niloticus*, and *Ompok bimaculatus*) for inland cage culture. The growth and survival of the fish were monitored. Limno-chemical parameters of water and sediment qualities of inside and outside cage site of Maithon Reservoir is given in the following table.

Table 5. Limno-chemical parameters of water inside and outside cage site in Maithon reservoir

Parameter	Inside cage	Outside cage
	Range (Mean)	Range (Mean)
Depth (m)	20.4-21.0 (20.7)	27-28 (27.5)
Transparency (cm)	290-300 (295)	318-321 (320)
Temp.°C	20.4-20.6 (20.3)	20.1-21.5 (20.8)
pH	7.6-8.6 (8.22)	20.1-21.5(7.8-8.6)
Sp.Cond.(µS/cm)	157-163 (160)	130-162.4 (151)
D.O. (ppm)	8.2-9.8 (8.9)	8.4-9.6 (8.97)
Free CO_2 (ppm)	Nil	Nil
Total alkalinity (ppm)	56-72 (62.4)	44-68 (58.4)
Total hardness (ppm)	50-72 (61.5)	46-66 (57.5)
Ca^{++} (ppm)	14.4-20.1 (17.8)	16-19.2 (16.8)
Mg^{++}(ppm)	0.04-8.8 (4.4)	0.5-6.3 (4.1)
Chloride (ppm)	14-22 (17)	18-22 (19.5)
Nitrate-N (ppb)	148-700 (443)	112-1070 (600)
Phosphate-P (ppb)	30-60 (47)	20-60 (30)
Silicate-Si (ppm)	9.6-11 (10.4)	9.8-10.9 (10.6)

Table 6. Sediment qualities of inside and outside cage site in Maithon reservoir

Parameter	Inside cage	Outside cage
	Range (Mean)	Range (Mean)
pH	5.5-5.8 (5.60)	5.7-5.8 (5.7)
Sp. Cond. (µS/cm)	0.064-0.416 (0.205)	0.103-0.233 (0.154)
Organic carbon (%)	1.0-2.3 (1.5)	0.95-2.4 (1.4)
Total nitrogen (%)	0.14-0.16 (0.15)	0.14-0.16 (0.15)
C/N ratio	7.14-14.38 (10.0)	6.79-15.0 (9.3)
Available phosphorus (mg/100gm)	3.6-4.8 (6.9)	3.6-3.8 (3.7)
Sand (%)	64-71 (67.6)	69-72 (70.0)
Silt (%)	21-29 (25.3)	22-25 (24.0)
Clay (%)	6-8 (7.0)	6.0-6.0 (6.0)

Cage culture demonstration at Pong reservoir, Himachal Pradesh

Cage culture demonstration at Govindsagar reservoir, Himachal Pradesh

Purbasthali beel, Burdwan, W. B.

FISHERIES RESOURCE AND ENVIRONMENTAL MANAGEMENT

Programme: Environment and health monitoring of inland open waters for ecosystem amelioration

Programme Co-ordinator : Dr. B. P. Mohanty

Project (FREM/ER/12/03/02) : Monitoring and benchmarking of ecosystem health of major river systems in India

Project staff: S. Samanta, S.K. Nag, M. Naskar, D. Sudheesan, Sajina A.M., Raju Baitha, Vikas Kumar, Sanjay Bhowmick, Keya Saha, S. K. Paul, S. Bandyopadhyay and Arijit Ghosh

Rivers get polluted with different substances some of which are highly hazardous and toxic in nature. Heavy metals and pesticide residues belong to such group of substances which are quite often encountered in aquatic systems including rivers mainly arising due to anthropogenic activities around the river basin area. From water and sediments ultimately these chemicals are transferred down the food chain to the aquatic animals, more importantly fishes, and accumulate there. Since fish is consumed by human as food, presence of any toxic xenobiotics is undesirable as it may pose serious health hazards. Keeping this in view, monitoring of River Gomti, which passes through highly populated and industrial districts of Uttar Pradesh was undertaken to find out the exact status of pollution.

Studies on fish diversity, water and sediment quality including heavy metal and pesticide level were carried out for ecological health assessment of River Gomti**.** Endangered fish species, *Chagunius chagunio*, and vulnerable species *Eutropiichthys vacha* were recorded in this river. Fish based Index of Biotic Integrity (IBI) estimated for the river indicated 85% of the studied sites to be moderately impaired.

River Gomti

Fish Diversity of Gomti River

During the study period, 44 fish species belonging to 34 genera, 18 families and 5 orders were recorded. Cyprinids were the dominant group (39%), followed by Bagrid catfishes (16%) and Channids (8%). Exotic species, namely, *Cyprinus carpio* and *Oreochromis niloticus* were recorded. Endangered fish species *Chagunius chagunio*, and vulnerable species *Eutropiichthys vacha* were also recorded during the study period.

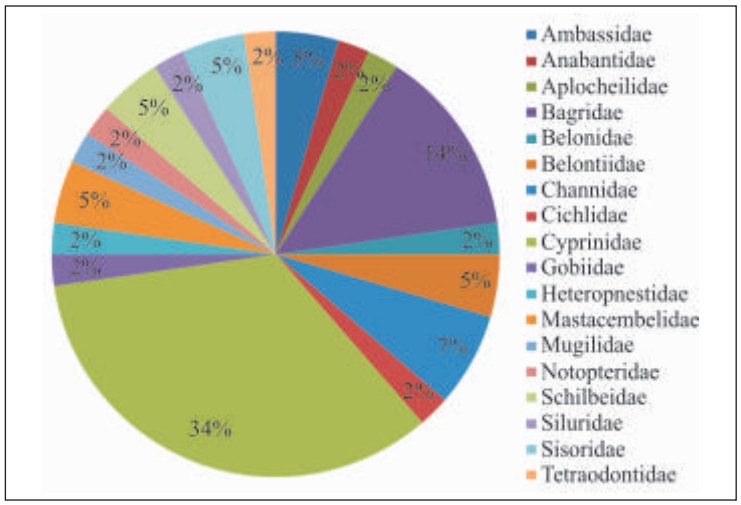


Fig. 49. Family wise distribution of fish species in River Gomti

Water and sediment quality

The physico-chemical analysis of water samples from the sites revealed optimum pH (7.77-8.78) and dissolved oxygen (4.38-7.69 mg/L). BOD (3.15-5.67 mg/L) and specific conductance (421-558 S/cm) were marginally higher indicating moderate level of organic pollution. The river sediments had slightly alkaline pH (7.33-7.9) and specific conductance varying from 118 – 786 S/cm.

Heavy metals

Toxic heavy metals like cadmium (Cd) and lead (Pb) were not recorded in the river water. However, chromium (Cr) was detected in water samples of Surajghat (Jounpur), Trimohini (Rajepur) and Saidpur (Gajipur). Cadmium (32-98 mg/kg) was detected in sediments of Trimohini (Rajepur) and Saidpur (Gajipur) and chromium (11-60 mg/kg) was detected in sediments of all the sites except Sultanpur. However, Cr concentrations were below the USEPA soil limit and do not warrant any clean up. Zinc (Zn) and copper (Cu) were present within limits but manganese (Mn) levels were quite higher, particularly in Goughat (Lucknow).

In fish flesh and tissues, Copper (Cu) and Manganese (Mn) concentrations were much below the safety limits but level of Zinc (Zn) was much higher than recommended level of 50 mg/kg in food, as specified by FSSAI, in samples from the lower stretch i.e. Wallipur (Sultanpur) to Saidpur (Gajipur). Cr and Pb were also detected in few samples of fish from lower stretch indicating contamination due to pollution from industrial and domestic discharge.

Pesticide residues

Water, sediment and fish samples from the river were analysed for residues of 16 organochlorines (OC), 10 organophosphates (OP) and eight synthetic pyrethroids (SP) pesticides. OC residues were detected in 52% water samples, 30% sediment samples and 43% fish samples, while OP contamination levels were 33%, 25% and 39% in water, sediment and fish samples respectively. No SP residues could be detected in any of the samples analysed.

Among the OCs, mainly HCH, OP and PP-DDE were frequently encountered in water and fish samples while other isomers of HCH, DDD, endosulfan and dicofol were detected in few samples. The concentrations of HCH, DDT and Endosulfan in water varied from 0.007-0.580, 0.15-1.70 and 0.033-1.200 g/l respectively. HCH, DDD (OP and PP), DDE (PP) and endosulfan (and sulfate) were detected in sediment samples. Although in fish tissues and flesh concentration of DDT was much below the tolerance limit of 7 mg/kg prescribed by FSSAI, but four samples had residue level exceeding the tolerance limit (0.25 mg/kg) for different HCH isomers.

Among the OPs, chlorpyriphos (0.01-0.178 g/L) and me-parathion (0.061-0.288 g/L) could be detected in water samples. Chlorpyriphos residues (0.002-0.015 mg/kg) were also found in sediments of Goughat, Surajghat (Jounpur), Trimohini (Rajepur) and Saidpur (Gajipur). Residue of dimethoate was also found in sediments of Sultanpur site. Residues of dichlorvos (0.05-0.42 mg/kg), dimethoate (0.7 mg/kg), me-parathion (0.01-0.07 mg/kg), malathion (0.01-0.11 mg/kg) and chlorpyriphos (0.003-0.095 mg/kg) were recorded in fish samples. The levels of OPs detected in fish samples are not alarming.

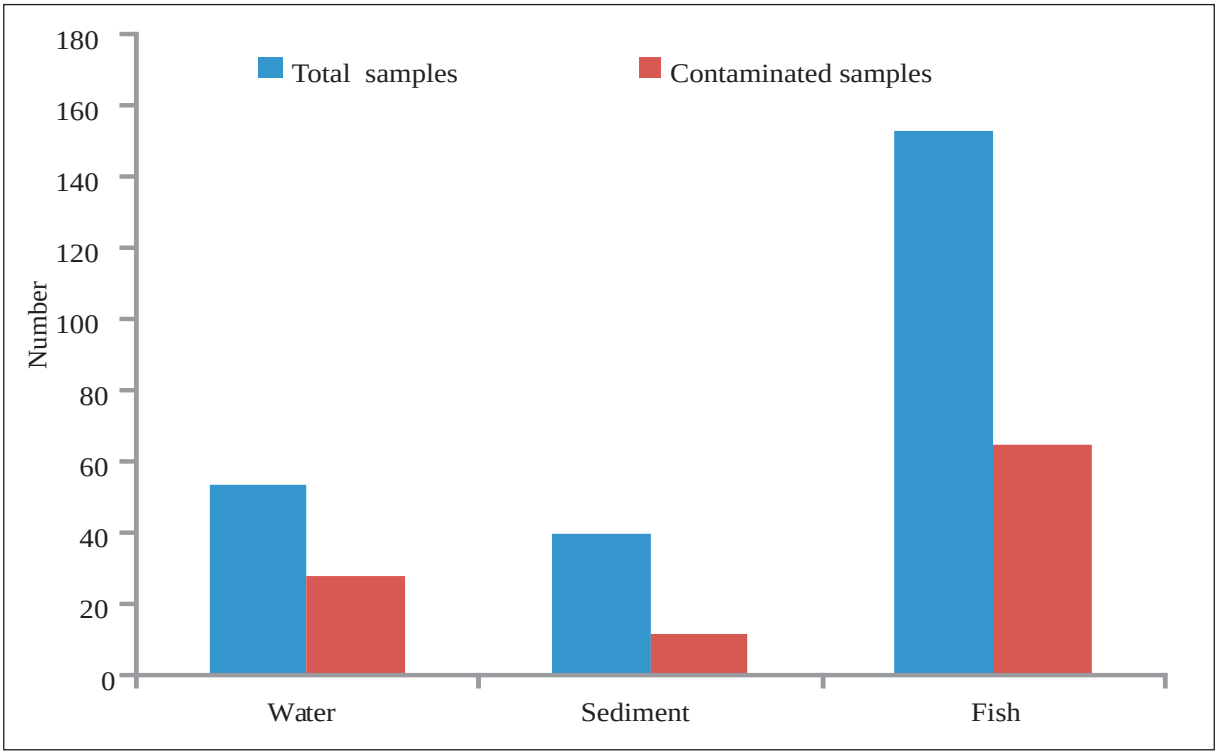


Fig. 50. Extent of OC contamination in water, sediment and fishes of River Gomti

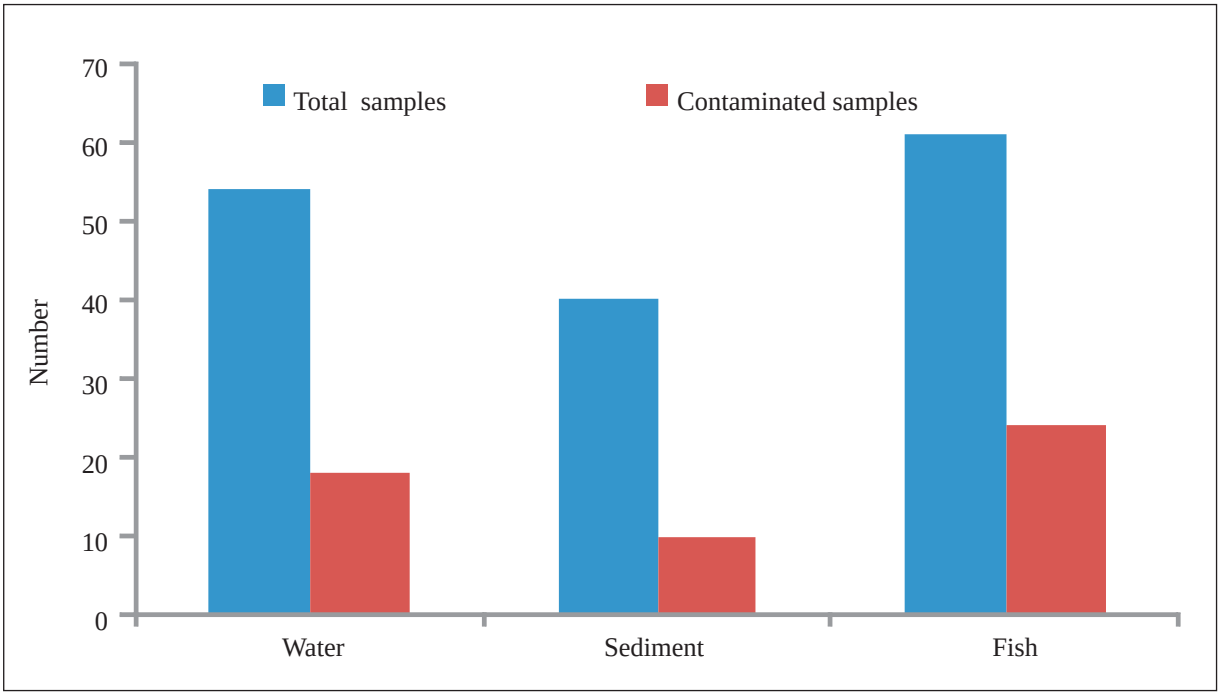


Fig. 51. Extent of OP contamination in water, sediment and fishes of River Gomti

Sampling at Goughat (Surajghat, Jaunpur), River Gomti,

Project (FREM/ER/12/03/03) : Developing microbiological protocol for bioremediation of polluted aquatic environment

Project staff : S. K. Manna, S. K. Nag, M. Aftabuddin, P. Maurye, S. Das Sarkar, S. K. Paul and Lokenath Chakraborty

Accumulation of organic matter is water and sediments cause short term and long term environmental degradation of aquatic ecology and environment. Bioremediation of polluted environments using microbes can be an effective way of restoration of degraded ecosystem. In this direction, bacteria were isolated and identified from various polluted environments for degradation of selected organic pollutants. A total of 84 bacteria were isolated and tested for degradation capability of organic contaminatnts like oil, phenol, chlorophenol and organic matter.

Pseudomonas aeruginosa, Ps. Putida, Ps. Citronellosis and *Acinetobacter pitti* were efficiecnt in degrading phenol and chlorophenol compounds while *Chryseobacterium teanense, C. geocarposphaerae, Bacillus cereus, B. flexus* and *B. megaterium* were efficient in degrading protein, lipid and starch. Microcosm experiment using sediment from highly polluted East Kolkata Wetlands showed capability of few strains to degrade organic pollution load upto 61%.

Identification of pollutant degrading bacteria

Bacteria isolated from varied polluted environments, have been identified and grouped in following genera or species:
Acinetobacter calcoaceticus, A. junii, A. pitti, A. soli,
Aeromonas veronii,
Alkaligenes faecalis,
Bacillus aerophilus, B. megaterium, B. cereus, B. flexus, B. subtilis
Chryseobacterium teaenense, C. geocarposphaerae, C. barnardeti,
Citrobacter freundi,
Cloacibacterium sp.,
Comamona sterrigena, C. testosteroni, C. Aquatica,
Cupriavidus sp.,
Flavobacterium sp.,
Klebsiell apneumoniae,
Ochrobactrum anthropi, O. triciti, O. intermedium, O. pseudointermedium,
Pseudomonas putida, Ps. citronellolis, Ps. aeruginosa, Ps. geniculata,
Stenotrophomonas maltophila

Pollutant degradation ability of different strains

Fifty two strains isolated from varied polluted environments that are reportedly not human and animal pathogens, were examined for their ability to degrade a wide range of pollutants viz., carbohydrate, protein, oils, phenol and phenolic compounds under in vitro laboratory conditions with the objective to select more effective strains for further testing. Study revealed that many isolates degraded a spectrum of pollutants, however, strains identified as *Pseudomonas aeruginosa, Ps. putida, Ps. citronelllolis* and *Acinetobacter pitti* were more efficient in degrading phenol and phenolic compounds, while *Chryseobacterium teanense, C. geocarposphaerae, Bacillus cereus, B. flexus* and *B. megaterium* efficiently degraded non-toxic organic matter.

Sediment organic matter degradation by selected strains

With an aim to degrade the organic matter accumulated in water and sediment, few strains were tested in a microcosm set up for organic matter degradation in highly polluted floodplain wetland sediments. It was observed that few strains effectively degraded up to 61% of sediment organic matter load in 2-3weeks period and would be useful in reducing pollution load *in situ* that would enhance water quality as well as water productivity.

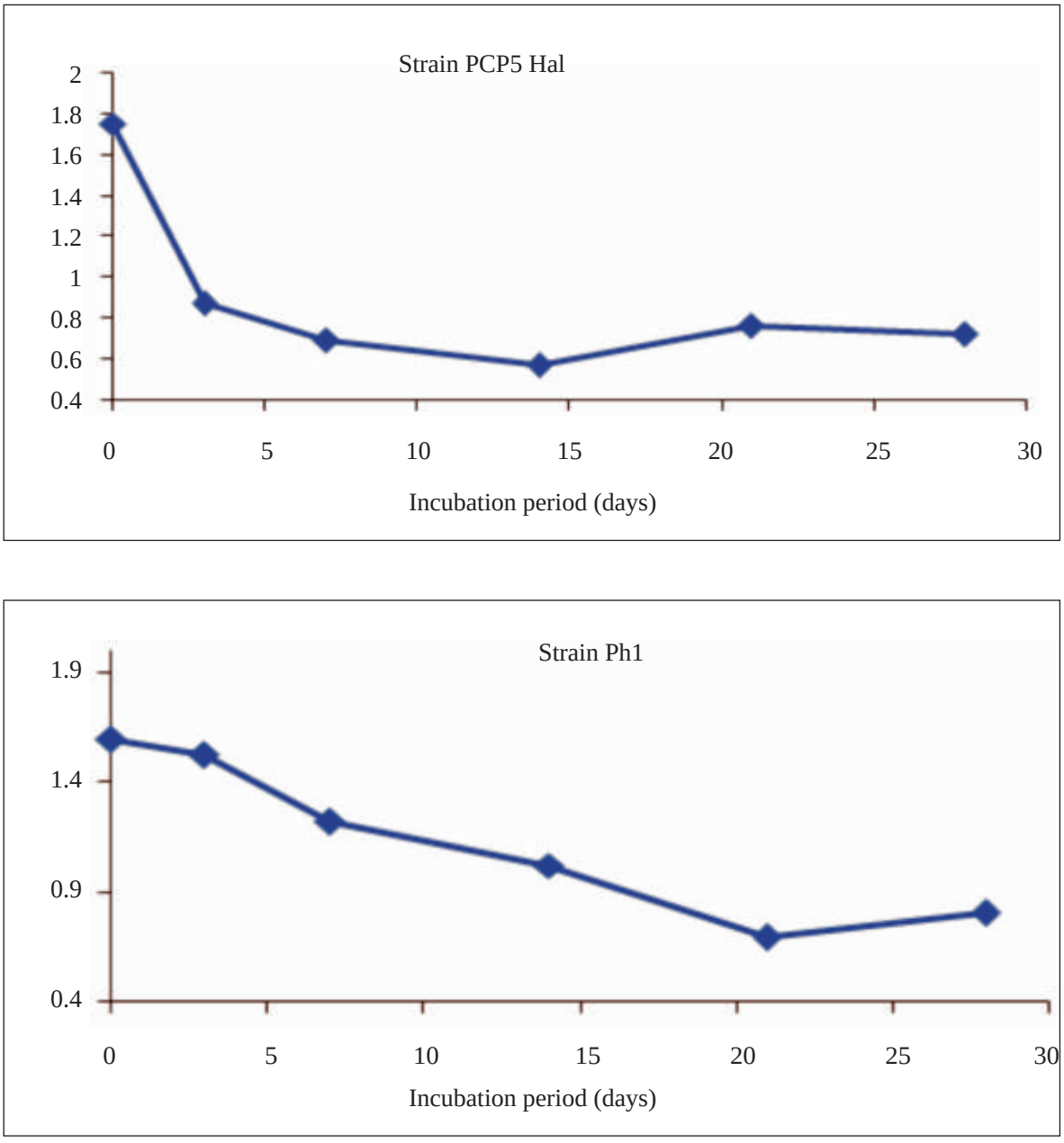


Fig. 52. Reduction of sediment organic load by a few representative bacteria

Project (FREM/ER/12/03/05) : Development of biotechnological tools for inland aquatic ecosystem health assessment

Project staff : B. P. Mohanty, D. Karunakaran, T. Abdulla, P. K. Parida, Prajna R. Behera, Vikas Kumar, S. N. Sahoo, Sanjay Bhowmick, L. R. Mahavar, S. K. Paul, A. Jana and Sk. Rabiul

Pollution management in large river systems requires periodic monitoring of pollutants in different stretches. Environmental quality is often assessed in terms of physical and chemical parameters. However, only chemical data of pollutants in environmental matrices is not sufficient to predict how it can affect the biotic components. Therefore, the need to detect the effects of contaminants at low concentration and in complex mixture on molecular and cellular processes of an organism have increased, which has led to the idea of using biological markers (biomarkers) to indicate the presence of contaminants. Efforts have been made under this project to search for biomarkers that can be used for pollution monitoring in inland aquatic ecosystems.

Gene ontology (GO), Clusters of orthology (COG), and pathway analysis (KEGG) showed that genetic pathways involved in energy metabolism, translational and transcriptional machinery, protein folding and degradation were highly affected in response to pollution stress. Gene expression analysis showed that *CYP1A1* and *CYP1A2* genes were up-regulated and pro-inflammatory cytokines were down-regulated in all the polluted stretches studied, compared to reference site. Immunoblot analysis carried out in liver tissues of *Rita rita* collected from polluted stretches of river Ganga showed high abundance of *p53* gene in the polluted stretches of river Ganga.

Comparative transcriptomic profiling of gill tissues of *Rita rita* to study the differential gene expression in response to pollution stress

Comparative transcriptomic profiling in gill tissues of *Rita rita* were carried out to study the alteration in gene expression profile in response to pollution by using next generation sequencing (illumina HiSeq 2500 platform). The transcriptomic

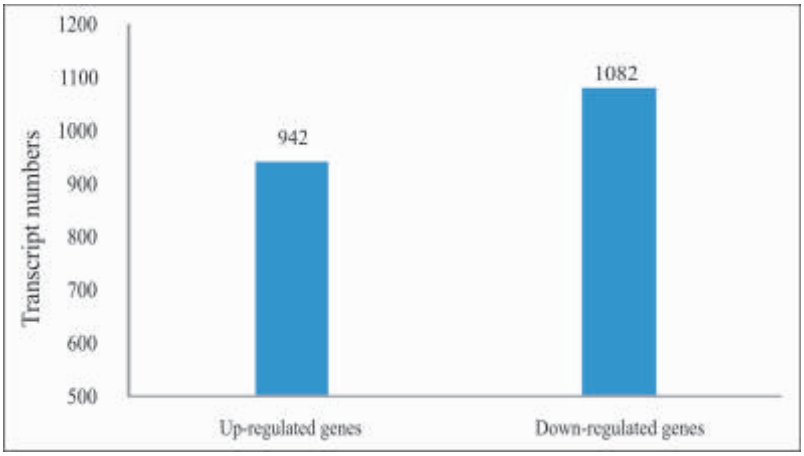


Fig. 53. Differentially expressed genes in response to pollution

information generated has been deposited in NCBI (Accession no. SRR5485008). BLASTX results indicated a high level of similarities and conservedness of transcript information of *R.rita* with *Astyanax mexicanus*, *Ictalurus punctatus*, followed by *Danio rerio*. Among the identified unigenes, 2024 differentially expressed genes (942 genes significantly up-regulated, and 1082 genes significantly down-regulated) were identified by Deseq programme from the fishes collected from polluted stretch (Kanpur), relative to the reference site (Farakka). Gene ontology (GO), Clusters of orthology (COG), and pathway analysis (KEGG) showed that genetic pathways involved in energy metabolism, translational and transcriptional machinery, protein folding and degradation were highly affected in response to pollution stress.

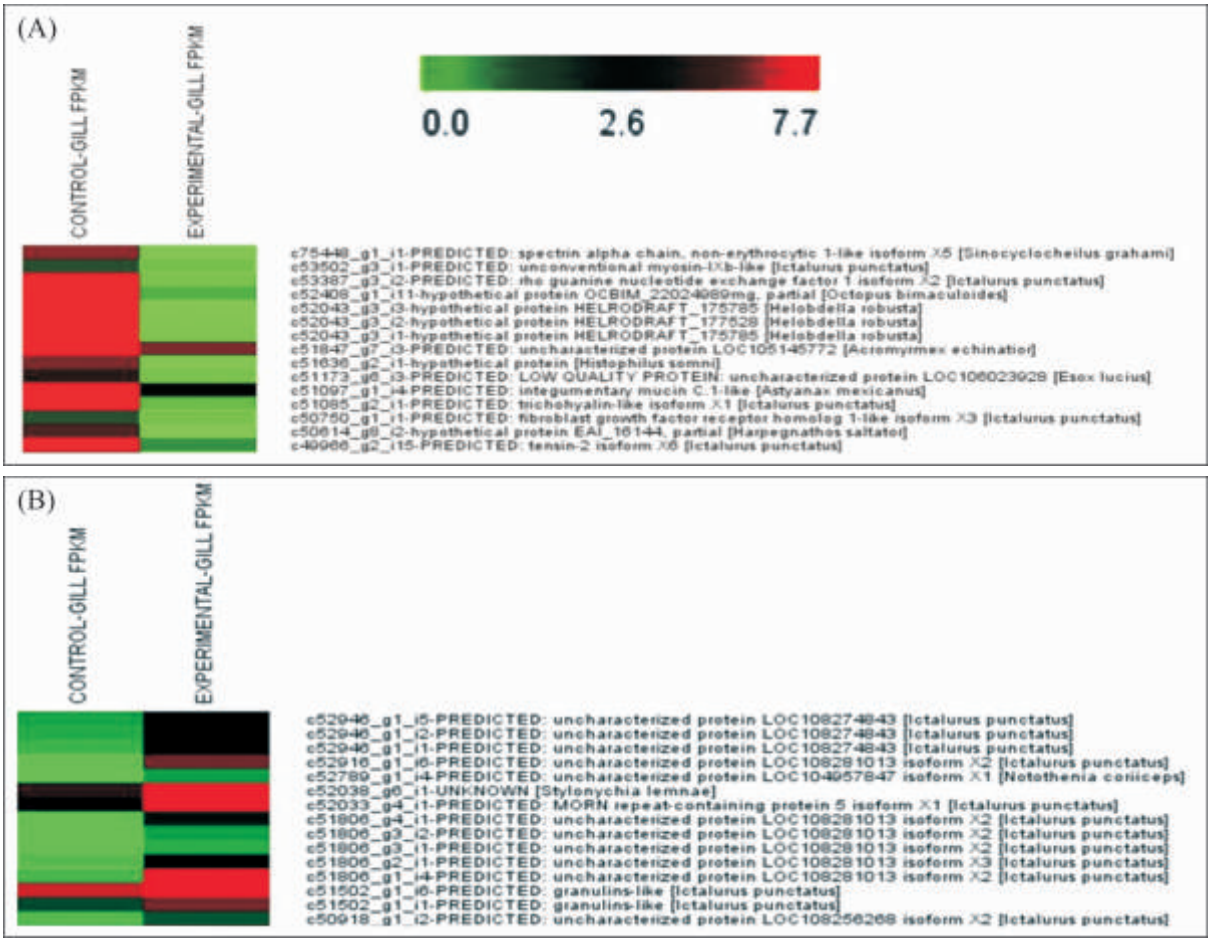


Fig. 54. List of top (a) down regulated and (b) up-regulated transcripts in 'EXPERIMENTAL GILL' as compared to 'CONTROL GILL' resulted from BLASTX search

Correlating gene expression patterns of CYP1A1, CYP1A2 and selected immune genes in *Rita rita* from riverine habitats to evaluate immunotoxicity of fish in open water ecosystems

Environmental quality is often assessed in terms of physical and chemical parameters. However, biological parameters are also good indicators of environmental quality. This has led to the idea to identify and use biomarkers to indicate presence of contaminants and to unravel their effects on organisms. In this

context, expression profiling of phase I biotransformation enzymes (CYP1A1 and CYP1A2) and proinflammatory cytokines were carried out by RT-PCR in liver tissues of freshwater catfish *R. rita* to evaluate the impact of environmental pollutants on fish residing in different stretches of River Ganga. Gene expression analysis showed that CYP1A1 and CYP1A2 were up-regulated and pro-inflammatory cytokines were down-regulated in all the polluted stretches studied, compared to reference site (Farakka). Down-regulation of cytokines indicated immunotoxicity in fish. PCA analysis showed that expression of biotransformation enzymes negatively correlated with the transcriptional variation of proinfammatory cytokines.

Expression profile of p53 (tumor suppressor gene) gene in fish (*R. rita*) in polluted stretches of river Ganga

The p53, tumour suppressor protein, has a fundamental role in cell cycle control and division, and in mammals certain genotoxic agents induce specific mutations in *p53*, leading to tumorigenesis. The normal protein is present only in minute amounts in normal tissues and cells and has a very short half-life. In contrast, mutant *p53* protein produced by malignant cells, is usually the product of a point mutation in the *p53* gene, leading to substitution of a single amino acid that significantly prolongs the half-life of the protein.The mutations of the *p53* gene are the most common molecular changes identified in several human cancers. In this context, immunoblot analysis was carried out in liver tissues of *R. rita* collected from some polluted stretches of river Ganga which showed high abundance of *p53* in the polluted stretch. Further investigation by transcriptomic analysis/mutation related studies will help to better understand the alteration of *p53* in response to aquatic pollution.

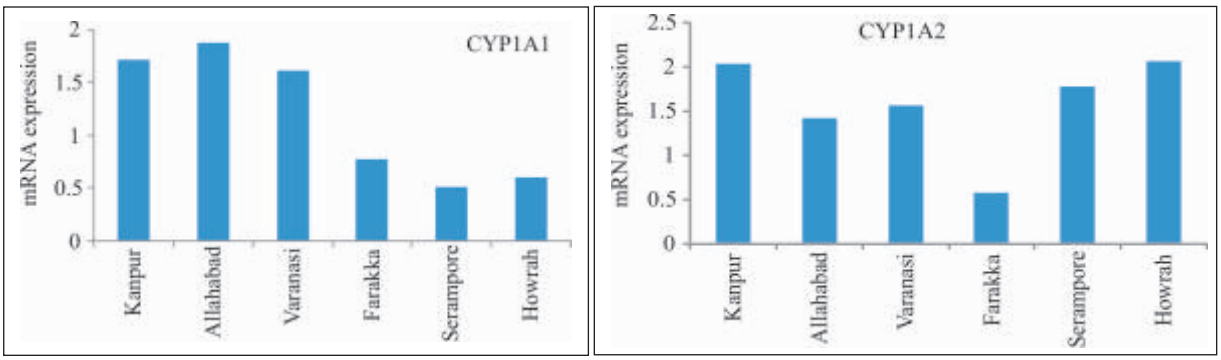


Fig. 55. Gene expression profile of CYP1A1 and CYP1A2 in liver tissues of *Rita rita*

Fig. 56. Immunoblot showing p53 protein bands in liver tissues of *Rita rita* collected from polluted stretches of river Ganga

Project (FREM/ER/12/03/07) : Acquisition of fish catch data and resource mapping of inland open-water resources on GIS platform

Project staff : S. K. Sahu, P. Maurye, D. Karunakaran, T. T. Paul, P. K. Parida, Sucheta Majumdar, B. Bose, S. Manoharan and U. Unnithan

Seasonal water level fluctuation is a major bottleneck in policy development for reservoir fisheries development. In general the fish seed stocking of reservoirs is based on water available at FRL of the reservoirs, which in reality is not available throughout the year for culture based fisheries (CBF). The reservoirs are marked by significant seasonal fluctuation in water level. In this regard remote sensing imageries and GIS tools were used to delineate mean water availability for CBF in reservoirs of Odisha and Chattisgarh.

Monthly variations of water area in 20 reservoirs of Chattisgarh were delineated using LE8 images. Water area (up to Dec 2015) reduces in the range of 45% to 3% of their maximum area. During Jan 2015 to Dec 2015 none of the reservoirs reached their Full Reservoir Level (FRL). Flood map was prepared with the help of NDWI (Normalize Differential Water Index) in floodprone districts of Assam indicating that 96% water bodies of Morigoan were inundated by floods, followed by Naogoan (92%), Darrang (85%), and Sonitpur (81%).

Monthly variations of surface water area in different reservoirs of Chattishgrah and Odisha

To address the problem and to quantify seasonal water level variations in reservoirs in Chattisgarh and Odisha, a total of seventy five remotely sensed imageries (LE8) of different dates of pass, starting from Jan 2015 to Dec 2016, were procured. Selected water bodies were delineated using band 3, 4, 5, 6 of Landsat 8. Initially

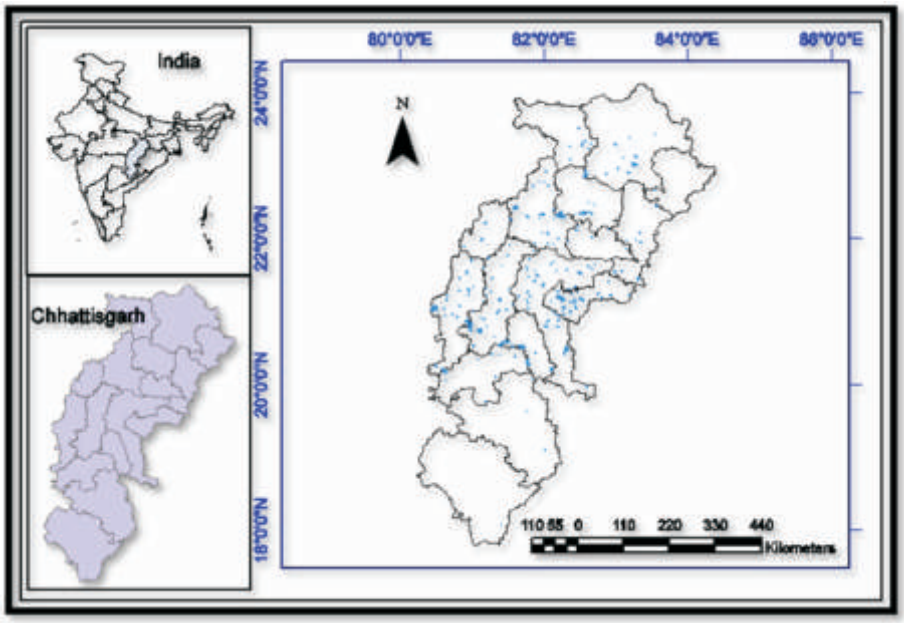


Fig. 57. Delineated reservoirs of Chattisgarh

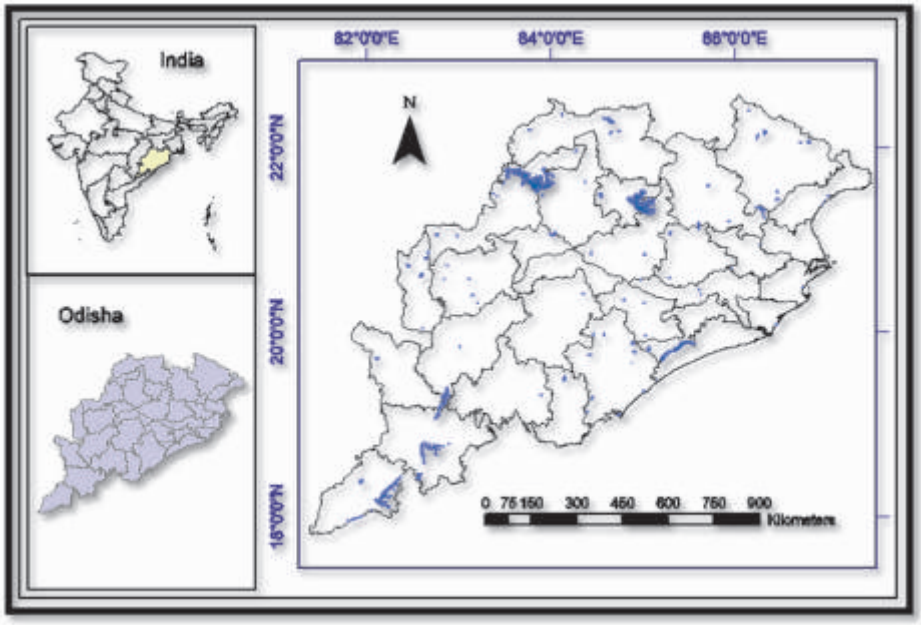
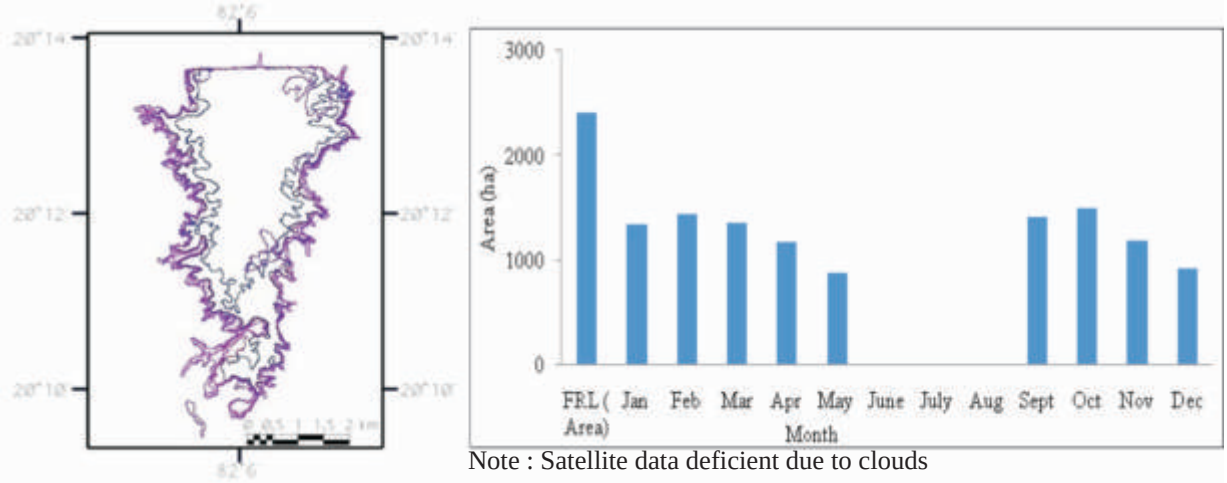


Fig. 58. Delineated reservoirs of Odisha

NDWI, NDBI and NDVI were derived using band 3, 4, 5, 6 and then they were transformed to HIS (Hue Intensity and Saturation). Surface water area was delineated on the basis of Hue, Intensity and Saturation.

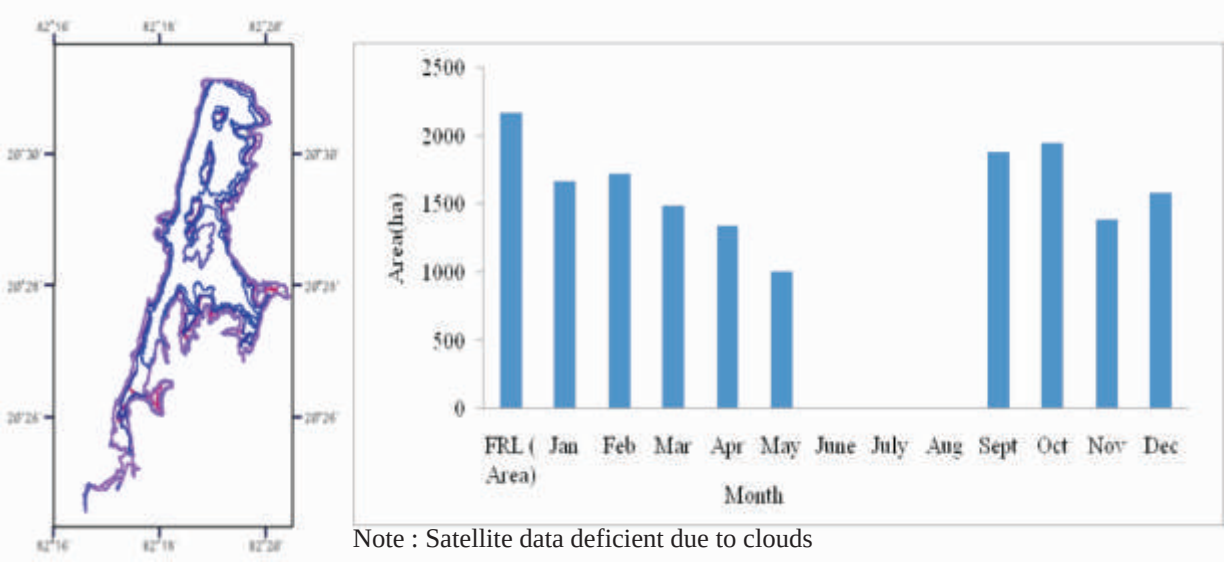
Sondur reservoir

Sondur Reservoir, located near Machka Village of Nagri Block, was constructed in 1988 across the Sondur River, a tributary of River Mahanadi. Major portion of the catchment of this reservoir lies in Dhamtari district of Chattisgarh and Koraput district of Odisha. The study showed that its maximum water spread area was 1506 ha in month of October. In the month of May its shrinkage was upto 885 ha. There is a 27% variation in water area around mean water area; water area reduces to 58% percent of its maximum area in lean season.



Note : Satellite data deficient due to clouds

Fig. 59. Surface water area variations of Sondur reservoir in different months



Note : Satellite data deficient due to clouds

Fig. 60. Surface water area variations of Siksar reservoir

Sikasar reservoir

Sikasar dam was constructed in 1977 across the River Pairy, a tributary of River Mahanadi near village Sikasar. During 2015 its maximum water spread area was 1937 ha, which is 90 % of its FRL area. In the month of May its water level was reduced to 995 ha showing 43% variation in water area; water area reduces even to 45% of its maximum area in the lean season.

Assessment of flood affected aquatic resources using spaceborne technology: a case study of Assam

Assam generally experiences heavy rainfall during monsoon and is often affected by flood and flood like situations. To study the flood affected areas during 2016 flood, satellite images of the study area were downloaded from the USGS. The study had been restricted to parts of six affected districts (Kamrup, Marigaon, Naogaon, Golaghat, Sonitpur, and Darrang).

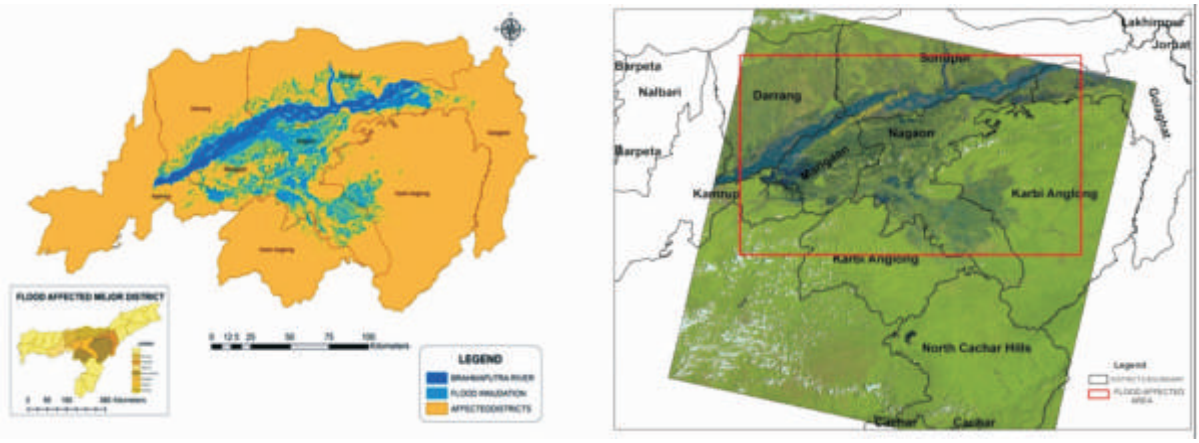


Fig. 61. Image of flood affected districts of Assam

Flood map was prepared with the help of NDWI (Normalize Differential Water Index) and it was super imposed on the water body layer. It was found that 96% water bodies of Morigoan were inundated by the floods, followed by Naogoan (92%), Darrang (85%) and Sonitpur (81%).

Project (FREM/ER/12/03/08) : Inference on some selected inland open waters through data mining and Generalized Linear Models

Project staff : M. Naskar, D. Das, S. K. Sahu, G. Chandra, Rohan Kumar Raman and T. Abdulla

Data driven decision support plays key role in management of inland fisheries resources. Apart from using primary data, secondary data can also be used for drawing inferences on inland fisheries. The project had been initiated for drawing inferences on inland fisheries of India by using statistical tools and techniques on secondary data.

Maximum observable flood at Bharuch (GRBF) had significant positive impact on hilsa catch and significantly negative influence on prawn, Bombay duck and *Wallago attu*. GRBF had negligible influence on mullet. Monsoon sediment load at Gurudeshwar had significantly positive influence on hilsa and prawn, and had insignificant influence on mullet, bombay duck and *Wallago attu*. Monsoon flow at Gurudeshwar had negative influence on prawn catch.

Influence of river hydrology on fisheries of river Narmada

Based on secondary time series data, multispecies analysis was carried out to identify common trend in catch and quantify the influence of river hydrology on the catch. The annual multivariate times series fish catch data of five fish species (Bombay duck, Mullet, Prawn and *Wallago attu*) and hydrological variables viz., monsoon sediment load at Gurudeshwar (gsm), monsoon flow at Gurudeshwar (gwm) and maximum observable flood at Bharuch (GRBF) for the period 1991 to 2008 were used for analysis. The Dynamic Factor Analysis (DFA) model was applied to identify underlying common catch patterns in fish catch time-series data. The analyses were carried out in R software environment, using MARSS package.

Identification of common trend

DFA model without explanatory variables was applied to identify common trend. The following nine models were compared:

1. Three trends with diagonal matrix of equal variance,
2. Three trends with diagonal matrix of unequal variance,
3. Three trends with unconstrained matrix,
4. Two trends with diagonal matrix of equal variance,
5. Two trends with diagonal matrix of unequal variance,
6. Two trends with unconstrained matrix,
7. Single trend with diagonal matrix of equal variance,
8. Single trend with diagonal matrix of unequal variance,
9. Single trend with unconstrained matrix

The best model was selected on the basis of minimum Akaike Information Criteria (AIC) value. The model with two common trends and diagonal matrix with unequal variance was found to be the best fitted model (AIC=223.84). Trend 1 showed decrease in catch with increase in time period while trend 2 showed decrease in catch initially and then increase in catch after year 2005. Horizontal axis represents year, and vertical axis represents the standardized value of catch.

Factor loadings of fish species on these two trends were computed as the proportionate contribution of these fishes catches in respective trend1 and trend 2. It is evident that the positive contribution of hilsa catch was very high as compared to the other species. Slight negative contributions of prawn and *Wallago attu* on trend1 were also observed. Thus trend 1 was representing the trend of hilsa. For trend 2, the

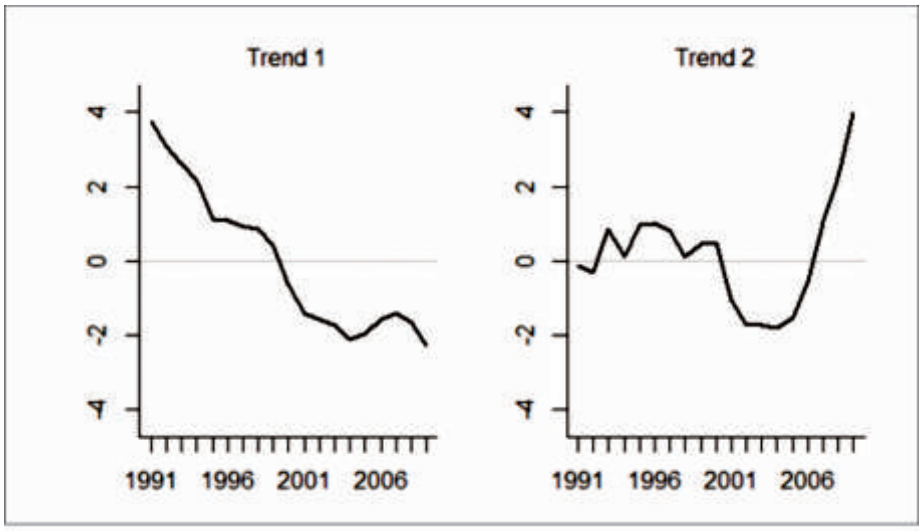


Fig. 62. Common trends in landings of five selected species in Narmada river estuary

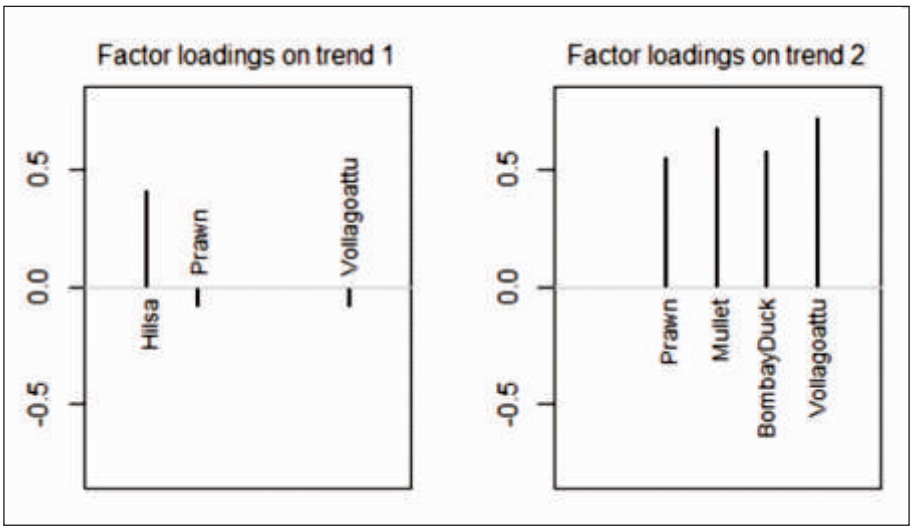


Fig. 63. Factor loadings of five selected fish species on trend 1 and trend 2 of river Narmada estuary system

factor loadings of prawn, mullet, *Wallago attu* and bombay duck had significantly positive contribution, while hilsa had negligible contribution. Hence, the trend 2 represented the common trend of four fish species prawn, mullet, *Wallago attu* and Bombay duck.

Influence of hydrological factors on fish catch pattern of River Narmada

Effects of hydrological variables, viz., monsoon sediment load at Gurudeshwar (gsm), monsoon flow at Gurudeshwar (gwm) and maximum observable flood at Bharuch (GRBF) on fish catch abundance in river Narmada were assessed by DFA modeling approach, considering two identified common trends and diagonal matrix of unequal variance. DFA models for all possible combinations of hydrological variables were compared to identify the best model. The results showed that the model for the explanatory variable i.e. a combination of three GRBF, gsm and gwm produces minimum AIC (=202.34). DFA models with two trends and three explanatory variables gave the better fit than the other combination of the explanatory variables. The separate effect of these three parameters on fish species showed that GRBF has significantly positive impact on hilsa catch and significantly negative influence on prawn, Bombay duck and *Wallago attu*. GRBF had negligible influence on the mullet. Monsoon sediment load at Gurudeshwar had significantly positive influence on hilsa and prawn and had insignificant influence on mullet, bombay duck and *Wallago attu*. Monsoon flow at Gurudeshwar had negative influence and prawn catch.

Table 7. Estimated regression parameters, standard errors and p values for the DFA model with two trends and three explanatory variables (GRBF, gsm and gwm)

Species catch vs hydrological variables	Estimate	SE	p-value
(Hilsa,GRBF)	0.40*	0.11	<0.05
(Prawn,GRBF)	-0.22*	0.14	<0.05
(Mullet,GRBF)	0.04	0.18	NS
(BombayDuck,GRBF)	-0.11*	0.20	<0.05
(*Wallago attu*,GRBF)	-0.23*	0.18	<0.05
(Hilsa,gsm)	0.77*	0.24	<0.05
(Prawn,gsm)	0.49*	0.32	<0.05
(Mullet,gsm)	-0.28	0.46	NS
(BombayDuck,gsm)	0.77	0.55	NS
(*Wallago attu*,gsm)	-0.70	0.47	NS
(Hilsa,gwm)	-0.44*	0.18	<0.05
(Prawn,gwm)	-0.59*	0.23	<0.05
(Mullet,gwm)	0.18	0.34	NS
(BombayDuck,gwm)	-0.10	0.40	NS
*5% level of significance, NS= Non significant at 5% level			

Note : gsm = monsoon sediment load at Gurudeshwar; gwm = monsoon flow at Gurudeshwar; GRBF = maximum observable flood at Bharuch

FISHERIES SOCIO-ECONOMICS

Programme: Economic valuation of inland fisheries resources in India

Programme Co-ordinator : Dr. Arun Pandit

Project (AES/ER/12/04/01) : Preparation of inventory of inland open-waters based on institutional arrangements and governance and mapping of fisher livelihood assets in inland open-waters

Project staff: Ganesh Chandra, Malay Naskar, S. K. Sahu, A. Roy, Anjana Ekka, D. K. Biswas and S. Majumdar

In Gujarat, ownership of reservoirs was found to be with Water Resources, Water Supply and Kalpasar Departments of the Government. The fisheries management rights were with the Departments of Fisheries. Revenue system of fisheries governance model was followed for distribution of fisheries management rights that were granted through open auction system to the highest bidder. In Chhattisgarh, lease of waterbody up to 20 ha was granted for five years to FFDA beneficiaries in non tribal area and above 200 ha to the highest bidder. In tribal area reservoir up to 20 ha was given on lease to individual tribal fishers, 20-1000 ha reservoir to tribal fisherman cooperative societies and above 1000 ha to federation of tribal fishers cooperative societies. Case studies for Ukai and Vallabh sagar reservoirs in Gujarat have been carried out to study institutional arrangements.

Institutional arrangements and fisheries governance in Gujarat

Fisheries in state of Gujarat is governed by the Gujarat Fisheries Act 2003, and the reservoir fishery is managed under the Gujarat Reservoir Fisheries Policy 2004. The administrative head of department of fisheries was Commissioner of Fisheries, under whom Deputy Commissioner, Deputy Director of fisheries, and Assistant Director/District Fisheries Officers work.

The ownership of water-bodies was with different departments of government. Major (more than 5,000 ha) and medium (1,000-5,000 ha) reservoirs were under the ownership of Water Resources Department except Sardar Sarovar reservoir which was under Sardar Sarovar Narmada Nigam Ltd. Stakeholders like State Departments of Revenue, Fisheries, Panchayat, Cooperative, Irrigation, Environment and Forest were involved in open water fisheries management. Others included Gujarat Tribal Cooperative Fisheries Federation and Fisheries Cooperative Societies. Local bodies, Fishers, end users and water users of the reservoirs were other stakeholders given as under.

Formation and transfer of fishing right

In Northern Gujarat and Saurashtra, the fishing right up to 200 ha water bodies was

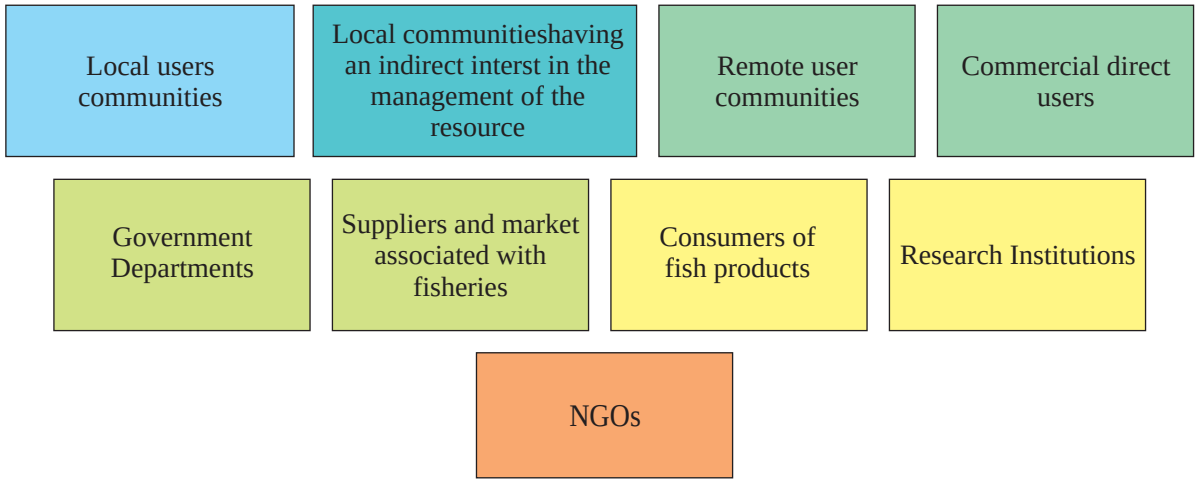


Fig. 64. Stake holders of openwater fisheries in Gujarat

granted only to the FFDA beneficiaries. While fishing rights of reservoirs above 200 ha were leased out through tendering to the highest bidder.

In south Gujarat especially in tribal areas, fishing rights up to 20 ha was given to individual tribal fishers, while fishing rights of 20-1000 ha water bodies was given to tribal fishers cooperative societies. In waterbodies above 1000 ha in tribal areas, the fishing rights were given to the federation of tribal fisheries cooperative societies. The authority of granting fishing rights up to 200 ha lies with the District Fisheries Officer, for water bodies having 200 - 1000 ha, the authority lies with regional fisheries officer/Deputy Director and for water bodies above 1000 ha, the authority lies with Commissioner of Fisheries.

Leasing system

The duration of lease was 5 years and could be extended up to a maximum period of 10 years. Mean water spread area of reservoir in last six years was considered for computing the effective water spread area of the reservoir and calculating upset price accordingly. The base price for lease fixation was being calculated on the water area discovered through this calculation.

Table 8. Area of reservoirs and lease amount

S. No.	Area of reservoir (ha)	Base Price (`)
1	Up to 20	480/ha
2.	21-200	9600 + 365/ha
3.	201-1000	75300 + 235/ha
4.	1001-5000	2,63,300 + 90/ha
5.	5000 and above	6, 23, 300 + 85/ha

Case studies of institutional arrangement in Vallabh Sagar Reservoir

Vallabh Sagar is the largest reservoir of Gujarat. It was constructed in the year 1972. It is located on River Tapti, 9 km from Songadh town within the geographical ordinates of 21°24'N and 73° 58'E. The total catchment area of the reservoir is 62,225 sq. km. 82% of the catchment area lies in Maharashtra, 15% in Madhya Pradesh and 3% in Gujarat. It has a gross storage capacity of 7,414 mcm and water spared area of 60,095 ha at FRL. The reservoir extends to 112 km in length and average width of 4.8 km. The average area of the reservoir as per the lease agreement (Dept. of Fisheries) is 32,000 ha. The dam's left bank canal feeds water to an area of 1,522 km^2, and its right canal provides water to 2,275 km^2 of land.

Ownership and stakeholders of the Reservoir

The ownership of this reservoir was with Narmada, Water Resources, Water Supply and Kalpasar Department, Government of Gujarat, and fisheries management lies under the department of fisheries, Government of Gujarat. Apart from Water Resource Department (WRD), the other stakeholders are Gujarat state electricity corporation limited (GSECL); Department of Fisheries, Gujarat; Dept. of Forest, Gujarat; Dept. of Revenue, Gujarat; local population etc.

Water distribution

The reservoir water was used for many purposes including irrigation, drinking water supply, generation of hydro power, water supply for industries etc. However, the first preference was given to irrigation for agriculture followed by drinking water, hydel power, and industrial use. Arround 3.8 lakh ha cultivable land was irrigated through water from this reservoir and 1000 mcm of drinking water was supplied to different human habitats in the vicinity including Surat City.

Fishing rights and legal provisions

In Sardar Vallabh Sagar reservoir, the institutional arrangement was based on fisheries cooperative governance system in which fishing lease was given to displaced tribals. This reservoir comes under the tribal sub plan area. Hence, system of fisheries management in this reservoir has been traditionally under the tribal cooperative governance system, an internal institutional structure model of distributed governance. As per the Gujarat Govt. leasing policy, fishing right of this reservoir has been given to the Tokarwa Vibhag Fisheries Cooperative Society at the rate of `10 lakh per annum since 2008. Under the tribal fisheries cooperative federation, 13 tribal cooperative societies with members do fishing in this reservoir. Fishing in the reservoirs was restricted only to the members of twelve tribal fishermen cooperative who were affected during the construction of the dam and reservoirs and whose house/land comes within area of impoundment. The lease amount has to be paid in three instalments in every year. The closed season of fisheries was observed from 10 June to 15 August every year.

Fishermen Cooperative Society

13 Tribal Cooperative Societies of Tapi and Narmada district were authorized for fishing in this reservoir. These fishers live in 118 fishermen villages in and around reservoir. These cooperative societies operated under *Ukai Asargrast Matsyodyog Vikas Sangh* (Tribal Cooperative Federation). Tribal fisheries cooperative governance system was operating in this reservoir. Each cooperative was being operated with executive committee of twelve members, who managed the operation of society. Each cooperative society stocked 253,000 fingerlings in the reservoir.

Socio-economics of fishers

The total fishermen population of the area was 44,932 persons out of whom 23,154 were male and 21,778 were female members. The total fisherman families were 9,722. The fishing operation was carried out by 14,956 active fishers who did fishing in the reservoir from the month of August to May. The numbers of crafts and gears were 2,327 and 35,584, respectively. 57 landing centres were located on this reservoir. But most of the catch was sold to the traders coming from Nandurbar, Maharashtra. Maximum active fishers were observed in the period from October to December while minimum active fishers were observed during March to May.

Fisher's livelihood asset mapping

A database has been developed on Microsoft access platform and 450 fishers' household data covering natural, physical, human, social and financial capital of fishers of four states of Bihar, Jharkhand, West Bengal and Uttar Pradesh of Ganga basin were populated on this database. The districts covered under this database were Varanasi in Uttar Pradesh; Saran, Siwan, Gopalganj, Mujaffarpur, Vaishali, Samastipur and Nawada in Bihar; Pakur in Jharkhand and North 24 Parganas, South 24 Parganas, Hooghli, Bardhman, Nadia and Murshidabad in West Bengal.

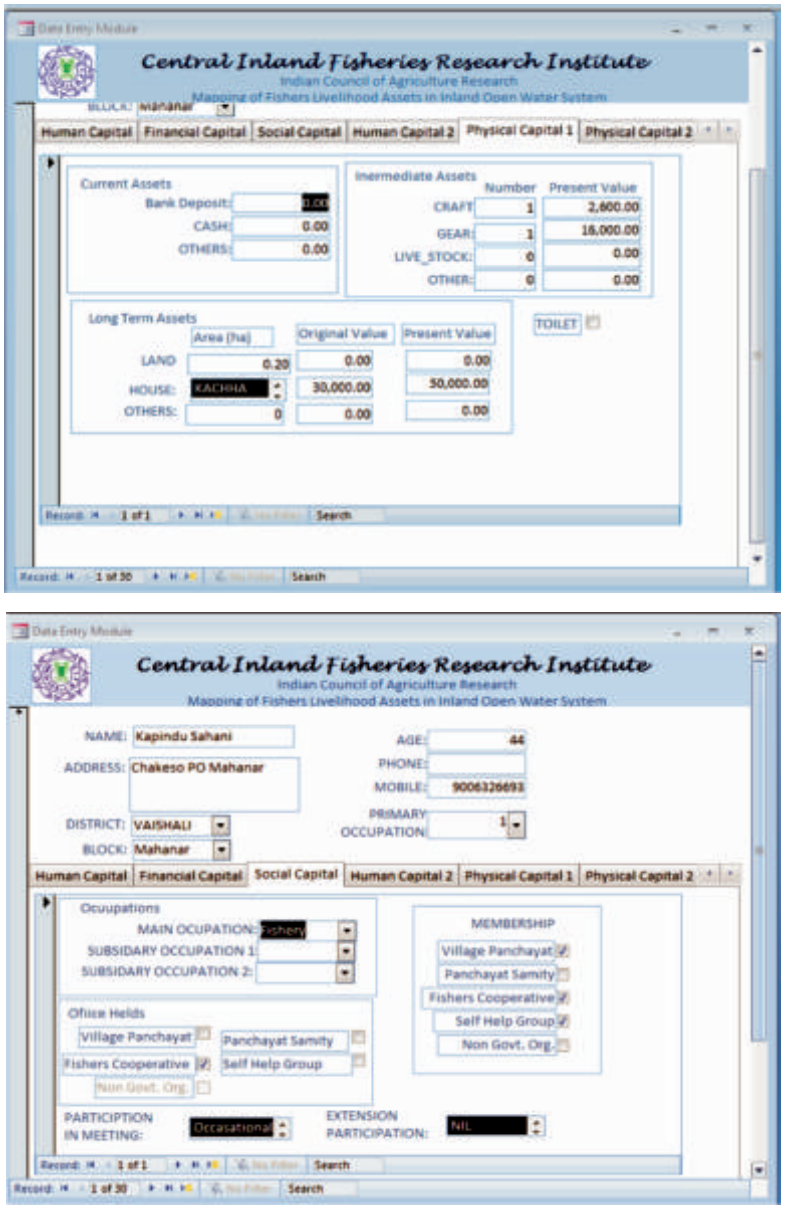


Fig. 65. Livelihood database in MS Access platform

Project (AES/ER/12/04/02) : Valuation of goods and services of inland open waters

Project staff : Arun Pandit, Anjana Ekka, Archana Sinha, Roshith C. M., D. K. Biswas and Lokenath Chakraborty

One of the major constraints towards appropriate policy and planning for development of fisher community is lack of information on their socio-economic conditions. Lack of data regarding their socio-economic condition is mainly due to lack of scientific study in this area. The present investigation aimed to collect and analyse information of fisher community of Chilika lagoon on demographic pattern, literacy, income status and their resourcefulness.

The total value of fish and shell fishes of Chilika lagoon was estimated to be around ` 235 crores per annum. Brackish water prawn contributed 36.5% in quantity term and 56% in value term. Nine major stakeholders were involved in governance system with each of them having specific activities and responsibilities in the lagoon. *Koibarta* was the predominant fishing caste among the fishers. Fishing was the primary occupation to around 73% of the households. The overall monthly income was estimated at around ` 9,600 of which 73% was contributed by fisheries. Around 7,500 fishing boats were operated in Chilika of which 40% were motorized. More than 70% of the fisher households were in debt, primarily through informal sectors. There has been fisher - non fisher conflicts since long, particularly after introduction of shrimp culture in 1984-85. Defined property rights, optimum dependence on wetlands, optimum exploitation and alternate income generating activities for fishermen may be helpful for sustainable management.

Economic value of the fish and shell fishes of Chilika lagoon

The analysis of secondary data regarding the catch of Chilika lagoon obtained from the Chilika Development Authority (CDA) and the primary data on price of fishes

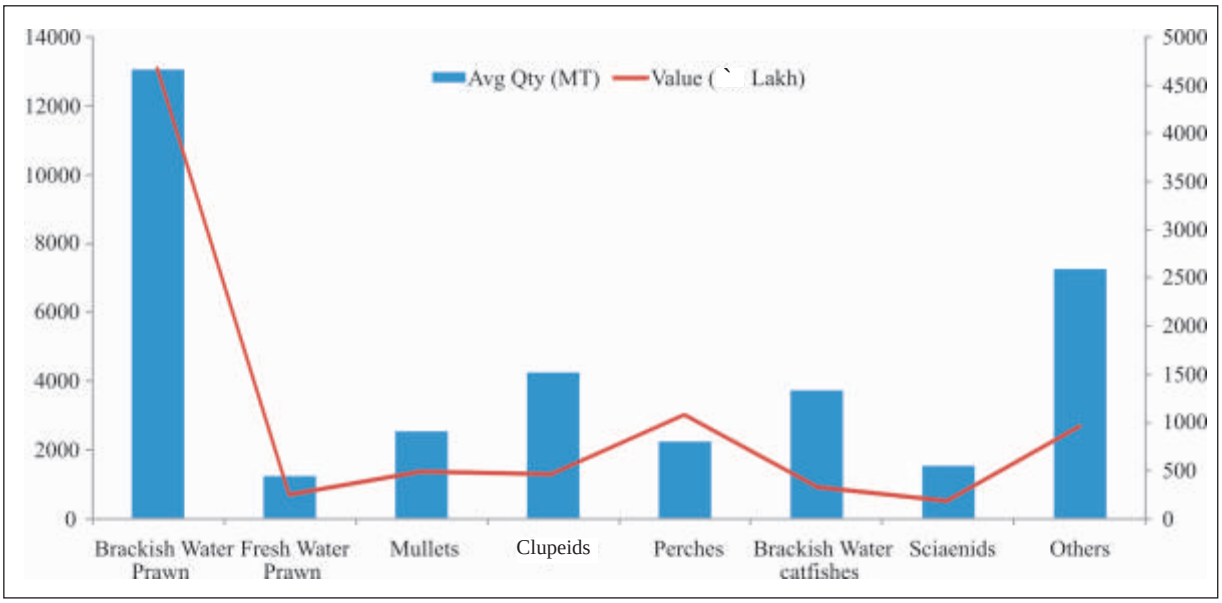


Fig. 66. Group-wise quantity and value of the fish and shell fishes of Chilika (2011-12 to 2015-16)

Data collection from fishermen

obtained by the survey revealed that the average catch of five years (2011-12 to 2015-16) were 12,781 metric tonnes and the total value of the catches came around ` 234.5 crores per annum. Brackish water prawn contributed 36.5% in terms of quantity and 56% in value followed by Clupeids and brackish water catfishes contributing around 12%, 5.5% and 10%, 4% respectively in terms of quantity and value.

Socio-economics and livelihood of the Chilika fishers

Primary data were collected during 2016-17 from 225 fishermen households across all the sectors, viz. northern, central, southern and outer channel to assess the socio-economic condition and livelihood at Chilika. In addition to this, the data were also collected from the Key informants (18) and Chilika Development Authority (CDA), Dept. of Fisheries, Odisha. The Institutional arrangement and governance system of the lagoon revealed that there were 9 major stakeholders viz. Dist. Collectors of Ganjam, Puri and Khordha; Revenue Dept.; Police; Task force at Dist. level; Asst. Register of Cooperative Society, Chilika Circle; DFO, Chilika Wildlife Division; Asst. Director of Fisheries, Balugaon; CDA and the Fishers. Each of the stakeholders has the specific activities and functions.

Socio-economic conditions

Analysis of socio-economic conditions revealed that *Koibarta* (also known as *Keuta* or *Khatia*) was the predominant fishing caste in the lagoon. *Kandara*, *Nolia*, *Tiara* were the other fishing castes found in the sampled fishermen. Although there was no clear cut demarcation of the fishing areas, a particular caste preferred to live and fish in a particular area. In few fishing villages more than one castes lived, however, harmony existed among different castes. There were 158 active PFCS operating in Chilika lagoon. Around 30% of fishers household possessed agricultural land in northern, central and southern sectors. The outer channel had least proportion of agricultural land holders.

Table 9. Socio-economic characteristics of Chilika fishers

Particular	Overall	Central	Northern	Southern	Outer Channel
Avg. age of respondent (yrs)	46.43	44.33	49.45	48.03	42.72
Year of schooling	5.00	5.70	3.88	6.22	4.43
Avg. family size	5.98	5.70	6.81	6.34	4.90
Literacy % (members above >6yrs)	77.43	78.99	75.44	81.10	75.00
% HH owned agri. land	25.58	30.30	31.67	31.25	15.52
Persons engaged in fisheries	1.62	1.64	1.78	1.59	1.48
Avg. income generating activities	1.77	1.48	1.67	2.00	1.79

Primary occupation

As per the 2011 census there were 23,115 fishermen households in and around the Chilika lagoon and the population was1.46 lakh. The survey revealed that the

fishing was the primary occupation in 73% of the households. Next predominant primary occupation was labour wage. Around 27% household took it as their primary occupation. Remittance from migration, agriculture farming petty business, Govt./Private service and fish vending/marketing were some of the other options of primary occupation.

Table 10. Primary occupation of the respondent household (% of the household)

Occupation options	Overall	Central	Northern	Southern	Outer Channel
Fishing	78.14	66.67	75	78.13	94.83
Auto rickshaw	1.86	3.03	0	4.69	0
Govt. service/pvt service	3.26	0	1.67	6.25	3.45
Labour	6.51	27.27	5	3.13	0
Remittance	5.58	0	15	3.13	1.72
Others*	3.74	6.06	4.69	1.56	1.72

*Others include fish marketing, business and crop farming

Monthly income

The overall monthly income from all sources was estimated around ` 9,600 across the sectors. Fishing in Chilika contributed around 73% of the total income. The analysis further showed that the income was significantly lower for fishing labour group who did not possessed any boats. The average monthly income for them was found to be around ` 7,900 which ranged from ` 6,067 in outer channel to around ` 8,900 in central sector. The monthly income of owners of motorized and non-motorized boats was found to be around ` 11,400 and ` 9,643, respectively. The higher income of motorized boat owners was not only due to higher catch but also due to their more resourcefulness. Sometimes they gave their surplus boat and nets on rent and earned extra income.

Table 11. Average household (HH) income (`) and livelihood support from fisheries

Sector	Non-motorized boat		Motorized boat		Fishing labour	
	Total	From Fishing (%)	Total	From Fishing (%)	Total	From Fishing (%)
Overall	9643	76	11360	73	7923	64
Central	9860	90	12071	69	8885	67
Northern	8891	72	11485	69	7735	66
Southern	9764	74	13073	73	8850	55
Outer Channel	10052	74	8750	83	6067	73

Livelihood analysis

Fishing in Chilika is done using a range of crafts and gears. Majority of the catch came from traditional *khonda* net and different types of gill nets. 63% of the fishers used *Khonda* followed by 29% *Dubi* and 20% *Menzia* (gill nets). The other nets used by the fishers were drag nets, sieve nets, long lines, scoop nets and cast nets. There are 7500 fishing boats. Around 65-70% of the fishermen households owned

boats across different sectors. Overall, among the boat possessors around 40% HHs possessed motorized boats. Many fishermen received Government help for purchasing fishing boats.

Table 12. Major fishing gears used by Chilika fishers (% of households)

Net	Overall	Northern	Central	Southern	Outer channel
Khonda	63.25	61.67	75.76	67.19	58.62
Dubi	29.30	18.33	27.27	37.5	31.03
Zero net	16.27	21.67	15.15	14.06	15.52
Menjia	19.53	16.67	18.18	20.31	18.97
Khepa	2.44	-	-	-	11
Patua/Vida	5.12	13.33	6.06	-	1.72
Dosti/Sahala	3.72	-	-	10.94	1.72

Table 13. Boat ownership of Chilika fishers (% households)

Sector	% HH owned boat	Among Boat ownership	
		% Motorized	% Non-motorized
Northern	71.67	46.51	53.48
Central	66.67	31.82	68.18
Southern	70.31	44.44	55.56
Outer channel	75.86	36.36	63.64
Overall	70.23	40.40	59.60

Changing livelihood strategies

Due to fishing pressure and other socio-ecological factors, the per head fish catch is decreasing. Subsequently, fishermen are finding alternative income sources to supplement their livelihood. Four types of livelihood strategies were adopted to cope with the decreasing income from fishing. Change in fishing methods was most commonly adopted as livelihood strategy which includes travelling long distances, catching all fishes. Earlier there were specific seasons for fishing based on availability of fish species. To maximize income from fish catch, fishermen were

Fisherman village in Southern Sector

Fishermen of outer channel

using mosquito net to catch everything that gets in fishing net. Migration and occupational diversification were other livelihood strategies adopted by fishermen to manage their household income. Long term and seasonal migration within state and outside state were common among fishers. Some of them have also adopted other occupations like labour, business and other related activities to fulfil their livelihood needs.

Defined property rights, optimum dependence on wetlands and use of other alternate income generating activities like eco-tourism should be encouraged for sustainable management of Chilika lagoon.

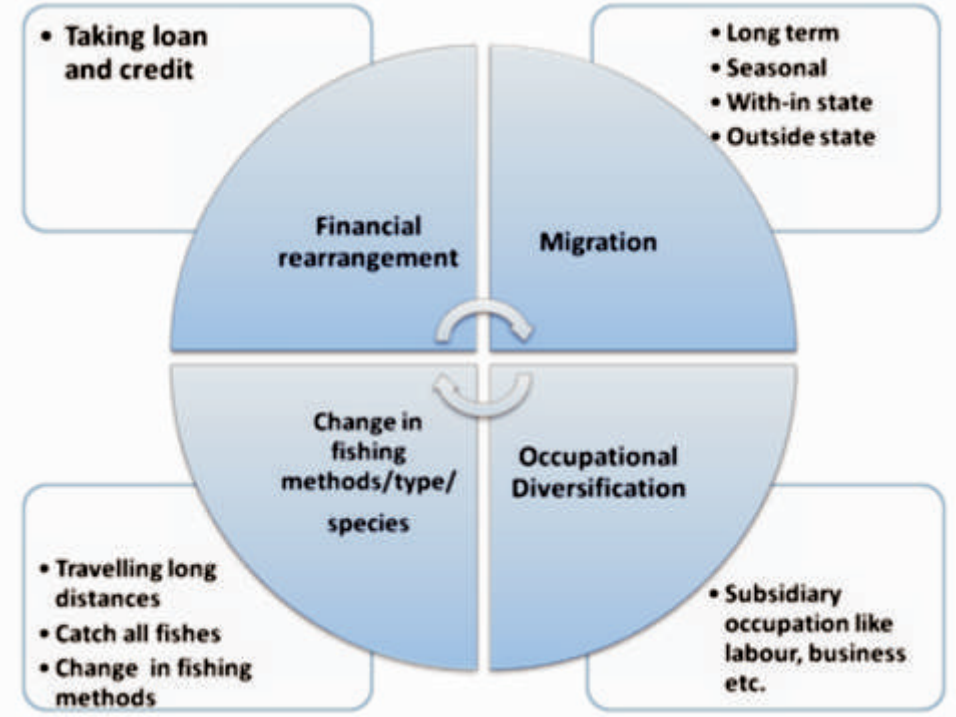


Fig. 67. Strategies adopted for livelihood

Socio-ecological factors affecting sustainable livelihood

Several socio-economic, ecological and institutional factors were identified affecting the sustainable livelihood of Chilika fishers. Among social factors, recognized caste based fishery has positive impact on livelihood. Involvement of non-fishers in fishing has negative impact, because most of the non-fishers have more money and power compared to traditional fishermen. This had led to occupational displacement and threatened livelihood of Chilika fishermen.

The cultural factors like religious importance of Chilika has positive impact on livelihood of fishermen as the seasonal fishing practices and communal fishing methods helps to maintain healthy lagoon system. The ecological factors like opening of mouth had a positive impact on fish production which in turn increased the income of Chilika fishers. Other ecological factor like weed infestation has negative impact on fish production. As siltation increases, weed infestation increases, decreasing the wetland productivity and in turn fish production from the

Fishermen of Central Sector

Balugaon fish landing centre

lagoon. The Chilika Leasing Policy of 1991 enforced by government of Odisha divided the whole fishery sources of the lake into capture and culture fisheries and allowed the non-fishermen of the locality to involve in 'shrimp culture' in the lake. This has resulted in major occupational threat to Chilika fisher's.

Table 14. Socio-ecological factors affecting sustainable livelihood of Chilika Lake

*Socio-ecological Key factors		Impact (+ve and –ve)
Social	Recognized caste based fishery (traditional)	+
	Involvement of non-fisher's in fishing	-
	Change in fishing practices (Use of zero size synthetic nets)	-
Cultural	Religious importance	+
	Fishing as a "way of life	+
	Sense of connection to the Chilika lagoon	+
Ecological	Weed Infestation	-
	Opening of mouth	+
Institutional	Creation of protected area	-
	Legalized prawn culture	-
	Change in leasing arrangement	-
	Formation of PFCS/FISHFED	-
	Local Fisher's Institution	+

*Based on discussion with key Informants & further validated by focused group discussion

Credit trap

The investigation revealed the limited presence of formal credit institutions. Moreover due to weak asset base fishermen were forced to take loans and advances from the middlemen (*Mahajan*). In turn the middlemen bought the entire catch at prices determined by the latter that were generally lower than the market prices. It has been found that more than 70% of the fisher households were in debt, primarily through informal sectors. The major purpose of the loan was to purchase fishing crafts and gears and sometimes for household purposes also.

Fish drying at outer channel, Chilika lagoon

OUTREACH PROJECTS

Project (OR/ER/08/09/01) : Carp culture in cages and pens using feed (Outreach - 1)

Project staff : M. A. Hassan, Md. Aftabuddin, Mishal P., D. K. Meena, Bablu Naskar, Y. Ali

The growth of Jayanti rohu as well as normal rohu was better in cages with feed installed in lotic environment as compared to lentic environment. In lotic water Jayanti rohu grew more than 2.2 times faster than normal rohu while in lentic water it grew only 1.7 times higher than normal rohu. Jayanti rohu exhibited better utilization and retention efficiencies as reflected by FCR, PER and ANPU. Lipid accumulation was more (6% higher) in lentic water compared to lotic water in Jayanti rohu while the same was 9% higher in case of normal rohu. All the species performed better in 5m cages compared to 10 and 20m cages. More lipid accumulation and protein accretion (fat free basis) took place in 5m cages corroborating with the high growth rate.

Performance of feed in cages in response to environment and domestication process in *Labeo rohita*

Commercially growing table size Indian major carp in reservoir cages is a big challenge because of their reduced growth performance compared to their counterparts growing in ponds or in natural waters. Formulated balanced feed failed to invoke normal growth of carp species in cages at par with growth obtained in pond farming. Among probable factors, deprivation of natural environment and associated food materials both dead and living may deter natural growth process of this fish group in cages. Considering the natural habitat of this fish group in flowing river, confinement in cages might have caused stress affecting their natural growth process. Other factor may be the absence of domestication process in this fish group that could have oriented these organisms to such changed environment favouring their normal growth process. In order to understand the role of these factors on the growth, feed efficiency and proximate composition, an experiment was conducted, involving major carp species, *Labeo rohita*, both domesticated (selective breeding) breed and normal breed, in flowing and stagnant water environment.

Over-wintered seed of selective breed rohu, *L. rohita* called Jayanti rohu with average weight 8.05g and normal breed rohu with average weight 31.3g were stocked in cages in 2x2 randomised blocks installed in lotic environment (1m/min) in a river channel near Balagarh, Hooghly and in lentic environment at Maithon reservoir in 2x2 randomised blocks. Stocking density maintained was 2 fish/m^3. Fishes were fed a iso-nitrogenous (C.P. :28. 4%) compact pellet of 3 hrs stability at 5% of fish biomass twice daily in feeding trays. Fish health and growth was

monitored at monthly intervals. Feed and flesh quality was assessed following standard methods of AOAC 1998.

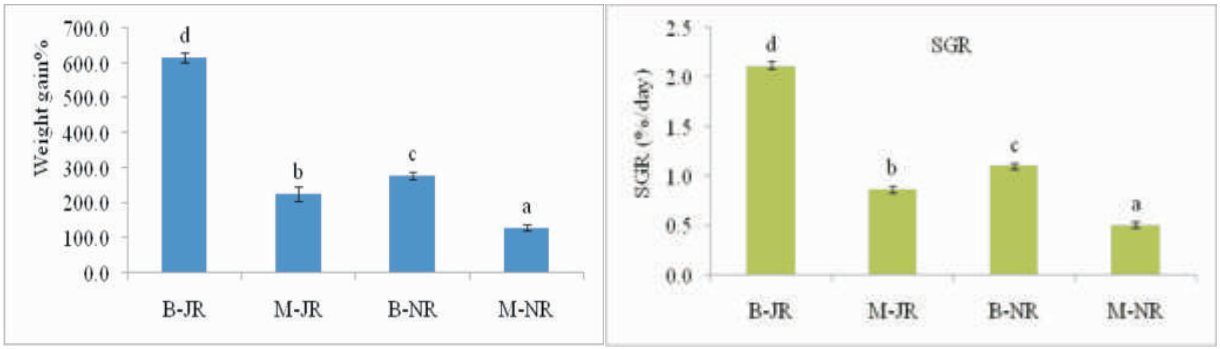
The growth of Jayanti rohu (% weight gain) was 2.7 times higher in cages installed in lotic environment flowing water compared to stagnant water after 90 days of feeding trial. The growth (% weight gain) of normal rohu was 2.15 times higher in flowing water as compared to stagnant water. In lotic water Jayanti rohu grew more than 2.2 times faster than normal rohu. In lentic water Jayanti rohu grew only 1.7 times higher than normal rohu.

FCR, PER and ANPU found better in fishes reared in lotic water. Jayanti rohu exibited better utilization and retention efficiencies. The proximate biochemical analysis of flesh revealed more lipid accumulation in stagnant water (6% higher compared to flowing water) in Jayanti rohu. In case of normal rohu lipid accumulation was 9% higher in stagnant water.

The results vividly indicated the role of environment and domestication process on the growth performance, conversion efficiency and flesh quality of carps in cage farming.

Growth performance of carp fingerlings in different dimensions of cages in polyculture system using sinking pellet

Cage farming of fishes in reservoirs revealed that growth performance of various species under the category of Indian major carps, is affected after certain growth stages, compared to their counterpart growing in pond or any natural environment despite being fed nutritionally formulated diet. In conventional pond farming of these carps the area of rearing spaces gradually increases with the progress of fish size and age besides encouraging growth of natural food. In contrast, such increments in rearing spaces are not provided in cage farming of these species in reservoirs that are mostly oligotrophic or mesotrophic may cause stress or deterrence in terms of deprivation of natural food and living space. To understand the role of rearing spaces a trial was conducted in Maithon reservoir involving carps in cages with provision for incremental living space created by changing cage dimensions.



Note : B = Balagarh (Lotic) ; JR= Jayanti Rohu; M = Mython (Lentic); NR = Normal Rohu

Fig. 68.Weight gain % and SGR of selective breed and normal breed of *L. rohita* fed with experimental diet in lentic and lotic environment

Hatchery bred fingerling of three species of Indian major carp, viz., *Catla catla, L. rohita* and *Cirrhinus mrigala* and cross breed of catla and rohu were stocked in 62.5, 125 and 250m^3 cages having dimension of 5m x 5m x 3m ; 10m x 5m x 3m and 20m x 5m x 3m. The initial weight of the fingerlings were 4.1g, 6.5g, 3.95g and 3.78g for catla, rohu, mrigal and rohu:catla cross breed, respectively at 5 fish/m^3 stocking density. The growth trial was conducted in 3x2 randomised design. Fishes were fed formulated iso-nitrogenous (34.83 % C.P.) compact diet twice daily at the rate of 4% of fish biomass split into three trays provided at different heights of water columns. Fish health and growth was monitored at monthly intervals. Feed and flesh quality was assessed following standard methods of AOAC 1998.

During 90 days of growth trial, significant difference (p<0.05) was observed in live weight gain (%) among the species tested in different dimensions of cages; catla performed best (1695%) and least by rohu. There was no significant difference in weight gain between rohu:catla cross-bred (280%) and mrigal (261%). Among the different dimensions of cages, all the species performed better growth in 5m cages compared to 10m and 20m cages. There were no significant difference in growth between 10 and 20 m cages.

Feed conversion ratio (2.1) was better (p<0.05) in 5 m cages compared to FCR 3.2 and 3.5 in 10m and 20m cages respectively. Flesh quality analysis revealed more lipid accumulation and protein accretion (fat free basis) in 5m cages corroborating with the high growth rate. It may be concluded from the present study that 5m x 5m x 3m cage is ideal for rearing fingerling to produce advanced fingerling in cages.

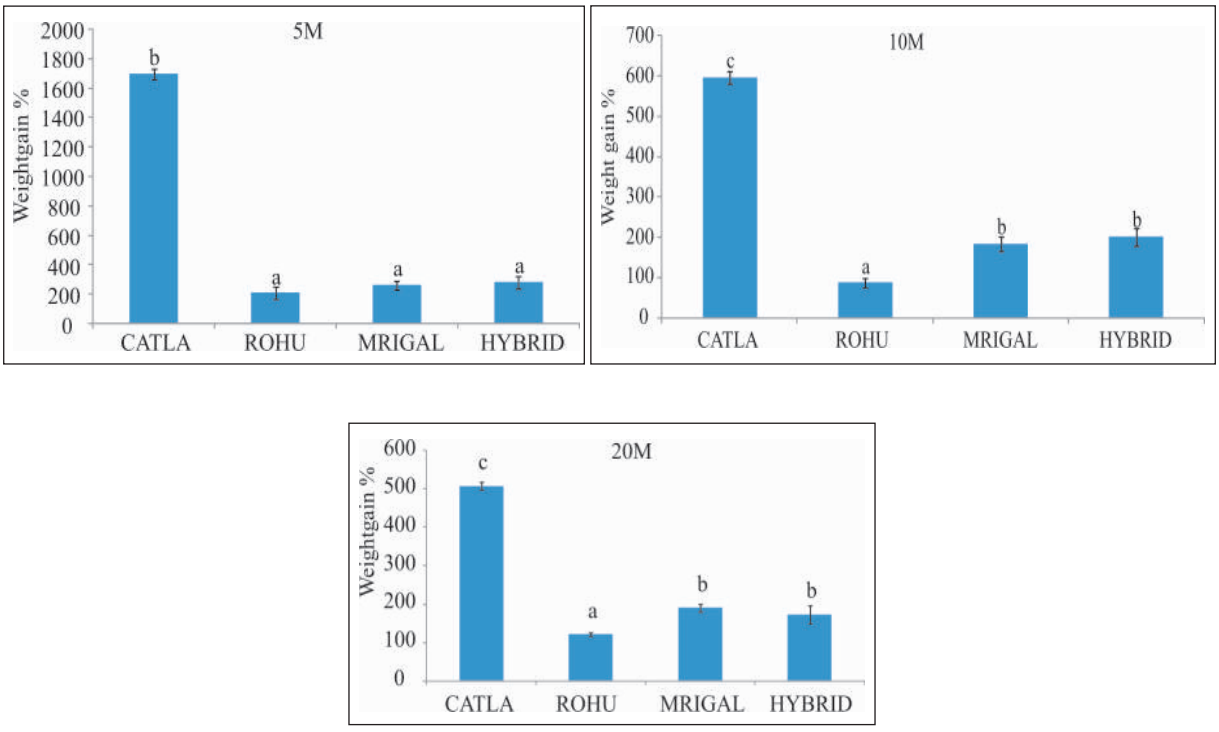


Fig. 69. Weight gain % of different species of major carp in different dimension of cages

Project (OR/ER/08/09/02) : Fish genetic stocks (Outreach - 2)

Project staff : B. K. Behera, D. K. Meena, P. Das, D. Bhakta, Kavita Kumari, P. K. Parida, Dipak Biswas, Asim Kumar Jana and A. Kakati

Labeo gonius is a lower risk Near Threatened (NT) species as per IUCN red list, distributed throughout the North Indian major rivers, reservoirs and lakes. This species has a larger scope as an alternative candidate species in carp aquaculture system.The present study explains the population structure and genetic diversity of medium carp *Labeo gonius* by analyzing partial sequence of mitochondrial DNA cytochrome b gene.

Labeo gonius haplotypes of Narmada river is genetically different from other haplotypes of river Ganga, Mahanadi and Brahamputra

The population genetic studies of *Labeo gonius* (Hamilton, 1822) using mitochondrial DNA Cytochrome b gene in Indian rivers

In the present investigation, 223 individuals of *Labeo gonius* were collected from five locations of phylogeographically isolated riverine ecosystems of India resulted in 12 haplotypes. These haplotypes showed 14 variables, out of which 9 were singletons and 5 were parsimony informative sites of nucleotide positions. The haplotypes H1 was considered as ancestral haplotype. All the haplotypes were connected to each other by 1–4 nucleotide mutations. The Narmada haplotypes (H10; H11 and H12) were isolated from H1 by four nucleotide mutations. The analyses resulted maximum expansion events (τ = 4.13672) in Narmada, with Fst scores more than other population pairs. The analysis of molecular variance

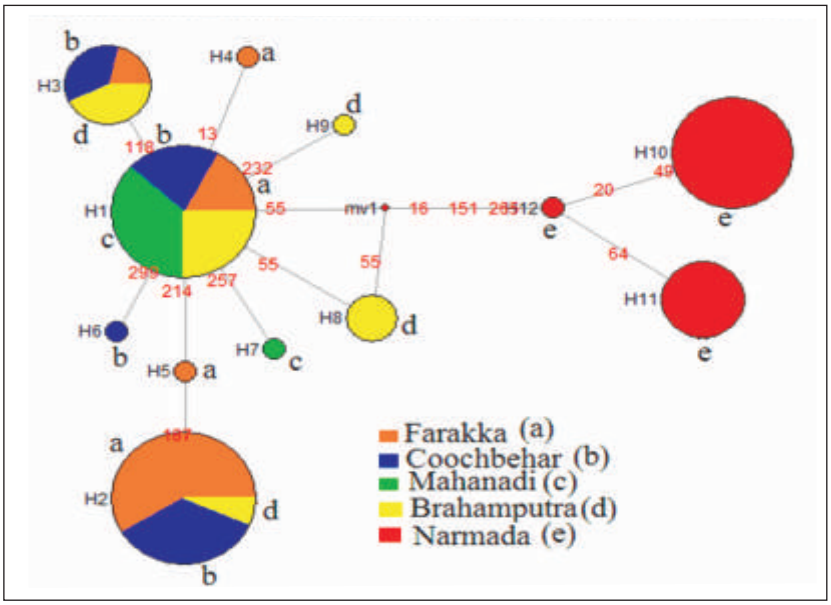


Fig. 70. The median-joining network based on 12 haplotypes of the mitochondrial Cyt b representing 223 *L. gonius* individuals (position of nucleotide mutation in red colour)

(AMOVA) showed significant genetic differentiation among populations (ØST= 0.69470, p<.000). The genetic differentiation patterns were significantly consistence with geographical distributions. This study rejected the null hypothesis of single panmictic population of medium carp, *Labeo gonius* in Indian water.

Project (OR/ER/08/09/03) : Nutrient profiling and evaluation of fish as a dietary component (Outreach - 3)

Project staff : B. P. Mohanty, A. Sinha, D. Karunakaran, D. Debnath, R. K. Raman, T. Abdulla, P. K. Parida, Sona Yengkokpam, Prajna R. Behera, Sanjay Bhaumick, Sk. Rabiul, S. K. Paul and Asim Jana

Fish is a healthy food, rich in quality animal proteins, polyunsaturated fatty acids especially the ω-3 eicosapentaenoic acid and docosahexaenoic acid and micronutrients. However, fish represents a large biodiversity with varieties of species which varies in their nutritional composition. Thus, it is necessary to generate nutritional information on different fish species for their utilization in achieving nutritional security and for prioritizing species for aquaculture. Efforts have been made under this project to generate and compile nutritional information on important Indian food fishes from India.

Data on proximate composition including DHA and EPA content, fatty acid and micronutrient profile of important food fishes from India have been generated. *Polynemus paradiseus, Ompok bimaculatus, Channa striatus, Channa punctatus* are lean fishes containing high amount of protein and low fat content. *Tenualosa ilisha, Sardinella longiceps, Nemipterus japonicus* and *Anabas testudineus* are rich sources of DHA and EPA which have immense utility in public health nutrition. Marine fishes are rich in sodium and potassium; small indigenous fishes (SIFs) in calcium, iron, and manganese; coldwater fishes in selenium; and the brackishwater fishes in phosphorous.

Homepage of Database *NutriFishIn* on 'Nutritional composition of food fishes from India' (http://www.cifri.res.in/nutrifishin/index.php)

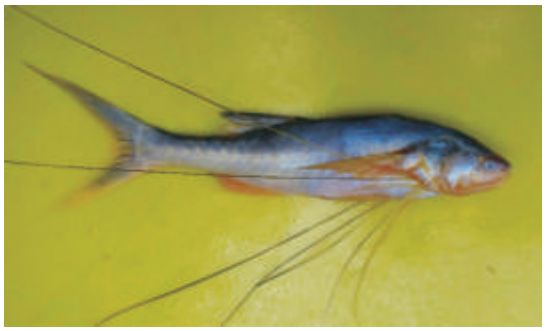
Proximate composition

Proximate composition of *Ompok bimaculatus, Polynemus paradiseus, Channa striatus, Chana punctatus* was carried out. These fishes were found to be lean fishes containing high amount of protein and low fat content. Amino acid composition analysis of *Liza parsia, Chitala chitala, Johnius coitor, Ompok bimaculatus, Channa striatus, Channa punctatus, Macrognathus pancalus* has been carried out. Fatty acid composition analysis of *Polynemus paradiseus, Liza parsia, Chitala chitala, Johnius coitor, Ompok bimaculatus, Channa striatus, Channa punctatus, Chitala chitala, Macrognathus pancalus* has been carried out

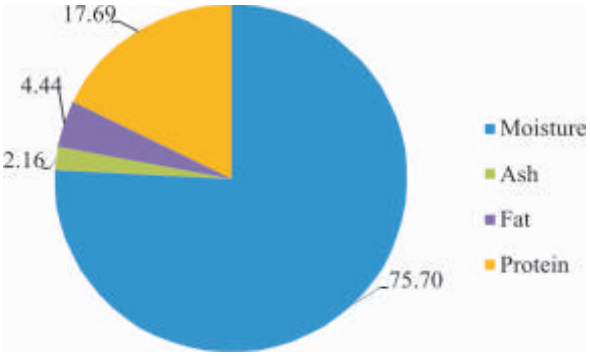
In this context, the database *NutriFishIn* "Nutritional Composition of Food Fishes from India" is being regularly updated with additional data on the nutrient composition of food fishes.

DHA, EPA and Fatty acid composition of important food fishes

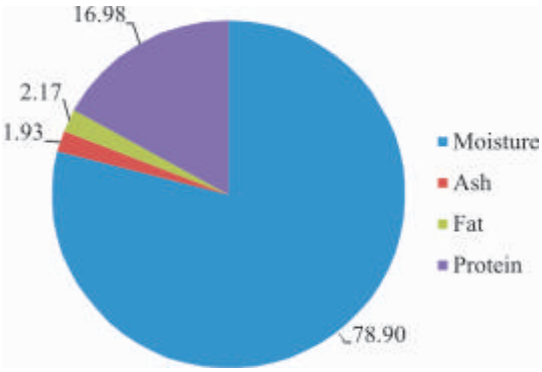
DHA, EPA content and fatty acid profile of important food fishes from India have been generated. The crude fat content showed that among the species studied, the migratory fish *T. ilisha* contains the highest amount of fat (10.5%) followed by the marine fish *S. longiceps* (9.2%). The fish species studied have been further



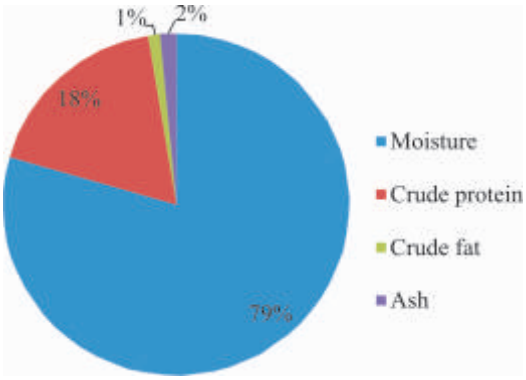
Polynemus paradiseus



Ompok bimaculatus



Channa striatus



Channa punctatus

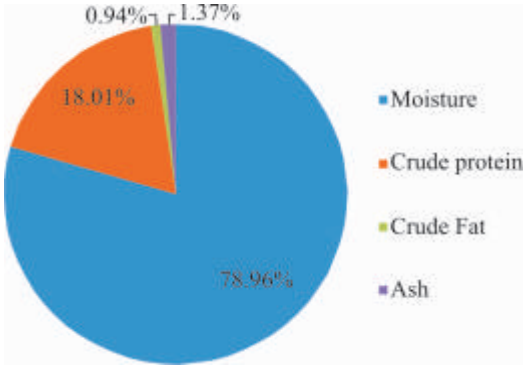


Fig. 70. Proximate composition of important food fishes

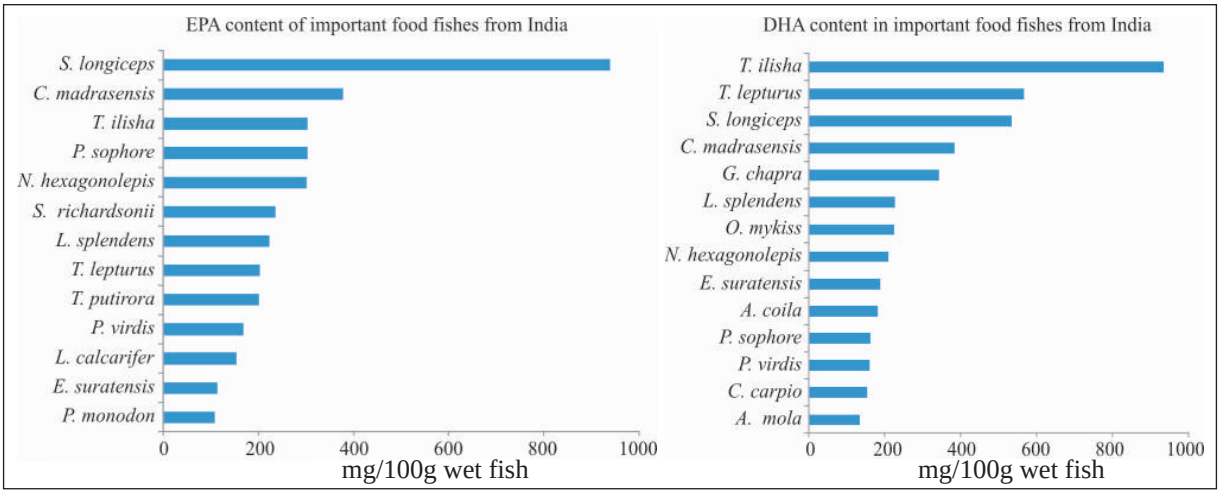


Fig. 71. EPA and DHA content of important food fishes from India

categorized into different groups such as lean fish, low fat, medium fat and high fat according to the fat content. *T. ilisha* was found to contain the highest amount of DHA followed by *T. lepturus*. Similarly, EPA content was highest in *S. longiceps* followed by *C. madrasensis*. Among the cold water fishes *N. hexagonolepis*, *O. mykiss*, were rich in DHA while *S. richardsonii* and *N. hexagonolepis* were rich in EPA. Among SIFs, *G. chapra*, was found to be rich in DHA and *P. sophore* in EPA. The study showed that fishes *Tenualosa ilisha*, *Sardinella longiceps*, *Nemipterus japonicus* and *Anabas testudineus* are the top species which are rich sources of DHA and EPA which have immense utility in public health nutrition.

Table 15. Classification of 39 Indian food fish species based on fat content

Classification	Samples
Lean meat (<2% fat)	*Euthynnus affinis, Ailia coila, Perna virdis, Rastrelliger kanagurta, Rita rita, Katsuwonus pelamis, Stolephorus commersonii, Stolephorus waitei, Epinephelus* spp , *Sperata seenghala, Fenneropenaeus indicus, Penaeus monodon, Xenentodon cancila, Thunnus albacares*
Low fat fish (2-4% fat)	*Leiognathus splendens, Oncorhynchus mykiss, Clarius batrachus, Trichiurus lepturus, Mugil cephalus, Neolissochilus hexagonolepsis, Cyprinus carpio, Catla catla, Cirrhinus mrigala, Crassostrea madrasensis, Heteropneustes fossilis, Labeo rohita, Lates calcarifer, Schizothorax richardsonii, Harpodon nehereus*
Medium fat fish (4-8% fat)	*Anabas testudineus, Gudusia chapra, Nemipterus japonicas Puntius sophore, Etroplus suratensis, Macrobrachium rosenbergii, Amblypharyngodon mola, Tor putitora*
High fat fish (> 8%)	*Tenualosa ilisha, Sardinella longiceps*

Micronutrient composition of important food fishes

Fishes rich in micronutrients would be useful in eradicating the micronutrient deficiency diseases prevalent in the developing countries. The micronutrient composition of important food fishes from India has been generated from varying

Table 16. Fish rich in specific minerals and fat soluble vitamins

Micronutrients	Species rich in particular micronutrient
Macro mineral	
Sodium	*Perna viridis, Nemipterus japonicas, Stolephorus commersoni*
Potassium	*Rastralliger kanagurta, Stolephorus commersoni, Perna viridis*
Calcium	*Xenentodon cancila, Gudusia chapra, Ailia coila, Puntius sophore, Amblypharyngodon mola*
Magnesium	*Xenentodon cancila, Gudusia chapra, Ailia coila*
Phosphorous	*Xenentodon cancila, Clarias batrachus, Epinephelus* spp
Micro mineral	
Iron	*Gudusia chapra, Amblypharyngodon mola, Puntius sophore*
Copper	*Thunnus albacores, Xenentodon cancila*
Zinc	*Stolephorus waiti, Xenentodon cancila, Stolephorus commersoni*
Manganese	*Gudisia chapra, Crassostrea madrasensis, Xenentodon cancila*
Selenium	*Neolissochilus hexagonolepsis, Labeo rohita, Clarias batrachus*
Fat soluble vitamins	
Vitamin A	*Amblypharyngodon mola, Epinephelus* spp, *Sardinella longiceps*
Vitamin D	*Amblypharyngodon mola, Puntius sophore, Epinephelus* spp
Vitamin E	*Epinephelus* spp, *Sardinella longiceps, Tenualosa ilisha*
Vitamin K	*Amblypharyngodon mola, Puntius sophore, Epinephelus* spp

aquatic habitats and fish species rich in specific minerals and vitamins have been prescribed. In general, the marine fishes were found to be rich in sodium and potassium; small indigenous fishes (SIFs) in calcium, iron, and manganese; coldwater fishes in selenium; and the brackishwater fishes in phosphorous. The marine fishes *Sardinella longiceps* and *Epinephelus* spp. and the SIFs were rich in all fat-soluble vitamins.

Freshness and spoilage markers in *Tenualosa ilisha* detected by static headspace GC/MS

Hilsa is a commercially important food fish and is known for its unique flavor and culinary properties. The volatile compounds present in the fish is an important factor responsible for the flavor. Hilsa is transported for import/export purpose in

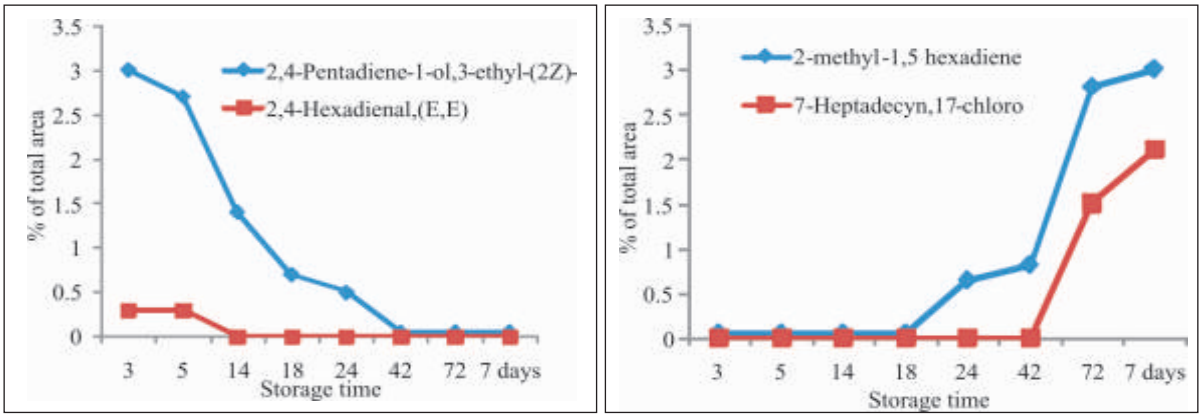


Fig. 72. Changes in volatiles compounds present in *hilsa* during different storage times assessed by static headspace GC/MS which may be considered as freshness indicators (a) and spoilage indicators (b)

large scale in ice packaging, especially in South East Asian countries; therefore, there is a need to access the quality of frozen fish during ice storage, both freshness and spoilage. Static headspace GC-MS combined with a statistical multivariate approach could be a useful method to identify volatile compounds and characterize fish freshness and spoilage. Static headspace gas chromatography mass spectrometry was used to investigate the volatiles in hilsa and volatolome profile was generated. 2,4-Pentadiene-1-ol, 3-ethyl-(2Z), and 2,4-hexadienal were identified as possible freshness indicators and 7-Heptadecyne-17- chloro and 2-methyl-1, 5 hexadiene as possible spoilage indicators which could be useful in assessing the quality of the fish.

Hilsa - rich in DHA

ACTIVITIES UNDER NEH

Project Staff : B. K. Bhattacharjya, S. Yengkokpam, D. Debnath, A. K. Yadav, P. Das, N. Sharma, Simanku Borah, N. Samarendra Singh, K. K. Sarma, B. C. Ray and A. Kakati

Fish stock enhancement in beel through supplementary stocking of Indian Major Carps

Supplementary stocking was carried out based on Indian major carps in Sorbhog beel (closed, spread area 34 ha), Barpeta district of Assam in collaboration with AFDC Ltd., Guwahati. Fingerlings of *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala* were stocked @ 3,000 nos./ha on 10.10.15. Sampling of fish to assess their growth and monitoring of water quality was performed every 3 months. Final sampling was carried out after 15 months of stocking. Catla attained the highest growth with specific growth rate (SGR) of 1.34, followed by rohu (SGR 1.3) and mrigal (SGR 0.99).

Table 17. Growth performance of fish stocked in Sorbhog beel, Assam

Fish species	Initial length (cm)	Initial weight (g)	Final length (cm)	Final weight (g)	Weight gain %	SGR
C. catla	15.52 ± 0.36	43.34 ± 3.75	32.33 ± 0.76	485.67 ± 41.50	1020.61	1.34
L. rohita	13.68 ± 0.20	26.21 ± 1.23	28.54 ± 0.53	272.9 ± 17.51	941.21	1.30
C. mrigala	15.80 ± 0.30	34.77 ± 1.92	27.04 ± 0.84	204.97 ± 24.61	489.59	0.99

The water quality parameters in the beel was characterized by favorable conditions for fish production i.e., pH (7.8-8.39), DO (7.6-8.6 mg/l), alkalinity (42-46 mg/l), free CO_2 (3-4 mg/l), TDS (78-80 ppm), conductivity (157-160 µS/cm), transparency (22-32 cm) and chlorophyll (127-197 µg/l).

Harvested fish samples of Sarbhog beel

Awarness camp at Sorbhog beel, Assam

In-situ raising of stunted carp fingerings in pen enclosures for stock enhancement in seasonally open beel

Pen aquaculture experiment was undertaken in a moderate-sized (20 ha) seasonally open Mer beel, Nagaon district of Assam to produce stunted carp fingerlings. Four big-sized (2500 m^2 each) rectangular pens were constructed using net-lined split-bamboo screens and installed in marginal areas of the beel during August. The pens were stocked with six species of carps (4 indigenous and 2 exotic) @ 5 nos. /m^2 and reared for 5 months. The pens were prepared following the technology developed by ICAR-CIFRI. Stocked fishes were initially fed with supplementary feed @ 3% of body weight, which was gradually reduced to 0.5% for adapting them for releasing to the beel. Important water quality parameters monitored were within the favorable range for growth and survival barring water temperature in the winter months (December - January). After 5 months of rearing, the highest specific growth rate was observed in mrigal (1.45) followed by gonius (1.14), grass carp (1.11), rohu (0.86), catla (0.86), whereas silver carp recorded the lowest SGR (0.70). The average weight of the stunted fingerlings was 150.9g with 86% survival. Stunted carp fingerlings raised in the pens were released to the beel proper for stock enhancement @ 2000 nos./ ha towards partial restocking of the beel following the first major part-harvest in the beel during January. The benefit-cost ratio was 1.92, showing that *in-situ* raising of stunted fingerlings of carps in pen enclosures is economically viable.

Pen Cultrure in Mer Beel

EXTERNALLY FUNDED PROJECTS

Project: Assessment of spawning behaviour of major fish species in inland environment with a view to harness the beneficial effects of temperature

under National Innovations on Climate Resilient Agriculture (NICRA)

Project staff: U. K. Sarkar, D. S. K. Rao, K. D. Joshi, B. K. Bhattacharjya, S. K. Nag, M. Naskar, M. Aftabuddin, Arun Pandit, P. Panikkar, A. K. Sahoo, D. Sudheesan, S. Das, A. K. Yadav, D. Debnath, G. Karnatak, Vaishakh G. and Sibina S. Mol

The impact studies of enhanced temperature and precipitation regime in inland open water fisheries were carried out for predicting spawning and reproductive traits of targeted fishes under changing climatic scenario. The potential of primary carbon capture and ultimate carbon accumulation in the sediments of different types of wetlands in West Bengal and Assam was determined. The changes in chlorophyll-a concentration of lower stretch of River Ganga was assessed and was predicted to increase by +0.17 ppm over the next three decades (2015-2045), under enhanced thermal and reduced precipitation regime. The impact of climate change and climate induced threats on wetland fisheries were studied using stakeholder driven approach and effective mitigation strategies suggested.

Reproductive plasticity of an amphidromous croaker *Johnius coitor* (Hamilton, 1822) in River Ganga under changing climate

Johnius coitor (Coitor croaker), locally known as '*kota bhola*' / '*bhola-bhetki*' in Bengali, is an amphidromous fish species belonging to the family Sciaenidae under order Perciformes which are popularly known as jew fish, croakers or drums. A study was conducted in the lower stretch of River Ganga for identifying the climatic preference for breeding and assessing the likely impacts of changing climate on reproduction. Information on various aspects of breeding was generated employing various models.

Johnius coitor

The species showed high spatial variation in reproductive phenology and capable of breeding during pre-monsoon, monsoon, post-monsoon and winter season. Water temperature is the most crucial environmental parameter influencing gonadal maturation and breeding. Models revealed water temperature near 23-25 °C and threshold GSI >3 units were necessary for breeding. Pre-spawning fitness (Fulton's condition factor) and size at 50% maturity, benchmarked through models, were in the range of 1.27-1.37 units and 19-24.5 cm respectively. First maturity of female was encountered at 11.4 cm within the size range 7.2-28.5 cm. Mapping of climate preferenda hinted water temperatures <20 °C and >32 °C to be detrimental for attainment of pre-spawning fitness while no dependence of the species on rainfall was observed. In general, the species seem to have high reproductive plasticity and based on the climato-hydrological influence on breeding and regional trends of changing climate along River Ganga, we infer minimal climate driven changes in breeding phenology of this amphidromous fish species.

Benchmarking pre-spawning fitness, climate preference of catfishes from river Ganga

The threshold condition factor (Fulton) beyond which ≥50% of the female population may attain readiness for spawning coined as *pre-spawning fitness* ($K_{spawn50}$) have been generated for female *Mystus tengara* (1.13-1.21 units), *M. cavasius* (0.846-0.945 units) and *Eutropiichthys vacha* (0.716-0.799 units) with binary coded Kaplan-Meier Survival fit estimates in R. Information on the range of egg parameters (fecundity, egg weight, egg diameter) expected at the pre-spawning stage was also generated. Additional information on species-specific thermal and precipitation window (*climate preferendum*) within which $K_{spawn50}$ is attained was also generated through LOESS fit in R. Water temperatures between 31-36 °C (*M. tengara*), 30-32 °C (*M. cavasius*) and 29.5-31 °C (*E. vacha*) and monthly rainfall between 200-325 mm (*M. tengara*), >250 mm (*M. cavasius*) and around 50 mm, between 350-850 mm (*E. vacha*) was found to be optimum for attainment of $K_{spawn50}$.

Climato-hydrological influence on breeding phenology of selected catfishes and modeling species response to climate change

The change in breeding phenology of the catfish species in relation to climate change has been analyzed and predicted in river Ganga basin using GAM model, though role of other factors like change in habitat, genetic variation etc. to be further considered. The study showed that changes in rainfall pattern may have the most profound effect on gonadal maturation and breeding of *M. tengara* and *M. cavasius* in River Ganga followed by the effect of air temperature rise manifested into

Mystus tengara

increased water temperature. Indication of region-specific adaptation of fishes was noticed in reproductive phenology of *Eutropiichthys vacha* based on local trends of warming climate along River Ganga. Among the habitat parameters studied water temperature, DO, alkalinity, nitrate and phosphate were found to be important in influencing gonadal maturity and spawning. The preliminary conclusion can be drawn that climate change has the potential to bring region specific changes in breeding phenology of fish species in Ganga river basin. Under a warming climate, changes in precipitation pattern manifested into riverine flow pulse may be the key driver in dictating breeding phenology. The cascading effect of changing climate on the important habitat parameters influencing breeding also needs to be studied. The study indicates *E. vacha* as a climate sensitive species that may be selected as a model for climate change impact studies and to formulate conservation plans.

Role of climatic and environmental parameters in gonadal maturation and spawning behaviour of spotted snakehead, *Channa punctata* in a tropical floodplain wetland

An attempt was made to identify the important climato-hydrological variables capable of influencing seasonality in gonadal maturation of spotted murrel *Channa punctata*, to predict threshold values of Gonado Somatic Index (GSI) in females for successful breeding and favorable range of identified climato-hydrological parameters having maximum influence on gonadal maturation. Among the climato-hydrological variables studied, rainfall was found to have the most profound effect on gonadal maturation and breeding in *C. punctata*. Based on model predictions, a threshold monthly rainfall of >350 mm was found to be necessary for attainment of threshold GSI (≥4.15 units) for breeding in the species in addition to mildly alkaline waters (>110 mgL^{-1}). An overall warming trend with reduction in total rainfall has been observed in the study area. Interestingly, the study indicated no significant climate driven change on breeding phenology of spotted snakeheads in a tropical floodplain wetlands suggesting it to be a potential climate resilient species.

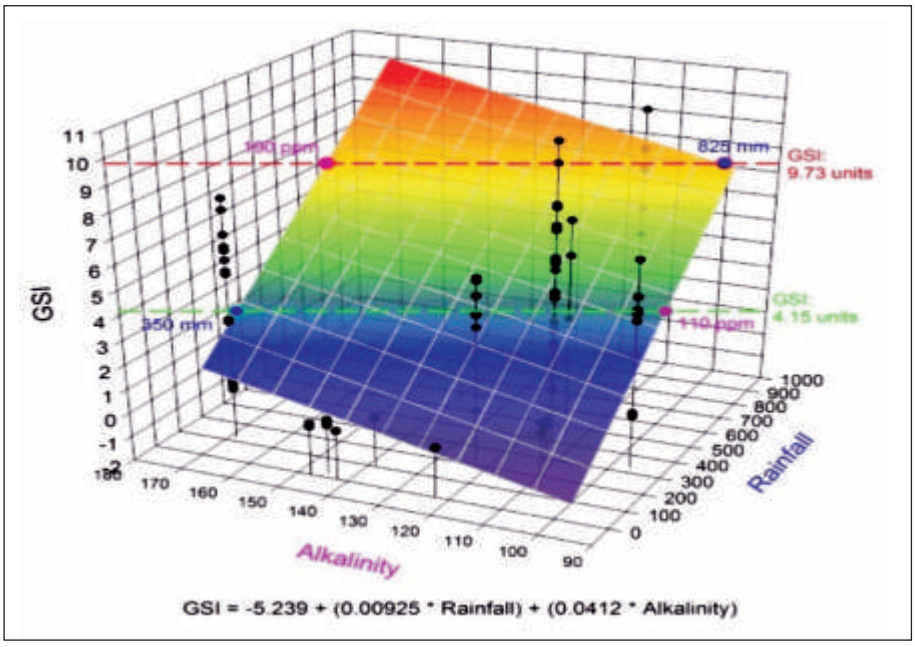


Fig. 73. Influence of climato-hydrology on gonadosomatic index of fishes

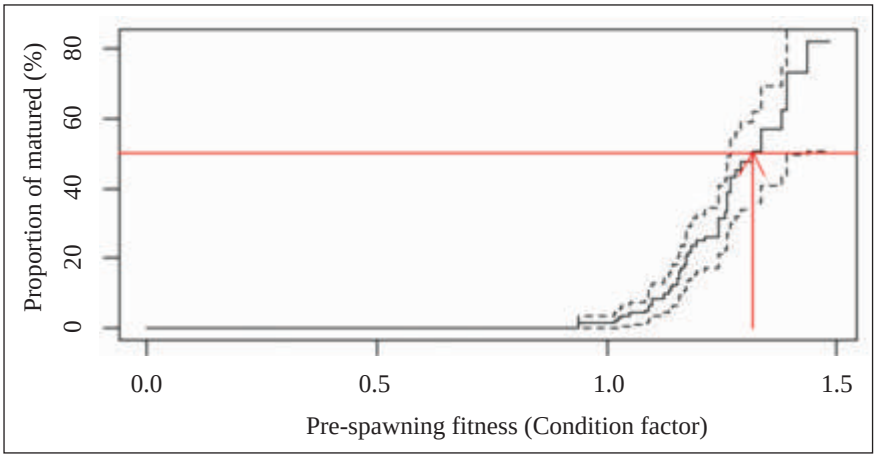


Fig. 74. Pre-spawning fitness of spotted snakehead *Channa punctata*

Benchmarking pre-spawning fitness and climate preference of spotted snakehead *Channa punctata* from Gangetic wetland

Pre-spawning fitness ($K_{spawn50}$) and length at 50% maturity (L_{M50}) have been generated for female *Channa punctata* with binary coded Kaplan-Meier Survival fit estimates in R. Information on the range of egg parameters (fecundity, egg weight, egg diameter) expected at the pre-spawning stage was also generated. Species-specific thermal and precipitation window (*climate preferendum*) for attainment of Pre-spawning fitness was identified through LOESS fit in R. Results revealed monthly rainfall around 100 mm and >500 mm to be optimum while the dependence on water temperature was weak. Pre-spawning fitness and size at 50% maturity were in the range 1.27-1.44 units and 20.3-21.8 cm, respectively. First maturity of females was encountered at 12 cm within the size range 9.7-32.1 cm. Egg parameters in mature-ripe females ranged between 0.73-0.83 mm (diameter), 0.78-0.95 mg (weight) and 3010-9005 eggs (absolute fecundity).

Shifting of spawning season in target fish species in selected stretches of Cauvery River

Studies on *Mastacembelus armatus* by different workers have indicated temperature as a primary environmental cue that regulates gonadal recrudescence and spawning. In the earlier studies conducted during 2001-2002, the breeding season was during April to July which further advanced to June - September in 2009-10. This trend continued during 2014-16 in the present study. The shift in spawning season could be attributed to increase in duration of high temperature regime in this region.

In *Mystus cavasius*, fully developed and ripe eggs were encountered during June-July. The breeding season synchronized with the onset of monsoon. In the earlier studies conducted during 1961-71, the breeding season was during August to September which further prolonged from July - September in 2006-07. This trend continued during 2015-16 which could be attributed to increase in duration of high temperature regime and change in rainfall pattern.

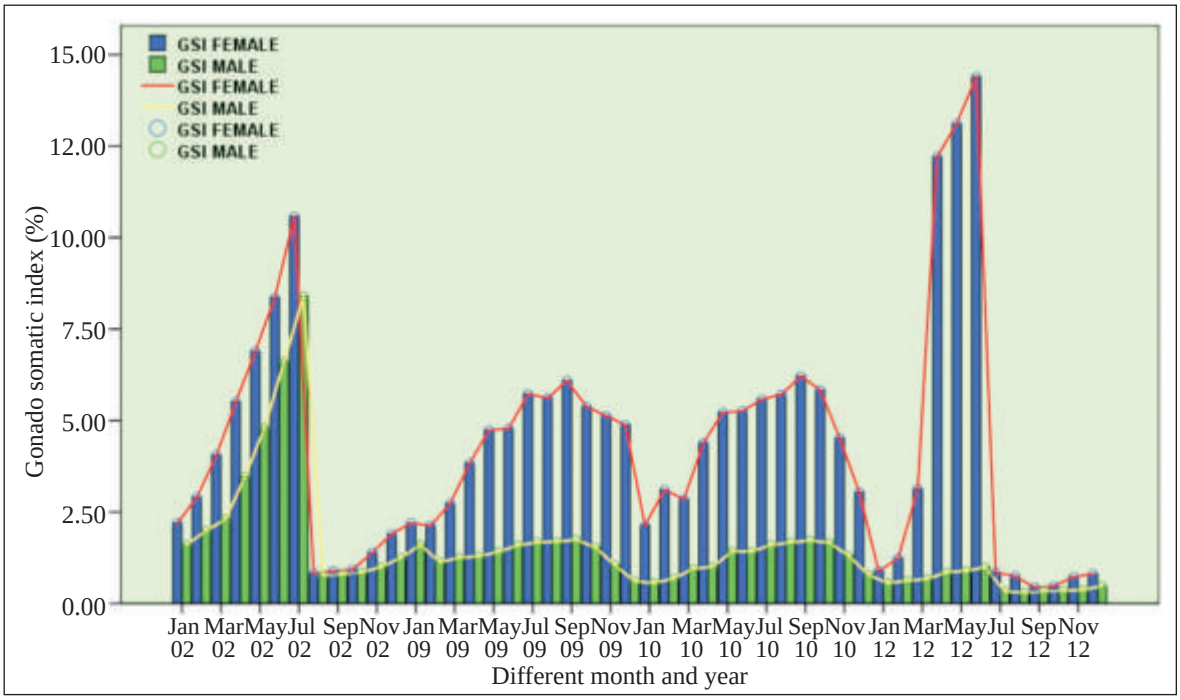


Fig. 75. Monthly variations of gonadosomatic index of *Mastacembelus armatus*

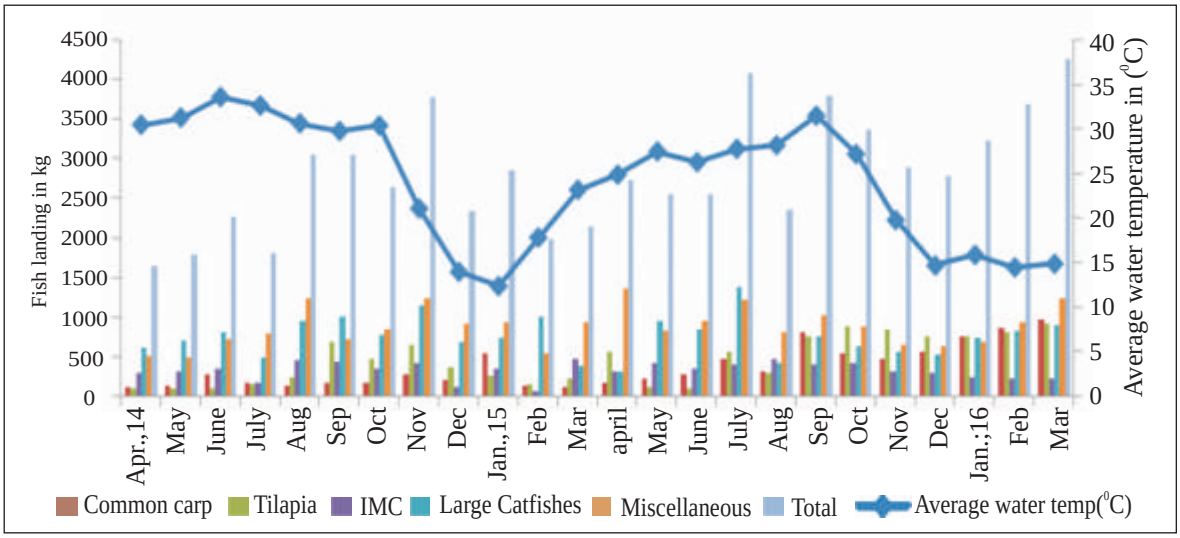


Fig. 76. Estimation of fish catch in Ganga at Allahabad

During April 2014 to March 2016 total of 67,542.9 kg of fishes were landed at Mehdauri fish market of the Ganga River at Allahabad. Overall, highest percentage was contributed by the miscellaneous groups 21,218 kg (31.4%) followed by the exotic fishes 20,030.2 kg (29.643%). IMC and large cat fishes shared 8,003.7 kg (11.85%) and 18,290.7 kg (27.07%), respectively in the total landing. The annual trend of fish catch when collated with the annual average water temperature existing in the river revealed that maximum fish catch is obtained in warmer waters

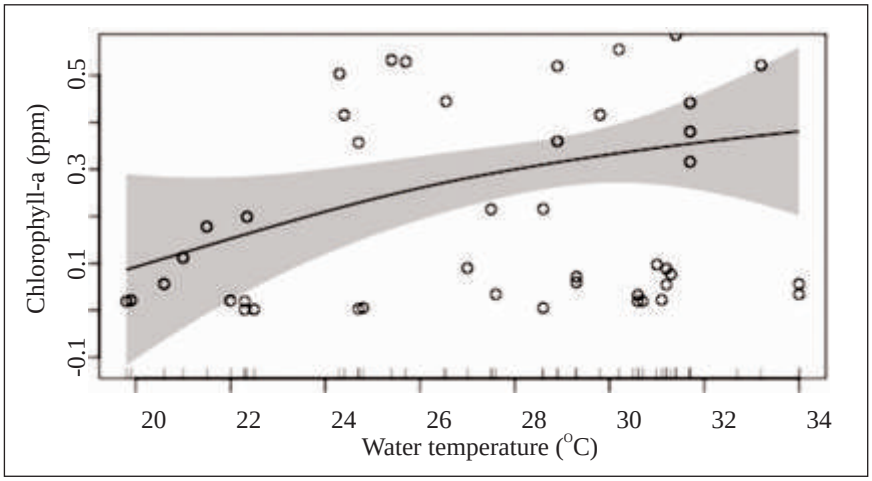


Fig. 77. Influence of water temperature on concentration of Chlorophyll-a

beyond 30°C while minimal catch is obtained at water temperatures around 15 °C reduced fishing efforts during winter is also one of the factors.

Climato-limnological influence on chlorophyll-a concentration in lower stretch of River Ganga

The present study attempted to examine changes in algal abundance in River Ganga under regional trends of changing climate and assessed the most influential limnological parameters on riverine chlorophyll concentration, quantified cascading effect of changing climatic variables on these parameters and budgeted changes in chlorophyll-a concentration expected. Only five limnological parameters were found to be the key factors among which water temperature was most important and had positive influence on chlorophyll-a concentration. Our model hints towards a gradual increase in the existing mean chlorophyll-a concentration (0.28 ppm) by approximately +0.17 ppm in the lower stretch of River Ganga that may probably occur over the next three decades.

Carbon sequestration potential of East Kolkata Wetland – a case study on climate change perspective

East Kolkata wetlands, a Ramsar site, covering an area of 12,500 ha came into existence almost 240 years ago. It is the world's largest sewage fed aquaculture system. Composite fish culture is adopted in the wetland comprising of species like Indian Major Carps, common carp, *Labeo bata* and Tilapia. The present investigation was conducted over a period of three years in one of the units of East Kolkata wetlands having 45 ha area. The rate of C accumulation in the wetland estimated through C budget taking into account input and output through different sources was found to be around 115 kg/ha/yr. Total C deposited in sediment up to 15cm depth was 29.37 Mg/ha, quite higher than the C deposited up to 15cm depth of reference upland soil which was measured at 23.79 Mg/ha. Thus the wetland is not only used for aquaculture but also rendering great ecological service since it has the potential to accumulate C from the atmosphere and sequester it in its sediments.

Carbon accumulation in (Mg/ha) of different wetlands

Experiments were conducted to find out potential of primary C capture and ultimate C accumulation in the sediments of different types of wetlands in West Bengal

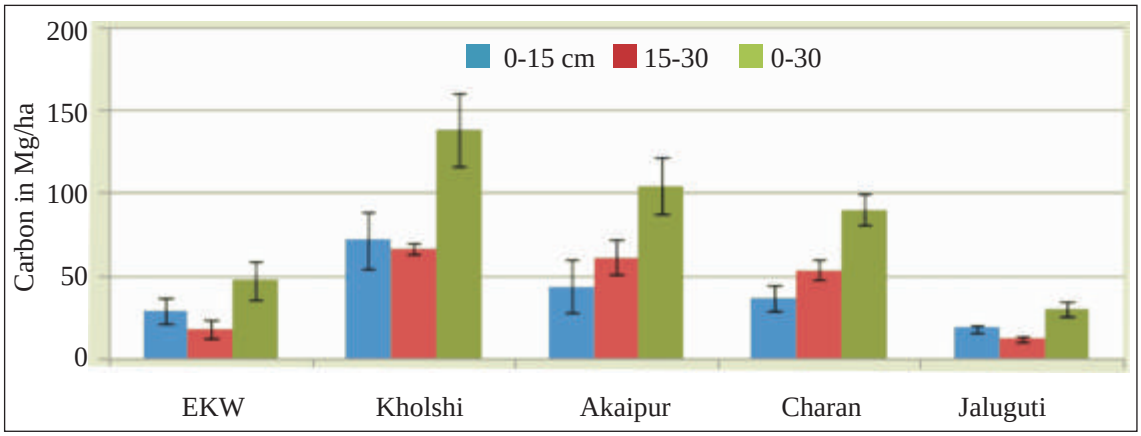


Fig. 78. Assessment of Carbon sequestration potential of freshwater wetlands

(Jhagrasisa, Kholshi and Akaipur wetlands) and Assam (Charan and Jaluguti wetlands). Biomass accumulation of the primary producers in the system is an important aspect of temporary C sequestration. Primary production from phytoplanktons and macrophytes of the studied wetlands were observed. The net primary planktonic productivity (NPP) of Jhagrasisa was much higher (778 mgC/m^3/hr) than that of Kholshi (191.6 mgC/m^3/hr) and Akaipur (450 mgC/m^3/hr). NPP of Charan and Jaluguti beels of Assam was even lesser, measuring at 150 and 175 mgC/m^3/hr. If the amount of C stored in up to 30cm sediments of the wetlands was compared, highest (138.82 Mg/ha) was in Kholshi followed by Akaipur (104.99 Mg/ha) while in East Kolkata wetland the figure was quite less (47.41 Mg/ha). Among the two beels of Assam, Charan had higher accumulation of C (90.55 Mg/ha) than Jaluguti (30.29 Mg/ha). Thus no definite correlation between C stored in sediments and the primary C capture in the studied wetlands could be obtained. This was because of many other factors coming into play like presence of macrophytes, application of organic matter and feed for aquaculture; dissolved and particulate organic matter inflow; loss of C through gas emission, harvest of vegetation, fish and other biological substances from the wetland; contributing significantly towards net C accumulation in sediments which was actually the balance between the input and the output. The rate of C accumulation in the wetland estimated through C budget taking into account input and output through different sources was found to be around 120 kg/ha/yr. Overall, the rate of C accumulation in the floodplain wetlands of West Bengal and Assam was estimated to be >0.1 Mg/ha/yr which is almost double of the global estimates given for large lakes and inland seas. Total C deposited in wetland sediment was quite higher than the carbon deposited in terrestrial upland soils.

Quantifying climate change induced threats to wetland fisheries: A stakeholder driven approach

The study presents a stakeholder driven approach to quantify the impacts of climate change on wetland fisheries. A modified Delphi Method was applied to accomplish this. It was revealed that water stress (95% consensus), wetland accretion / sedimentation (85%), aquatic weed proliferation (70%), loss of wetland connectivity (65% consensus) need to be tackled immediately on high priority. These issues are also expected to further exaggerate with passing of time in future climate scenario. Increasing the depth of wetlands through de-silting programs may be an effective mitigation strategy to ameliorate most of these issues.

Economic vulnerability of the fishermen households of floodplain wetland

In India fishermen communities, in general and inland fishermen in particular, are one of the most marginalized and vulnerable group of people with extreme poverty and very low economic base. The study was conducted to investigate the economic vulnerability of the fishermen households of two beels (floodplain wetlands) of west Bengal (Kholshi and Akaipur) and one wetland of Assam (Deepor) taking a sample of 185 fishermen households. By employing the methodology developed by Bene (2009) it was found that the average vulnerability scores were 0.21, 0.14 and 0.33 for Kholshi, Akaipur and Deepor beel, respectively on a scale of 0 to 1. The study showed that in flood plain wetlands, agricultural holding has negative impact on economic vulnerability of the fishermen households. The study suggests the Government to facilitate the creation of supplementary income generating opportunities and integrated agricultural activities in the vicinity of the wetlands. The eco-tourism may also be developed in beels like Deepor where potential exists with suitable infrastructure. Fishermen may get supplementary employment in this sector.

Project : Strengthening database and Geographical Information System of the fisheries sector

Project staff : V. R. Suresh (upto 29.07.16), B. K. Das, Malay Naskar, K. D. Joshi, B. K. Bhattacharya, M. Karthikeyan, S. K. Sahu, D. N. Jha and Mishal. P.

The activities of the project include enumeration of fishery resources, conducting sample survey to estimate their potential in fish production. Along with this catch assessment survey following the methodology developed in ICAR-CIFRI is also conducted through this project. Development of Geographical Information System of the Fisheries Sector is another work being done through this project.

Water body delineation

Data were collected through ground survey for water bodies above 50 ha in the North 24 Parganas of West Bengal. During the survey 27 water bodies with a water spread area of 330 ha were surveyed. Water body delineation for pre and post monsoon seasons was taken up for Assam, followed by Andhra Pradesh, Telangana and Arunachal Pradesh.

Water resources and fish catch were estimated and categorized in 23 districts of Uttar Pradesh. Data collection and village demarcation have been completed for 7 districts viz., Allahabad, Mahoba, Srawasti, Mathura, Varanasi, Chitrakoot and Kannauj.

Estimation of water resources

A total of 23 districts of Uttar Pradesh were selected randomly for the study. Water resources and fish catch were estimated and categorized in group I, II and III. Work for Group I (up to 10 ha) water bodies of U.P. has been initiated in first phase. Data collection and village demarcation have been completed for 7 districts viz., Allahabad, Mahoba, Srawasti, Mathura, Varanasi, Chitrakoot and Kannauj.

Dam and Reservoir map was completed during this period. Socio-economic data

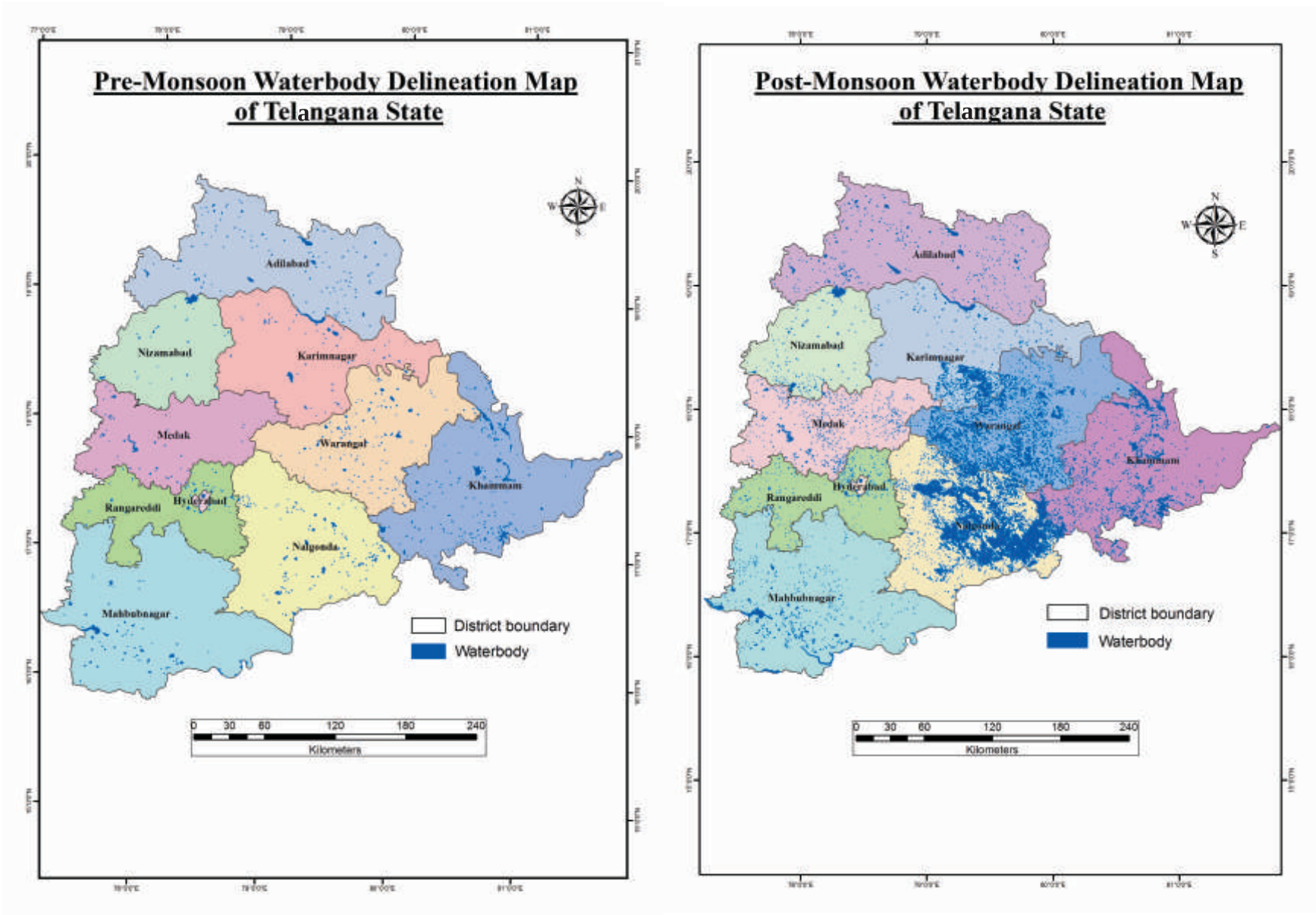


Fig. 79. Waterbody delineation map of Telangana State

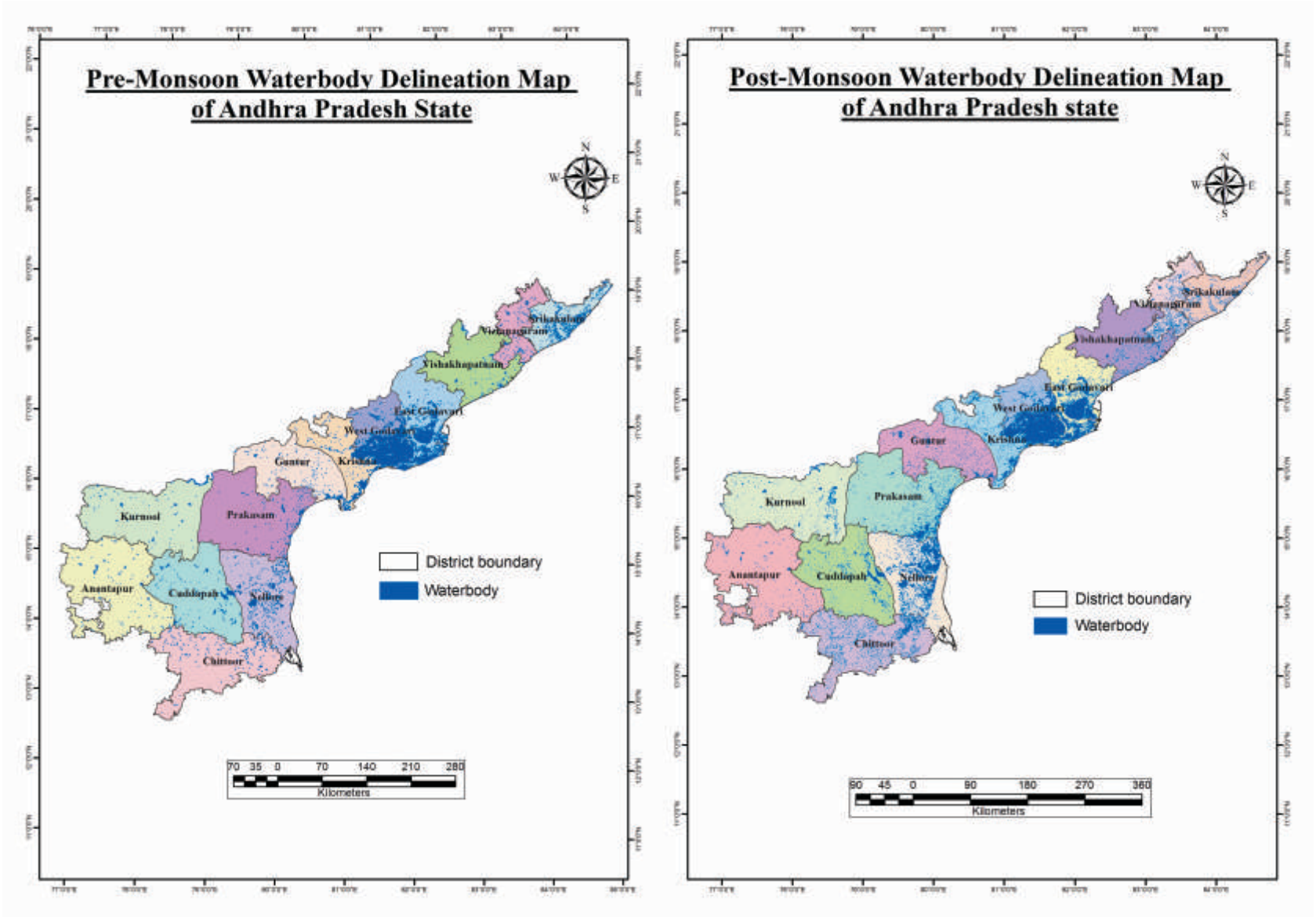
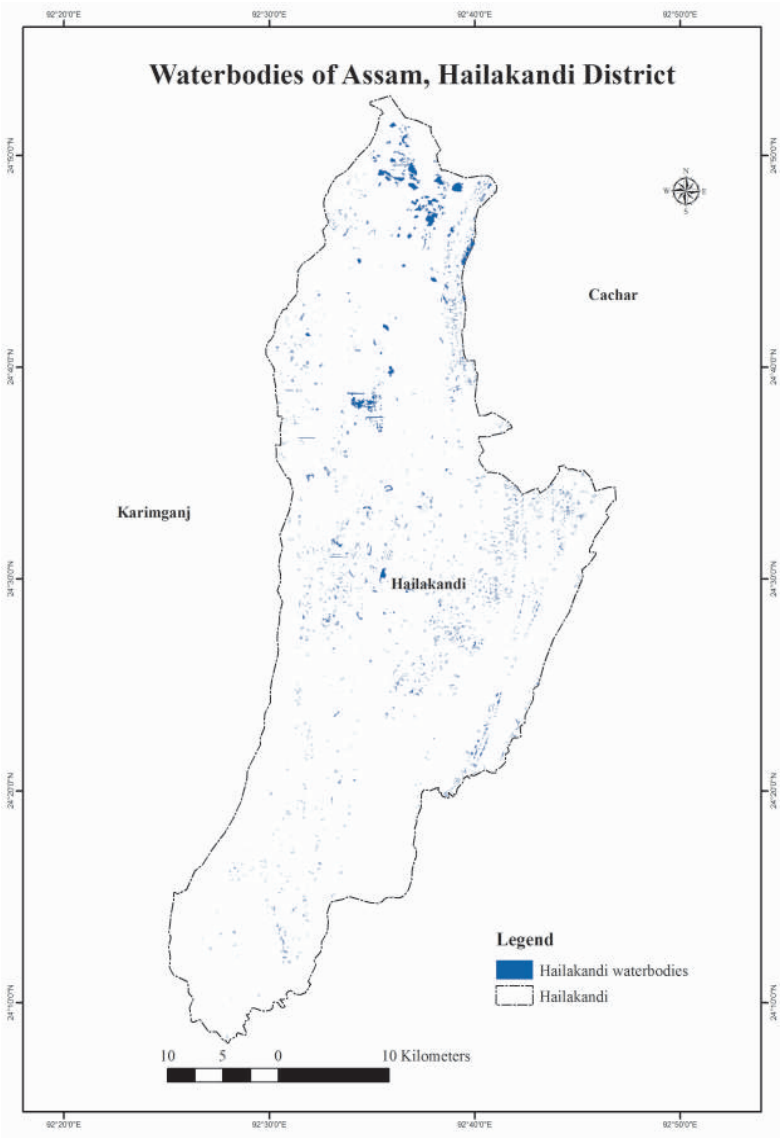


Fig. 80. Waterbody delineation map of Andhra Pradesh State



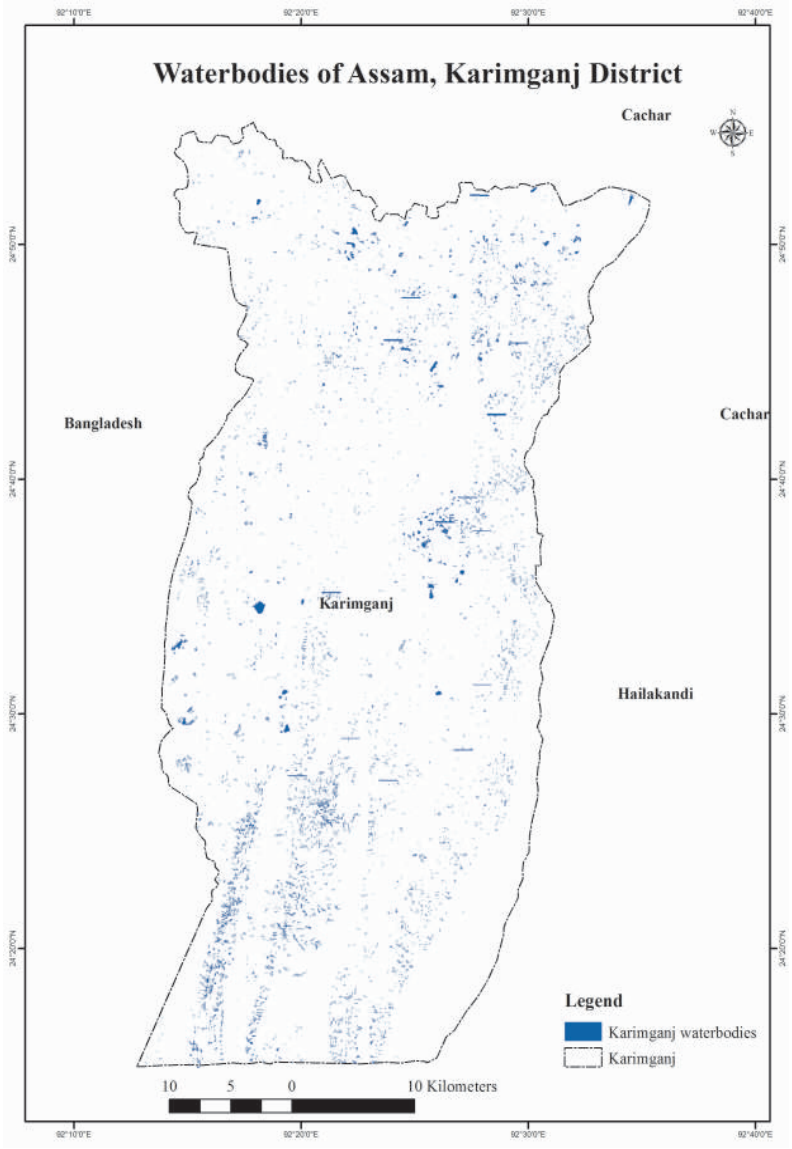
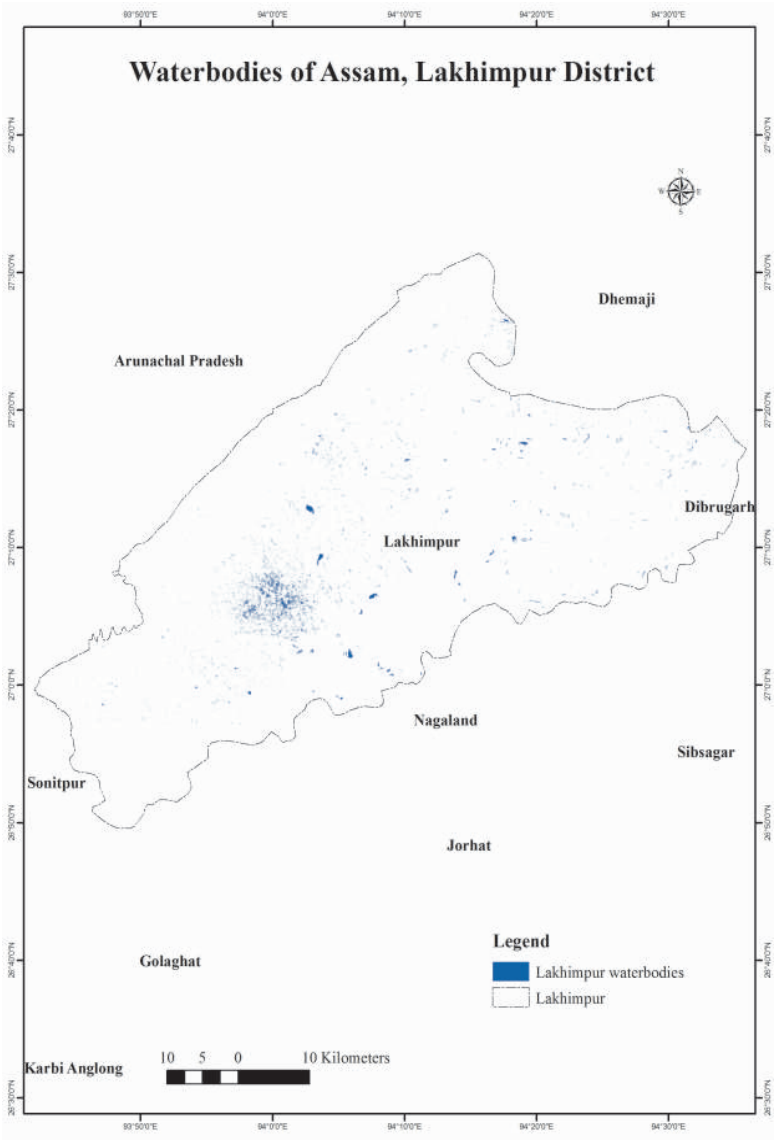


Fig. 81a. Waterbody delineation map of districts of Assam State



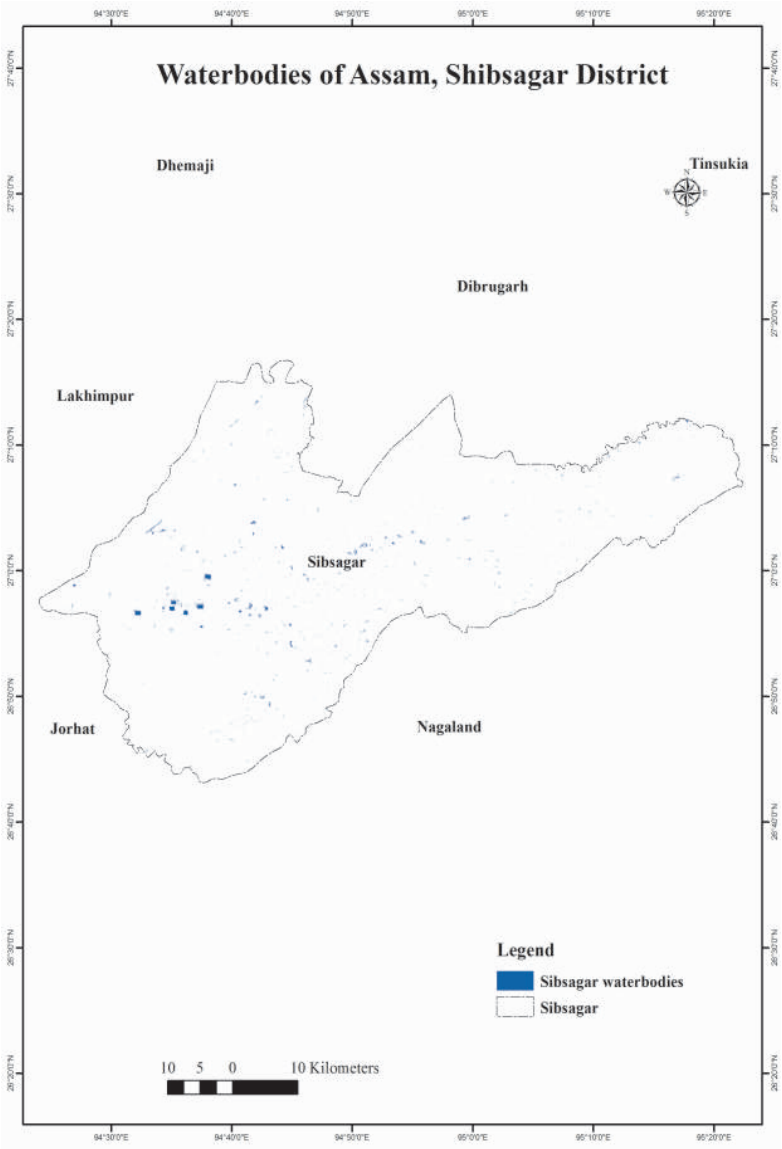
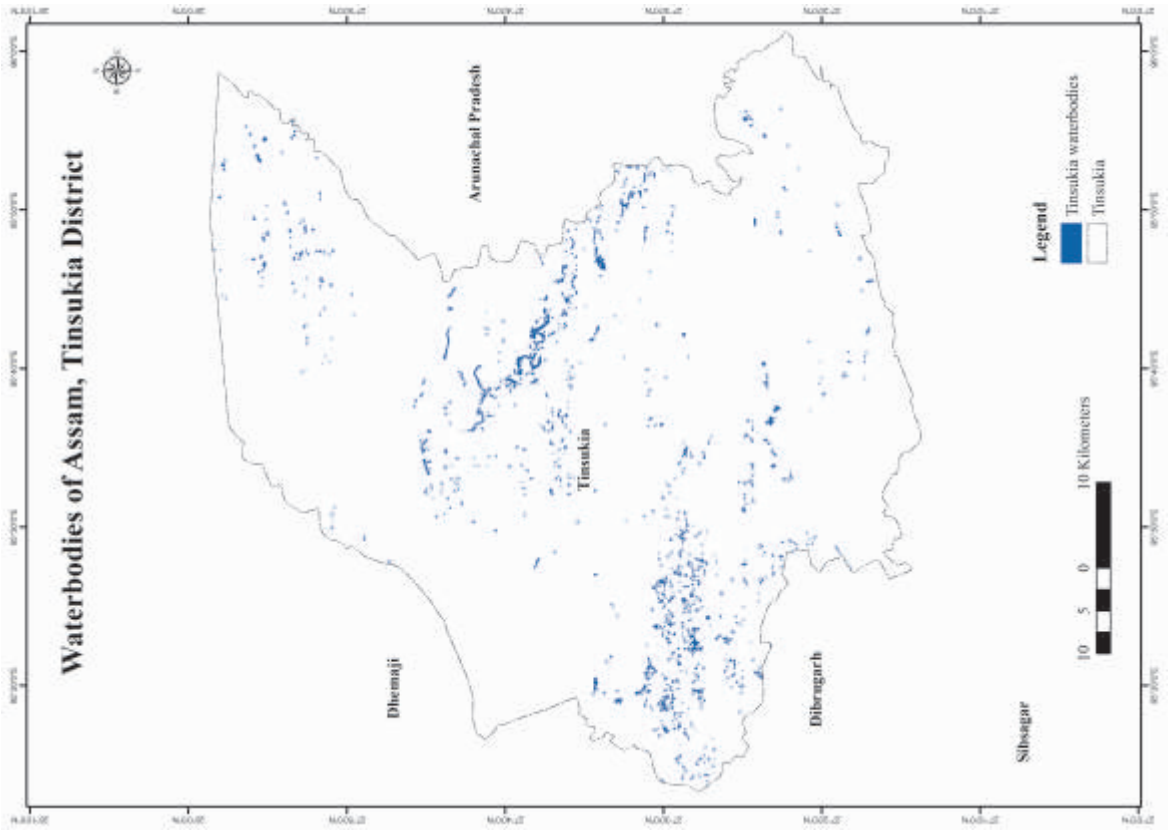


Fig. 81b. Waterbody delineation map of districts of Assam State



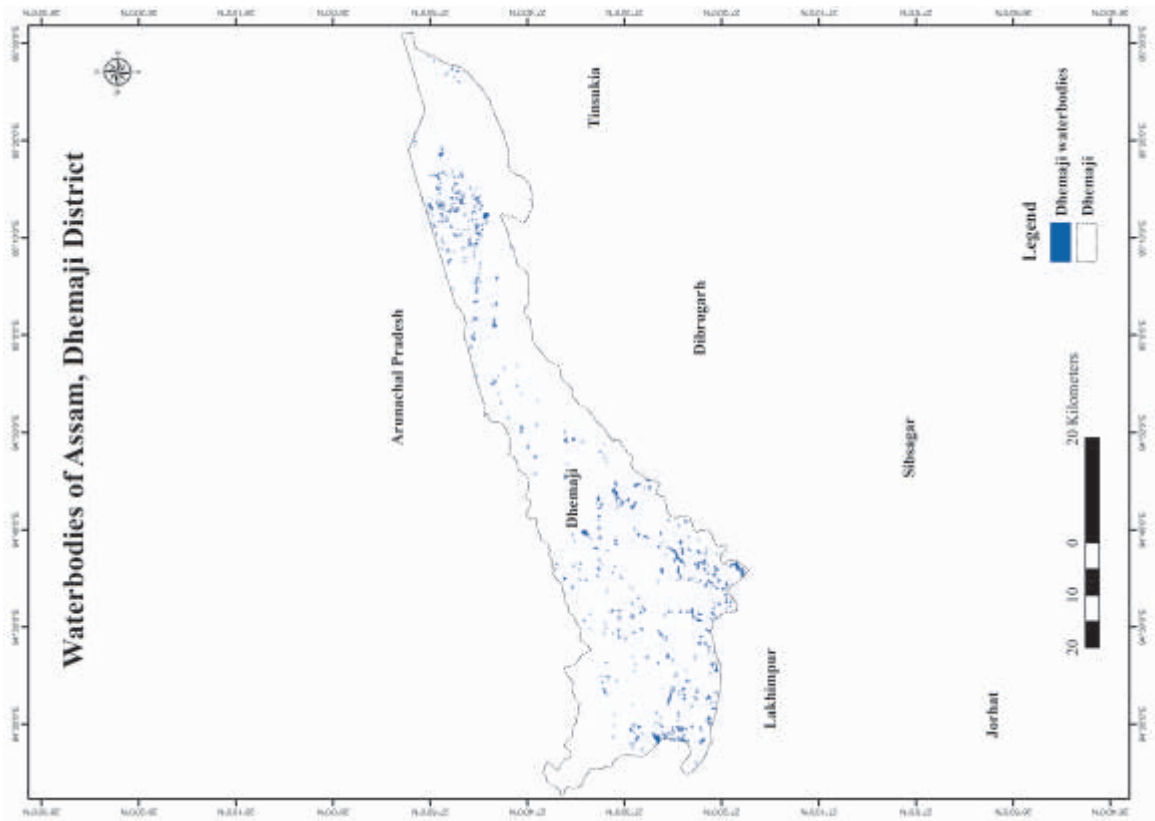


Fig. 81c. Waterbody delineation map of districts of Assam State

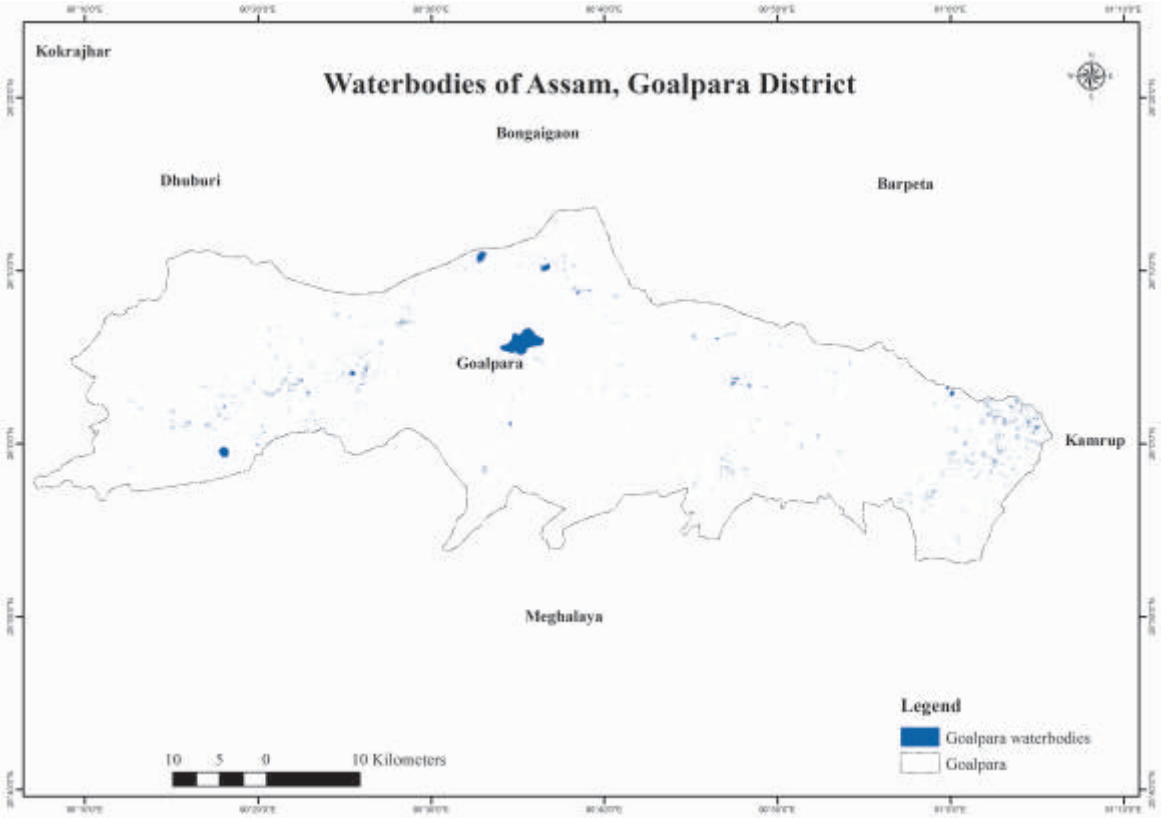


Fig. 81d. Waterbody delineation map of districts of Assam State

Table 18. Possession of water resources in selected villages of UP

Districts	Total Villages	Non-fishing villages	Pond villages	Fishing Ponds villages	% of Fishing Ponds villages
Allahabad	3090	1747	1343	716	23.17
Mahoba	505	236	269	137	27.13
Srawasti	537	35	502	113	21.04
Mathura	900	233	667	92	10.22
Varanasi	1347	589	758	178	13.21
Chitrakoot	631	244	387	79	12.52
Kannauj	767	221	546	83	10.82
Total	**7777**	**3305**	**4472**	**1398**	**17.98**

Table 19. Water bodies and their area in selected districts of Assam

Sl. No.	District	No. of water bodies	Area (ha)
1	Dhemaji	1343	640.02
2	Tinsukia	3606	738.81
3	Lakhimpur	13486	3219.79
4	Sibsagar	4418	1491.34
5	Goalpara	3696	2116.28
6	Karimganj	6458	4766.19
7	Hailakandi	3296	3044.43

Table 20. Number of waterbodies surveyed in different states

S.No.	State	Districts	No. of waterbody field completed
1.	Odisha	18	290
2.	Bihar	4	188
3.	Chattisgarh	8	386
4.	West Bengal	2	69
	Total	32	933

Socio - economic survey

were collected from Bihar, Chhattisgarh, Odisha and West Bengal. 933 large water bodies from 32 districts spread over 4 states were covered. Waterbodies of Assam has been delineated for Hailakandi, Karimganj, Lakhimpur, Shibsagar, Goalpara, Dhemaji and Tinsukia districts. Lakhimpur with the highest number of water bodies (13486) has a total water spread area of 3219.79 hectares and Dhemaji with the least number of waterbodies has a total water spread area of 640.02 hectares.

Project: Stock characterisation, captive breeding, seed production and culture of Hilsa (*Tenualosa ilisha*)

Project staff: V. R. Suresh, B. K. Behera, R. K. Manna, Sajina A. M and K. M. Sandhya

The catch from Hooghly-Bhagirathi system for 2016-17 was 48,922 t, out of which 99.4% was realized from marine sector. The estimated MSY is 32,953 t. The catch of hilsa from the Hooghly-Bhagarithy system has been near to MSY. Further increase in effort might affect the sustainability of the stock. Hilsa of 341-360 mm size group had maximum reproductive potential in terms of fecundity, higher gonado somatic index, sex ratio. The mesh size of gill nets to avoid catch of specimens up to this size group estimated was 110 mm or higher. Godakhali on main stream Hooghly and Kolaghat on Rupnarayan tributary of Hooghly were identified as two major hilsa breeding zones.

Stock assessment

Catch estimation of hilsa from Hooghly-Bhagirathi river system, Narmada estuary and Ukai reservoir has been continued using stratified multistage random sampling method, from sixteen major stations and through random surveys in minor stations.

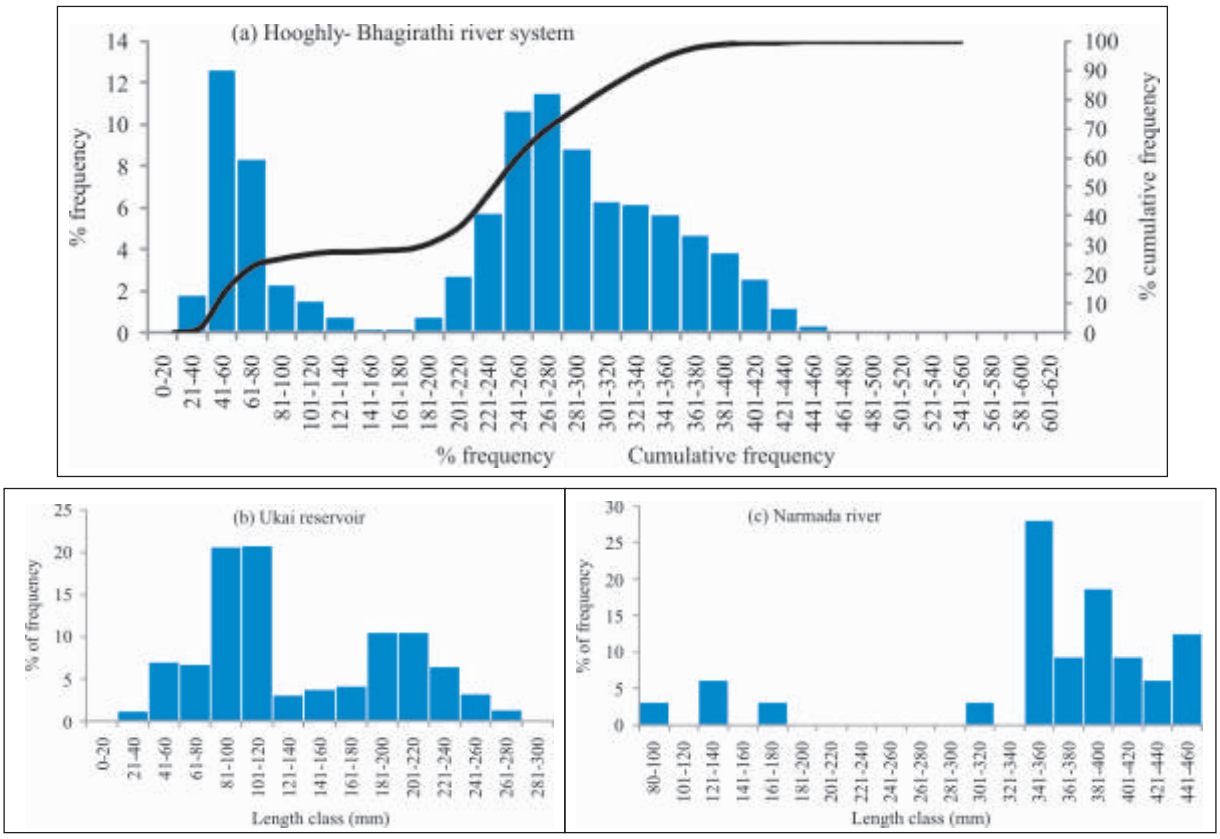


Fig. 82. Length frequency distribution of hilsa from Hooghly-Bhagirathi river system (a), Ukai reservoir (b) and river Narmada (c)

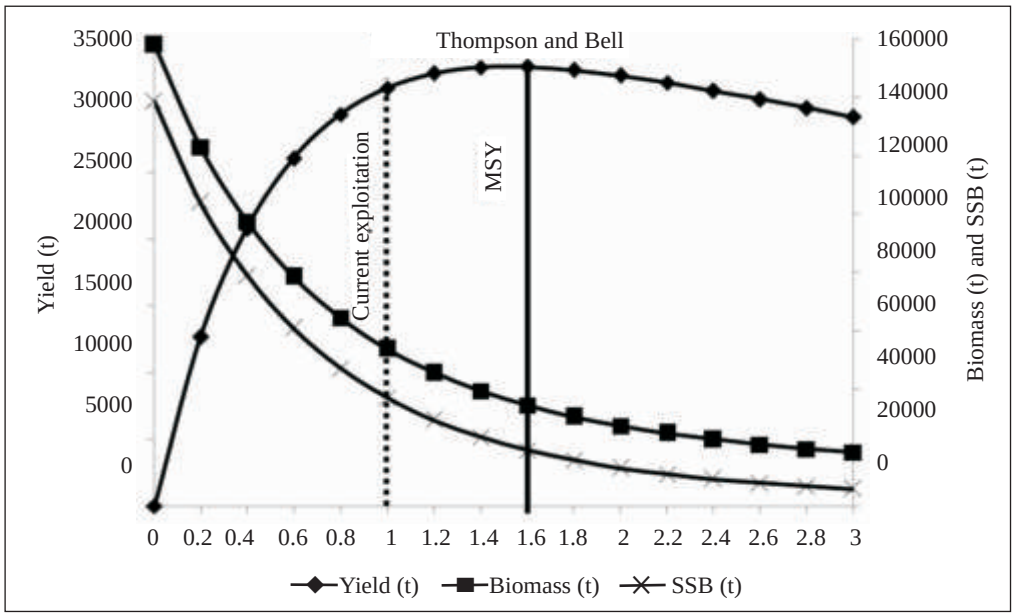


Fig. 83. MSY, SSB and biomass of hilsa estimated using Thompson and bell model

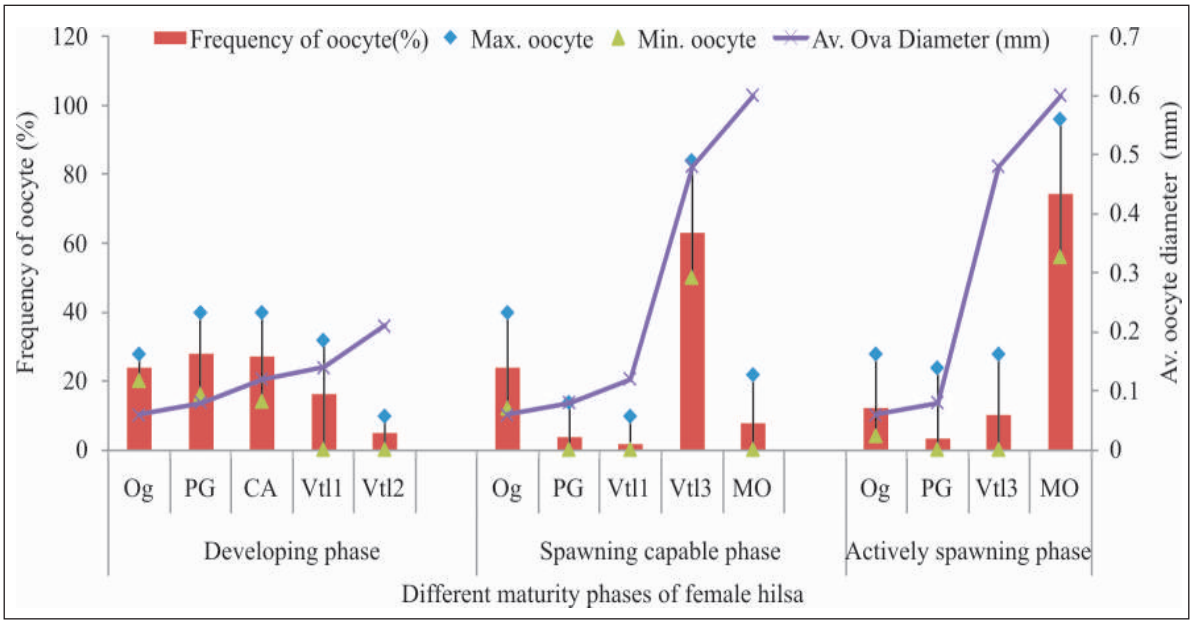


Fig. 84. Frequency distribution of *T. ilisha* oocytes with average diameter of different maturity stages. (Og-Oogonia, PG-primary growth, CA- cortical alveoli, Vtl1-primary vitellogenesis, Vtl2- secondary vitellogenesis, Vtl3- Tertiary vitellogenesis, OM- oocyte maturation, MO- mature oocytes.)

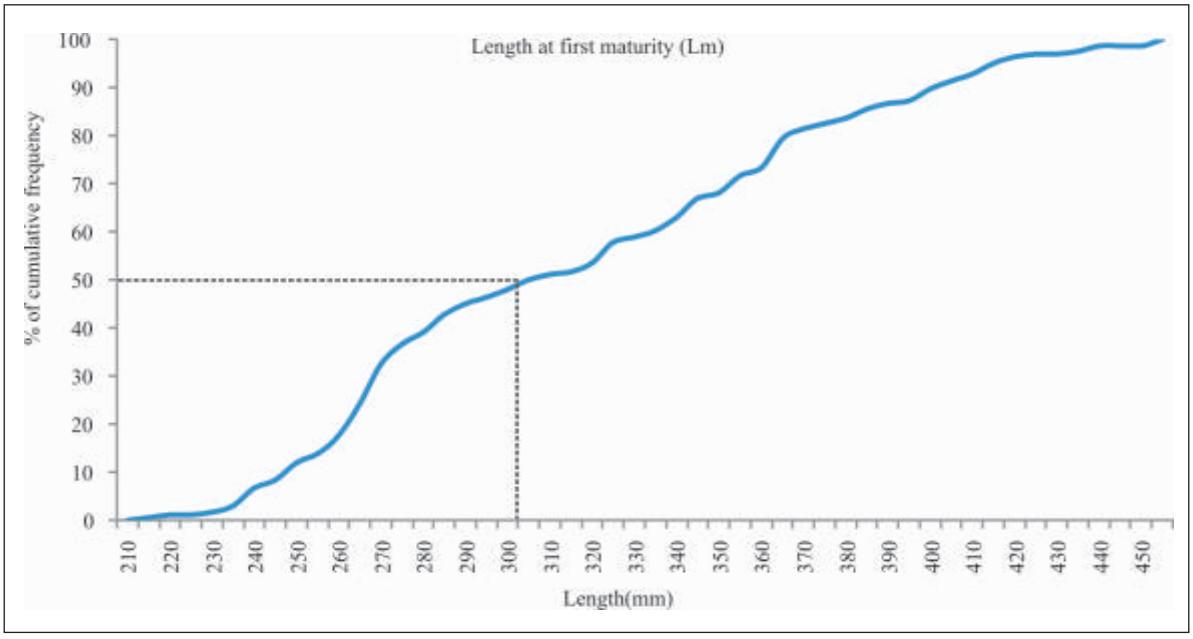


Fig. 85. Length at first maturity of *T. ilisha* in Hooghly-Bhagarithy system

The estimated annual catch was 48,922 t during April 2016 to March 2017, which showed high fluctuations from previous year catches. Maximum catch (99.4%) came from the marine sector, whereas only 0.6 % was realized form freshwater and brackish water sectors together. The Catch per Unit Effort (CPUE) varied from 69-500 kg/boat/day for multiday marine gillnetters, indicating good catch in the peak fishing months (July-September), whereas in estuarine and freshwater zones, it was 0.13-15 kg/boat/day and 0.25-4.50 kg/boat/day for single day gill netters, respectively. The fishery was dominated by the length class of 261-280 mm (TL). Length frequency analysis showed serious capture of smaller size groups or juveniles (68%) pointing towards growth overfishing. Large number of ripe/oozing fishes in catch also signaled recruitment overfishing. Hilsa fishery of river Narmada in west coast mainly comprised of 340 mm and above size groups, whereas in Ukai the catch was dominated by 120 mm and below size group.

The mean annual catch of the fish in the last fifteen years from Hooghly-Bhagirathi system has been 30,537 t; the same for the last four years (study period) has been 30,762 t. The MSY estimated using Thomson and Bell model is at 32,953 t. The catch of hilsa from the Hooghly-Bhagarithy system has been nearer to MSY. Further increase in effort might affect the sustainability of the stock.

The fishing effort needs to be maintained at the most current level to avoid over harvesting. However, the current spawning stock biomass (SSB) in the system remains at 26.8 %, which is bare minimum to sustain stock of the fish. The SSB level needs to be raised at least up to 30%, hence there is need for reducing capture of brooders.

Reproductive biology and dynamics

Reproductive dynamics of hilsa in Hooghly-Bhagirathi river system was studied for deciding the size of fish at which the reproduction potential is maximum for protection of that size groups. Data on fecundity, sex-ratio, abundance of brooders

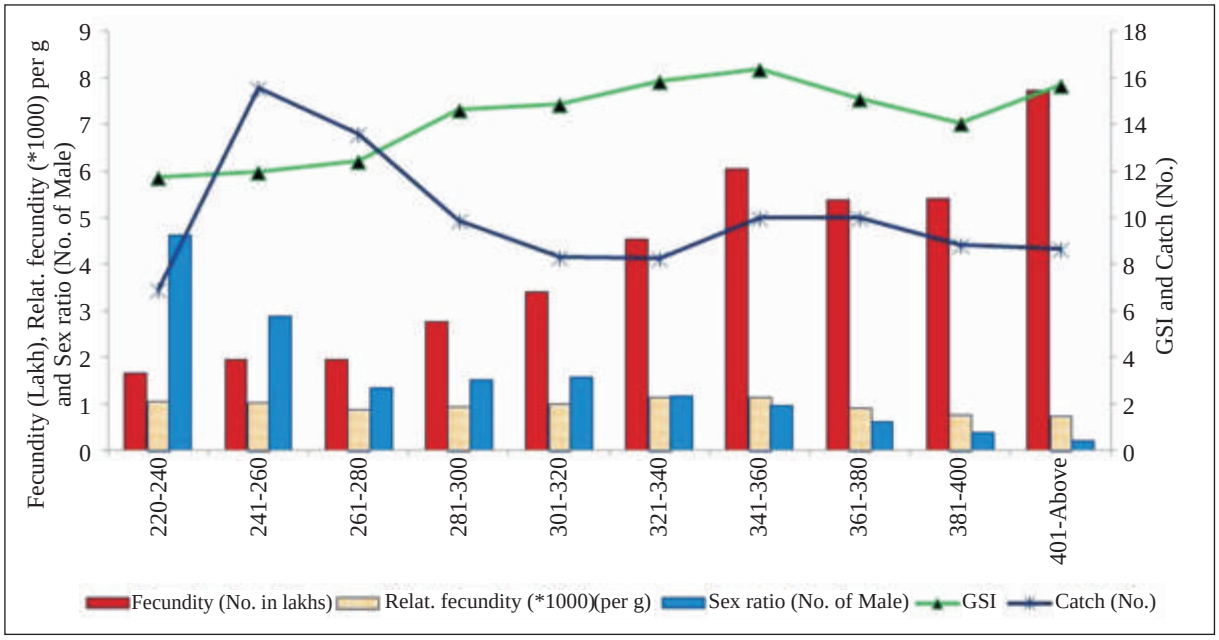


Fig. 86. Reproductive indices and % of adult hilsa in Hooghly Bhagirathi river system

were considered. To record different maturity phases of females, the mean percentage of oocytes under different stages and mean oocyte diameter (mm) were recorded through histological examination.

The immature phase (Stage I to II) is characterized by presence of only oogonia and primary growth oocytes in ovary. The developing phase ovary (Stage III) consisted of Og-oogonia (24%), PG-primary growth (28%), CA- cortical alveoli (27%), Vtl1-primary vitellogenesis (16%), Vtl2- secondary vitellogenesis (5%)(Fig 84). The oocyte diameter was up to 0.21± 0.03 mm. This phase showed appearance of CA-cortical alveoli oocytes in ovary but no evidence of Vtl3 stage oocytes. In spawning capable phase (Stage IV), developed oocytes reached Vtl3-tertiary vitellogenesis stage and mean percentage of Vtl3 stage oocytes was 63. The diameter of Vtl3 oocytes was 0.46 ±0.08 mm. Some percentage of matured oocytes (MO-7.75%) was also recorded. The fish is considered mature once the oocytes in the ovary reaches spawning capable stage (Stage IV). In actively spawning phase (Stage-V and above), the ovaries exhibited maximum mean percentage of matured oocytes (MO-74.5%) like OM (oocyte maturation), germinal vesicle break down stage and also OG, PG, Vtl3. The mean oocyte diameter of MO was 0.6±0.03 mm. In spent phase, mainly regressed oocytes were recorded. Hence ovaries with more than 70% oocytes of >0.6 mm diameter were considered mature ovaries. Based on this, the length at first maturity (Lm) of females, the length at which 50% of the population mature, has been estimated at 305 mm TL, while the lowest length at which females mature has been recorded at 213 mm TL.

For analysis of reproductive traits of mature hilsa (average ova diameter 0.6 mm and above) of different size groups were considered. The mature females in the size range of 281 to 360 mm TL had highest reproductive potential in terms of fecundity, relative fecundity, high gonado somatic index, favourable sex ratio and frequency in catch. Of this, the maximum potential was for the size group 341-360 mm TL.

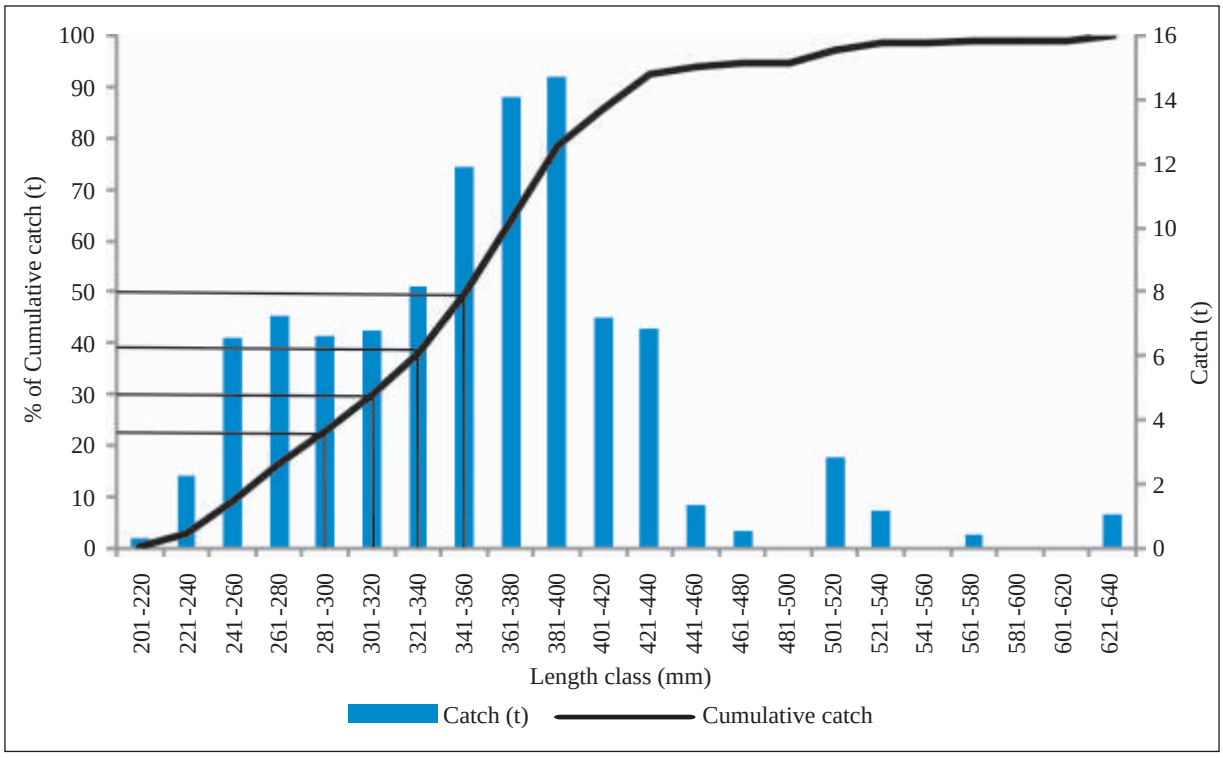


Fig. 87. Size wise cumulative catch contribution in Hooghly-Bhagirathi river system

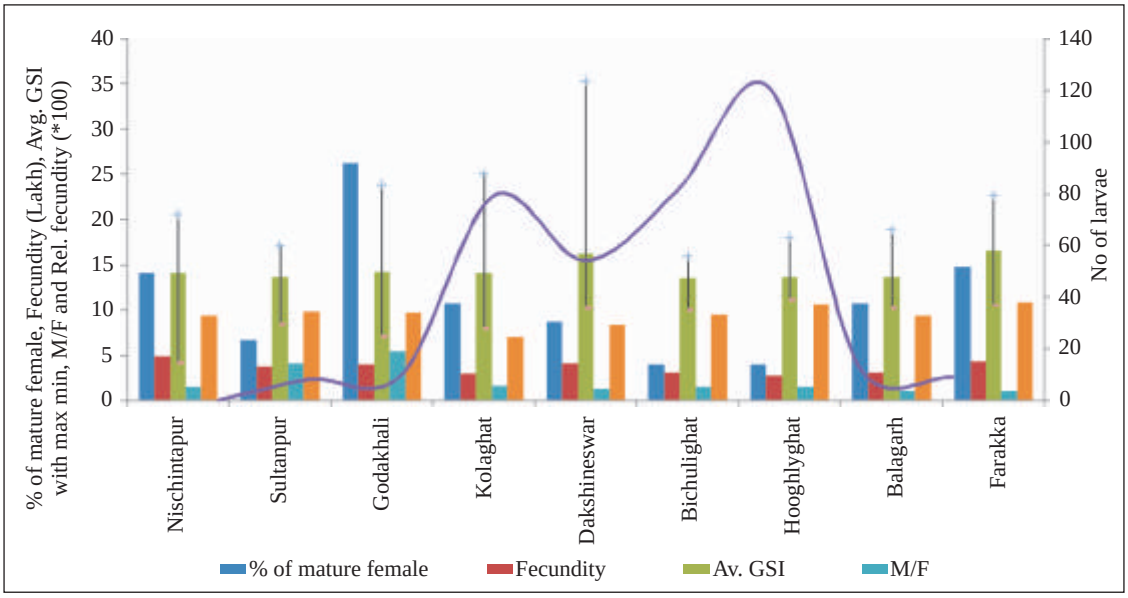


Fig. 88. Identified breeding zone based on various parameters

Larvae collection from Hooghly-Bhagirathi river and larvae of Hilsa

Gill net selectivity in catch

Surveys conducted along Hooghly river system revealed that gill nets of 40 to 110 mm mesh size at sizes of 5 mm difference are available in the market and are being used by fishers for catching hilsa. Of this, nets with 60, 65 and 70 mm mesh are the most prevalently used (59%). To estimate the size of hilsa that will be caught with these gill nets of various mesh sizes, a model was fitted using input values as mesh size, head height and body depth of the hilsa caught. The size range thus obtained were validated using experimental gill nets using similar mesh size. There was no significant difference in model fit size range and that obtained through experimental fishing.

For protecting the size group having most reproductive potential (321 to 360 mm TL) use of 110 mm mesh size gill net is ideal as minimum size caught in this net is 362 mm TL and all size below 362 mm will escape capture. But bulk of the catch is contributed by hilsa up to 360 mm size, implementing 110 mm mesh size regulation may cause 50% loss in catch. Considering this, if the next best option of 301-320 mm TL may be protected by using gill nets of 100 mm mesh size, with 38% loss in catch. The last of the option of 281-300 mm TL size group require 90 mm mesh gill nets that will incur 23% loss in catch. Hence at least 301-320 mm length group must be protected through 100 mm mesh size gill net, which will enable escape of size below 330 mm TL.

Larval stages were collected by deployment of specially designed triangular conical spawn collection net made of 0.3 mm nylon mesh having mouth area of 0.707 m^2 and 1 meter length with a collection bottle at the tail end.

Larval stages from natural waters were matched with the preserved specimens from artificial breeding and further confirmed with the reference of Jones and Menon (1951). Larval abundances were 49 nos/m^3 at Kolaghat, 9 nos/m^3 at Godakhali during monsoon season, whereas 92 nos/m^3 and 36 nos/m^3 at Kolaghat and Godakhali respectively during winter season. Larval abundance of other stations were also recorded.

Within a station larval abundance varied at different zone of the river. Maximum larvae were recorded in the littoral erosion zone of the river. The Figure 88 shows

that from Godakhali to Balagarh in Hooghly-Bhagirathi river system and Kolaghat in Rupnarayan river were the most potential breeding zones, based on abundance of mature brood fish, mean GSI and abundance of larval stages.

Project: National surveillance programme for aquatic animal diseases

Project staff: B. K. Behera, S. K. Manna, A. K. Sahoo, P. Das, B. K. Bhattacharjya, Sanjay Bhowmick and A. K. Jana

Study reported involvement of *Acinetobacter baumannii* in the disease outbreak of *Labeo rohita* for the first time. Phylogenetic tree was generated using neighbour-joining method by the MEGA 6 software.

Incidence of bacterial disease in Indian Major Carp, *Labeo rohita* (Hamilton 1822) in West Bengal

A fish pathogenic bacterium was characterized at molecular level and attempt has been made to understand its pathogenicity associated with mortality of farmed rohu, *Labeo rohita*. Diseased fish samples were collected from cultured ponds of Nadia, West Bengal, India for the isolation of the pathogen. The 16S rRNA gene sequence of the bacteria revealed that the isolate was 100% identical with *Acinetobacter*

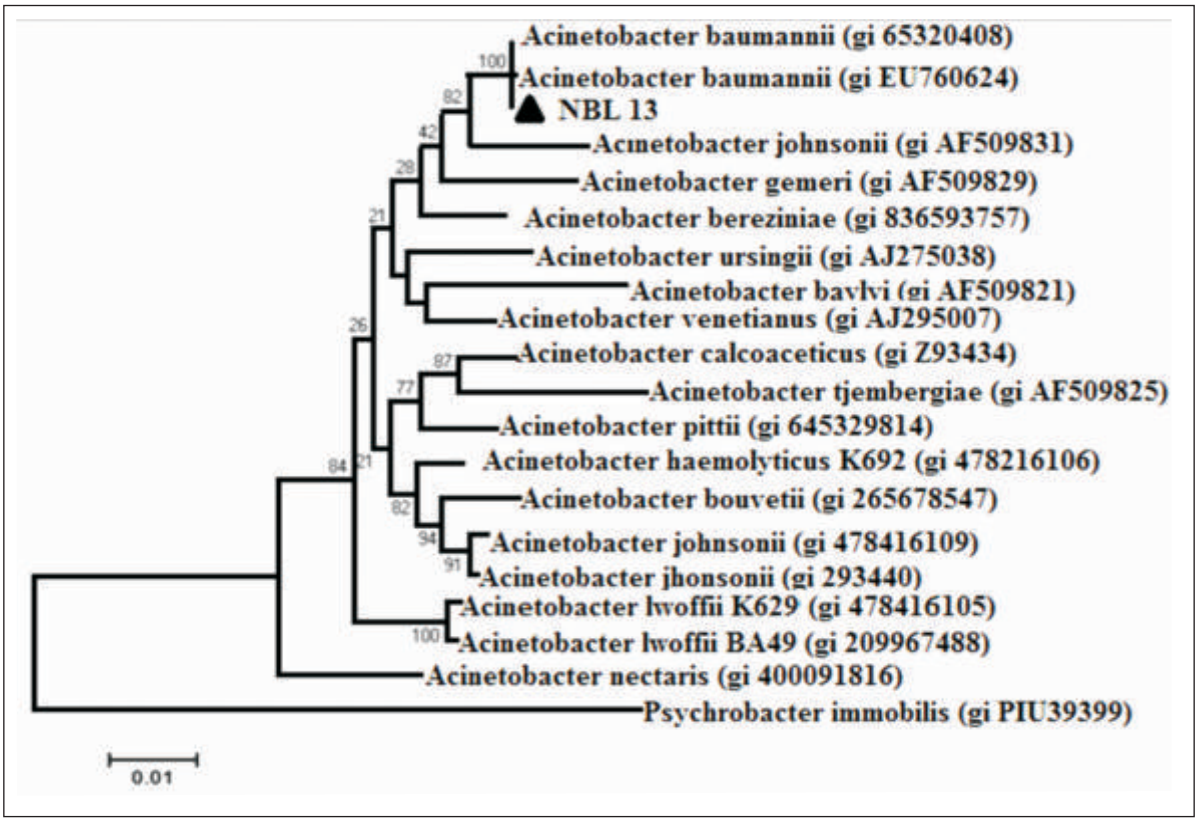


Fig. 89. Phylogenetic tree analysis of *Acinetobacter* sp. based on 16S rRNA nucleotide sequences

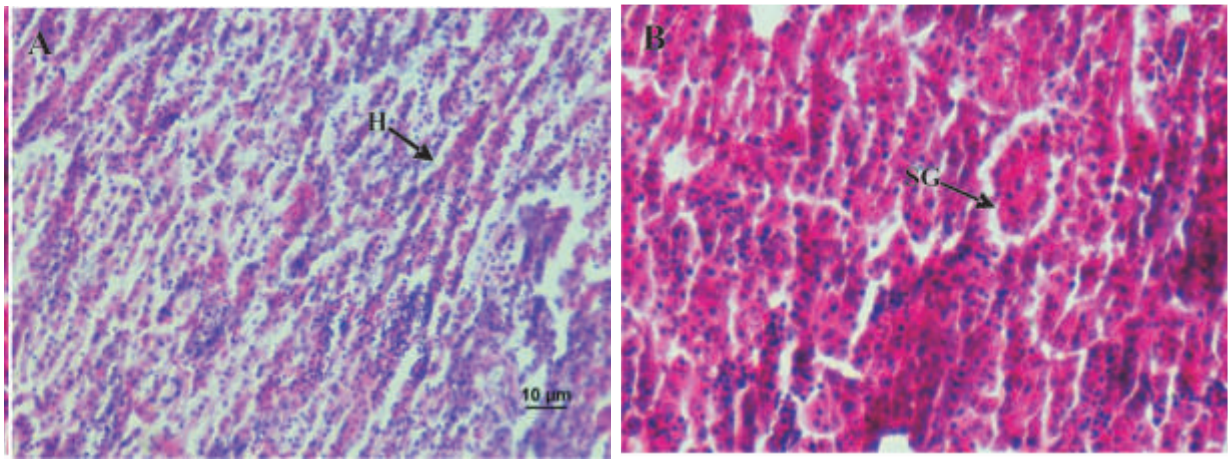


Fig. 90. Photomicrograph of Kidney of *Acinetobacter baumannii* challenged *Labeo rohita* showing [A]: haemorrhages (H)(H & E staining; 60X); [B]: shrunken glomeruli with densely basophilic nuclei (SG) (H & E staining ; 60X).

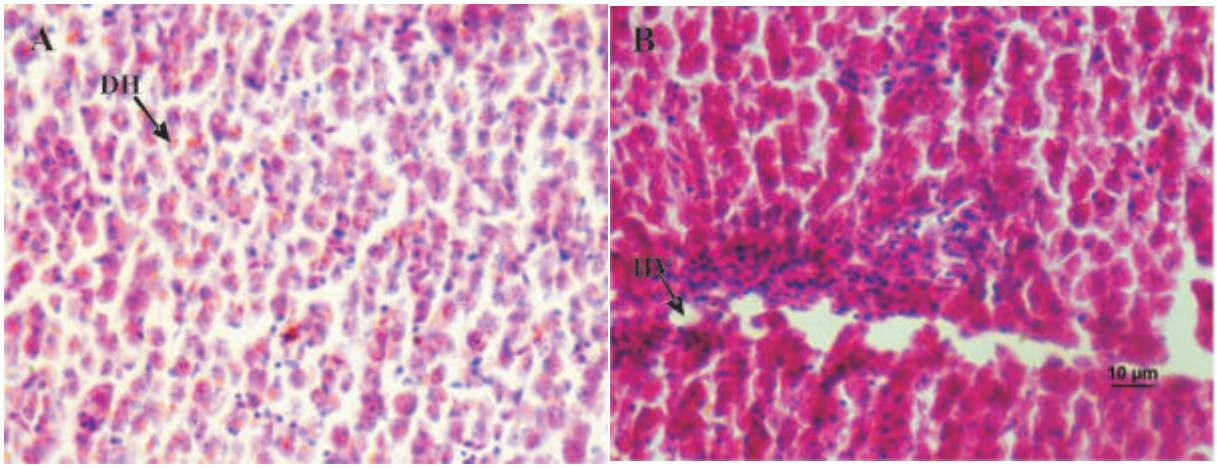


Fig. 91. Photomicrograph of Liver of *Acinetobacter baumannii* challenged *Labeo rohita* showing [A]: degenerated hepatic tissue (DH) (H & E staining; 60X); [B]: increased hepatocyte vacuolation (HV)(H & E staining; 60X).

baumannii (NCBI Accession Number Kt156752). Intra-peritoneal injection of the isolate at the level of 2.1×10^8 cells/ml in fish caused mortality. The challenged fish had loss of mucus and reddish lesion near the pectoral fin, however there was no sign in the gill. The histology of experimentally challenged *Labeo rohita* showed hemorrhages and shrunken glomeruli with densely basophilic nuclei in kidney whereas degenerated hepatic tissue and increased hepatocyte vacuolation in liver. This study underlines the first time involvement of *Acinetobacter baumannii* in the disease outbreak of *Labeo rohita*.

Phylogenetic tree (Fig. 89) was generated using neighbour-joining method by the MEGA 6 software. The numbers next to the branches indicate percentage values for 10,000 bootstrap replicates. Bootstrap values are shown at the nodes. The isolate NBL13 identified in this study are indicated by the shaded triangle.

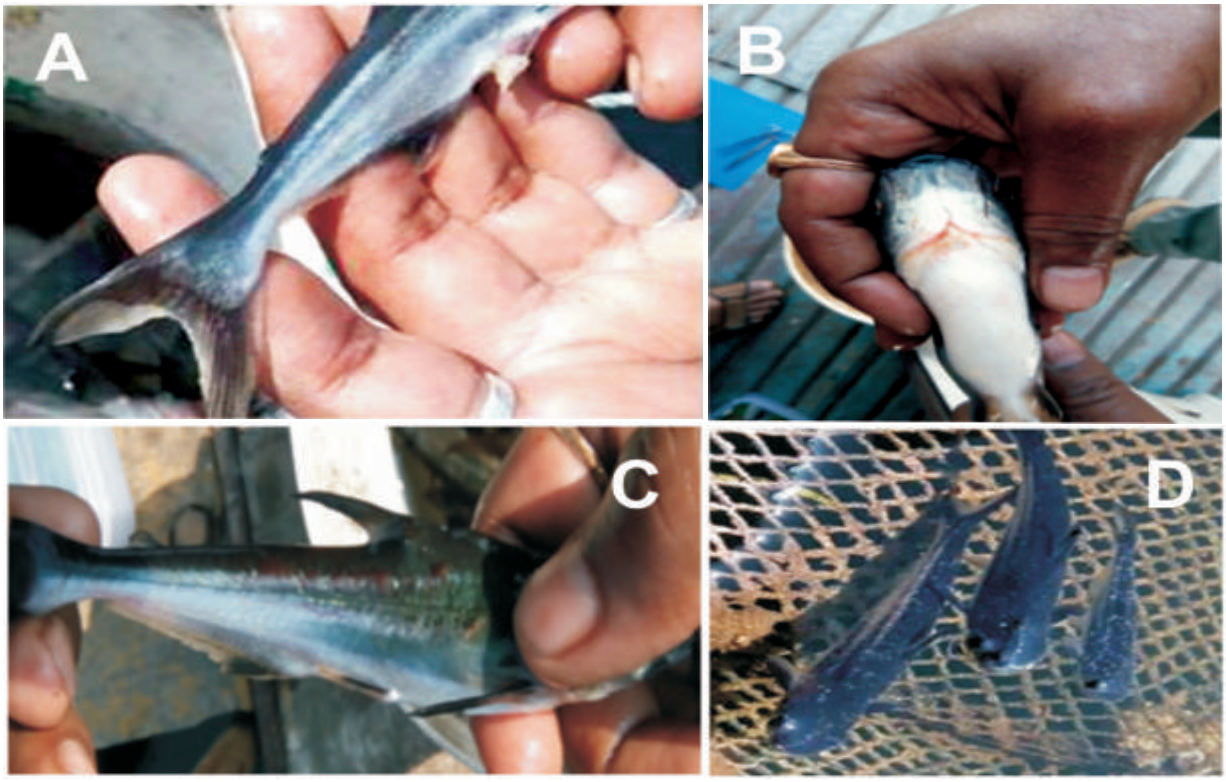
Project: All India Network Project on Fish Health

Project staff: Sanjib K. Manna, S. K. Nag, P. Panikkar, A. K. Bera, Anjana Ekka, D. Debnath, Raju Baitha and Vikash Kumar

More than 90 drug formulations were used in Nagaon, Morigaon and Cachar districts of Assam whereas in Raichur, Shimoga and Bellary districts of Karnataka about 40 drug formulations were in use. Parasite infestations are more common in Karnataka and as a result farmers frequently use anti-parasite drugs like Dichlorvos, Cypermethrin, Deltamethrin, Quinolphos; antibiotics and water sanitizers like Enrofloxin, Glutaraldehyde, Formaldehyde, $KMnO_4$, Calcium Peroxide; are also used. Mortality was high in fry and fingerlings stages of Pangasius in cages in reservoirs, and specially during winter months. Important diseases identified in Pangasius in cages were: superficial fungal infestation (cotton wool disease) in young fishes, bacterial septicaemia caused by *Acinetobacter soli*, *Aeromonas hydrophila* and *A. veronii*, and Ich as the major parasite infestation.

Use of drugs and chemicals in Assam and Karnataka

Drug usage in fisheries sector of India is grossly unknown. Surveys conducted in Nagaon, Morigaon and Cachar districts of Assam have listed more than 90 drug formulations in use. In Assam fish farmers often use nutritional supplements and probiotics for enhancing fish growth; sanitizers, water quality enhancers etc. are



Important disease conditions in *Pangasionodon hypopthalamus* in cages. A: Fungal infection, B and C: Bacterial septicaemic infection, D: Ich infestation.

also used in the state, but at lesser extents. The surveys also revealed presence of many dubious drugs, including those lacking detailed composition, in the market. Surveys conducted in Raichur, Shimoga and Bellary districts of Karnataka have listed about 40 drug formulations in use. Parasite infestations are more common in Karnataka and farmers are frequently using anti-parasite drugs in aqua farms. Majority of farmers are using pesticides like Dichlorvos, Deltamethrin, Quinolphos; antibiotics and water sanitizers like Enrofloxin, Glutaraldehyde, Formaldehyde, $KMnO_4$, Calcium Peroxide, Cypermethrin are also used.

Fish health investigation for health management in cages and BMP development

Cage culture of *Pangasionodon hypophthalmus* has revolutionized reservoir fisheries with impressive level of production. Cage culture is an intensive culture process which makes it prone to diseases and mortality. To identify fish health as well as management problems in cages towards BMP development, cage culture in few reservoirs were investigated. Study revealed that mortality was high in fry and fingerlings stages of Pangasius in cages, which may even lead to total loss of the stock in some cases. Mortality of *Pangasionodon hypophthalmus* is high during winter months. Important diseases identified in Pangasius in cages were: superficial fungal infestation (cotton wool disease) in young fishes, bacterial septicaemia caused by *Acinetobacter soli, Aeromonas hydrophila* and *A. veronii*, and Ich as the major parasite infestation.

Project: FSSAI Project on Development of standard protocols and molecular tools for fish food authentication for food safety and quality assurance

Project staff : B. P. Mohanty and P. K. Parida

Developing protocols/tools for detection of adulteration of commercial important fishes with prohibited preservatives (e.g. formalin and other substances) are very important from public health point of view. Identification of molecular and biochemical indicators would be helpful for evaluation of freshness/spoilage status in imported fish species.

Tenualosa ilisha has shown the presence of forty-two volatile compounds: 12 alcohols, 1 ketone, 2 aldehydes, 5 furans, 3 acids, 7 esters, 5 alkadienes, 3 alkynes, 3 aromatic compounds and 1 epoxide derivative. Volatile profile of *Labeo rohita* showed presence of 2-hexen-1-ol, 3-decyn-2-ol; ketone: cyclohexanone; alkene: R-lemonene, whereas in *C. catla*, Cyclopentanol and 5-methyl-5-hexen-2-ol were the predominant volatile compounds. In *C. mrigala*, methane oxybisdichloro, nitrosomethane, lactic acid, and gycolic acid were found to be the major volatile compounds. Endogenous levels of formaldehyde were not detected in these species. A method for detection of formaldehyde by HPLC has been standardized.

Volatile compounds in fish flesh

Volatile compounds present in the Indian major carps (IMCs) *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala* and Indian shad *Tenualosa ilisha* were analysed using GC-MS. Volatile profile of *Labeo rohita* showed presence of alcohol: 2-hexen-1-ol,

3-decyn-2-ol; ketone: cyclohexanone; alkene: R-lemonene, whereas in *C. catla*, the alcohols: Cyclopentanol and 5-methyl-5-hexen-2-ol were the predominant volatile compounds. In *C. mrigala*, methane oxybisdichloro, nitrosomethane, lactic acid, and gycolic acid were found to be the major volatile compounds. 2-pentyl furan was found to be common volatile compound in *T. ilisha*, *C. catla* and *L. rohita* fishes. Some of these compounds could be contributing to the flavor of the fishes. Time-scale changes in volatile profiles of these fishes are being studied in search of spoilage/freshness indicators.

Volatile profiles of *Tenualosa ilisha* showed the presence of forty-two volatile compounds: 12 alcohols, 1 ketone, 2 aldehydes, 5 furans, 3 acids, 7 esters, 5 alkadienes, 3 alkynes, 3 aromatic compounds and 1 epoxide derivative which corroborates with our earlier findings on presence of these volatiles in fresh hilsa meat.

A commercially available patented kit was used for detection of the presence of endogenous levels of formaldehyde in *L. rohita, C. mrigala, and O. niloticus* as there are reports which indicate the presence of endogenous formaldehyde in other fishes (*Harpodon nehereus*). Endogenous levels of formaldehyde were not detected in these species, which could be due to its absence or presence in very low concentration. A method for detection of formaldehyde by HPLC has been standardized and method for extraction of formaldehyde from fish tissues and detection by HPLC is under standardization.

Project: Metagenomic applications and transcriptome profiling for inland aquatic environmental health surveillance

Project staff: B. K. Behera, S. K. Manna and Asim Kumar Jana

The River Ganga is life line of millions of Indians living along its course for their livelihood. It has also got immense spiritual and socio-cultural importance. However, The Holy river has been highly polluted from municipality and city sewages, industrial effluents, agriculture run off which made it fifth most polluted river in the world in 2007. Metagenomics studies have the great potential to monitor the pollution status of the river.

A significant relationship between abundance of pathogenic infectious bacteria and their bacteriophages was established. The investigation is the first attempt to demonstrate diversity of bacteriophages against infectious organism, which play a significant role in maintaining purity or healing property of the Ganga river water.

Sediment samples were collected from polluted sites (Ganga Barrage Bridge, Azad Nagar, Nawabganj, Jajmau, Jana village) near Kanpur in Uttar Pradesh and a total of 24 GB metagenomic sequence data have been generated. Similarly, sediment samples were collected from three less polluted sites (Farakka Bridge, Dhulian and, Lalbagh) of near Farakka and a total of 28 GB metagenomic sequence data have been generated.

Virus diversity in different sites of River Ganga

The population of Mimiviridae was highly abundant in polluted locations of Kanpur

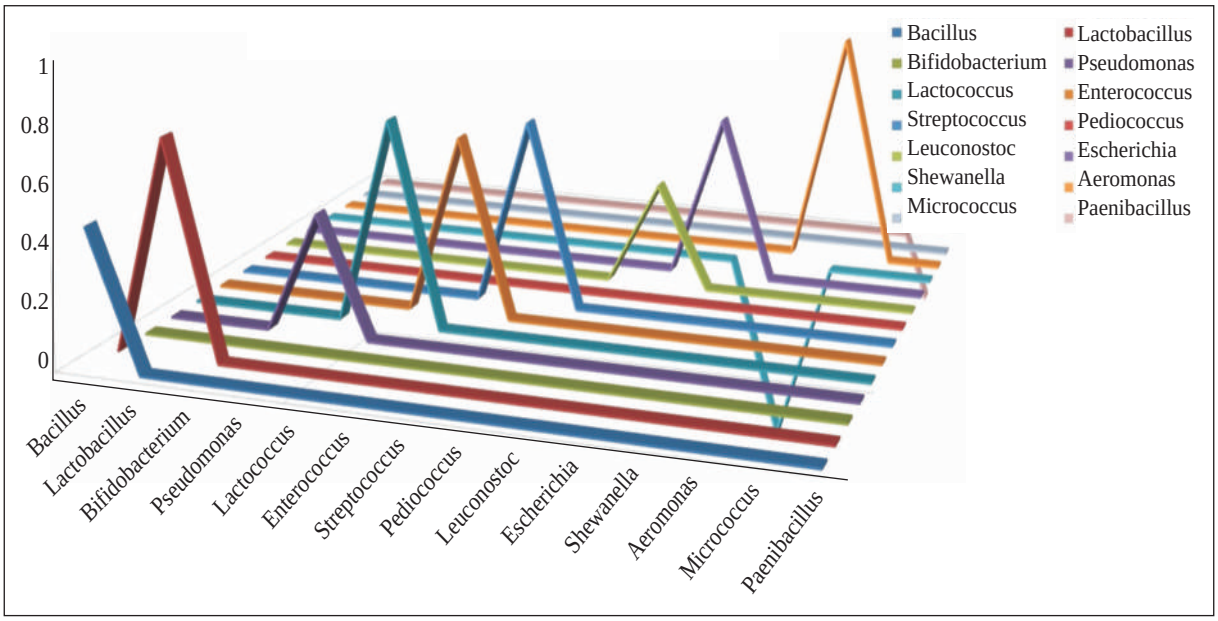


Fig. 92. Bacteria versus phage correlation for different probiotics genus

as compared to unpolluted site of Farraka (3.8 % versus 2.8%, with p-value 0.03). There was marginal increase in Phycodnaviridae, Iridoviridae, Marseilleviridae, Papillomaviridae in polluted Kanpur. In contrast, Retroviridae population decreased in Kanpur and there was substantial increase in populations of Poxviridae, Baculoviridae, Caulimoviridae, Adenoviridae in Farrakka. This may be due the killing of hosts of these viruses at high pollution level in Kanpur. It was also found that thirteen more families of viruses, i.e., Asfarviridae, Circoviridae, Herpesviridae, Nimaviridae, Geminiviridae, Ascoviridae, Hepadnaviridae, Bicaudaviridae, Alloherpesviridae, Polyomaviridae, Reoviridae, Inoviridae and Anelloviridae were available in similar percentage both at Kanpur and Farakka indicating that these virus families are unaffected by pollution in Kanpur. We also found phylogenetic diversity of viruses in both Kanpur and Farakka locations.

Bacteriophage diversity in different sites of River Ganga

In the sample from Kanpur, upstream site had only 631 Bacteriophage species that included Mycobacterium phage Sheen, Pseudomonas phage PaBG, Salicola phage CGphi29, Salmonella phage FSL SP-076 etc. However, the most polluted site of the Kanpur had 905 different species of bacteriophages together with Mycoplasma phage P1, Pseudomonas phage AF, Salmonella phage Shivani, Shigella phage pSb-1, Vibrio phage phi 2 etc., in the downstream of most polluted sites of Kanpur 720 different species of bacteriophages were found. This included Escherichia phage EC1-UPM, Mycobacterium phage AnnaL29, Salmonella phage 9NA, Vibrio phage CP-T1.

The samples collected from Farakka stretches exhibited higher number of bacteriophages in three locations, i.e., 809 (Farakka bridge), 777 (Dhulian) and 726 (Lalbag) respectively. Also, a lot of phage viruses were identified first time in the River Ganga. These viruses that can destroy pathogenic bacteria were Acinetobacter phage Acj9, Bacillus phage CP-51, Campylobacter phage CP30A, Cyanophage KBS-P-1A, Escherichia phage APCEc03, Mycobacterium phage

DaHudson, Pseudoalteromonas phage TW1, Salmonella phage SPT-1, Staphylococcus phage JD007, Synechococcus phage S-CBP2, Vibrio phage ICP2, Yersinia phage phiR201 etc.

Probiotics bacteria in different sites of River Ganga

A good number of probiotic bacterial species in the Kanpur and Farakka stretches were identified using metagenomics approaches. Sixteen *Lactobacillus* species including *L. brevis*, *L. curvatus*, *L. helveticus*, *L. fermentum*, and *L. reuteri* and nine *Bacillus* species including *B. clausii*, *B. circulans*, *B. subtilis*, *B coagulans* etc. were identified. Five *Bifidobacterium* species, namely, *B. animalis*, *B. bifidum*, *B. longum*, *B. breve*, and *B. Adolescentis* were identified. The study found *Pediococcus pentosaceus* in higher proportion at Farakka and significantly higher proportion of *Pediococcus acidilactici* in Kanpur. Probiotics species belonging to genera *Pseudomonas*, *Lactococcus*, *Enterococcus*, *Streptococcus*, *Pediococcus*, *Leuconostoc*, *Escherichia*, *Shewanella*, *Aeromonas*, *Micrococcus*, and *Paenibacillus* were also recorded in the river Ganga.

Project: Identification and characterization of aquaporin gene from freshwater catfish *Clarias batrachus* and their expression during reproduction

Project Staff: B. K. Behera, A. K. Sahoo and A. K. Jana

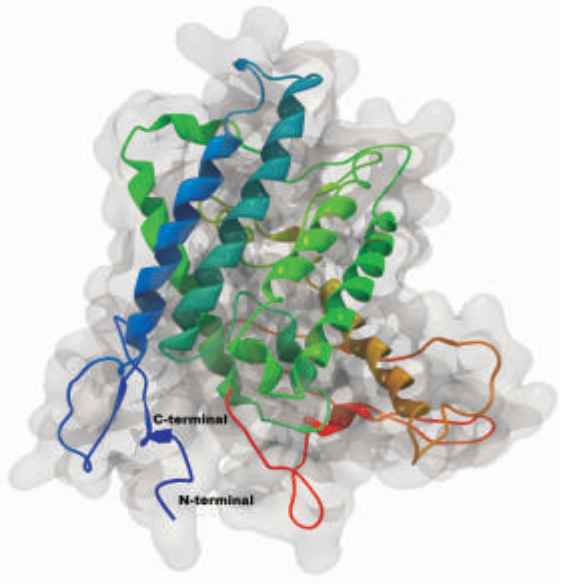


Fig. 93. Homology model structure of aquapoin4

In induced spawning of Magur, *Clarias batrachus*, male is sacrificed as milt does not ooze out spontaneously after administration of inducing agent. Aquaporins, the channel proteins which facilitate water and ion exchange, are proved to hydrate oocytes during ovulation and suggested that they may be involved in the hydration of the seminal fluid as well as in sperm physiology. In this connection, total RNA was extracted from the testis of *C. batrachus* and cDNA was prepared. PCR was performed for characterization and differential expression study of the aquaporin genes during maturation.

The transcriptomic sequencing of *Clarias batrachus* was carried out and four full length genes viz. Aquaporin 9, Aquaporin 3a, Aquaporin 4 and Aquaporin 12 were predicted.

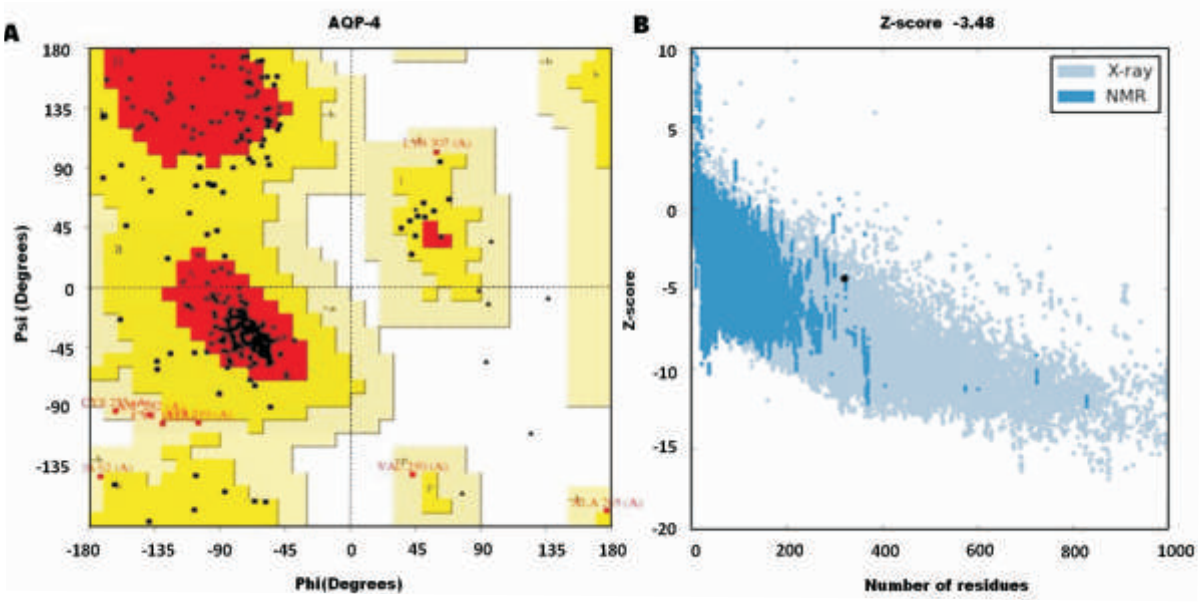


Fig. 94. Structural validation of aquaporin4 model

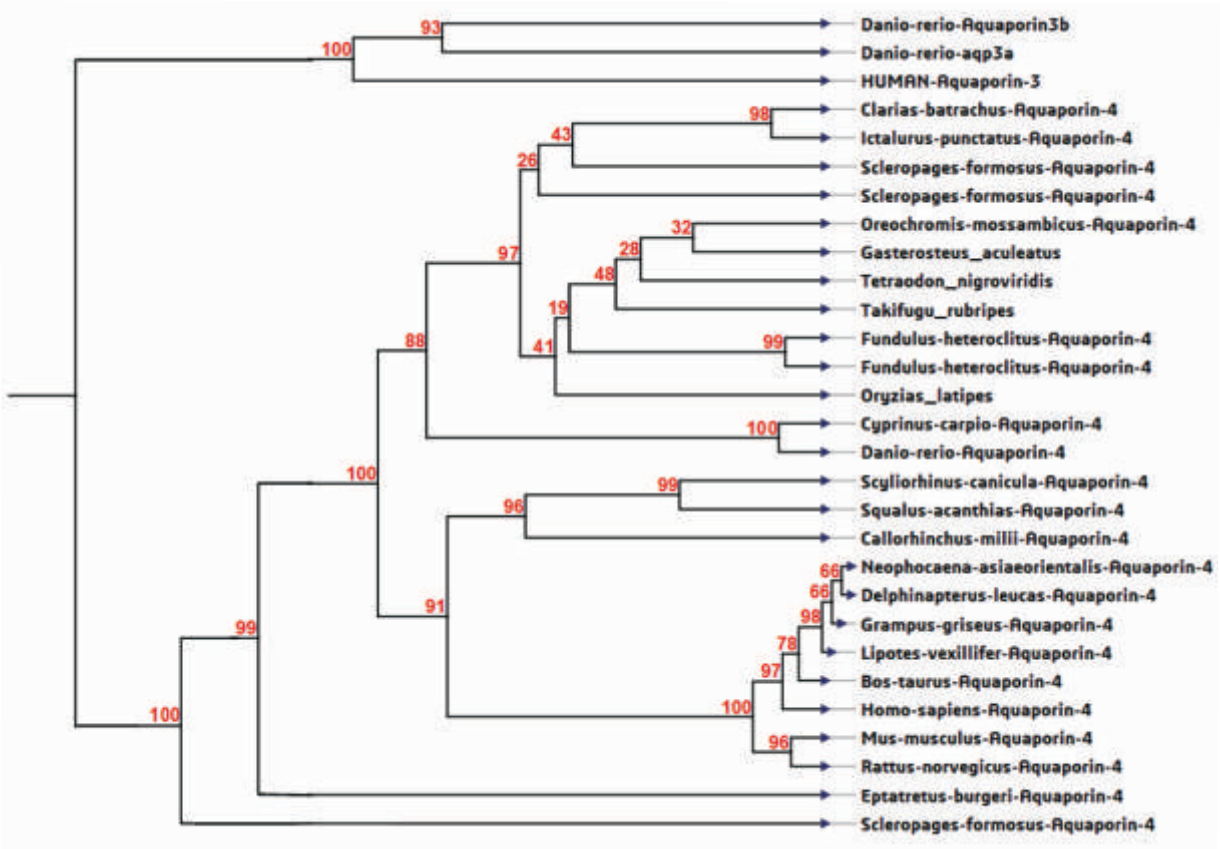


Fig. 95. Phylogenetic tree of aquaporin4 with different organism

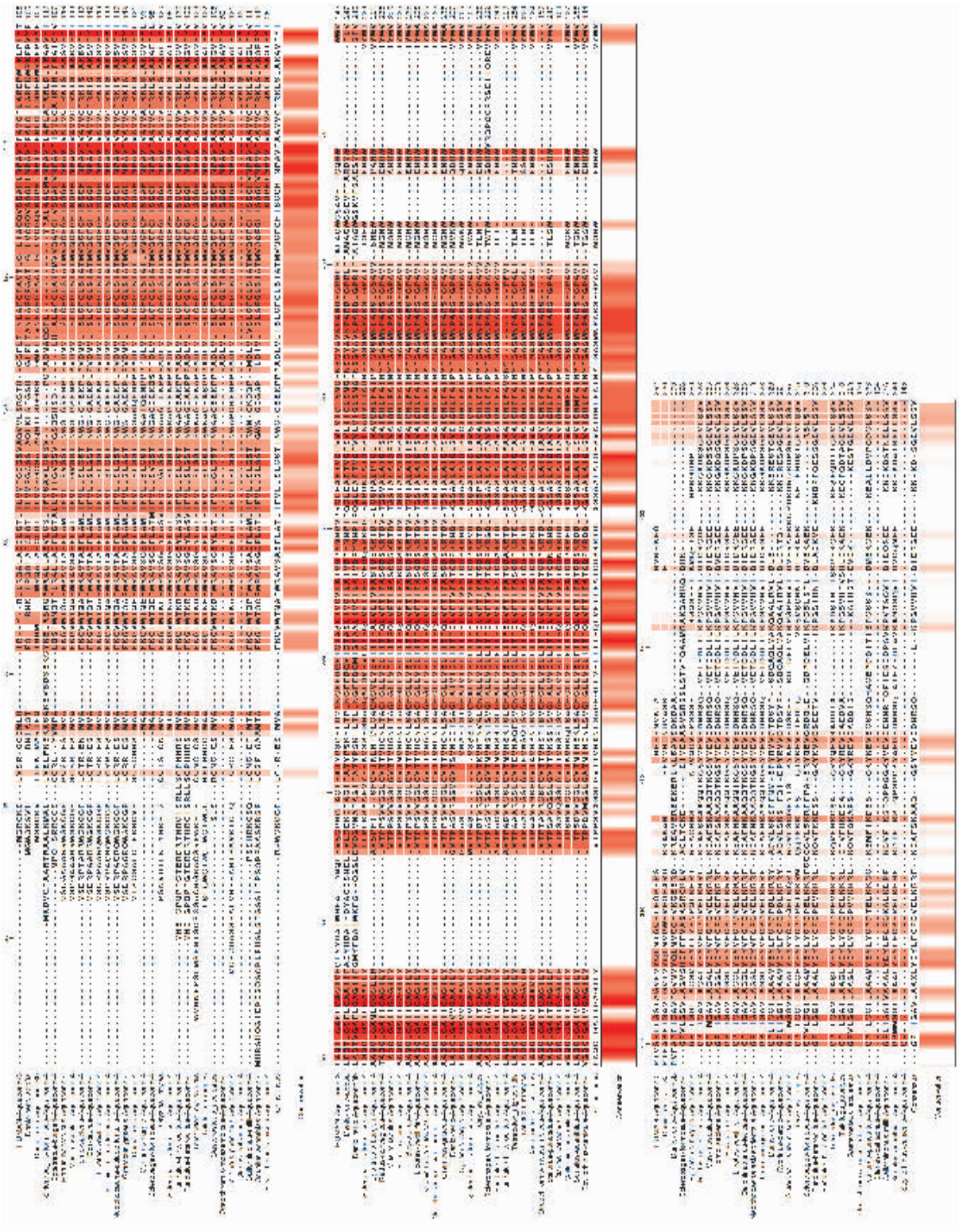


Fig. 96. Multiple sequence analysis

Project: Assessment of fish and fisheries of the Ganga river system for developing suitable conservation and restoration plan

Project staff: B. K. Das, R. S. Shrivastava, V. R. Suresh, R. K. Manna, D. N. Jha, A. Alam, Raju Baitha, Manas H. M., Mitesh Ramteke, T. Nirupada Chanu and H. S. Swain

Distribution of 158 fish species have been recorded so far from Tehri, Uttarakhand to Fraserganj, West Bengal stretch out of these, 1 no of 'Endangered', 2 nos of 'Vulnerable' and 14 nos of 'Near threatened' category as per IUCN Red list were found. A unique indigenous hook and line fishing namely “Tuka” or “Feka” was observed at Ballia, Uttar Pradesh for catching large sized Indian Major Carps (IMC). Use of zero mesh seine net in middle and lower stretch and bag net catching mostly fish larvae and juveniles in estuarine stretch were of real concern. Average concentration (µg/gm) of heavy metals in river bed surface sediments are found as, Mn (416.627) > Cr (41.556) > Zn (39.948) > Pb (31.969) > Cu (21.753) > Cd (0.354). Mass awareness generation programmes on '*Nirmal Dhara'* at Mirzapur and ranching programme at Rishikesh were organised.

Conservation status of fish species in River Ganga

The Institute is investigating the conservation status of fish species presently available in river Ganga through quarterly sampling at selected 18 stations from Tehri, Uttarakhand to Fraserganj, West Bengal. Both qualitative and quantitative distribution of 158 fish species (out of reported more than 350 fish species from entire stretch of river Ganga) have been recorded so far, out of which 1 no of 'Endangered', 2 nos of 'Vulnerable' and 14 nos are of 'Near threatened' category as per IUCN Red list. Need based ranching and other management measures like declaration of fish sanctuary etc. may be planned to restore the endangered fish species in their own habitat in river Ganga based on data generated under the project. Information generated on different chemical parameters of water like pH, dissolved oxygen, TDS, BOD, COD etc. and soil parameters like soil pH, organic carbon etc highlighted the present ecological condition of the river.

Wild IMC brooders are being collected from river Ganga

IMC brooders collected from river Ganga are maintained in a pond at Balagarh, West Bengal

A total of 118 prospective brooders of Indian Major Carps (IMC) have been collected from river Ganga and are being reared in pond at Balagarh, West Bengal. The brooders are fed with specially prepared feed for attaining maturity in captive condition so that they can be utilized for artificial breeding followed by ranching of fingerling in depleted stretches of the River Ganga.

Use of unscientific fishing gears is identified as the major reason behind loss of fish diversity as well as decline of total catch. Existing fishing gears (fishing nets, hook & line and traps) used in river Ganga are being documented with analysis of their role in sustainable fishery. As many as, sixteen different types of baits under seven categories were recorded in multiple hook & line fishery of river Ganga. Out of several fishing gears, use of zero mesh seine net in middle and lower stretch is of real concern. In estuarine stretch, bag net with very small mesh sized cod end and set barrier also observed to harvest mostly fish larvae and juveniles demeaning the very idea of sustainable fisheries.

An interesting indigenous hook and line fishing namely “Tuka” or “Feka” was observed in River Ganga during the survey at Kotwa Ghat, Saraikota, Ballia, Uttar Pradesh that is mainly used for catching large sized Indian Major Carps (IMC). Unlike normal hook and line fishery, seven number of 15 mm size hooks are being aggregated and tied to form a unified structure to capture large sized fishes. Indigenously manufactured bait made of dust of gram, mustard oil cake, jowar, etc. with lot of different types of attractants like cardamom, fenugreek, camphor etc. are being used for bait preparation. Even dolphin oil was reportedly used as attractant in the bait which is highly detrimental towards conservation of the National Aquatic Animal 'Gangetic Dolphin'. The gear is operated mainly during February to July month because of the greater availability of IMC in that particular period in lower volume of water.

The “H” shaped structure of “TUKA”/ “FEKA” fishery

Bait preparation for use in “TUKA”/ “FEKA” fishery

Concentrations of heavy metals are being monitored at all ecological niches of river Ganga to understand their bioaccumulation pattern. Average concentration (µg/gm) of heavy metals in river bed surface sediments are found as, Mn (416.627) > Cr (41.556) > Zn (39.948) > Pb (31.969) > Cu (21.753) > Cd (0.354).

Fishermen are being sensitized about such malpractices through mass awareness programmes. Local stakeholders like Fishers Cooperative Societies, NGO, peoples' representatives etc. were involved. They have also been made aware to keep the river clean to maintain '*Nirmal Dhara*' of river Ganga. One such large mass awareness programmes have been organized at Malguda village, Vindhyanchal,

Mass awareness programmes at Malguda village, Vindhyanchal, Mirzapur district of Uttar Pradesh

Mirzapur district of Uttar Pradesh in July, 2016 where more than 200 active fishers have participated.

ICAR Extramural Project : Small Indigenous Fishes to boost nutritional security : A roadmap for nutri smart village in Deltaic Sunderbans

Project staff : Aparna Roy, Md. Aftabuddin, A. Sinha and P. K. Parida

Small Indigenous Fishes (SIFs) have been contributing significantly towards rural livelihood and nutrition in Sundarban. Developing a multifaceted road map for Nutri-smart village through promotion of conservation, culture and consumption of SIFs in Madanganj area of Namkhana will be of great help towards livelihood and nutritional security.

The morbidity in the 0-5 years age group was much higher among female children (70%) of fishers compared to that of male children (30%) in Madanganj village of Sundarbans. About 27 percent of the women of the study area were under weight and 3.3% were having severe thinness. 25.5% of the children were under weight and 20% of the women were anaemic. Almost 67% of the population were deficient in blood calcium and 27% were deficient in blood phosphorous. Fishes were the sole source of animal protein for majority of the people and contributed 8% or 38 grams on an average to the daily diet, which is significantly below recommendation. After one month of feeding trial with SIFs, blood calcium was improved and the occurrence of anaemia was decreased among the women from 20% to12%. Experimental demonstration trials were conducted in four ponds to showcase the potential of SIFs in income generation and livelihood improvement. A community pond has been developed as conservation site which served as seed banks of small indigenous fishes.

Nutritional gap of the fishermen population

Morbidity Pattern

The study in the Madanganj village reveals that the morbidity in the 0-5 years age

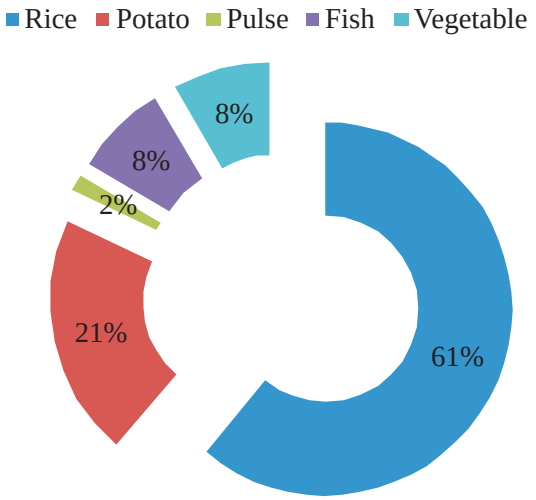


Fig. 97. Percentage distribution of food items in daily meal

group was much higher among female children (70%) compared to that of male children (30%) during June-December, 2016 period when the study was conducted. Marked difference between the two genders in the age group of 31-44 years was noticed. Further, the survey revealed that the female morbidity rate to be 53.57% which was slightly higher than that of the male (46.42%).

Food consumption pattern

The study of the food consumption pattern revealed an overwhelmingly carbohydrate based (82%) diet (Fig. 97). Percentage distribution of food items in the average daily diet reveals that rice and potato make up 61% and 21% of the daily diet respectively. Pulses contribute a measly 1% of the average daily diet due to its occasional consumption. Fishes are the sole source of animal protein for majority of the people and contribute 8% or 38 grams on an average to the daily diet, which is significantly low considering only about 17-19 grams of protein is available from 100 grams of fish.

Anthropometry

Measurements of nutritional anthropometry are based on growth in children and body weight changes in adults. The BMI is the most widely used anthropometric index for the assessment of the nutritional status in adults.

Body Mass Index (BMI)

In the present study, BMI was calculated for 300 households with average family size of 4.9. It is evident from the study that 27 percent of the women of the study area are under weight. Among the women 3.3% were having severe thinness. Among the children 25.5% are under weight followed by adult male (15%) members of the households.

Biochemical tests: Biochemical tests of selected population (30 women) for certain blood parameters were done with the help of medical professionals. Complete hemogram, blood calcium and blood phosphorus were analyzed and it was found that 20% of the women of the sampled population were anaemic. Almost 67% of the

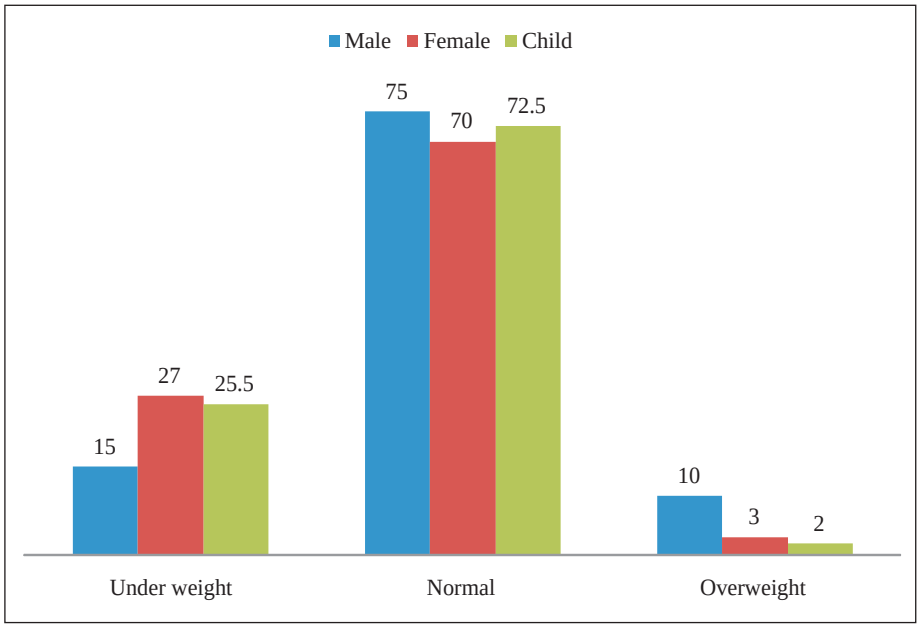


Fig. 98. Percentage distribution of sample population based on BMI

sampled populations were having deficiency in blood calcium where as 27% of them were deficient in blood phosphorous.

Small indigenous fishes in regular dietary regimes

The study shows that almost 27% women are underweight and are susceptible for being morbid. Keeping this in view, a human feeding trial was organized for one month in collaboration with the ICDS centre Madanganj, by incorporating SIFs in their daily diet for a group of women. The 30 women of age group18-35 years, married and having at least one child were selected for the trial. The anthropometry, clinical tests and biochemical tests of certain blood parameters were taken. Mola (*Amblipharingodon mola*) and Jat Puti (*Puntius sophore*) were selected for incorporating in their daily diet, as these two species were available in that area and having high Ca and good protein content. After one month of feeding trial it was found that blood calcium has been improved for almost all (Fig. 99). The occurrence of anaemia was decreased among the women from 20% to12%. But, blood phosphorus was no improved by this trial. Significant improvement could be noticed in case of blood calcium and Hemoglobin.

Table 21. Average range of blood parameters before and after the trial

Parameters	Reference interval	Before	After
Blood Calcium (mg/dl)	8.4-10.4 (Adult Male/ Female)	7.48	8.56
Blood Phosphorous (mg/dl)	4-6.5 (Children) 2.5-5 (Adult Male/ Female)	2.86	2.73
Haemoglobin (g%)	11.0-15.5 (Children) 13.0-17.0 (Adult Male) 11.0-15.0 (Adult Female)	12.20	12.33

*Child, adult male and adult female, respectively

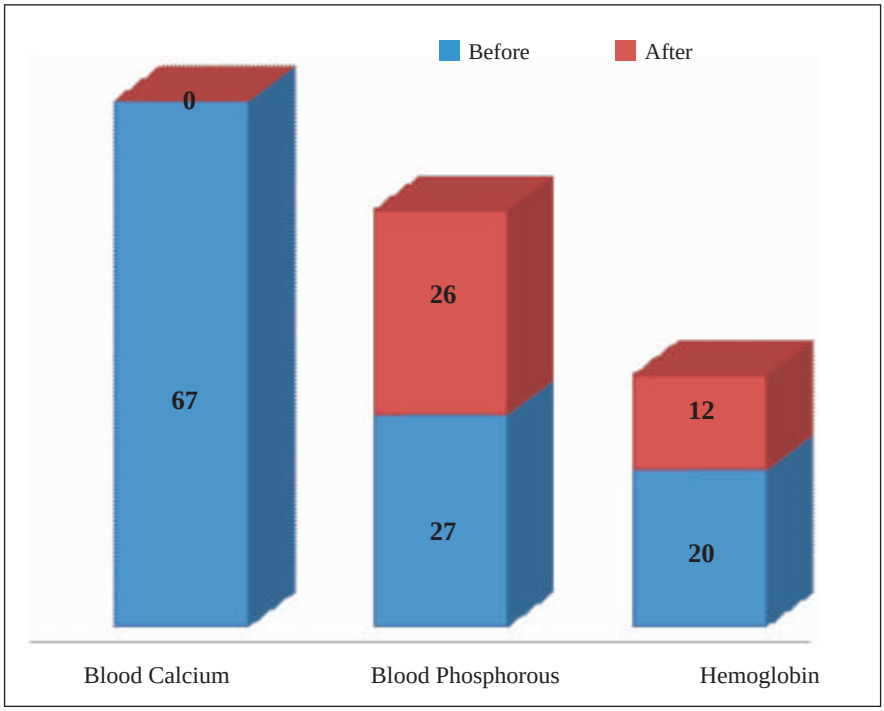


Fig. 99. Effect of SIFs feeding trial on deficiency of blood parameters (percentage of sample)

Developing 'nutri-smart villages' by promoting culture of SIFs

To conserve the valuable SIFs, suitable culture practices is necessary to revamp the situation. Experimental demonstration trials were conducted in four ponds at Madanganj village of Namkhana for six months to showcase the possibilities of SIFs in income generation vis-a-vis livelihood improvement. In pond 1, mola and chela were introduced to culture with rohu, mrigal, catla and grass carp. In pond 2, only SIFs mola, chela and punti were stocked with supplementary feed. Same species composition (mola, chela and punti) were stocked in pond 3 without giving any supplementary feed. In pond 4, fresh water prawn (galda) were stocked with Mola.

After six month culture period, the net return from the treatments (per 0.1 ha) were found to be ` 26740.6, 6103, 6925, 1398.5 from Pond1, Pond 2, Pond 3 and Pond 4 respectively. From this study it can be suggested that SIFs can be easily cultured in small ponds with less input cost. And as it can be harvested partially, so there will be a continuous flow of income. Moreover, it can be cultured in backyard ponds of the households. Culture of SIFs can be a alternative livelihood option for the women of that particular area as input cost and engagement is minimal for culturing SIF species alone. SIFs cultured in backyard ponds can also be a source of nutritional food for the households.

Development of conservation site for SIFs Culture

Owing to the reduction in availability of SIFs in the water channels of Sundarbans need was felt for conservation of these invaluable species. A community pond which is connected to a natural canal has been developed as conservation site through community participation. The SIFs seeds collected from the canals are

reared and the pond has been converted as 'seed bank'. Awareness camps, adult education programmes and group meetings have been conducted in that area to make awareness among the people about the nutritional value, source of income and livelihood. Twenty beneficiaries have been selected and seeds of SIFs have been distributed to them to culture in their own ponds and each beneficiary will distribute small fish seed from their ponds to 10 people of that village and a 'Seed chain' will develop.

Prof. P. Basu, Vice Chancellor, WBUA&FS inaugurating the conservation site for SIFs

SPECIES DESCRIPTION/ NEW RECORDS

Trichogaster lalius (Hamilton, 1822) in River Cauvery

Trichogaster lalius (Hamilton, 1822), popularly known as "Dwarf gourami" belonging to family Osphronemidae is native to Bangladesh, Nepal, Pakistan and Eastern and North-eastern India (Arunachal Pradesh, Assam, Bihar, Manipur, Uttaranchal, Uttar Pradesh and West Bengal). Feral populations also exist in other countries, including Singapore, USA and Colombia. The fish is traded as an ornamental fish in India. *Trichogaster lalius* has been reported for the first time from Thippagondanahalli reservoir. This is the first report of *T. lalius* from the Cauvery river system. Total of nine specimens were collected in various seasons. According to IUCN, this species has been categorized under 'Least concern' status.

Bangana dero (Hamilton, 1822) in Deepor beel of Assam

ICAR-CIFRI reported 67 fin-fish species in the the Deepor beel located in Kamrup district, Assam (Latitude: 26°05'26"N to 26°09'26" N; Longitude: 90°36' E to

90°41'25'' E). During October 2016 twenty eight specimens of *Bangana dero*, belongling to cyprinidae family, were collected from this beel for the first time . Total length of the reported specimens ranged from 8.77 – 10.14 cm and weight ranged from 6.74 – 10.61 g. The length-weight relationship of the species was worked out as $W = 0.074*L^{2.103}$.

Hilsa kelee in River Mahanadi

Kelee shad, *Hilsa kelee* has been recorded from the gill net catches of Mahanadi estuary near Paradip (20°20'19''N; 86°36'52'' E). This is the first record of *H. kelee* from Mahanadi estuary. Previously, the Hilsa shad, *Tenualosa ilisha* was the sole representative among shads (Subfamily: Alosinae) reported from Mahanadi estuary.

DEMONSTRATION AND TRANSFER OF TECHNOLOGY

Demonstrations

Demonstration on sustainable inland fisheries development at Sagar Island, Sundarbans, West Bengal

ICAR-CIFRI demonstrated "Empowerment of rural tribal through sustainable fisheries and utilization of underutilized/fallow water resources for livelihood security" in Khan Saheb Abad and Khas Ramkarer Char, tribal dominated villages located in Sagar Island of South 24 Parganas district, West Bengal. 10 tribal ponds were selected and the fishers were imparted training-cum-mass awareness on "Utilization of derelict open waters to rear and produce indigenous fishes for socio economic development of tribal community". Dr. B. K. Das, Director, ICAR - CIFRI distributed fishing drag nets, cast nets and a water pump (5 hp) to the tribal fisher families. Rearing of small indigenous self recruiting fishes, along with conventional carp culture provided additional income and nutritional security for the poor tribal families. Villagers and the members of Gram Panchayat evinced keen interest in producing fish from other available water bodies.

Inputs distribution to tribal fishers of Sagar Island

Fishing activity by tribal woman

Demonstration on canal fisheries development for livelihood support of tribal fishers of Sundarbans, West Bengal

Three canals (0.07 sq. km.) namely Chingrikhali-I, Chingrikhali-II and Sagunkhali under Kalitala Gram Panchayat, Hingalganj Block and two canals (0.06 sq.km) namely Adibasipara canal and Harintana canal were stocked with 5000 advanced fingerlings (TL : 8 to 10 cm) of Indian major carps /0.01 sq.km during July to September, 2016 for table size fish production. Necessary technical guidance and field demonstration were given to tribal fishers for fish health and water quality management in the canal. Forty one tribal families of Kalitala and twenty seven of Bali island were benefited from the programme.

Fish seed transportation to Bali island

Stocking of fish seed in Adibasipara canal

Demonstration on promotion of inland fisheries in check dams in tribal areas of Purulia and Burdwan district, West Bengal

A field demonstration was conducted on check dams, viz., Chakka dam and Indrabeel, in Purulia district of West Bengal during the period April to June, 2016. A five days training programme on "Livelihood improvement of tribal fish farmer through inland fisheries management" was also organized at Barrackpore for them. The advanced fingerlings (TL:8 to 10 cm) of Indian major carps were stocked @ 35,000 numbers in Chakka dam (7.0 ha.), Puncha Block; 6000 numbers each in Sarak Bundh (1.2 ha.) and Upper Bundh (1.2 ha.) under Kasipur Block of Purulia district for table size rearing. Likewise, 10,000 numbers of advanced fingerlings of Indian major carps were stocked in Gardanmari Adibasi Dighi (9.6 ha.) at Karjanachati, Burdwan district, West Bengal for grow out culture. A total of 1500 kg pelleted fish feed was distributed among tribal fishers for rearing of stocked fishes.

Fish seed stocking in Sarak Bundh, Purulia

Demonstration on fishery enhancement and conservation at Chandan Chouki, Lakhimpur-Kheri district, Uttar Pradesh

The Regional Centre of ICAR-CIFRI, Allahabad conducted demonstration activities in Chandan Chouki area, Lakhimpur Kheri district of Uttar Pradesh, under the TSP programme. The area is inhabited by 99 % of Tharu population, spread in 40 hamlets and 15 Gram Sabha's. Sixty tribal fish farmers from Ramnagar, Beladandi, Kajaria, Dhuskiya, Pachpeda, Muhnochani, Balera, Parsia, Puraina, Chhediya Purv, Chhediya Paschim, Chandan Chouki and Najhauta villages were

Fish seed in hapa for distribution

Fish seed distribution among tribal fishers

benefitted from the programme. Fingerlings of Indian major carps and exotic carps of 235 kg along with 1200 kg fish feed were distributed to 47 tribal fisher families for adoption of carp farming in their ponds. They were also imparted training on inland fisheries management.

Demonstration on fish stock enhancement in Sorbhogbeel, Barpeta district, Assam by supplementary stocking of IMCs

ICAR-CIFRI Regional Centre, Guwahati in collaboration with AFDC Ltd., carried out supplementary stocking of Indian major carps in Sorbhog *beel* (closed beel, water spread area: 34 ha) in Barpeta district of Assam under the NEH component. Fingerlings of *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala* were stocked @ 3,000 nos./ha during October 2015. The initial and final length/weight of reared fishes were as follows: catla (15.52 cm/ 43.34 g and 32.33 cm/485.67 g), rohu (13.68 cm/26.21 g and 28.54 cm/272.9 g) and mrigal (15.80 cm/34.77 g and 27.04 cm/170.23 g). Catla attained the highest growth with specific growth rate (SGR) of 1.34, followed by rohu (SGR 1.3) and mrigal (SGR 0.99).

Demonstration on *in-situ* raising of stunted carp fingerings in pen enclosures for stock enhancement in seasonally open beel

Pen aquaculture experiment was undertaken in a moderate-sized (20 ha) seasonally open floodplain wetland of Assam (Merbeel, Nagaon district) to produce stunted carp fingerlings. Four big-sized (2500 sq. m each) rectangular pens were constructed using net-lined split-bamboo screens and installed in marginal areas of the beel during August 2016. The pens were stocked with six species of carps (4 indigenous and 2 exotic) @ 5 nos./sq. m and reared for 5 months. The pens were prepared as per the technology developed by ICAR-CIFRI. Suplementary feed @ 3% of body weight, which was gradually reduced to 0.5% was provided for adapting them before release in the beel proper. After five months of rearing, the highest specific growth rate was observed in mrigal (1.45) followed by gonius (1.14), grass carp (1.11), rohu (0.86), catla (0.86), whereas silver carp recorded the lowest SGR (0.70). The average weight of the stunted fingerlings was 150.9g with 86% survival. Stunted carp fingerlings raised in the pens were released to the beel proper for stock enhancement @ 2000 nos./ha towards partial restocking of the beel following a major partial harvest from the beel during January. The benefit-cost ratio was 1.92, showing that *in-situ* raising of stunted fingerlings of carps in pen enclosures is economically viable

Commercialization of model CIFRI GI CAGE

CIFRI GI CAGE technology of the institute was commercialized on 28 January 2017. The technology was licensed to M/s Das and Kumars, Mahmoorganj, Varanasi, Uttar Pradesh through competitive bidding with one- time fee of ` 6.5 lakhs. The price of single CIFRI GI Cage unit has been fixed at ` 73,500 and a battery of 16 cages would cost ` 11,76,000 inclusive of prevailing taxes. The transport cost will be extra.

CIFRI GI Cage

Representative of M/s Das and Kumars signing the MoU

AWARDS AND RECOGNITIONS

The Director receiving "Cashless ICAR Institute Award" from Shri Radha Mohan Singh, Honb'le Minister of Agriculture & Farmers Welfare, Govt. of India, at New Delhi

Awards

Awardees	Awards
ICAR–CIFRI, Barrackpore	• The Institute received "Cashless ICAR institute award" from Shri Radha Mohan Singh, Honb'le Minister of Agriculture & Farmers Welfare, Govt of India, at New Delhi on 14 February, 2017
Dr. B. K. Das	• Received "*Krushi Ratna Award*", 2016 from Orissa Krushak Samaj, Bhubaneswar on World Food Day, 16 October, 2016 • He was also felicitated by Sahada Aqua farmer Welfare Society and by Madanganj Matsyajeevi Samabay Society, Namkhana, West Bengal
Dr. B. P. Mohanty and others	• "Best Poster Award" to paper entitled "Correlating transcript profiles of cyp1a1 and cyp1a2 in liver of *Rita rita* with water quality characteristics for evaluating their suitability as biomonitoring tools" authored by Tandrima Mitra, Arabinda Mahanty, Satabdi Ganguly, Laduram Mahaver, Samir Kumar Pal, Pranaya Kumar Parida, Sasmita Mohanty, Bimal Prasanna Mohanty, in National Seminar on Priorities in Fisheries and Aquaculture (PFA-2017) jointly organized by IFSI, CoF-OUAT, OFCAAR and CIFRI, Barrackpore, 11-12 Mar 2017, at OUAT-College of Fisheries, Rangeilunda, Berhampur, Odisha • "Best Poster Award" to "Investigations on the mechanism of thermo tolerance with the aim of identifying mitigation leads against heat stress" authored by Arabinda Mahanty, Gopal Krishna Purohit, Sasmita Mohanty, B. P. Mohanty, in 2nd International Conference on Translational Research jointly organized by Indian Society of Translational Research, JNU, New Delhi and KSBT, KIIT University at KIIT University, Bhubaneswar, 14-16 Oct, 2016, at KIIT University, Bhubaneswar

Awardees	Awards
Dr. Archana Sinha	• "Bharat Gaurav Award", 2016 from India International Friendship Society, New Delhi
Dr. A. K. Das and others	• "Best Oral Presentation Award" to paper entitled "Impact of culture-based fisheries (CBF) in Manchanbele reservoir, Karnataka" authored by A. K. Das *et al.* in National Seminar on Priorities in Fisheries and Aquaculture (PFA- 2017) jointly organized by IFSI, CoF-OUAT, OFCAAR and CIFRI, Barrackpore, 11-12 Mar 2017, at OUAT - College of Fisheries, Rangeilunda, Berhampur, Odisha
Dr. R. K. Manna and others	• "Best Oral Presentation Award" to paper entitled "Soil organic carbon accumulation in Chilika lake, India" authored by R. K. Manna, A. Raut, S.K. Banik, S. Mandal, M. Mukherjee, S.K. Karna, V.R. Suresh and B. K. Das in National Seminar on Priorities in Fisheries and Aquaculture (PFA- 2017) jointly organized by IFSI, CoF-OUAT, OFCAAR and CIFRI, Barrackpore, 11-12 Mar 2017, at OUAT - College of Fisheries, Rangeilunda, Berhampur, Odisha • "Best Oral Presentation Award" to paper entitled "Tuka or Feka Fishery- an Indigenous Fishing Practices to catch IMC in Ganga river at Ballia, Uttar Pradesh" authored by S. Samanta, R. K Manna, T. S. Bhowmik, A. Ray, A. Singh, Manas H. M, M. H. Ramteke, S. Mondal, S. K. Behera, B. K. Das National Seminar on "Priorities in Fisheries and Aquaculture' organised by COF, Rangeilunda, Odisha during 11 to 12th March, 2017
Dr. A. K. Sahoo and others	• "Best Poster Award" award to paper entitled " Hilsa, *Tenualosa ilisha* (Ham. 1882): A potential candidate species for aquaculture in South East Asia" authored by A.K. Sahoo, A.P. Sharma, Utpal Bhuamik, B.K. Behera and B.K. Das in National Seminar on Aquaculture Diversification: The way forward for blue revolution at CIFA-Bhubaneswar, 1-3 December 2016
Dr. Aparna Roy and others	• "Best Oral Presentation Award" to paper entitled "Imperatives and strategies to improve nutritional status of women in Indian Sunderbans" authored by A. Roy, A. Ghosh, S. Bayen, Md. Aftabuddin, A. Sinha and P. Parida during 8th Extension Congress 29-31 January, 2017 at NAARM Hyderabad
Shri. D. K. Meena and others	• "Young Scientist Award" to paper entitled "Utilisation of brewery waste as a feed ingredient for *Catla catla* in enclosure culture" authored by D. K. Meena, M. A. Hassan, Md. Aftabuddin, P. Mishal, U. K. Sarkar and B. K. Das from Academy of Environmental Biology on 25 November, 2016 at Hamdard University New Delhi
Shri. Dibakar Bhakta and others	• " Best Oral Presentation Award" entitled "Determination of lethal concentration of *Zanthoxylum rhetsa* seed extracts at grass carp fingerlings (*Ctenopharyngodon idella*) in captive condition" authored by S. Behera, O. Jomang, D. Bhakta, S. Kumar, S. Bakshi and S. Saha in National Symposium on "Enhancement of livelihood security through sustainable development of livestock and fishery sector" organized during 10-11th January, 2017 by WBUAFS, Belgachia, Kolkata, West Bengal

Dr. B. K. Das, Director receiving "*Krushi Ratna*" award

Recognitions 2016-17

Scientist	Recognitions
Dr. B. K. Das	• Guided Ph.D. student (Binod Bihari Behura; Thesis title: Pathogenesis and pathology of vibriosis in freshwater fishes), Department of Zoology, Utkal University, Bhubaneswar, Odisha • Supervised M.Sc. student (Pragyan Roy; Thesis Title: Molecular characterisation and expression of Mx protein in *Cirrhinus mrigala* (Hamilton), KIIT University, Bhubaneswar, Odisha • Supervised M.Sc. student (Sibasish Panda; Thesis title: Studies on the antigenic profile of OMP of *Flavobacterium columnare*), Department of Microbiology, Orissa University of Agriculture and Technology, Bhu baneswar • Supervised M.Sc. student (Debasmita Mishra; Thesis title: Effect of Biocontrol agents on pathogenic bacteria and fish). Department of Microbiology, Utkal University, Bhubaneswar, Odisha
Dr. B. P. Mohanty	• Invited lecture on "Omics technology in Fish Health and Disease Management" at ICAR Winter School on Current Trends in Molecular Diagnosis for better Health Management in Aquaculture. 15 Feb -7 Mar 2017, ICAR-CIFA, Bhubaneswar • Invited lecture on "Fish for Nutritional Security and Food Safety & Quality Control Issues" in Fish Trade Innovations in Food Safety and Security organized by OUAT, Bhubaneswar, Odisha, 8-9, March 2017, OUAT - Bhubaneswar • Supervised (Major Guide) doctoral student (Ph.D., Biochemistry), Calcutta University in Dec. 2016. Thesis Title: Investigations on arsenic toxicity in a fish model under proteomics platform
Dr. U. K. Sarkar	• Member, Institute Management Committee, ICAR-NBFGR by ICAR • Advisory committee member, UGC of the UGC SAP research programme, Department of Zoology, Guru Nanak Dev University, Amritsar by the UGC, New Delhi • External expert and reviewer of DSIR funded research project at BCKVV, Kalyani • Co- Chair and invited speaker in technical session, National Conference on Mahseer Conservation held at Indore from 8-10 September, 2016 • Technical Expert, State Fisheries Department, Govt. of West Bengal for delivering talk on the occasion on Wetland Day on 16.06.2016
Dr. B. K. Bhattacharjya	• Member, Board of Directors, AFDC Ltd., Guwahati by Department of Fisheries, Govt. of Assam, Guwahati as an experienced researcher on beel fisheries • Expert for a Phone-in-live programme on 'Fisheries management of beels' for Doordarshan Kendra, Guwahati • Expert Member of Assam State Biodiversity Board, Guwahati
Dr. K. D. Joshi	• Delivered a radio talk on "*Matsya Palan ka Vaigyanik Tarika*" at All India Radio, Allahabad on 03.08.2016
Dr. M. Aftabuddin	• Member, Editorial Board of Inland Fisheries Society of India, Barrackpore • Supervised Ph. D. Student (Biochemistry), Vidyasagar University for thesis on 'Understanding biochemical changes due to thermal stress of carp fishes and their mitigation measures'
Dr. A. K. Sahoo	• Member, Expert Appraisal Committee, Minsitry of Environment, Forest and Climate Change, New Delhi • Invited speaker in three days training programme on "Prevention and management of fish and shrimp diseases" 14-16th Feb. 2016, Barasat, NSPAAD, CoF, West Bengal
Dr. Pronob Das	• Expert in Krishi Darshan Programme on "Aquaculture and Fish health", Doordarshan Kendra, Guwahati
Shri. D. K. Meena	• Represented ICAR-CIFRI as Director Nominee in Global Rajasthan Agritech Meet (GRAM) and delivered a lecture on "Status and possibility of fisheries in Rajasthan during 24-27th May, 2017 at Kota, Rajasthan"

Ms. Sibina Mol S.

Ms. Sibina Mol S. was adjudged the Best Woman Athlete in the ICAR Eastern Zonal Sports held at ICAR-NRRI, Cuttack during 6-9 March 2017. She won four Gold, one Silver and one Bronze medals.

The institute has also won Gold medals in Table Tennis (TT), both in individual and team events. The TT team comprised of Sh. Sukumar Sarkar, Sh. Somnath Banerjee, Sh. Debasish Singha, Sh. P. R. Mahata and Sh. Swapan Das. Sh. M. Roy also won the Silver medal in javelin throw.

ICAR-CIFRI Sports Contingent

TRAINING AND CAPACITY BUILDING

Training and capacity building attended by staff members

Sl. No.	Name of the programme	Date	Participants	Organizer and venue
1	Preparation, Appraisal Monitoring and Evaluation of Fisheries Project	25-29 April 2016	Arun Pandit and Mishal P.	NFDB, Hyderabad
2	Professional Attachment Training	18 May-18 August 2016 18 May-18 August 2016 21 May-21 August 2016	Pritijyoti Majhi Tasso Tayung Himanshu Sekhar Swain	ICAR-CIFE, Mumbai ICAR-CMFRI, Karwar Research centre ICAR-CMFRI, Mandapam Regional centre
3	Hospitality Management for Technical Officers	10-12 August 2016	K. Sucheta Majumdar	ICAR- NAARM, Hyderabad
4	Competency Enhancement Programme for Technical Officers	17-26 August 2016	S. Manoharan	ICAR- NAARM, Hyderabad
5	Biofloc Technology: Basic concepts, Benefits and Application in Aquaculture	15-17 September 2016	Himanshu Sekhar Swain	ICAR-CIBA, Chennai
6	Synthesis and Characterization of Nanomaterials for Agricultural Applications	19-28 September 2016	S. K. Nag	ICAR-CIRCOT, Mumbai
7	e-Procurement Implementation for Technical Officers	26-28 September 2016	K. Sucheta Majumdar	ICAR- NAARM, Hyderabad
8	Fisheries Project Formulation	27 November - 03 December 2016	Gunjan Karnatak	NFDB, Hyderabad and National Institute of Plant Health Management, Hyderabad

Sl. No.	Name of the programme	Date	Participants	Organizer and venue
9	Good Laboratory Practices for Technical Staff of ICAR	27 November - 03 December 2016	Ladu Ram Mahaver and Samir Kumar Paul	ICAR-CIFE, Mumbai
10	Competency Enhancement Programme for Technical Officers	28 November - 07 December 2016	Dipak Kumar Biswas and Sanjay Bhowmick	ICAR- NAARM, Hyderabad
11	Water Quality and its Management	19-21 December 2016	S. K. Srivastava	CPCB Sponsored, National Institute of Hydrology, Roorkee
12	Application of Molecular Markers in Fish Breeding	31 January - 09 February 2017	A. Alam	ICAR-CIFE, Mumbai
13	Application of Medicated Feed in Aquaculture	13-23 February 2017	D. K. Meena	ICAR-CIFE, Mumbai
14	Instrumentation Techniques for Analysis of Soil, Plant and Water	13-22 February 2017	Debasis Saha and Subrata Das	ICAR-IARI, New Delhi
15	Simulation Modelling for Climate Impact Assessment	14-18 February 2017	R. K. Raman	ICAR-IISS, Bhopal
16	Analysis of Experimental Data	20-25 February 2017	Jitendra Kumar	ICAR-NAARM, Hyderabad
17	Competency Enhancement Programme for Effective Implementation of Training Functions by HRD Nodal Officers of ICAR	23-25 February 2017	S. K. Nag	ICAR-NAARM, Hyderabad
18	Water Quality and its Management	20-24 March 2017	Vijay Kumar	National Institute of Hydrology, Roorkee

Training Imparted

TSP Farmers Training

Sl. No.	Name of the training	Date	Venue	Participants
1	Livelihood Improvement of Tribal Fish Farmer Through Inland Fisheries Management	30 March-04 April 2016	ICAR-CIFRI, H.Q. Barrackpore	28 tribal farmers from Purulia under TSP programme.
2	Livelihood improvement of tribal fish farmer through inland fisheries management	22 October 2016	Paharpur, Murshidabad (On-field)	150 fishers/fish farmers of Paharpur, Murshidabad under TSP programme

Officials Training

Sl. No.	Name of the training	Date	Venue	Participants
1	Inland Fisheries Management	29-01 August 2016	ICAR-CIFRI, H.Q. Barrackpore	12 Officials from DoF from Chhattisgarh
	Application of Statistical Tools for Assessment of Aquatic Ecology and Fisheries	02-12 October 2016	-do-	Six staff of Chilika Development Authorities
2	Inland Fisheries Management	22-26 November 2016	-do-	16 Officials from DoF, Madhya Pradesh, Chattarpur

Fishers/ fish farmers Training

Sl.No.	Name of the training	Date	Venue	Participants
1	Inland open water fisheries management & development	02-08 June 2016	ICAR-CIFRI, H.Q. Barrackpore	24 farmers from Muzaffarpur, Bihar (DoF)
2	-do-	22-28 June 2016	-do-	26 farmers from EastChamparan, Bihar (DOF)
3	-do-	02-08 July 2016	-do-	30 farmers from WestChamparan, Bihar (DoF)
4	-do-	22-28 July 2016	-do-	27 farmers from Vaishali, Bihar (DoF)
5	-do-	04-10 August 2016	-do-	25 farmers from Gopalgunj, Bihar (DoF)
6	-do-	22-28 August 2016	-do-	26 farmers from Saran, Bihar (DoF)
7	-do-	02-08 September 2016	-do-	28 farmers from Samastipur, Bihar (DoF)
8	-do-	17-23 September 2016	-do-	28 farmers fromSaharsa, Bihar (DoF)
9	Development of freshwater ornamental fisheries sector of Northeast India	04-06 October 2016	ICAR-CIFRI, R. C. Guwahati	56 ornamental fishers and entrepreneurs
10	Inland open water fisheries management & development	13-19 October 2016	ICAR-CIFRI, H.Q. Barrackpore	26 farmers from Madhepura, Bihar (DoF)
11	-do-	09-15 November 2016	-do-	30 farmers from Katihar, Bihar (DoF)
12	-do-	15-17 November 2016	-do-	13 farmers from Tripura and Assam (Sponsored by Tata Trusts)
13	-do-	17-23 November 2016	-do-	26 farmers from Araria, Bihar (DoF)
14	-do-	03-09 December 2016	-do-	25 farmers from Kishagunj, Bihar (DoF)
15	-do-	16-22 December 2016	-do-	26 farmers from Bhagalpur, Bihar (DoF)
16	-do-	23-26 December 2016	-do-	31 farmers from Mayurbhajn (DoF), Odisha.
17	-do-	03-09 January 2017	-do-	29 farmers from Begusarai, Bihar (DoF)
18	-do-	25-31 January 2017	-do-	24 farmers from Sheikhpura, Bihar (DoF)

Students Training

Sl. No.	Name of the training	Date	Venue	Participants
1	Inland Fisheries Management	15 - 24 July 2016	ICAR-CIFRI, H.Q. Barrackpore	P.G. Students from P. K. Roy Memorial College, Dhanbad (14) & P.G. Students from Vinoba Bhave University, Hazaribag(6),Total 20 students
2	-do-	06 - 16 August 2016	-do-	7 M.F. Sc. Students from ICAR-CIFE Mumbai under FRM Division
3	-do-	16 August - 15 September 2016	-do-	6 M.F. Sc. Students from ICAR-CIFE Mumbai under FRM Division
4	-do-	24 November - 01 December 2016	-do-	24 B.Sc. (IFF) students from APC College, New Barrackpore & 4 students from M.L.S.M. College, Darbhanga, Total 28 students
5	-do-	15 - 22 March 2017	-do-	30 P.G. Students from VinobaBhave University, Hazaribag
6	-do-	23 March - 01 April 2017	-do-	25 P.G. Students from P. K. Roy Memorial College, Dhanbad
7	-do-	28-31 March 2017	-do-	44 P.G. Students from Utkal University, Bhubaneswar, Odisha.
8	Job training programme on Industrial fish and fisheries	03-08 March 2017	Regional Centre, ICAR-CIFRI, Guwahati	50 students of Cachar College, Silchar


ICAR-CIFE Students with Institute Staff

Exposure / Educational Visits

Sl. No.	Particulars of visitors	Date of visit
1	7 M.Sc. (4th Semester with Fish Biology & Fishery Science) students & 2 Professors In charge from Department of Zoology, Pandu College, Guwahai University	21 April 2016
2	43 B.F.Sc. (Final year) students & 2 Professors In charge from College of Fisheries, Mangalore	03 May 2016
3	12 P.G. students, Dept. of Zoology (Fishery & Aquaculture Special) & 2 Professors In charge from Vidyasagar College, Kolkata	01 June 2016
4	23 School Teachers from K.V.	06 June 2016
5	20 trainees from Manipur, IFTC	25 July 2016
6	21 M.F.Sc. students (3rd year) &1 Assistant Professor In charge from College of Fisheries, Nellore, Andhra Pradesh	06 August 2016
7	16 B.F.Sc. students from College of Fisheries, Raha, Assam	14 September 2016
8	20 final year B.F.Sc. students & 2 Professors In-charge from College of Fisheries, GBPUAT, Pantnagar, Uttrakhand	18-21 September 2016
9	24 B.F.Sc. students from College of Fisheries, Chakgaria	23 September 2016
10	2 Scientists from ICAR-CIFE, Mumbai	14 October 2016
11	24 M.Sc. (3rd semester) students &2 Professors In charge from Department of Zoology, North Bengal University, Darjeeling	31 October 2016
12	7 Officials from DoF, Himachal Pradesh	19 November 2016
13	31 B.F.Sc. students from College of Fisheries, Ratnagiri, Maharashtra	01 December 2016
14	134 B.Sc. students (1st, 2nd, 3rd year) & 4 Professors In charge from Dum Dum Motijheel College, Dum Dum, Kolkata	14 December 2016
15	30 B.F.Sc. students & 2 Professors In charge from College of Fisheries, Mangaluru, Karnataka	15 December 2016
16	20 B.Sc. (3rd year) students & 1 Professor In charge from Anandamohan College, Raja Ram Mohan Sarani, Kolkata	16 December 2016
17	19 B.F.Sc.students & 2 Professors In Charge from College of Fisheries, GADVASU, Ludhiana	02 January 2017
18	Block level exposure visit programme for the Farming Community under ATMA Programme. (Progressive farmers, KPS, Staff and FEO from Barasat, Nilgunj, Babpur) Total persons = 69	05 January 2017
19	9 B.Sc. students & 1 Professor In Charge from Maharaja Manindra Chandra College, Kolkata	16 January 2017
20	25 B.F.Sc. (3rd Year) students & 2 Professors In Charge from college of Fisheries, Kawardha, Chhattisgarh	23 January 2017
21	14 B.Sc. (3rd Year) students & 2 Professors In Charge from Sri Kishan Sarda College, Hailakandi, Assam	24 January 2017
22	9 Progressive Fish Farmers & 1 AFDO from A & N Island, Port Blair	06 February 2017
23	20 Fish Farmers from & NGO members from Nagaon Assam	14-16 February 2017
24	9 P.G. students, Dept. of Zoology (Fishery & Fishery Science) & 1 Assistant Professor In charge from Darrang College, Tezpur (Assam)	29 March 2017

Exhibitions

Sl. No.	Date	Particulars	Place
1	24-25 April 2016	Punjab Fish Festival-2016	GADVASU, Ludhiana
2	27-29 April 2016	3rd PAF Congress and Seminar on Social entrepreneurship in aquaculture	ICAR-CIFE, Mumbai
3	10-14 August 2016	20th National Agriculture Exhibition, organised by Central Calcutta Science & Culture Organization for Youth	Surer Math, Dum Dum
4	22-23 September 2016	Jharkhand Matsya Mahotsav-2016	Vidhan Sabha Ground, Dhurwa, Ranchi
5	16 October 2016	World Food Day function, organised by Orissa Krushak Samaj, Bhubaneswar	Institute of Engineers Sachivalaya Marg, Bhubaneswar
6	28-29 November 2016	Pig-Expo	ICAR-NRC of Pig, Rani, Guwahati Assam
7	28-30 November 2016	Regional Agriculture Fair (Krishi Kumbh-2016)	Muzaffarnagar, U. P.
8	01-03 December 2016	National Seminar on 'Aquaculture Diversification: the way forward for Blue Revolution'	ICAR-CIFA, Bhubaneswar.
9	16-19 December 2016	Alukarbarh Seba Sangha.	Purba Medinipur.
10	20-29 December 2016	Sunderban-KrishtiMela-O-LokoSanskritiUtsab, organised by Kultali Milan Tirtha Society	Kultali, 24 PGS (S)

Cont.....

Exhibition Continued .....

Sl. No.	Date	Particulars	Place
11	22-31 December 2016	Sunderban Yuba Mela-2016, Organised by Bahurpee Sangha, Taldi	Taldi Mohan Chand High School Compound, 24 Pgs. (S)
12	24-31 Decem,ber 2016	NaihatiUtsav- 2016	Bijoynagar, Naihati.
13	06-12 January 2017	21st Agriculture-Industry-Tourism & Science Festival, organised by Contai Pallpara Saradadevi Mahila Mondal	Baruipur Science Fair Campus, Purba Medinipur
14	06-09 January 2017	4th Assam International Agri-Horticultural Show	Khanapara, Guwahati
15	08-15 January 2017	Srijani Sangha, Manmohan Mela	Chotojagulia, 24 Pgs.(N)
16	23-30 January 2017	10th Sunderban Lokoprio Utsav-2017	Basanti, 24 Pgs.(S)
17	13 February 2017	Foundation Stone Laying Ceremony of KVK, Nilgunj	ICAR-CRIJAF, Barrackpore
18	03-05 February 2017	2nd national Students Convention on Innovative Approaches for Academic Excellence in Higher Fisheries Education	ICAR-CIFE, Mumbai
19	11-12 March 2017	National Seminar PFA-2017, organized by ICAR-CIFRI, IFSI, Barrackpore & CoF, OUAT, OFCAAR Rangeilunda, Odisha	CoF, OUAT, Rangeilunda, Odisha
20	25-27 March 2017	Science & Technology Fair & Exhibition	Institute of Engineering and Management, Salt Lake, Sector - V, Kolkata

Mass Awareness

Sl. No.	Programme	Date	Venue	Participants
1.	Fish Health Awareness Camp under NASPAAD (National; Aquatic Surveillance Programme on Aquatic Animal Diseases) & *Mera Gaon Mera Gaurav* programme	05 November 2016	Bantala village, East Kolkata Wetlands	Fishers/Fish Farmers
2.	Fish health management in aquaculture and open water systems	28-29 December 2016	Sargachi, Murshidabad, West Bengal	Fishers/Fish Farmers
3.	Mass awareness camp-cum-Kishan Ghosthi	13 January 2017	Akaipur village, North 24 Parganas, West Bengal	Fishers/Fish Farmers
4.	Mass awareness camp-cum-Kishan Ghosthi	20 January 2017	Bishnupurbeel, Berhampore, Murshidabad, West Bengal	Fishers/Fish Farmers
5.	Livelihood improvement of the rural women through integrated wetland management in Damos beel	24 March 2017	Sujapur, Murshidabad, West Bengal	Fishers/Fish Farmers

ONGOING PROJECTS

Institutional Projects

Programme: Restoration of rivers and estuaries for ecosystem integrity and conservation of fish stocks

Project Code	Project Title	Scientists
REF/ER/12/01/02	Population characteristics of small indigenous fishes (SIFs) in rivers and associated ecosystems in relation to rural livelihood and nutritional security	A. Sinha, S. K. Das, A. Roy, S. Roy, Kavita Kumari, Raju Baitha, S. K. Koushlesh, Nirupada Chanu, P. Gogoi and Mitesh H. Ramteke
REF/ER/12/01/03	Assessment of environmental variability, nutrient dynamics, biodiversity, fish stock assessment of selected estuarine and mangrove ecosystems	S. K. Das, R. K. Manna, Roshith CM., D. Sudheesan, D. Bhakta, Manas, H. M., S. Roy, W. A. Meetei, T. Nirupada Chanu, S. K. Koushlesh, Vaisakh G., V. L. Ramya and P. Gogoi
REF/ER/12/01/05	Quantification of environmental flows requirement for ecosystem functions in rivers with special focus on fisheries	A. K. Sahoo, Roshith CM., S. Das Sarkar, Rohan K. Raman, Manas, H. M., Kavita Kumari, Simanku Borah, Lianthuamluaia and Shravan K. Sharma
REF/NR/12/01/06	Impact assessment of multiple habitat alterations on ecosystem functions and fisheries in the river Ganga	K. D. Joshi*, R. S. Srivastava, D. N. Jha, M. A. Alam, Vaishak G, J. Kumar, S. C. S. Das and A. K. Yadav

*Upto 30.11.2016

Programme: Ecosystem based fisheries management in reservoirs and wetlands

Project Code	Project Title	Scientists
RWF/NE/12/02/01	Sustainable management of floodplain wetlands for enhanced fishery and livelihood	B. K. Bhattacharjya, B. K. Das, U. K. Sarkar, M. A. Hassan, D. Debnath, S. Yengkokpam, A. K. Yadav, P. Das, S. C. S. Das, D. N. Jha, M. Aftabuddin, D. K. Meena, M. A. Alam, Arun Pandit, Sandhya K. M, Lianthuamluaia, Suman Kumari, Vikash Kumar, Vaishak G, J. Kumar, Niti Sharma, Simanku Borah, N. Samarendra Singh, Mishal P. and Priti J. Majhi
RWF/SR/12/02/02	Habitat characteristics, fish assemblage and stock dynamics and impact of stocking in selected reservoirs	D. S. K. Rao*, U. K. Sarkar, M. Karthikeyan, R. Palaniswamy, P. Panikkar, D. Bhakta, Sandhya, K. M., T. T. Paul, V. L. Ramya, Suman Kumari, Lianthuamluaia, Vikash Kumar, Gunjan Karnatak, Mishal P., Sibina Mol S., A. K. Bera, Himanshu S. Swain, Tasso Tayung and Priti J. Majhi
RWF/SR/12/02/03	Application of acoustics and trophic models for ecosystem – based fisheries management in reservoirs	M. F. Khan, P. Panikkar, V. L. Ramya and Sibina Mol S.
RWF/ER/12/02/04	Refinement of enclosure fish culture (pens and cages) in reservoirs and wetlands for production of stocking materials and table fish	A. K. Das, B. K. Das, U. K. Sarkar, D. N. Jha, A. Alam, Suman Kumari, Vikash Kumar, Gunjan Karnatak, A. K. Bera, Himanshu S. Swain and Tasso Tayung

*Upto 31.10.2016

Programme: Environment and health monitoring of inland open waters for ecosystem amelioration

Project Code	Project Title	Scientists
FREM/ER/12/03/02	Monitoring and benchmarking of ecosystem health of major river systems in India	S. Samanta, S. K. Nag, M. Naskar, D. Sudheesan, Sajina A. M., Raju Baitha and Vikas Kumar
FREM/ER/12/03/03	Developing microbiological protocols for bioremediation of polluted aquatic environment	S. K. Manna, S. K. Nag, Md. Aftabuddin, P. Maurye and S. Das Sarkar
FREM/ER/12/03/05	Development of biotechnological tools for inland aquatic ecosystem health assessment	B. P. Mohanty, D. Karunakaran, T. Abdulla, P. K. Parida, Prajna R. Behera, Vikas Kumar and S. N. Sahoo
FREM/ER/12/03/06	Biomanipulation of fishes for eutrophic lake restoration	M. K. Bandyopadhyay and D. Das
FREM/ER/12/03/07	Acquisition of fish catch data and resource mapping of inland open –waters on GIS platform, using modern tools	S. K. Sahu, P. Maurye, D. Karunakaran, T. T. Paul and P. K. Parida
FREM/ER/12/03/08	Inference on fisheries of some selected open water through data mining and generalized linear models	M. Naskar, D. Das, S. K. Sahu, G. Chandra, Rohan Kumar Raman and T. Abdulla

Programme: Economic valuation of inland fisheries resources in India

Project Code	Project Title	Scientists
AES/ER/12/04/01	Preparation of inventory of inland open waters according to their institutional arrangement and governance and mapping of fisher's livelihood assets	G. Chandra, M. Naskar, S. K. Sahu, A. Roy and A. Ekka
AES/ER/12/04/02	Valuation of goods and services in inland open waters	Arun Pandit, A. Ekka, A. Sinha and Rosith CM.

Outreach projects

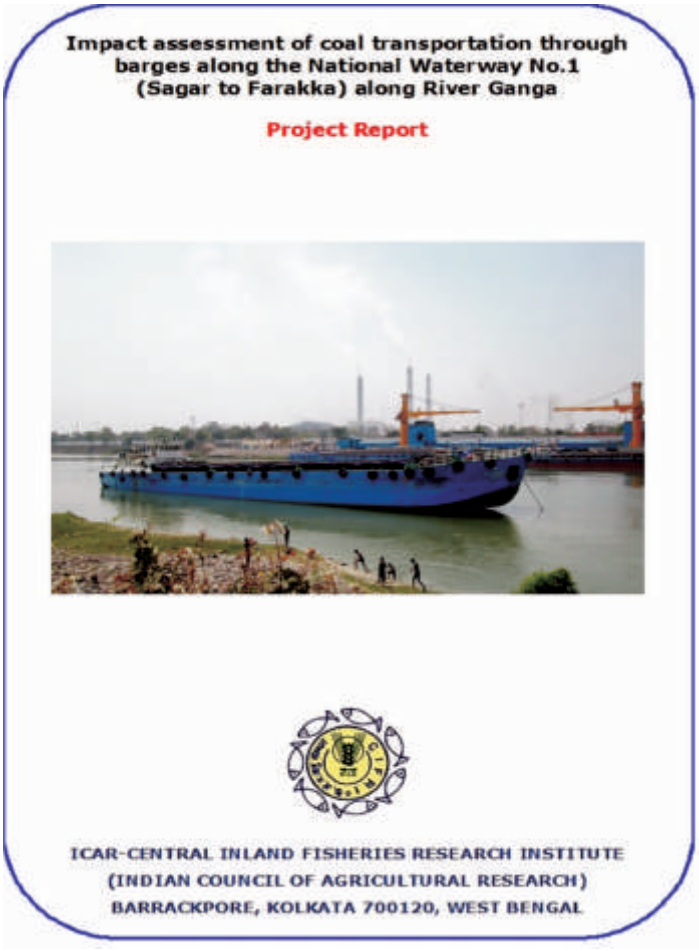
Project Code	Project Title	Scientists
OR/ER/08/09/03	Nutrient profiling and evaluation of fish as a dietary component	B. P. Mohanty, A. Sinha, D. Karunakaran, D. Debnath, R. K. Raman, T. Abdulla, P. K. Parida, Sona Yengkokpam and Prajna R. Behera
OR/ER/08/09/01	Carp culture in cages and pens using feed	M. A. Hassan, Md. Aftabuddin, D. K. Meena and Mishal P.
OR/ER/08/09/02	Fish genetic stocks	B. K. Behera, D. K. Meena, P. Das, D. Bhakta, Kavita Kumari and P. K. Parida

Externally funded projects

Project	Scientists	Sponsoring agency
Strengthening of database and geographical information system of the fisheries sector	V. R. Suresh (upto 29.07.16), B. K. Das Malay Naskar, K. D. Joshi, B. K Bhattacharya, M. Karthikeyan, S. K. Sahu, D. N. Jha and Mishal, P.	DAHD&F: Database-GIS
Assessment of fish and fisheries of the Ganga river system for developing suitable conservation and restoration plan	B. K. Das, R. S. Srivastava, V. R. Suresh, R. K. Manna, D. N. Jha, A. Alam, Raju Baitha, Manas H. M., Mitesh Ramteke, T. Nirupada Chanu and H. S. Swain	Namami Gange programme
Stock characterisation, captive breeding, seed production and culture of Hilsa (*Tenualosa ilisha*)	V. R. Suresh, B. K. Behera, R. K. Manna, Sajina A. M and K. M. Sandhya	NASF
Assessment of spawning behavior of major fish species in inland environments with a view to harness the beneficial effects of temperature	U. K. Sarkar, D. S. K. Rao, K. D. Joshi, B. K. Bhattacharjya, S. K. Nag, M. Naskar, M. Aftabuddin, A. Pandit, P. Panikkar, A. K. Sahoo, D. Sudheesan, S. Das, A. K. Yadav, D. Debnath, G. Karnatak, Vaishakh G. and Sibina Mol S.	NICRA
National surveillance programme for aquatic animal diseases	B. K. Behera, S. K. Manna, A. K. Sahoo, P. Das and B. K. Bhattacharjya	NFDB-NSPAAD
Metagenomic Applications and transcriptome profiling for inland aquatic environmental health surveillance	B. K. Behera and S. K. Manna	ICAR-IASRI
Small Indigenous Fishes to Boost Nutritional Security: A Roadmap for nutri smart village in Deltaic Sunderbans	Aparna Roy, A. Sinha, Md. Aftabuddin and P. K. Parida	ICAR-Extramural
Identification and characterization of aquaporin gene from freshwater catfish *Clarias batrachus* and their expression during reproduction	B. K. Behera and A. K. Sahoo	DBT
All India Network Project on Fish Health	S. K. Manna, S. K. Nag, P. Panikkar, A. Ekka, D. Debnath, Raju Baitha and Vikash Kumar	ICAR-CIBA
Development of standard protocols and molecular tools for fish food authentication food safety and quality assurance	B. P. Mohanty, A. K. Sahoo and P. K. Parida	FSSAI

Consultancy Projects (2016-17)

Sl. No	Name of the Project	Funding Agency
1.	Post-restoration assessment of the ecology and fisheries diversity of Chilika Lake	Chilika Development Authority
2.	Study of minimum environmental flow requirement for aquatic life in River Tangon for Attunli Hydroelectric Power project	Attunli Hydroelectric Power Company Limited
3.	Implementation of cage culture scheme in State Reservoirs	Directorate of Fisheries, Govt. of Himachal Pradesh
4.	Impact assessment of coal transportation through barges along the National Waterways No. 1 (Sagar to Farakka) along river Ganga	IWAI
5.	Study on assessment of efficacy of Fish Pass/ Fish Ladders in Teesta Low Dam III and Teesta Low Dam IV Power Stations, West Bengal	NHPC Limited



NATIONAL SEMINAR ORGANISED

National Seminar on "Priorities in Fisheries and Aquaculture"

ICAR-CIFRI, in collaboration with the College of Fisheries, OUAT, Rangeilunda, Odisha; Inland Fisheries Society of India and Odisha Fisheries College Alumni Association (OFCAAR) jointly organized the National Seminar on "Priorities in Fisheries and Aquaculture(PFA)" at College of Fisheries, Rangeilunda, Berhampur, Odisha during 11-12, March 2017. Chief Guest in the inaugural session was Shri Bishnupad Sethi, IAS, Commissioner cum Secretary, Government of Odisha. Dr. B.K. Das, Director ICAR-CIFRI, Barrackpore was Convener of the event while Dr. Joy Krushna Jena, Deputy Director General (Fisheries Science), ICAR, New Delhi delivered presidential address. Dr. (Mrs) S. Mishra, Director, College of Fisheries, Rangeilunda, Dr. N. P. Srivastava, Secretary, Inland Fisheries Society of India, Kolkata Dr. N. Sarangi, former Director, ICAR-CIFA, Bhubaneswar, Dr. S. Dam Roy, Director, ICAR-CIARI, Port Blair, Dr. S. D.Tripathi, Former Director & VC,

Inaugural ceremony of the PFA

ICAR-CIFE, Mumbai and Dr. Dilip Kumar, former Director ICAR-CIFE, Mumbai and FAO Expert spoke on the occasion. A Souvenir, Book of Abstracts, few technical bulletins namely Phytoplankton of river Mahanadi in Odisha, India- A pictorial guide; Fishes of River Mahanadi in Odisha, India: A field guide; Hindi magazine "Nilanjali", and OFCAAR alumni profile book were released by the Chief Guest. OFCAAR website was also hosted in this event.

Inaugural speech by Shri Bishnupad Sethi, Chief Guest

Speech by Dr. J. K. Jena, DDG (Fisheries Sc.)

Welcome address by Dr. B. K. Das, Convener, PFA

MEETINGS

IRC meeting

The Institute Research Committee Meeting 2015-16 was held at Barrackpore during May 23-25, 2016. Dr. V. R. Suresh, Director (Acting), ICAR-CIFRI chaired the meeting. All the scientists including the scientist probationers attended the meeting. The house recounted the contributions of Prof. A. P. Sharma, former Director of the Institute, and paid tributes to two CIFRIans, Prof. H. P. C. Shetty and Mr. James Murmu, who passed away recently. The Chairman stressed that the research programmes of inland open water fisheries need to be based on ecosystem approach with focus on sustainable management. All scientists presented their achievements and recommendations were made for the research projects.

IRC meeting in progress

Participants of IRC Meeting

Launching of project under *Namami Gange*

Launching ceremony of the project "Assessment of Fish and Fisheries of the Ganga

Project launch meeting at Barrackpore

Project launch meeting at Allahabad

River System for Developing Suitable Conservation and Restoration Plan" sanctioned by National Mission for Clean Ganga (NMCG) under *Namami Gange* was held on July 07, 2016 simultaneously at the Institute Head Quarter, Barrackpore and Allahabad Regional Centre. The programme at Head Quarter was graced by Prof. R. K. Kole, BCKV, as Chief Guest and Dr. M. K. Das, Former Head, ICAR - CIFRI as Guest of Honour. The launching function at Allahabad Centre was inaugurated by Shri Shyama Charan Gupta, Member of Parliament (M.P.), Allahabad. Various activities envisaged under the project during its 5 years duration was discussed.

NFDB sponsored workshop on "Formulation of guidelines for cage culture in India"

A meeting was organized by NFDB, Hyderabad at ICAR-CIFRI, Barrackpore on 30 July, 2016 to prepare a draft document on interim guidelines for sustainable cage culture in India. Dr. V. V. Sugunan, Senior Consultant, NFDB chaired the meeting and Dr. S. D. Tripathi former Vice-Chancellor, ICAR-CIFE co-chaired the meeting.The meeting was attended by Dr. B. K. Das, Director, ICAR-CIFRI; Dr. B.C. Jha, Former Head, ICAR-CIFRI; Johnson D Cruz, Project Manager, RGCA; Dr. V. R. Suresh, Head, REF Division, ICAR-CIFRI; Dr. U. K. Sarkar, Head, RWF Division, ICAR-CIFRI and scientists of RWF Division. The Director, ICAR-CIFRI urged CIFRI scientists to take lead in formulating the guidelines in collaboration with NFDB, ICAR-CIFA and RGCA. Dr. V. V. Sugunan proposed a structure of the guidelines. Dr. A. K. Das, Principal Scientist, made a presentation on the status of cage culture in Indian reservoirs. Based on the discussions during the meeting, recommendations were made on different aspects of cage culture.

NFDB workshop in progress

6th Advisory committee meeting of NASF project on Hilsa

The 6th Advisory Committee Meeting of the project "Stock characterization, captive breeding, seed production and culture of hilsa (*Tenualosa ilisha*)," funded by ICAR-National Agricultural Science Fund (NASF) was held during 30-31 August, 2016 at the Institute Hqs, Barrackpore. Dr. P. K. Agrawal, ADG, NASF, emphasized need for protection of raw data and information generated through the repository system of NASF. Dr. B. K. Das, Director, ICAR-CIFRI, stressed upon the need for more research attention on breeding and culture of hilsa. Dr. K. G. Padmakumar, Director, International Research and Training Centre for Below Sea Level Farming, Kerala

Project reviewmeeting at Barrackpore

Visit to ICAR-CIFA, Kalyani farm

emphasized on the need to look into the impact of climate change on hilsa and also stressed on aspects of developing hilsa broodstock under captivity. Mr. R. F. Lepcha, Additional Director, and Dr. Saptarshi Biswas, Assistant Director, Department of Fisheries, West Bengal and members of the advisory committee also participated in the meeting.

Interactive workshop on "Aquatic animal diseases in Assam"

The meeting was organised on 20 September 2016 at ICAR-CIFRI Regional Centre, Guwahati. Mr. M. C. Jauhari, IAS, Principal Secretary Fisheries, Government of Assam inaugurated the programme in presence of Dr A. K. Sahu, DBT, Visiting Professor and former Head Aquaculture Production, ICAR-CIFA and Dr. B. K. Das, Director, ICAR-CIFRI, Barrackpore. Shri Parimal Sukla Baidya, Hon'ble Minister of PWD, Fisheries and Excise, Government of Assam and Shri Bimal Borah, Hon'ble MLA, Assam graced the valedictory session of the workshop. A total number of 77 participants including fish farmers (31) and Fishery Extension Officers, Deputy Director and Joint Director (29) from Department of Fisheries covering 17 districts of Assam; officials from National Fisheries Development Board Regional Centre, Guwahati; College of Fisheries (AAU), Raha, FISHCOPFED Regional Centre, Guwahati; Fisheries NGO and Private Sector Enterprises participated in the workshop.

Release of publications on fish disease management

Interactive workshop in progress

Meeting of the ICAR retired employees association

The ICAR retired employees association meeting was held at ICAR-CIFRI, Barrackpore on 27 September, 2016. The Director of ICAR-CIFRI chaired the meeting. Dr. K. K. Satapathy, Ex-Director,ICAR-NIRJAFT, Dr. Dipak Sarkar, Ex-Director, ICAR-NBSSLUP, Dr. Samir Kanti Naskar, Ex-Director, ICAR-Central Tuber Crops Research Institute and 50 other ICAR retired employees participated in the meeting. During the meeting, the matters related to pension, medical facilities of pensioners and other related issues were discussed.

Mid-term IRC meeting

The mid-term Institute Research Committee meeting was held at the Institute Headquarters, Barrackpore during 3-4 October, 2016. Dr. B. K. Das, Director, ICAR-CIFRI chaired the meeting. Scientists from the CIFRI Headquarters including Kolkata Centre and all the Principal Investigators of the institute projects from RRCs attended the meeting. The house acknowledged the significant contributions of Dr. D. S. Krishna Rao, Principal Scientist, Bengaluru RRC who was due to retire from the council's service on 31 October, 2016. The Chairman urged all the Scientists to fulfill the targets assigned to them within the stipulated time as most of the projects will be ending by March 2017. Further, he stressed on the deliverables of the projects as per the RAC recommendation. Following the remarks of the Chairman, the Principal Investigators (PI) presented the achievements of their respective projects.

Mid-term IRC meeting in progress

Participants of the mid-term IRC Meeting

On-field workshops on cage culture at Bhakra and Pong dams, Himachal Pradesh

Two on-field workshops were organized by the Institute on reservoir fisheries management with special emphasis on cage culture. The event was sponsored by Dept. of Fisheries, Govt. of Himachal Pradesh at cage installation sites near village Proiana, Bhakra Dam on 27 October, 2016 and Astt. Director of Fisheries (ADF) Office, Pong Dam on 28 October, 2016. A total number of 140 fishers from the Fishers' Cooperative Societies near cage installation sites in two reservoirs participated in the programme. Various lectures on reservoir fisheries management, cage culture for producing stocking materials vis-a-vis table fish production with diversification of fish species including field practical of water analysis also were done. The officials of DoF, H.P. including ADF and FEO, Pong Dam and Supdt. Inspector, Bhakra Dam also took part in the workshop.

Fish health awareness camp at East Kolkata Wetlands

ICAR-CIFRI organized a fish health awareness camp under National Aquatic Surveillance Programme on Aquatic Animal Diseases and *Mera Gaon Mera Gaurav* programme at Bantala village in East Kolkata Wetland area on 5 November, 2016, in collaboration with Department of Fisheries, Govt. of West Bengal. The awareness camp was organized with the objective to sensitize the

Water quality testing

Lecture on fish disease by the Director

people of East Kolkata Wetland areas about fish health and to secure sustainable livelihoods and nutritional security for them. Dr. B. K. Das, Director, ICAR-CIFRI, Dr. V. V. Sadamate, Former Advisor of Planning Commission, Govt. of India and Dr. Priyanshi, Environmentalist, Institute of International Water Management, Dr. Tapas Paria, ADF were among the dignitaries attended the programme. On spot fish disease diagnosis and water quality analysis were also done by team CIFRI, based on which proper recommendations were given to the farmers.

Consultation on roadmaps for blue revolution in Eastern India

An interactive meeting was organized on 7 December 2016 for discussion on fisheries road map developed by the Institute for bringing Blue Revolution in 4 Eastern states, viz. Bihar, Jharkhand, Odisha and West Bengal. The meeting was conducted under the chairmanship and guidance of Dr. B.K. Das, Director.The meeting was attended by Dr. Dilip Kumar, Former Director ICAR-CIFE, Mumbai; Dr. B. C. Jha, Former HoD, ICAR-CIFRI; Dr. Nishat Ahmad, Director, Department of Fisheries, Govt. of Bihar; Shri S. Biswas, Joint Director, Department of Fisheries, Govt. of West Bengal; Shri Debananda Bhanja, Joint Director, Department of Fisheries, Govt. of Odisha; Shri Prashant Kumar, DFO, Department of Fisheries, Govt. of Jharkhand; Prof. P. N. Pandey, President, Zoological Society of India; Prof. B. N. Pandey, Working-President, Zoological Society of India; Prof. P. K. Sur, Professor, University of Kalyani and ICAR-CIFRI scientists. The Road Map prepared by ICAR-CIFRI was presented and discussed with the state fisheries officials. Different issues were discussed in the meeting and the suggestions deliberated during discussion were incorporated in the document.

Awareness-cum-training programme on fish health management

A 2-days Awareness-cum-Training Programme on “Fish Health Management in Aquaculture and Inland Open Water Systems” was organized under the ‘ICAR Network Project on Fish Health’ project at Sargachi, Murshidabad Dist., West Bengal during 28-29 December, 2016. A total of 219 fishers and fish farmers participated in the programme. Hon'ble Swamy Viswamayananda, Secretary, Ramakrishna Mission Ashram at Sargachi graced the occasion as Chief Guest and Dr. Pranab Chattopadhyay, Retd. Professor, BCKV acted as Guest of Honour in the programme. Both theoretical and practical aspects of different fisheries technologies and practices, including aquatic and fish health management measures

Address by the Chief Guest Hon'ble Swamy Viswamayananda,

Participants in the programme

in ponds and floodplain wetlands were taught. Dr. A. K. Das, Dr. M. K. Bandyopadhyay, Dr. S. K. Manna and Dr. B. K. Behera, Principal Scientists from ICAR-CIFRI acted as resource persons in the training.

Kishan gosthi-cum-mass awareness camp at Murshidabad, West Bengal

The ICAR-CIFRI, in association with the Dept. of Fisheries, Govt. of West Bengal organized a Mass Awareness Camp-cum-Kisan Gosthi on 20 January, 2017 in the premises of *Beel Bishnupur Agragami Matsyajibi Samabay Samiti*, Berhampore block, district Murshidabad,West Bengal. The objectives of this gosthi were to sensitize the fishermen about the potential, scope and benefits of scientific beel fisheries management including strategies of stocking enhancement, enclosure culture and to create awareness about climate change and its impact on fishery and feeding strategies in inland fisheries. More than fifty fishermen and women of the Bishnupur and neighbouring beels participated in the programme. Dr. U. K. Sarkar, Head, RWF division chaired the event in which Dr. M. A. Hassan, Dr. Aftabuddin; Dr. Arun Pandit; Sh. D. K. Meena, Ms. Pritijyoti Majhi, and Mr. Bablu Naskar from ICAR-CIFRI discussed various issues. Shri Jayanta Pradhan, ADF; Shri Biswajit Biswas and Shri Ramkanai, DFO's from Department of Fisheries, Govt. of West Bengal; Shri Samir Biswas, President, Shri Alamat Hossain, Secretary, Shri Biswanath Mallick, Manager from the PFCS were also present on the occasion.

Address by Dr. U. K. Sarkar in the Kishan gosthi

RAC meeting

The Meeting of the Research Advisory Committee of the Institute was held at Barrackpore during 17-18 March 2017. Prof. Dr. B. Madhusoodana Kurup, Former Vice-Chancellor, Kerala University of Fisheries and Ocean Studies, Kochi, presided over the meeting. The meeting was attended by the members of the Committee namely Dr. N.N. Rai, Dr. H.C. Joshi, Dr. G.N. Chattopadhyay, Dr. Sudhir Raizada, Dr. B.K. Das, Director and Dr. S.K. Nag, Member Secretary. Inter alia, the Chairman called upon the scientists to focus on the research for knowledge based management of inland open waters and to formulate strategic action plans and highlighted the necessity of sustainable development of inland open water fisheries. The RAC also felt the need of action oriented research and research for societal gain and livelihood improvement. The RAC expressed concerns over depleting fish biodiversity, lack of quality water resources, heavy metal and pesticide pollution, invasion of the exotic fish, climate change.

Presentation by Member Secreatary, IRC

Kishan gosthi-cum-mass awareness camp at Sujapur, Murshidabad, West Bengal

The institute conducted Kisan Gosthi cum-Mass Awareness Camp on 24 March, 2017 at Sujapur, Murshidabad to sensitize rural women for livelihood improvement

The Director addressing the Kishan gosthi meet at Sujapur, Murshidabad

through integrated wetland management in collaboration with Sargachi Ramakrishna Mission and State Fisheries Department, West Bengal. Bhagirathi-Damos beel (44ha) is an un exploited, largely weed chocked wetland with plenty of indigenous fishery resources. The institute facilitated 1800 women of 155 Self Help Groups to take that wetland on lease to support their livelihood. The programme was graced by Maharaja Sri Viswamayanada of Sargachi Ramakrishna mission. Dr. B. K. Das, Director, CIFRI interacted with the women Self-help group members and informed them about the economic feasibility of beel fisheries. Dr. B. P. Mohanty, Dr. A. K. Das, Dr. B. K. Behera and Dr. Aparna Roy also interacted with the rural women. A GIS map regarding the present condition of the wetland was prepared by ICAR-CIFRI and a strategic plan was developed for the integrated management of the wetland in participatory approach.

A large gathering of women participants in the Kishan gosthi meet at Sujapur, Murshidabad

EVENTS

International yoga day

The institute celebrated International yoga day on 21 June, 2016. The Yoga Session was conducted based on the Common Yoga Protocol provided by Ministry of AYUSH, Government of India and under the guidance of eminent Yoga experts, Mrs. Romela Mustafi and Mr. Sujit Ghorei of Yoga Kendra, Barrackpore . Earlier, on 20th June, 2016 a Workshop on, "Health benefits of Yoga" and a practice session was also organized. Staff members of ICAR-CIFRI and their family members attended the programme.

National fish farmers' day

ICAR-CIFRI, Barrackpore celebrated National Fish Farmers' Day on 10 July 2016. Prof. Purnendu Biswas, Vice Chancellor, West Bengal University of Animal and Fishery Sciences, graced the occasion as Chief Guest. In his address, he urged that State Government, ICAR-CIFRI, Universities, Entrepreneurs and Fish farmers to join hands for judicious utilization of the resources for the development of Fisheries Sector. He called for more interaction between innovative farmers of different States. Sri Silbhadra Dutta, Member of Legislative Assembly, West Bengal was the

Fish farmer being awarded

A section of fishers/fish farmers

Guest of Honour. Dr. V. R. Suresh, Director ICAR-CIFRI (Acting) said scientists of CIFRI are striving for developing sustainable open water fisheries management in the country. He informed that CIFRI has organized capacity building programmes for about 500 farmers from various states of India viz. Bihar, West Bengal, Uttar Pradesh, Assam, Karnataka, Kerala, Jharkhand, etc during, 2015-16. More than 100 farmers, State Government Officials, Scientists and staff of CIFRI attended the function. Six progressive fish farmers, representing West Bengal, Bihar, Jharkhand were given "Best Fish Farmer Award 2016" by the Institute.

ICAR foundation day

The Institute celebrated ICAR Foundation Day at the Head Quarters on 16 July 2016. Dr. V. R. Suresh, Director (Acting), welcomed Dr. Utpal Bhaumik and Dr. B. C. Jha, former Heads of Divisions and the staff of CIFRI. Dr. U. K. Sarkar, Head, RWF Division, Mr. N. K. Jha, AO and the other staff members of CIFRI shared their experiences on working in CIFRI. Prizes were distributed to the winners of different competition held during the programme.

Institute staff

Distribution of prizes

ASRB NET examination

The Institute regulerly conducts National level examinations like ARS Examinations, NET etc. on behalf of ASRB, New Delhi. The National Eligibility Test (NET I) 2016 Examination was conducted by the Institute for the Barrackpore Centre of ASRB during 01 August 2016 to 06 August 2016.

Independence day

The institute celebrated the 70th Independence Day of India on 15 August 2016 at the ICAR-CIFRI, Barrackpore with great enthusiasm. Director, Dr. B. K. Das hoisted the tri-colour and paid rich tribute to the nation. In his maiden Independence Day speech, he addressed the staff and their family members and emphasized that present young generation should remember the sacrifice made by our earlier leaders. He also spoke about the contribution of ICAR as well as ICAR-CIFRI in nation building. CIFRI staff and

Hoisting of National Flag by the Director

Installation of CIFRI Model cage at campus pond

their family members organized cultural events during the Independence Day celebration.A 'CIFRI Model Cage' was installed on the occasion of AZADI 70 to showcase CIFRI's contribution in the field of cage culture in inland fisheries. All the ICAR-CIFRI staff gathered on the occasion. This model cage culture will help in hands-on-training and capacity building programmes on 'Inland Fisheries Management'.

Inauguration of 'Office-cum ladies room' for women cell

An 'Office-cum Ladies Room for Women Cell' was inaugurated on 15 August, 2016. The members of CIFRI Women Cell and Women Complaint Committee joined hands together to organize a cultural programme on the occasion of AZADI70. A separate room for 'Office-cum Ladies Room" was allotted to Women Cell for better functioning of the cell.

Vigilance awareness week

Display of paintings

The vigilance awareness week-2016 (31 October - 5 November, 2016) commenced at the Institute headquarters, Barrackpore, with a pledge taking ceremony. The pledge was administered by Dr. B. K. Das, Director. The theme of this year's vigilance awareness week was "Public participation in promoting integrity and eradicating corruption". Celebration of the week was marked by several programmes like drawing cartoons, posters, banners; essay writing and debate competition; guest lecture etc. Another pledge was administered by the Director to all the staff of the institute to commemorate the Birth anniversary of Sardar Ballav Bhai Patel which is celebrated as National Integration Day.

World fisheries day

The Institute celebrated World Fisheries Day at 'Nutri-smart village' Madanganj in Namkhana block of Sundarban, West Bengal on 21 November, 2016. In his address, the Chief Guest Prof. Purnendu Biswas, Vice Chancellor, West Bengal University of Animal Science and Fisheries, Kolkata, said that small indigenous fishes are important especially for children as they provide required micronutrients. Dr. B. K. Das, Director emphasized that intake of these fishes in daily meal provide the required quantity of micronutrients and vitamins to the family. Publications entitled "Small Indigenous Fishes for nutritional security of the rural economy (in Bangla and English)" and "Hilsa calendar in Bangla" was released on this occasion. Seed bank of Small Indigenous Fishes was also inaugurated under the Nutritional village project at Madanganj. More than 250 fishers and fisherwomen participated in this programme.

Releasing of publications

Agriculture education day

The ICAR has designated the 3rd December as "Agricultural education day" to commemorate the birth anniversary of first President of Independent India and Union Minister of Agriculture, Bharat Ratna Dr. Rajendra Prasad. ICAR-CIFRI has celebrated this day with great fanfare and enthusiasm. The objective of this day was to expose school 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 agri-entrepreneurs in future. The Institute organized essay competitions, painting competition and interaction with scientists for school children on this day.

A student expressing his views

World soil day

ICAR-CIFRI, Barrackpore celebrated World soil day on 5 December , 2016. The main aim of the Soil Day campaign was to create awareness regarding importance of soil in our lives. The theme of World Soil Day 2016 was "Soils and Pulses, a

Symbiosis for Life". Shri Madhusudan Ghosh, local MLA, Noapara Constituency was the Chief Guest of the function. He shared his experiences of soil conservation and its importance in the life of rural people. He raised concern about the immense use of pesticides in agriculture. Dr. B. K. Das, Director spoke about the status of soil health and raised issues of soil sustainability. Dr. S. K. Nag and Dr. Srikanta Samanta delivered lectures on importance of soil health in agriculture. Dr. Ashok Chattopadhyay, Reliance Foundation, students from A. P. C. College, New Barrackpore, fish farmers from Kishanganj district, Bihar and Barrackpore and the scientists of CIFRI participated in the programme.

Felicitation of the Chief Guest


A section of the audience

Republic day

The institute celebrated the Republic day with great enthusiasm and fanfare on 26 January, 2017. Dr. B. K. Das, Director of the institute hoisted the tri-colour and paid rich tribute to the nation. He elaborated that India gained freedom after a lot of struggle and bloodshed by the freedom fighters. Hence, preserving the unity of our nation is our sacred duty. In his speech, the Director also recounted the achievements of CIFRI during the last one year and also recalled the golden journey of CIFRI. He remarked that a good working atmosphere and team spirit are the key to success. All the CIFRI staff and members of the family were present on the occasion. Swachhta rally was organized to make aware the general public for sanitation and hygiene. The special swachhta drive was undertaken at Nimai Tirtha Ferry Ghat and Fishery Gate Bus Stand of Barrackpore.


Republic day speech by the Director


Swachhata rally

National productivity week

National productivity week 2017 was celebrated at the institute during 13-18 February 2017. The theme of the year was "From Waste to Profits - Reduce, Recycle and Reuse". Dr. B. K. Das, Director, explained the ways by which the institute staff can improve their as well as institute's productivity. During the week-long celebration different activities were organized like essay writing, slogans writing, quiz, painting etc. Closing ceremony was held on 18 February in which prizes/appreciation certificates were awarded to the winners and participants of the different competitions. At Vadodara centre the National Productivity Week was also celebrated and the Productivity day was observed on 17 February 2017. Different activities were performed to mark the occasion.

Painting competition for the children

International women's day

The institute celebrated the International women's day on 8 March 2017. International women's day is a global day celebrating the social, economic, cultural and political achievements of women. The day also marks a call to action for accelerating gender parity. Thus International women's day is all about unity, celebration, reflection, advocacy and action. Acted on 'think global, act local' principle, the Director called for showing respect to all the women employee of the institute and congratulated all the women staff. He recounted the contributions of women to build the modern India.

Celebrating Institute foundation day

Institute foundation day and curtain raiser of platinum jubilee year celebration

The institute celebrated 71st foundation day on 17 March 2017, by conducting interaction cum farmers' meet programme at its Headquarters in Barrackpore. It was an amalgamation of knowledge and veracity as a large number of farmers, students, scientists and a team of distinguished personalities attended the proramme. Dr. B. K. Das, Director, ICAR-CIFRI gave a brief account of the institute technologies, activities, outreach programmes and researchable issue. The Chief Guest of the function Dr. B. Madhusudana Kurup, former V. C. of KUFOS, Kochi, in his address, stressed upon the importance of fish for livelihood and nutritional security particularly to the weaker section of the society. He also congratulated the ICAR-CIFRI scientists for releasing several policies and protocols for ecosystem-based fisheries management. Dr. Sudhir Raizada, ADG, Inland Fisheries, ICAR; Dr. S. M. Shivaprakasha, Director of Extension, KVAFSU; Dr. N. N. Rai, Director, Hydrology (NE), CWC, New Delhi; Dr. G. N. Chattopadhyaya, Former Professor, Visva Bharati, Santiniketan; Dr. H. C. Joshi, Former Principal Scientist, ICAR-IARI, New Delhi graced the occasion as Guests of Honour. The meritorious children of CIFRI staff members were also felicitated on this occasion. An extension pamphlet in Hindi and a pamphlet on "Proposed activities for celebration of platinum jubilee year" were released. About 60 farmers from 50 *MGMG* villages attended the farmers' meet in which inland fisheries issues were discussed. A cultural programme was also organised by the institute staff members to celebrate the occasion.

Farmer-Scientist interaction meeting

TRIBAL SUB PLAN ACTIVITIES

The Institute has been continuing its efforts to uplift the socio-economic condition of the tribals in different parts of the country through the Tribal Sub Plan (TSP) activities. In the month of August, 2016 32,000 fish fingerlings of Indian major carps were stocked in six freshwater and four brackishwater ponds with water area of 0.66 ha in Khansaheb village of Sagar Block of South 24 Parganas district in western side of the Sundarbans. Inorganic fertilizers and fish feed were also distributed to the tribal fishers benefitting 40 tribal families in derelict ponds.

Stocking of fingerlings in Sagar Block of South 24 Parganas district

A training-cum-mass awareness programme for utilization of derelict open water to rear and produce indigenous fish was organized during 16-17 September 2016. A total of twelve cast nets, two drag nets, & rope for fencing the water bodies and one 5 HP water pump were distributed by the institute to the beneficiaries. A total of 250 fishers/fish farmers participated, of which 150 were tribal women farmers.

Training-cum-mass awareness programme at Sagar Block of South 24 Parganas district

Distribution of inputs at Sagar Block of South 24 Parganas district

In the eastern flank of Sundarbans, ICAR-CIFRI has been undertaking TSP activities in Kalitala *Gram Panchyat* in Hingalganj block of North 24 Parganas district of West Bengal. A team visited and inspected the Sagunkhali Canal at Samsernagar during 22-23 July, 2016 from where fish mortality was reported by fishers. After analysing the water and fish samples necessary technical advice were given to fishers for controlling fish mortality in the canal.

Water quality analysis in canals

Investigation of fish disease

Stocking of fingerlings at Kalitala canal

A total of 35,000 advanced fingerlings (8-10 cm size) of Indian major carps namely *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala* were stocked in three canals with a total water area 0.07 sq. km during the month of August, 2016. Forty one tribal families are being benefitted through the programme.

In another attempt, two canals, namely, Adibasipara (0.01sq.km) at Birajnagar and Harintana (0.05 sq. km) at Satyanarayanpur in Bali Island (Sundarbans), Gosaba Block, South 24 parganas, were stocked with advanced fingerlings of Indian major carps @5000 nos /0.01 sq. km. during 7-9 September 2016. Twenty seven tribal families are being benefited from the carp rearing programme in canals. The ICAR-CIFRI personnel provided technical guidance to tribal fishers for post stocking management of carp seeds in these canals.

Stocking of fingerlings at ponds of Bali island

The institute has also attempted to improve the livelihood of the tribal fishers of Purulia and Burdwan districts of West Bengal through development of fisheries in the check dams and bundhs under TSP. A five-days training programme on "Livelihood improvement of tribal fish farmer through inland fisheries management" was organized at the institute head quarter, Barrackpore for twenty eight tribal fishermen and women of Purulia district, West Bengal. 35,000 advanced fingerlings of *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala* were stocked in Chakka Dam (7.0 hectare) located at Rajakhanda village, Puncha Block, and 6000 advanced fingerlings each were stocked at Sarak Bundh (1.2 hectare) and Upper Bundh (1.2 hectare) at Village Pochagora under Kashipur Block, on 1st and 2nd October, 2016, respectively. Ninety five tribal families are being benefited from this programme.

Stocking in Chakka dam

Stocking in Sarak Bundh

Similarly 10,000 advanced fingerlings of Indian major carps were partially stocked in Gardanmari Adibasi Dighi (9.6 ha.) at Karjanachati, Burdwan district, West Bengal for grow out culture and this benefits one hundred tribal families. A total of 1500 kg balanced pelleted fish feed was distributed to the tribal fishers of Gardanmari Adibasi dighi, Burdwan district; Sarak Bundh and Upper Bundh, Purulia district in West Bengal for feeding to cultivated major carps during March,2017.

Distribution of pelleted fish feed at Burdwan district

Distribution of pelleted fish feed at Purulia district

An on-field workshop was organized by the Scientists of Barrackpore on inland fisheries management with special emphasis on Beel fisheries at Paharpur, Murshidabad, West Bengal on 22 October 2016. 170 fishers including 42 fisher women participated in the programme.

Demonstration on water quality analysis at Paharpur

Delivering of lecture by CIFRI scientist

The Allahabad centre is executing the TSP activities in the tribal area of Chandan Chouki in Lakhimpur Kheri district of Uttar Pradesh since 2013 for empowerment of the tribals Tharu tribals. In the same tempo, the Centre conducted training cum awareness programme and distribution of fish seed (fingerlings) and feed in the first week of September 2016. About 60 participants comprising farmers and fishers attended the awareness programme and benefited from commodities distribution. Quality fish seed in the form of fingerlings (235 kg, comprising Indian major carps and exotic carps) was distributed to 47 progressive tribal fish farmers and stocked in

their ponds. Fish feed (12.0 quintals, comprising mustard oil cake and rice bran in the ratio of 1:1) @ 30 kg /farmers to 40 farmers was also distributed. The beneficiaries were from 13 tribal villages in and around Chandan Chouki area, Paliya tehsil, Lakhimpur-Kheri district, Uttar Pradesh.

Participants in the programme at Lakhimpur-Kheri, UP

Seed and feed distribution Lakhimpur-Kheri, UP

The centre conducted multiple fisheries development activities during 19-21 October 2016 including netting operation in fishers' ponds, evaluation of earlier stocked fish seed, conducted fishery awareness programme and distribution of fish seed (stunted fingerlings of Indian major carp and exotic carps) & feed in the area. More than 50 tribals participated in the programme and received inputs. The fingerlings of Indian major carps and exotic carps (250 kg) plus fish feed 2000 kg (Rice bran and Mustard oil cake in 1:1) were distributed to 50 progressive tribal fish farmers for partial stocking in 11.0 ha pond area. The tribal fish farmers were trained in diversification of culture practices like integrated fish farming and adoption of appropriate fishery technology and management techniques.

Farm inputs were distributed to the tribal farmers after assessment of their fish ponds and successful completion of awareness/ training. Quality fish seed in the form of fingerlings (about 28,000 number, total weight 250 kg) were distributed to 50 progressive tribal fish farmers for partial stocking in about 11.0 ha pond area (pond size 0.1- 1.2 ha). Also distributed fish feed (20.0 quintals, comprising mustard oil cake and rice bran in the ratio of 1:1) @ 40 kg /farmers to 50 farmers. The beneficiaries were from 13 tribal villages in and around Chandan Chouki area, Paliya tehsil, Lakhimpur-Kheri district.

The region witnessed significant impact of the fisheries development activities undertaken by the centre. The current estimated average fish production from the

Fish seeds stocking

Inputs ready for distribution

region considerably increased to 2.5 to 3.8 tons/ ha, from less than 1.5 tons/ ha before initiation of the above efforts. Further, the tribal farmers expanded fish farming activities in all the available patches of the ponds and derelict water spread areas in the region, owing to intensive awareness campaigns, trainings and empowerment efforts initiated by ICAR-CIFRI. Some farmers have also started rearing fish in nursery and selling of fish seed after this initiative.

The Allahabad centre has also attempted to develop the Kol tribe dominated area in Rewa district of Madhya Pradesh through TSP. Kol tribes of Rewa district inhabited in and around Loni Wetland were selected for beneficiary. During 24-25 January 2017 the centre organized fishery awareness programme and distributed fishery inputs including cast nets and drag nets with the objective to enhance their livelihood.

The Minister accepting the projects presented by ICAR-CIFRI for improving the livelihood of tribal people

The Bengaluru centre distributed fishery requisites and safety equipment to the members of the Tribal Fisheries Co-operative Society of Banasura Sagar Reservoir, Wayanad, Kerala on 6 February, 2017. Smt. J. Mercy Kkutty Amma, Minister of Fisheries and Harbor Engineering, Govt. of Kerala graced the input distribution ceremony in which 8 fiberglass coracles and 16 life jackets were distributed benefitting 16 families. The District *Grama Panchayat* Member, Scientist-in-charge of Bengaluru centre, representatives of local Panchayat and senior officials of Kerala Fisheries Department and Kerala State Electricity board were also present on the occasion.

Distribution of fiberglass coracles and life jackets

ACTIVITIES UNDER *MERA GAON MERA GAURAV*

This Institute adopted 70 villages under *Mera Gaon Mera Gaurav* programme and disseminated technical knowledge through discussion, meetings, phone calls, *Kisan Gosthi*, distributing literatures for overall agricultural development in the villages. Scientists of Barrackpore Headquarters organized many *Kisan Gosthis* for productivity enhancement of agriculture crops, livestock and fisheries, pest and disease management, management of fish culture ponds, conservation of small indigenous fishes etc. Linkages were made with *Krishi Vigyan Kendras*, State Departments, local *Panchayat*, NGOs and ICAR institutes to solve various problems faced by the farmers.

Kisan Gosthi at Barasat 1 block, 24 Parganas (N)

Field visit by the MGMG Staff of Barrackpore HQ

Awareness was generated on various issues including fish diseases, nursery pond management, hilsa conservation, soil and water testing, improved variety of crops, and pest/disease incidences in agricultural crops. Various scientific literatures/ leaflets, pamphlets etc. were distributed to upgrade farmers knowledge.

Distribution of literature

Discussion with Pradhan of Akaipur Panchayat

An interaction programme was conducted at village Saibana, Barasat Block-I, 24 Parganas (N) on October 5, 2016. *Krishi Prayukti Sahayak* from Agriculture Department, Govt. of West Bengal also participated in the interactive session.

A fish health awareness camp was organized in association with National Aquatic Surveillance Programme on Aquatic Animal Diseases at Bantala village in East Kolkata Wetland area on 5 November 2016, in collaboration with Department of fisheries, Govt. of West Bengal.

ICAR-CIFRI Scientist making a point in a camp

Fish harvesting for disease investigation

A Kisan Gosthi was organized at this village on 29 November 2016, in collaboration with Department of Agriculture (DoAg), Govt. of West Bengal and Ichapur-Neelgunj Gram Panchayat. More than 200 farmers from 10 villages adopted under *MGMG* took part in this programme.

Director is making a point at Nilgunj

Release of publications at Nilgunj

Another *Kishan Gosthi* was organised on 13 January 2017 at Akaipur Gram Panchayat for farmers of Akaipur and surrounding villages of North 24 Parganas district, West Bengal. More than sixty farmers of five villages of Akaipur Panchayat adopted under *MGMG* programme participated in the *gosthi*. A village pond was adopted for demonstration of composite fish culture to the farmers.

Kisan Gosthi at Akaipur

Adopted pond at Akaipur

Another *Kisan Gosthi* was organized at Babpur, under Khilkapur Gram Panchayat, 24 Parganas (N), West Bengal on 30 January 2017. More than 500 farmers, mostly women members (75%) of Women Self-Help Groups (SHG) and tribals from 10 *MGMG* adopted villages took part. The BDO of Barasat Block-I; *Panchayat Pradhan*, Khilkapur Gram Panchayat and Dr. B. K. Das, Dr. B. K. Behera and Dr. A. K. Das were also present on the occasion.

Kisan Gosthi at Babpur

A section of women farmers

Scientists of Guwahati centre visited the adopted villages of Kamrup district, inhabited mostly by scheduled caste and tribal families (75%) and organized an interactive programme in association with a Trust who are working for up-liftment of the farmers on community-management principles. The scientists visited the water bodies and made preliminary assessment of water quality as well as discussions with the fish farmers including the Trust members.

Interactive programme on fisheries development at Jajikona village, Kamrup under *Mera Gaon Mera Gaurav*

Staff of Bangalore centre organized a meeting at Manchanbele reservoir site in Averehalli village, Ramanagaram District. A total number of 25 fisher-folk and the office bearers of the fisher cooperative society attended the meeting where inputs were distributed on regulated use of fishing gears and also discussed other societal issues.

Field Visit by the Staff of Bangalore RRC

Discussion with fisher folk by the Staff of Bangalore RRC

Collecting baseline data

Awarness generation among school children

GLIMPSES OF *SWACHH BHARAT* ACTIVITIES

Swachhta pledge at Barrackpore

Awareness campaign among School children in Barrackpore

Distribution of sanitary soaps in a school at Barrackpore

Cleaning of campus pond at Barrakpore

Donating garbage bin at Ganga Ferry Ghat

Sanitizing ICDS premises at Sundarbans

Awareness campaign at Sagar Island, Sundarbans

Cleaning campaign in a village of Sundarbans

Swachh Bharat awareness at a village in North 24 Parganas district

Swachh Bharat oath in a school of Ramanagaram district

'Go Green' initiative by ICAR-CIFRI Bangalore RRC

Swachh Bharat oath by the staff of ICAR-CIFRI Guwahati RRC

Swachh Bharat rally by ICAR-CIFRI Guwahati, RRC

Hon'ble Minister of Fisheries,Govt of Assam participated in a *Swachh Bharat* programme Organized by ICAR-CIFRI Guwahati RRC

Swachh Bharat activities by ICAR - CIFRI Vadodara RRC staff

Swachh Bharat activities by ICAR - CIFRI Vadodara RRC staff

Cleaning campaign by staff of ICAR-CIFRI Kochi Res. Station

Special cleaning drive by staff of CIFRI Kochi Res. Station

हिन्दी कक्ष के कार्यकलाप

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Hkk—vui&dUæh; vrLFkyh; ekfRL;dh vul/kku lLFkku] cjdij }kjk fVli.k rFkk çk : i y[ku 'kyh fo"k; ij fnukd 22 fnlEcj] 2016 dk ,d dk; 'kkyk dk vk;kt u fd;k x;kA bl dk; 'kkyk e lLFkku d 15 vf/kdkfj;k o depkfj;k u Hkkx fy;kA

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LIBRARY AND INFORMATICS

Library and Informatics Section facilitates knowledge sharing through its resources of approximately 10,000 numbers of books, 5,000 journals, and 5,000 other valuable documents. During 2016-2017, ICAR-CIFRI Central library located at institute HQ, Barrackpore added more than 100 numbers of library documents including 17 scientific books, and also subscribed 13 foreign journals and 20 Indian journals to strengthen its resources. ICAR-CIFRI Central library has also strengthened libraries of its six Regional centres and stations by procuring books and journals to enrich libraries of the centers. Library and Informatics Section at HQ have four distinct segments - Scientific books, Journals, ICAR-CIFRI publications and Hindi books. Whole catalogue of books in Central Library is presently digitized under KOHA Open Source Library Management Software and available for online search through institute website as well as through 'Agricat', a Union catalogue available to all NARS institute for online search. It is regularly updated whenever new entries are added in the library holdings. About 264 old valuable documents have been scanned and already uploaded in institute and '*Krishikosh*' website for easy reading and download. ICAR-CIFRI library has become an active member of 'CeRA' Consortium by sending 77 documents to different NARS institutes through Document Delivery Request (DDR) during the year.

STAFF INFORMATION

Staff Position (as on 31. 03. 2017)

Category	Sanctioned Strength	Filled up	Vacant
R. M. P.	1	1	-
Scientist	95	83	12
Technical	85	51	34
Administrative	67	37	30
Skilled Supporting Staff	130	46	84
Total	378	218	160

Centre-wise staff in position (as on 31. 03. 2017)

Name of the Centre	RMP	Scientist	Technical	Administrative	SSS	Total
Barrackpore	1	52	36	31	22	142
Allahabad	-	7	5	2	8	22
Bangalore	-	7	1	2	2	12
Guwahati	-	8	3	-	4	15
Kochi	-	2	2	-	5	9
Kolkata	-	3	1	1	-	5
Vadodara	-	4	3	1	5	13
Total	1	83	51	37	46	218

3rd Meeting of Joint Working Group

Dr. B. K. Das, Director visited Dhaka during 25-26 October 2016 for 3rd Meeting of Joint Working Group between Bangladesh and India

He again visited Dhaka during 2-3 November 2016 for 1st Joint Consultation on the sustainable development of inland water ways transport and fish biodiversity conservation

PERSONNEL

Headquarter, Barrackpore
Director
Dr. B. K. Das
Heads of Divisions
Dr. V. R. Suresh
Dr. B. P. Mohanty
Dr. U. K. Sarkar
Principal Scientists
Dr. S. Samanta
Dr. M. K. Bandopadhyay
Dr. Subir Kumar Nag
Dr. M. Abul Hassan
Dr. Malay Naskar
Dr. S. K. Manna (In-Charge PME Cell)
Dr. A. K. Das (In-Charge E & T Cell)
Dr. M. Aftabuddin
Dr. Bijay Kumar Behera
Dr. Arun Pandit (In-Charge Agricultural Economics Section)
Senior Scientists
Dr. R. K. Manna (In-Charge L & I Section)
Dr. Asit Kumar Bera
Scientists
Shri. P. Maurye
Shri. Ganesh Chandra
Dr. D. Das
Shri. D. Karunakaran
Shri. S. K. Sahu
Dr. Amiya Kumar Sahoo
Shri. Roshith C. M.
Shri. Dharmendra Kumar Meena
Dr. Sandhya K. M.
Dr. Deepa Sudheesan
Dr. Aparna Roy
Ms. Anjana Ekka
Dr. Sajina A.M.
Dr. Soma Das
Dr. Rohan Kumar Raman
Smt. Suman Kumari
Shri. Lianthuamluaia
Shri. Mishal P
Ms. Tanuja Abdulla
Shri. Raju Baitha
Ms. Gunjan Karnatak

Scientists
Shri. Vikash Kumar
Ms. Suvra Roy
Dr. Manas H. M.
Ms. Kavita Kumari
Dr. Pranaya Kumar Paraida
Ms. Piyashi DebRoy
Ms. Thangjam Nirupada Chanu
Shri. Satish Kumar Koushlesh
Shri. Himanshu Sekhar Swain
Shri. Tasso Tayung
Shri. Vikas Kumar
Ms. Prajna Ritambhara Behera
Ms. Pritijyoti Majhi
Shri. Mitesh H. Ramteke
Shri. Shravan Kumar Sharma
Technical Staff
Dr. Sanjoy Bhowmick
Shri. R. C. Mandi
Shri. Dipak Kumar Biswas
Shri. C. N. Mukherjee
Smt. K. Sucheta Majumder
Smt. Keya Saha
Shri. Soumitra Roy
Md. Quasim
Smt. Abhijita Sengupta
Shri. Sujit Chowdhury
Shri. L. R. Mahavar
Shri. S. K. S. S. Hameed
Ms. Sunita Prasad
Shri. S. K. Paul
Shri. Atanu Das
Smt. Subhra Saha
Shri. Sundarsan Bandopadhyay
Shri. Subrata Das
Shri. Santosh Kumar Biswas
Shri. Debasis Saha
Shri. Ashis Roy Chowdhury
Shri. Manabendra Roy
Shri. A. K. Mandal
Shri. Lokenath Chakraborty
Shri. G. Pramanick
Shri. Subhendu Mandal
Shri. Arijit Ghosh

Technical Staff
Md. Rabiul Sk.
Shri. Sanjay Kumar Das
Shri. Ashis Chakraborty
Shri. Ashim Jana
Md. Yousuf Ali Sk.
Shri. Bablu Kumar Naskar
Shri. Biswanath Bose
Shri. T. K. Halder
Senior Finance Accounts Officer
Shri. N. K. Jha (Acting)
Administrative Officers
Shri Rajeev Lal (CAO)
Shri Navin Kumar Jha (AO)
Administrative Staff
Shri. Sudipta Gupta (AAO)
Shri. Biswajit Barua (AAO)
Shri. Sujit Kumar Ghosh (AAO)
Smt. Sefali Biswas (AAO)
Shri. Shyam Sunder Ghosh (AAO / DDO)
Smt. Jolly Saha
Shri. Subir Das (AAO)
Ms. Pausali Mukherjee (AAO)
Shri. Pratyay Sarkar
Shri. S. Karmakar
Shri. Chandan Chakraborty
Shri. Ganesh Chandra Barman
Shri. Kishore Shaw
Shri. Sukumar Sarkar
Smt. Swapna Chattopadhyay
Shri. Malay Kumar Joarder
Smt. Shamali Mitra
Shri. Santosh Sarkar
Smt. Ruma Ghosh

Administrative Staff
Shri. Pradipta Sen
Smt. Mousumi Banerjee (Nan)
Shri. Bijoy Kumar Ray
Shri. R. K. Roy
Shri. Suranjan Kumar Singh
Shri. Swapan Kumar Das
Shri. Fazal Khan
Shri. Ganesh Bhanja
Shri. Bhola Lal Dhanuk
Supporting Staff
Shri M. Dutta
Shri P. C. Paramanick
Shri. D. K. Das
Shri. Mohanlal Sarkar
Smt. S. Bhattacharjee
Shri Sukhen Das
Shri P. R. Mahata
Shri. S. Banerjee
Shri D. Singha
Shri Sabbir Ahmed
Shri B. K. Sahani
Shri Ratan Das
Smt. B. Singh
Shri K. C. Malakar
Shri A. N. Prasad
Shri U. S. Ram
Shri S. K. Gayen
Shri A. C. Das
Shri. Tapan Gayen
Smt. K. Biswas
Shri G. C. Roy
Shri R. K. Sonkar

CIFRI Head Quarter, Barrackpore

Allahabad Regional Research Centre

Regional Centre, Allahabad
Dr. R. S. Srivastava (Sr. Scientist and Officer- in-Charge)
Scientist
Dr. Dharm Nath Jha
Md Absar Alam
Shri. Shyamal Chandra Sukla Das
Shri. Jeetendra Kumar
Shri. Venkatesh Ramrao Thakur
Shri. Rahul Das
Technical Staff
Shri. S. K. Srivastava
Dr. Kalpana Srivastava
Shri. Sita Ram Meena
Shri. Ram Sajiwan
Shri. Vijay Kumar
Shri. Jitendran Kr. Singh
Administrative Staff
Shri. A. C. Biswas
Smt. Divya Jain
Supporting Staff
Shri. Shitala Prasad
Shri. Gopal Chand
Shri. K. Kumar
Shri. M. Panika
Shri. M. R. Rana
Shri. Joyram Prasad
Smt. Laxmi Devi
Shri. Anil Kumar

Regional Centre, Bangalore
Dr. M. Feroze Khan (Scientist and Officer-in- Charge)
Principal Scientist
Dr. (Mrs.) Preetha Panikkar
Scientist
Shri. M. Karthikeyan
Ms. Ramya V. L.
Ms. Sibna Mol S.
Shri. Ajoy Saha
Ms. Jesna P. K.
Technical Staff
Shri. M. E. Vijaykumar
Administrative Staff
Smt. Vinoda Lakshmi G
Smt. S. Sumithra Devi
Supporting Staff
Shri. K. Mohanan
Shri. M. Penappa
Shri. M. Mari

Bangalore Regional Research Centre

Kochi Research Station

Guwahati Regional Research Centre

Regional Centre, Guwahati
Dr. B. K. Bhattacharjya (Principal Scientist & Acting Head)
Scientist
Dr. Dipesh Debnath
Ms. Sona Yengkokpam
Shri. A. K. Yadav
Shri. Pronob Das
Ms. Niti Sharma
Shri. Simanku Borah
Shri. Ningthoujam Samarendra Singh
Technical Staff
Shri. K. K. Sarma
Shri. A. K. Goswami
Shri. Amulya Kakati
Shri. Bipul Chandra Ray
Supporting Staff
Shri. K. C. Das
Shri. S. Kalita
Shri. Sudama Basfore
Shri. N. Deka
Shri. Hemanta Das

Kolkata Station
Dr. Archana Sinha (Principal Scientist & Officer-in-Charge)
Principal Scientist
Dr. S. K. Das
Scientist
Shri. Pronob Gogoi
Technical Staff
Shri. Arunava Mitra
Administrative Staff
Ms. Suvra Bhattacharyya

Kochi Station
Dr. (Mrs) Rani Palaniswamy (Principal Scientist & Of ficer-in-Charge)
Scientist
Dr. Thankam Theresa Paul
Technical Staff
Shri. S. Manoharan
Ms. Usha Unnithan
Supporting Staff
Shri. R. Nagrajan
Shri. T. V. Velayudhan
Shri. R. Rajendran
Shri. S. Govindarajan
Shri. P. V. Shajil
Ms. M. G. Soudamon i

Regional Centre, Vadodara
Shri. Wakambam Anand Meetei (Scientist-in-Charge)
Scientist
Shri Dibakar Bhakta (On Study Leave)
Shri.Vaisakh G
Shri. Kamble Suhas Prakash
Technical Staff
Shri. R. K. Sah
Shri. J. K. Solanki
Administrative Staff
Shri. C. D. Parmar
Supporting Staff
Shri. N. K. Rathava
Shri. J. C. Solanki
Shri. Santibhai Chandubhai Tadvi
Shri. R. N. Kantibhai
Shri. S. C. Machhi
Shri. Arjan Valabhai Dangar

Kolkata Research Station

Vadodara Regional Research Centre

PROMOTIONS

Name & Designation	Promoted to	With effect from
Mrs. T.T. Paul, Scientist	Probation Clearance	December 15, 2011
Dr. D.N. Jha, Scientist RGP 6000	RGP 7000	November 06, 2013
Dr. Sandhya K.M., Scientist	Probation Clearance	January 23, 2014
Shri Sanjeev Kumar Sahu, Scientist RGP 8000	RGP 9000	February 25, 2014
Ms. Anjana Ekka, Scientist	Scientist with RGP Rs. 7000/-	June 23, 2014
Shri Tarun Kanti Halder, Sr. Technician	Technical Assistant	August 12, 2014
Dr. Absar Alam, Scientist RGP 6000	RGP 7000	August 14, 2014
Dr. Soma Das Sarkar, Scientist	Scientist with RGP Rs. 7000/-	September 01, 2014
Dr. Sajina A. M., Scientist	Scientist with RGP Rs. 7000/	September 01, 2014
Dr. Deepa Sudheesan, Scientist	Scientist with RGP Rs. 7000/	September 01, 2014
Shri D.K. Meena, Scientist	Scientist with RGP Rs. 7000/	December 15, 2014
Shri Dibakar Bhakta, Scientist	Probation Clearance	January 01, 2015
Dr. B. K. Biswas, ACTO	Chief Technical Officer	January 01, 2015
Shri Santosh Kumar Biswas, S.T.A.	Technical Officer	February 03, 2015
Shri C. N. Mukherjee, ACTO	Chief Technical Officer	February 03, 2015
Shri Amulya Kakati, Technician	Senior Technician	May 25, 2015
Dr. Rohan Kumar Raman, Scientist	Probation Clearance	July 01, 2015
Mrs. Suman Kumari, Scientist	Probation Clearance	July 01, 2015
Shri Ashis Roy Chowdhury, STA	Technical Officer	August 27, 2015
Shri Samir Kumar Paul, Tech Officer	Sr. Tech Officer	October 16, 2015
Dr. Lianthuamluiaia, Scientist	Probation Clearance	January 01, 2016
Dr. Manas H.M., Scientist	Probation Clearance	January 01, 2016
Shri Mishal P., Scientist	Probation Clearance	January 01, 2016
Shri Raju Baitha, Scientist	Probation Clearance	January 01, 2016
Dr. Kavita Kumari, Scientist	Probation Clearance	January 01, 2016
Ms. Gunjan Karnatak, Scientist	Probation Clearance	January 01, 2016
Shri D. K. Biswas, ACTO	Chief Technical Officer	January 01, 2016
Shri Rajesh Kumar Sah, STA	Sr. Technical Assistant	January 01, 2016
Mrs. Tanuja Abdulla, Scientist	Probation Clearance	January 03, 2016
Shri A. K. Mondal, STA	Technical Officer	June 29, 2016
Shri Ram Sajiwan, STA	Technical officer	June 29, 2016
Shri Ram Prasad, TA	Sr. Technical Assistant	June 29, 2016
Shri Subhendu Mandal, TA	Sr. Technical Assistant	June 29, 2016
Shri Asim Kumar Jana, TA	Sr. Technical Assistant	June 29, 2016
Shri Yousuf Ali Sk., TA	Sr. Technical Assistant	June 29, 2016
Shri K.K. Sharma, ACTO	Chief Technical Officer	July 01, 2016
Shri Sujit Chowdhury, STO	Asstt. Chief Technical Officer	July 22, 2016
Smt. Abhijita Sengupta, STO	Asstt. Chief Technical Officer	August 27, 2016
Smt. Mousumi Bannerjee, UDC	2nd MACP with G.P. Rs. 2800/-	September 13, 2016
Shri Bipul Chandra Roy, Tech Officer	Sr. Tech Officer	September 14, 2016
Smt. Shyamali Mitra, Assistant	3rd MACP with G.P. Rs. 4600/-	December 02, 2016
Smt. Pausali Mukherjee, Assistant	Asstt. Admn. Officer	February 13, 2017
Shri Subir Das, Assistant	Asstt. Admn. Officer	February 13, 2017

NEW APPOINTMENTS

Nine ARS Scientists joined the institute in April 2016.

Mr. Himanshu Sekhar Swain
Aquaculture

Mr. Tasso Tayung
Aquaculture

Mr. Mitesh H. Ramteke
Aquaculture

Ms. Prajna Ritambhara Behera
FRM

Mr. Pranob Gogoi
FRM

Ms. Pritijyoti Majhi
FRM

Mr. Shravan Kumar Sharma
FRM

Mr. Vikas Kumar
Agri. Chemicals

Mr. Satya Narayan Sahoo
Fish Health

SUPERANNUATIONS

Name & Designation	Last place of posting	Date of superannuation
Shri M. Balmiki, SSS	Barrackpore Hqs.	May 31, 2016
Shri A. K. Goswami, STA (T-4)	Guwahati RRC	June 30, 2016
Shri K. C. Das, SSS	Guwahati RRC	June 30, 2016
Shri G. Lal, SSS	Allahabad RRC	July 31, 2016
Shri U. Nayak, SSS	Barrackpore Hqs.	July 31, 2016
Shri J. Balmiki, Senior Technician	Barrackpore Hqs.	August 31, 2016
Shri A. K. Bhanja, SSS	Barrackpore Hqs.	August 31, 2016
Smt. Anita Majumder, AAO	Barrackpore Hqs.	September 30, 2016
Dr. D. S. K. Rao, Principal Scientist	Bangalore RRC	October 31, 2016
Shri K. Mohanan, SSS	Bangalore RRC	October 30, 2016 (VRS)
Shri G. J. Raundale, SSS	Vadodara RRC	December 31, 2016
Smt. S. Chakraborty, SSS	Barrackpore Hqs.	December 31, 2016
Shri A. C. Biswas, Assistant	Allahabad RRC	January 31, 2017
Shri B. K. Halder, SSS	Barrackpore Hqs.	January 31, 2017
Shri S. C. Sadhukhan, SSS	Barrackpore Hqs.	January 31, 2017
Shri M. P. Das, SSS	Barrackpore Hqs.	March 31, 2017

TRANSFERS

Name & Designation	From	To
Shri Gulshan Kumar Sharma, Scientist	ICAR-CIFRI, Barrackpore	ICAR-CAZRI, Jodhpur
Shri N. Samarendra Singh, Scientist	ICAR-CIFRI, Barrackpore	ICAR-CIFRI, Guwahati RRC
Shri Vaisakh G., Scientist	ICAR-CIFRI Allahabad RRC	ICAR-CIFRI, Vadodara RRC
Dr. Debabrata Panda, Scientist	ICAR-CIFRI, Barrackpore	ICAR-CIFA, Bhubaneswar
Dr. K. D. Joshi, Principal Scientist	ICAR-CIFRI Allahabad RRC	ICAR-NBFGR, Lucknow
Shri Satya Narayan Sahoo, Scientist	ICAR-CIFRI, Barrackpore	ICAR-CIFA, Bhubaneswar
Mrs. Jesna P.K., Scientist	ICAR-CIFA, Bhubaneswar	ICAR-CIFRI, Bangalore RRC
Dr. Ajoy Saha, Scientist	ICAR-DMAPR, Ananad	ICAR-CIFRI, Bangalore RRC
Shri S. R. Meena, STO	ICAR-CIFRI Allahabad RRC	ICAR-CIFRI, Barrackpore
Shri Rajeev Lal, CAO	ICAR-NIRJAFT, Kolkata	ICAR-CIFRI, Barrackpore

PUBLICATIONS

Research papers

1. Aftabuddin M, Hassan MA, Das AK, Jha BC and Sharma AP (2017). Effect of river connectivity on hydrochemistry, sediment enzyme activity and biotic communities of wetlands. *Aquatic Ecosystem Health & Management*, 20 (1-2):1–11.

2. Alam A, Joshi KD and Das SC (2016). Feeding and reproductive behavior of river catfish *Rita rita* (Hamilton, 1822) in the river Ganga at Allahabad. *Indian Journal of Animal Sciences*, 86(6): 736-740.

3. Anand PS, Kumar S, Kohli MPS, Sundaray JK, Sinha A, Pailan GH and Dam Roy S (2017). Dietary biofloc supplementation in black tiger shrimp, *Penaeus monodon* : effects on immunity, antioxidant and metabolic enzyme activities. *Aquaculture Research*, doi:10.1111/are.13276.

4. Banerjee S, Mahanty A, Mohanty S, Guha Mazumder D, Cash P, Mohanty BP (2017). Identification of potential biomarkers of hepatotoxicity by plasma proteome analysis of arsenic-exposed carp *Labeo rohita*. *Journal of Hazardous Materials*, 336: 71-80.

5. Baruah A, Das R, Kumar S, Roy P, Sahu A, Panda SP, Mishra SS and Das BK (2016). A novel and effective *Clostridium bifermentans* cpss2 against selected fish pathogenic bacteria. *International Journal of Advanced Research*,4 (9): 2140-2150.

6. Behera BK, Baisvar VS, Kumari K, Rout AK, Pakrashi S, Paria P, Das A, Rao AR and Rai A (2016). The complete mitochondrial genome of the Asian stinging catfish, *Heteropneustes fossilis* (Siluriformes, Heteropneustidae) and its comparison with other related fish species. *Mitochondrial DNA Part B*, (1): 804–805.

7. Behera BK, Baisvar VS, Kunal SP, Meena DK, Panda D, Pakrashi S, Paria P, Das P, Bhakta D, Debnath D, Roy S, Suresh VR and Jena JK (2016). Population structure and genetic diversity of Indian Major Carp, *Labeo rohita* (Hamilton, 1822) from three phylo-geographically isolated riverine ecosystems of India as revealed by mtDNA cytochrome b region sequences. *Mitochondrial DNA Part A*, doi:10.1080/24701394.2016.1267156.

8. Behera BK, Kunal S, Baisvar V, Meena DK, Panda D, Pakrashi S, Paria P, Das P, Debnath D, Parida P, Das BK, Jena JK (2016). Genetic variation in wild and hatchery population of *Catla catla* (Hamilton, 1822) analyzed through mtDNA cytochrome b region. *Mitochondrial DNA Part A*, doi: 10.1080/24701394.2016.1253072.

9. Behera BK, Paria P, Das A, Bhowmick, Sahoo AK and Das BK (2017). Molecular characterization and pathogenicity of a virulent *Acinetobacter baumannii* associated with mortality of farmed Indian Major Carp *Labeo rohita* (Hamilton 1822). *Aquaculture*, 471:157–162.

10. Bhagawati K, Chadha NK, Sarma D, Akhtar MS, Sawant PB and Borah S, (2016). Effect of dietary zince on the growth and metabolic enzyme activities of golden mahseer *(Tor putitora*) fry. *Journal of Applied and Natural Science*, 8(3) : 1692-1698.

11. Bhakta D, Srikrishnadhas R, Das SCS and Canciyal J (2016). Effect of non-steriod hormones HCG and DES on growth and maturation of Indian river prawn, *Macrobrachium malcolmsonii* (H. Milne Edwards). *National Journal of Life Sciences*, 13(2): 207-210.

12. Bhakta D and Rao DSK (2016). Ecology and fishery status of Ukai reservoir, Gujarat. *Journal of Inland Fisheries Society of India*, 48(2): 8-13.

13. Bhakta D, Manna RK, Meetei WA, Solanki JK and Sah RK (2016). Traditional fishing crafts and gears of Ukai reservoir, Gujarat, India. *International Journal of Fisheries and Aquatic Studies*, 4(4): 142-145.

14. Bhattacharjya BK, Bhaumik U and Sharma AP (2017). Fish habitat and fisheries of Brahmaputra River in Assam, India. *Aquatic Ecosystem Health and Management*, 20(1-2): 102-115.

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3. Roy A and Das AK (2016). *Antardeshiya Matsya Chaser Byabashthapanar Madhyame Adibashi Matsypalakder Jibikar Unnati*, Training Manual No. 3, ICAR-CIFRI, Barrackpore, pp. 54.

4. Das AK (2016). *Inland Fisheries Management*, Training Manual No. 4 prepared for M.FSc students of ICAR-CIFE, Mumbai, pp. 178.

5. Das AK (2016). Training Manual on *Inland Fisheries Management*, prepared for Dept. of Fishery Officials of Chhattisgarh, ICAR-CIFRI, Barrackpore, pp. 188.

6. Das P, Bhattacharjya BK, Parida PK, Behera BK and Das BK (2016). *Aquatic Animal Diseases in Assam*. ICAR-CIFRI, Barrackpore, ISSN: 0970-616X, pp. 100.

Technical Bulletins

1. Sinha A. and Roy A. 2015. *Sundarbans mein Ajivika evang Poshkiya suraksha hetu chhoti deshi machhli ka utpadan avang sanrakshan*, Bulletin No. 195, Published by Director, ICAR-CIFRI, Barrackpore, Kolkata, 24pp.

2. Sarkar SD, Sahoo AK, Sadhukhan D, Mohanty BP, Raman RK and Das BK (2017). *Phytoplankton of River Mahanadi in Odisha, India: A Pictorial Guide*. Bulletin No. 196, ICAR-Central Inland Fisheries Research Institute. Barrackpore, Kolkata, India. 61pp.

3. Roshith CM, Sahoo AK, RoyChowdhury A and Das BK (2017). *Fishes of River Mahanadi in Odisha, India: A Field Guide*. Bulletin No. 197, Bulletin, ICAR-Central Inland Fisheries Research Institute, Barrckpore, Kolkata, 97pp.

4. Sarkar UK, Nag SK, Das MK, Karnatak G and Sudheesan D (2016).*Conserving Wetlands- An Effective Climate Change Adaptation in India*. Bulletin No. NICRA/CIFRI/2015-16/2. ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata, India (ISSN: 0970-616X), 20pp.

Leaflets

1. Debnath D, Yengkokpam S, Mohanty BP, Bhattacharjya BK and Payeng L (2016). *Aamar khadyot byabarhita machar poshtijanita upakarita*. IICAR-Central Inland Fisheries Research Institute, Barrackpore.

2. Debnath D, Yengkokpam S, Mohanty BP, Das BK and Bhattacharjya BK (2016). *Nutritional significance of fish in our diet*. ICAR-Central Inland Fisheries Research Institute, Barrackpore.

3. Roy A, Aftabuddin M, Sinha A, Parida P, Ghosh A and Bayen S (2016). *Small indigenous fishes (SIFs) in nutritional security for rural community*, Pamphlet. ICAR-Central Inland Fisheries Research Institute, Barrackpore.

4. Roy A, Aftabuddin M, Sinha A, Parida P, Ghosh A and Bayen S (2016). *Sunderbaner manusher pushtisurakhay deshio chhoto machh,* Pamphlet. ICAR-Central Inland Fisheries Research Institute, Barrackpore.

5. Roy A, Aftabuddin M, Sinha A, Parida P, Ghosh A and Bayen S (2017). *Poshakiya suraksha ebam gramin vikash hetu chhoti deshi matsya prajatio ka palan,* Pamphlet. ICAR-Central Inland Fisheries Research Institute, Barrackpore.

6. Roy A, Manna SK, Sandhya KM, Parida PK and Bandopadhyay MK (2017). *Proposed activities for celebration of CIFRI's 70th Foundation Year*, Leaflet. ICAR-Central Inland Fisheries Research Institute, Barrackpore.

7. Sarkar UK, Das MK, Nag SK, Nakar M and Karnatak G (2016). *Climate change impact and adaptive measures in wetland Fisheries*, Pamphlet. ICAR-Central Inland Fisheries Research Institute, Barrackpore.

Lecture Compendium

1. Das P., Bhattacharya B. K., Parida P. K., Behera B. K. and Das B. K. (Eds.), 2016. *Aquatic Animal Diseases in Assam*. ICAR-Central Inland Fisheries Research Institute, Barrackpore, West Bengal, pp 135 .

2. Das A. K. and Roy A. (Eds.), 2016. *Inland Fisheries Management*. ICAR-Central Inland Fisheries Research Institute, Barrackpore, West Bengal.

3. Das A. K. and Roy A (Eds.), 2016. *Inland Fisheries Management*. ICAR-Central Inland Fisheries Research Institute, Barrackpore, West Bengal.

4. Das A. K. and Roy A (Eds.), 2017. *Inland Fisheries Management*. ICAR-Central Inland Fisheries Research Institute, Barrackpore, West Bengal.

5. Roy A and Das A. K. (Eds.), 2017. *Antardeshio matsya chasher babosthaponar madhyame adibasi matsya palokder jibikar unnati*, ICAR-Central Inland Fisheries Research Institute, Barrackpore, West Bengal.

Newsletter

1. Pandit Arun (ed). CIFRI Newsletter "CIFRI News" Vol 20, No.2.
2. Pandit Arun (ed). CIFRI Newsletter "CIFRI News" Vol 21, No.1.

Others

- Calendar on Small fishes of River Gandak and its conservation.
- Documentary film on 'Torsa River Lifeline of Terai region'.
- Video / Documentary on success story of ICAR-CIFRI Tribal Sub Plan Activities

LINKAGES

The institute maintains close linkages with several organizations involved in fisheries research and development in India and abroad. The institute collaborated with them in research, development, extension, outreach activities, seminars, workshops and publications. The key partners of the institute in 2016-17 were:

International organizations

- Bay of Bengal Large Marine Ecosystem, FAO
- International Union for Conservation of Nature (IUCN)
- World Fish Centre, Malaysia
- Wetland International, New Delhi
- WWF-India, New Delhi

National

Universities

- State Institute of Rural Development (SIRD), Govt. of Assam
- Uttarbanga Krishi Viswavidyalaya, Poondibari, West Bengal
- G. B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand
- Rajendra Agricultural University, Pusa, Samastipur, Bihar
- West Bengal University of Animal and Fisheries Sciences, Kolkata, West Bengal
- Assam Agricultural University, Jorhat, Assam
- Assam Fisheries Development Corporation Ltd., Guwahati, Assam
- Department of Zoology, University of Calcutta, West Bengal
- Department of Environmental Science, Manonmaniam Sundar University, Alwarkurichi, Tamilnadu
- University of Kalyani, Kalyani, West Bengal
- Vidyasagar University, Midnapore, West Bengal
- West Bengal Biodiversity Board
- Visva-Bharati University, Santiniketan, West Bengal
- Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal
- Garhwal University, Srinagar, Uttarakhand

- Centre for Innovation in Public Sector, Hyderabad
- University of Agriculture Science, Dharward
- Central University of Bihar, Patna
- Manipur University, Imphal, Manipur
- College of Fisheries, Central Agricultural University, Lembucherra, Agartala
- Indian Institute of Science Education and Research, Kolkata
- Indian Statistical Institute, Kolkata, West Bengal
- Indian Institute of Technology, Kharagpur
- Faculty of Life Sciences, Manipur University, Imphal
- School of Environmental Sciences, JNU, New Delhi

Central organizations

- National Fisheries Development Board, Hyderabad
- Department of Animal Husbandry, Dairying and Fisheries, New Delhi
- National Institute of Oceanography (NIO), Dona Paula, Goa
- Chilika Development Authority, Bhubaneswar
- National Institute of Ecology, Jaipur
- Space Applications Centre, Ahmedabad
- ITCOocean, INCOIS, Hyderabad
- National Mission for Clean Ganga, Ministry of Water Resources (MoWR), New Delhi
- Central Water Commission, New Delhi

ICAR organizations

- Indian Agricultural Research Institute, New Delhi
- ICAR-Central Institute of Fisheries Education, Mumbai
- National Academy of Agricultural Research Management, Hyderabad
- ICAR-ICAR Research Complex for NEH , Umiyam, Meghalaya
- ICAR-ATARI, Umiam, Meghalaya
- ICAR-Central Marine Fisheries Research Institute, Kochi
- ICAR-Central Institute of Fisheries Technology, Kochi
- ICAR-Central Institute of Freshwater Aquaculture, Bhubaneswar
- ICAR-Central Institute of Brackishwater Aquaculture, Chennai
- ICAR-Directorate of Coldwater Fisheries, Bhimtal
- ICAR-National Bureau of Fish Genetic Resources, Lucknow
- ICAR-NRC on Pig , Rani, Assam
- ICAR-ATARI, Kolkata

- ICAR-National Institute of Research on Jute & Allied Fibre Technology, Kolkata
- ICAR-Central Research Institute of Jute & Allied Fibre, Barrackpore, Kolkata
- ICAR- NIANP, Bangalore

State Departments

- Commissioner of Fisheries, Gujarat
- Directorate of Fisheries, Assam
- Directorate of Fisheries, Bihar
- Directorate of Fisheries, Jharkhand
- Directorate of Fisheries, West Bengal
- Directorate of Fisheries, Odisha
- Directorate of Fisheries, Himachal Pradesh
- Directorate of Fisheries, Chattishgarh
- Directorate of Fisheries, Telengana
- Directorate of Fisheries, Karnataka
- Directorate of Fisheries, Madhya Pradesh
- Directorate of Fisheries, Kerala
- Directorate of Fisheries, Uttar Pradesh
- Directorate of Fisheries, Andhra Pradesh
- Gujarat Forest Department, Ukai
- Narmada, Water Resources, Water Supply and Kalpasar Department, Gandhinagar, Gujarat

Industries/Corporations/ State Boards

- Assam Fisheries Development Corporation
- SardarSarovar Narmada Nigam Limited
- NHPC
- Inland Waterways Authority of India
- Madhya Pradesh Fish Cooperative Federation
- Gujarat Maritime Board, Bharuch
- Sundarban Development Board, West Bengal
- Farraka Barrage Authority, Murshidabad

CIFRI IN MEDIA

SEMINARS/SYMPOSIA/ MEETINGS ATTENDED

Sl. No.	Name of the Programme	Date	Participants	Organizer and Venue
1	Annual Day celebration of ICAR-CIFA, Bhubaneswar	1 April 2016	B. P. Mohanty	ICAR - CIFA, Bhubaneswar
2	Annual Day celebration of CIFA, Centre, Anand	1 April 2016	C. D. Parmar, J. K. Solanki, W. Anand Meetei	CIFA, Centre, Anand, Gujarat
3	Meeting with Chief Engineer & Additional Secretary, Narmada, Water Resources, Water Supply and Kalpasar Department	2 April 2016	R. K. Sah, W. Anand Meetei	Gandhinagar, Gujarat
4	Meeting on National Mission on Clean Ganga (NMCG)	10 April 2016	K. D. Joshi	NMCG, Ministry of Water Resources, River Development and Ganga Rejuvenation and Chandi Ghat, Haridwar
5	National Consultation on Ornamental Fish	27 - 28 April 2016	Archana Sinha	NFDB, Hyderabad
6	Pillay Aquaculture foundation Social Entrepreneurship in Aquaculture	28 - 29 April 2016	A. K. Das, Archana Sinha, Gunjan Karnatak, Suman Kumari	ICAR - CIFE, Mumbai
7	Consultation Meeting on Identification and Assessment of Wetlands in Bihar in the context of Wetland (Management and Conservation) Rule, 2010	29 - 30th April 2016.	M.A.Hassan	Environment & Forests Department. Government of Bihar, Aranya Bhawan, Riding Road, Patna-800014.
8	National Workshop on Breeding and Culture of *A. mola*	3 May 2016	Archana Sinha	NFDB, Hyderabad
9	1st International Training Workshop on Taxonomy of Bivalve Molluscs	10 - 14 May 2016	W. Anand Meetei, T. Nirupada Chanu	Department of Marine Biology, Microbiology and Biochemistry, School of Marine Sciences, CUSAT, Kochi and Cochin University of Science and Technology, Kochi
10	Meeting with Chief Engineer & Additional Secretary, Narmada, Water Resources, Water Supply and Kalpasar Department	8 June 2016	J. K. Solanki, Vaisakh G., W. Anand Meetei	Gandhinagar, Gujarat
11	State Level Conference on Wetland Conservation	16 June 2016	U. K. Sarkar	Nalban Park, Salt lake, Kolkata
12	Meeting on Evaluation of Progress of a Researcher under UGC, BSR Fellowship for up gradation from JRF to SRF	18 June 2016	K. D. Joshi	Dept. of Zoology, University of Allahabad, Allahabad
13	Meeting of the Minister of Agriculture & Farmers' Welfare and DG, ICAR, on Agriculture and Green revolution in Eastern Region	20 June 2016	U. K. Sarkar	Grand Hotel, Kolkata
14	Meeting with Minister for Fisheries and Harbour engineering, Govt. of Kerala	20 June 2016	M. Feroz Khan	ICAR - CMFRI, Kochi
15	Workshop for Monitoring and Evaluation Studies	23 June 2016	Aparna Roy	ICAR - NAARM, Hyderabad
16	23rd Meeting of ICAR – Regional Committee II	24 - 25 June 2016	V. R. Suresh, Arun Pandit, S. Samanta, S. Majumdar	ICAR - NAARM, Hyderabad
17	Meeting on Nagar Rajbhasa Karyanvan Samati	26 June 2016	C. D. Parmar W. Anand Meetei	Race course, Vadodara and Vadodara, Gujarat

Sl. No.	Name of the Programme	Date	Participants	Organizer and Venue
18	Multi-stakeholders Action for River Rejuvenation	27 June 2016	K. D. Joshi	U. P. State Irrigation Department and Water Resources Group and Chief Minister's Residence, Lucknow
19	Steering Committee Meeting of the Second Green revolution in Eastern India	27 June 2016	U. K. Sarkar	ICAR-Research Complex for Eastern Region, Patna
20	National Perspective plan of Aquaculture in Kerala	9 July 2016	Preetha Panikkar	Department of Fisheries, Govt. of Kerala at Kollam, Kerala
21	First State Co- ordination Committee for 2nd Green Revolution held at Agriculture Directorate	14 July 2016	U. K. Sarkar	Nabanna Building, Kolkata, West Bengal
22	Workshop on *Rastriya Paripreksha Me Samavesi Takneeki Shikshya: Chunautiyan Evam Samadhan*	16 July 2016	K. D. Joshi	Motilal Nehru National Institute of Technology, Allahabad
23	Inter-state Horti Sangam and Kisan Gosthi	9 - 10 July 2016	Ganesh Chandra	Horti Sangam, Hajipur, Bihar
24	TOLIC meeting	23 July 2016	M. Feroz Khan and Preetha Panikkar	NAL, Bangalore
25	Drafting Karnataka State Fisheries Policy	2 August 2016	M. Feroz Khan	Directorate of Karnataka State Fisheries, Vikas Soudha, Bangalore
26	National Agricultural Exhibition	10 - 14 August 2016	Sandhya K. M.	Central Calcutta Science & Culture Organization for Youth
27	Video Conferencing on Namami Gange Programme	13 August 2016	K. D. Joshi	Office of the District Magistrate, Allahabad
28	1st Regional Science & Technology Congress, 2016	13 - 14 August 2016	Dibakar Bhakta	NITTTR, Kolkata
29	Meeting of Departmental Promotion Committee	17 August 2016	K. D. Joshi	NBFGR, Lucknow
30	XXIII Meeting of Regional Committee - IV	26 - 27 August 2016	K. D. Joshi	ICAR - RCER, Patna
31	Financial and Technical Review Meeting of NICRA	2 - 3 September 2016	U. K. Sarkar	CRIDA, Hyderabad
32	Workshop on Enhancement of Fish Productivity	4 September 2016	B. K. Bhattacharjya, D. Debnath, P. Das, S. Borah	Directorate of Fisheries, Guwahati, Assam
33	Technical Session on Mahseer Conservation and Enhancement	8 - 10 September 2016	U. K. Sarkar	Devi Ahilya University, Indore, Madhya Pradesh
34	Meeting with CDA, Bhubaneswar on Restoration of Hilsa Fishery in Chilika Lake, Health Card of Chilika lake, Fish Diversity in Anshupa lake under Project Mode	9 September 2016	A. K. Sahoo	Chilika Development Authority Office, Bhubaneswar
35	XXIV ICAR- Regional committee meeting at ICAR - CAZRI, Jodhpur	13 - 16 September 2016	W. Anand Meetei	ICAR - CAZRI, Jodhpur and Jodhpur, Rajasthan
36	Institute Technical Management Committee Meeting of ICAR - NIRJAFT	14 September 2016	M. Naskar	ICAR – NIRJAFT, Kolkata
37	Workshop cum training programme on Biofloc Technology	15 - 17 September 2016	Mishal P., S. N. Sahoo, H. S. Swain	ICAR-CIBA, Chennai

Sl. No.	Name of the Programme	Date	Participants	Organizer and Venue
38	*Rajbhasha takhniki sangoshti*	22 September 2016	Preetha Panikkar	Dept of Official Language / Ministry of Home affairs/Regional Implementation office (South) at Bangalore
39	ZREAC meeting (Rabi 2016-17) for Lower Brahmaputra Valley Zone of Assam	6 October 2016	B. K. Bhattacharjya	Chief Scientist, Regional Agricultural Research Station (AAU), Gosaigaon and Horticultural Research Station , Kahikuchi, Guwahati
40	2nd International Conference on Translational Research	14 - 16 October 2016	B. P. Mohanty	KIIT University, Bhubaneswar
41	Meeting with S.D. Vora (Add P.C.C.F), Dr. S.M. Saiyad, Deputy Conservator of Forests and Dr. Afroz Ahmad Member N.C.A. (E&R), Gandhi Nagar	18 October 2016	C. D. Parmar W. Anand Meetei	Block No. 12, New Sachivalaya, Gandhinagar, Gujarat
42	Workshop on Hygienic Handling of Fishes	31 October 2016	B. K. Bhattacharjya D. Debnath, P. Das, S. Borah	Directorate of Fisheries, Guwahati, Assam
43	Review Meeting of Outreach Activities under Fisheries Science Division, ICAR	3 November 2016	B. P. Mohanty, B. K. Behera, M. A. Hassan	ICAR, New Delhi
44	1st International Agrobiodiversity Congress	6 - 9 November 2016	B. P. Mohanty Sandhya K. M.	ICAR, New Delhi
45	26th *Swadeshi* Science Congress	7-9 November, 2016	Thankam Theresa Paul	ICAR-Central Marine Fisheries Research Institute, Kerala and Swadeshi Science Movement, Kerala
46	25th ICAR regional committee meeting	11 - 12 November, 2016	Rani Palaniswamy	TNAU, Coimbatore
47	National Workshop on Mainstreaming Climate Change and Adaptation in Agriculture and Allied Sectors	16 - 17 November 2017	Preetha Panikkar	MANAGE, Hyderabad
48	World Fishery Day	21 November 2016	S. K. Nag	KVK, ICAR-CRIJAF, Bud Bud, Burdwan, West Bengal
49	National Seminar on Aquaculture Diversification: The Way Forward for Blue Revolution	1 - 3 December 2016	B. K. Das, A. K. Das, A. K. Bera, A. K. Sahoo, Aparna Roy, Arun Pandit, B. P. Mohanty, R. K. Raman, U. K. Sarkar	ICAR - CIFA, Bhubaneswar
50	Meeting for project proposal (Potential of Insects as fish feed	03 December 2016	M. Feroz Khan and Preetha Panikkar	ICAR-NBAIR, Bangalore
51	Consultation programme on Developing Roadmap for Fisheries in Eastern Region of India	7 December 2016	All Scientists of Headquarters	ICAR - CIFRI, Barrackpore
52	Stakeholders' Workshop on Wetlands by IWMI, New Delhi Office	8 December 2016	B. K. Das, Arun Pandit and A. K. Sahoo	Khadya Bhawan, Govt. of W.B., Kolkata

Sl. No.	Name of the Programme	Date	Participants	Organizer and Venue
53	International Conference on Climate change adaptation and biodiversity: Ecological sustainability and resource management for livelihood security	8 - 10 December 2016	S. K. Nag	Andaman Science Association and ICAR-CIARI and ICAR - CIARI, Port Blair
54	Annual Review Workshop of NICRA	9 - 10 December 2016	U. K. Sarkar	NASC Complex, New Delhi
55	National Consultation on Small Farmer Production Systems: Way Forward	22 December 2016	Preetha Panikkar	ICAR-NIANP, Bangalore
56	Workshop on 'Fish feed formulation, preparation and its importance in Northeast India'	22 - 23 December 2016	B. K. Bhattacharjya, A. K. Yadav, P. Das, N. Sharma, S. Borah and N. S. Singh	NFDB, ICAR-CIFA and ICAR - CIFRI, Guwahati
57	Meeting of the 20th National Committee on Introduction of Exotics Aquatic Species in to Indian Waters	23 - 24 December 2016	U. K. Sarkar	Krishi Bhawan , New Delhi
58	Finalisation of Studies on Impact Assessment of Coal Transportation through Barges along the National Waterway No. 1 (Sagar to Farraka) along River Ganga	26 December 2016	A. K. Sahoo	IWAI, Noida and New Delhi
59	National Action Plan on Antimicrobial Resistance in Developing Country	27 December 2017	A. K. Bera	NASC, New Delhi
60	Institute Technical Management Committee Meeting of ICAR - NIRJAFT	30 December 2016	M. Naskar	ICAR - NIRJAFT, Kolkata
61	Inception workshop on 'Assessment of food loss from selected gillnet and trammel net fisheries for India',	04 January 2017	Rani Palaniswamy	CIFT, Kochi
62	TOLIC jkt•k"kk d Á•koh Á;¨x e jkt•k"kk dk;kZo;u lfefr dh •fedk	10 January 2017	Preetha Panikkar	ISRO, Bangalore
63	National Symposium on Enhancement of Livelihood Security through Sustainable Development of Livestock and Fishery Sector	10 - 11 January 2017	Dibakar Bhakta	WBUAFS, Belgachia, Kolkata
64	Awareness-cum-workshop on Fish Disease Surveillance: Nutritional Importance of Fish Consumption on Human Health	13 January 2017	B. P. Mohanty, U. K. Sarkar, S. K. Nag, Arun Pandit, Raju Baitha, B. Behera	Akaipur, Bangaon Block, North 24 Parganas
65	Scientists interaction meeting on visit of Dr. TrilochanMohapatra, Secretary DARE & DG, ICAR ; DDG (Fy.Sc.) and Director of ICAR-CIFRI	15 January 2017	M. Feroz Khan, Preetha Panikkar, M. Karthikeyan, Ramya V. L.	ICAR - CIFRI Research Centre, Bangalore
66	Meeting for presentation of report on "Assessment of environmental flows for Shivasamudram Seasonal Power Scheme on River Cauvery, Karnataka"	21 January 2017	M. Feroz Khan and Preetha Panikkar	Karnataka Power Corporation Limited, Bangalore
67	8th National Extension Congress	28 - 31 January 2017	Aparna Roy	ICAR - NAARM, Hyderabad

Sl. No.	Name of the Programme	Date	Participants	Organizer and Venue
68	Workshop on Collection, Preservation and Identification of Insects and Mites of Economic Importance	30 - 31 January 2017	M. Naskar	Zoological Survey of India, Kolkata
69	Technical Knowledge Exchange Workshop for Bangladesh and India on Vulnerability of Sundarban in a Changing Climate	3 February 2017	Sandhya K. M. U. K. Sarkar	Ramakrishna Mission Institute of Culture, Kolkata
70	Expert Appraisal Committee Meeting of Inland Waterways Authority of India for the sponsored Project on Impact Assessment of Coal Transportation through barges along the National Waterway No - 1 (Sagar to Farakka) along River Ganga	14 February 2017	S. Samanta	Ministry of Environment, Forest and Climate Change, Govt. of India, New Delhi
71	Polavaram Project Meeting on Fish Management and Design of Fish Ladder in Polavaram Irrigation Project	14 - 15 February 2017	A. K. Sahoo	Department of Irrigation, Andhra Pradesh and Polavarum Project Site, Polavarum, Andhra Pradesh
72	Workshop cum Training programme on Simulation modelling for Climate Impact Assessment under NICRA	14 - 18 February 2017	R. K. Raman	ICAR-IISS Bhopal
73	UGC SAP National Seminar and Meeting of the Advisory Committee of UGC SAP Programme	17 February 2017	U. K. Sarkar	Guru Nanak Dev University, Amritsar
74	Agricultural Crop Seminar	18 February 2017	B. K. Bhattacharjya	Doordarshan Kendra, Guwahati and Centre of Excellence on Citrus, Boko, Assam
75	XIII Agricultural Science Congress 2017	21 - 24 February 2017	R. K. Raman	UAS, Bengaluru
76	Competency Enhancement Programme for Effective Implementation of Training Functions by HRD Nodal Officers of ICAR	23 - 25 February 2017	S. K. Nag	ICAR - NAARM, Hyderabad
77	Conference on Effect of Climate Change on Faunal Diversity	27 February 2017	U. K. Sarkar	Kalyani University, West Bengal
79	Student Convention and Jalchari Pradarshani	3 - 5 March 2017	Ganesh Chandra	ICAR - CIFE, Mumbai
80	Fisheries Institute ABI – Industry Meet	4 March 2017	Ganesh Chandra	ICAR - CIFE, Mumbai
81	Institute Technical Management Committee Meeting of ICAR - NIRJAFT	6 March 2017	M. Naskar	ICAR - NIRJAFT, Kolkata
82	Fish Trade Innovations in Food Safety and Security	8 - 9 March 2017	B. P. Mohanty	OUAT, Bhubaneswar

Sl. No.	Name of the Programme	Date	Participants	Organizer and Venue
83	National Seminar on Priorities in Fisheries and Aquaculture	11 - 12 March 2017	B. K. Behera, A. K. Bera, A. K. Das, A. K. Yadav, Anjana Ekka, Aparna Roy, Arun Pandit, B. K. Bhattacharjya, B. P. Mohanty, S. Samanta, D. Debnath, D. K. Meena, Dibakar Bhakta, Ganesh Chandra, Gunjan Karnatak, H. S. Swain, Lianthuamluaia, M. Naskar, M. A. Hassan Mishal P., N. S. Singh, N. Sharma, S.K. Manna, P. Das, Pritijyoti Majhi, R. K. Raman, R. Palaniaswamy, S. Borah, S. K. Nag, S. K. Sahu, Sandhya K. M., T.T. Paul, Sibina Mol S., Tasso Tayung, U. K. Sarkar, W. Anand Meetei, T. Nirupada Chanu, Satish Koushlesh, D.N.Jha Md. Absar Alam, S.C.S.Das, Jeetendra Kumar, D. Sudheesan, S. N. Sahoo	College of Fisheries, Rangeilunda, Odisha
84	Hindi Rajbhasa Workshop	16 March 2017	C.D. Parmar, R.K. Sah	Power Grid Corporation of India Ltd., Vadodara, Gujarat
85	Science and Technology Fair	25 - 27 March 2017	Ganesh Chandra	Vivekanand Vigyan Kendra, Kolkata and IEM Ground, Salt Lake, Kolkata
86	International conference on Natural Resources Management and Technology Trends	27 - 29 March 2017	Sona Yengkokpam	Department of Zoology, Manipur University, Imphal

DISTINGUISHED VISITORS

Shri Radha Mohan Singh, Honourable Union Minister of Agriculture and Farmer's Welfare, Government of India visited Allahabad Regional Centre of ICAR-Central Inland Fisheries Research Institute on 13 June 2016.

Dr. Trilochan Mohapatra, Secretary, DARE and DG, ICAR, New Delhi visiting the Institute HQ

Visit by Principal Secretary, Govt. of M.P.

Interaction meeting of Financial Advisor, ICAR with the Institute staff

Shri Parimal Suklabadya, Honourable Minister of PWD, Fisheries and Excise, Government of Assam, visited Regional Centre of ICAR-CIFRI, Guwahati on 25 December 2016

Shri Jayant Sahasrabuddhe, National Organising Secretary, Vijnanabharati, visited ICAR-CIFRI, Barrackpore on 27 November 2016

- Shri Shyama Charan Gupta, Member of Parliament, Lok Sabha
- Sri Silbhadra Dutta, Member of Legislative Assembly, West Bengal
- Shri Madhusudan Ghosh, Member of Legislative Assembly, West Bengal
- Shri Bimal Borah, Member of Legislative Assembly, Assam
- Shri Sunil Kumar Singh, IAS, Additional Secretary & Financial Advisor, DARE/ICAR, New Delhi
- Dr. J. K. Jena, DDG (Fisheries Sc.), ICAR, New Delhi
- Prof. Purnendu Biswas, Vice Chancellor, West Bengal University of Animal and Fishery Sciences, Kolkta, West Bengal.
- Dr. Gopal Krishna, Director cum Vice Chancellor, ICAR-CIFE, Mumbai
- Mr. M. C. Jauhari, IAS, Principal Secretary of Fisheries, Government of Assam
- Shri Vinod Kumar, IAS, Principal Secretary of Fisheries, Government of Madhya Pradesh
- Major General A. K. Pal, VSM, Indian army, Kolkata
- Dr. Sudhir Raizada, ADG, Inland Fisheries, ICAR, New Delhi
- Dr. P. G. Karmakar, Director, ICAR-CRIJAF, Barrackpore
- Dr. K. K. Vijayan, Director, ICAR-Central Institute of Brackishwater Aquaculture, Chennai
- Dr. B. Madhusudana Kurup, former VC of Kerala University of Fisheries and Ocean Sciences, Kochi
- Dr. Dilip Kumar, Former Director & Vice Chancellor, ICAR-CIFE, Mumbai
- Dr. S. M. Shivaprakasha, Director of Extension, Karnataka Veterinary and Fisheries Science University, Bidar, Karnataka
- Dr. N. N. Rai, Director, Hydrology (NE), Central Water Commission, New Delhi
- Dr. B. K. Dwivedi, Director, Bioved Institute, Allahabad

Interaction with Scientists by the DDG (Fisheries Science) at the Institute HQ

- Dr. U. S. Gautam, Director, ICAR-ATARI, Kanpur, Uttar Pradesh
- Shri Atharv Tripurari, IPS, Special IG, Armed Police, Barrackpore
- Shri S. K. Das, ACS, Director of Fisheries, Government of Assam
- Shri Nishat Ahmed, Director of Fisheries, Government of Bihar
- Dr. K. Kannan, IPS, Commandant, West Bengal Armed police, Barrackpore
- Shri Jayant S Sahastrabudhe, National Organising Secretary, Vigyan Bharati
- Dr. K. K. Satapathy, Ex-Director, ICAR-NIRJAFT, Kolkata
- Dr. Dipak Sarkar, Ex-Director, ICAR-NBSS & LUP, Nagpur
- Dr. Samir Kanti Naskar, Ex-Director, ICAR-Central Tuber Crops Research Institute, Kerala
- Shri S. Biswas, Joint Director, Department of Fisheries, Government of West Bengal
- Shri Debananda Bhanja, Joint Director, Department of Fisheries, Government of Odisha
- Dr. B. Lahon, Senior Consultant, NFDB, Regional Centre, Guwahati, Assam
- Mr. Bart Hilhorst, Senior consultant, IWMI, New Delhi
- Shri S. D. Vora, Additional Principal Chief Conservator of Forest, SSNNL, Gandhinagar
- Dr. S. M. Saiyad, Deputy Conservator of Forest, Gandhinagar

The DG (ICAR) visiting Bengaluru RRC

The DG (ICAR), DDG (Fisheries Sc.), ICAR and other Dignitaries releasing publications at Bengaluru RRC

ACRONYMS

ab Maneri1	Above Barrage Maneri1	**IISS**	Indian Institute of Soil Science
ADF	Assistant Director of Fisheries	**IMC**	Indian Major Carp
ADG	Assistant Director General	**IRC**	Institute Research Committee
AFDC	Assam Fisheries Development Corporation	**ISTM**	Institute of Secretariat Training and Management
AKMU	Agricultural Knowledge Management Unit	**ITK**	Indigenous Technical Knowledge
Ald rs	Allahabad	**ITMU**	Institute Technology Management Unit
ANOVA	Analysis of Variance	**IUCN**	International Union for Conservation of Nature
bl Maneri2	Below Barrage Maneri1	**Kanj**	Kannauj
BCKVV	Bidhan Chandra Krishi Vishwa Vidyalaya	**Kanp Ab**	Kanpur Above Barrage
Bijn. Ab	Bijnor Above Barrage	**Kanp bb**	Kanpur Below Barrage
Bijn. Bl	Bijnor Below Barrage	**Kanp bb**	Kanpur Below Barrage
BMI	Body Mass Index	**l**	litre
BMP	Best Management Practice	**MDS**	Multi-dimensional Scaling
CABIN	Centre for Agricultural Bio-informatics	**MEI**	Morpho Edaphic Index
CBF	Culture Based Fisheries	**Mg**	Mega gram
CCA	Canonical Correspondence Analysis	**MGMG**	*Mera Gaon Mera Gaurav*
CDA	Chilika Development Authority	**MoEF & CC**	Ministry of Environment, Forest and Climate Change
Chilasis	Chinyalisaur	**MSY**	Maximum Sustainable Yield
CIBA	Central Institute of Brackishwater Aquaculture	**MT**	Metric Tonnes
CIFA	Central Institute of Freshwater Aquaculture	**NAARM**	National Academy of Agricultural Research Management
CIFE	Central Institute of Fisheries Education	**Narora ab**	Narora Above Barrage
CIFRI	Central Inland Fisheries Research Institute	**Narora bl**	Narora Below Barrage
CMFRI	Central Marine Fisheries Research Institute	**NASF**	National Agricultural Science Fund
CPCB	Central Pollution Control Board	**NBFGR**	National Bureau of Fish Genetic Resources
CPUE	Catch Per Unit Effort	**NBSSLUP**	National Bureau of Soil Survey and Land Utilization Planning
CPWD	Central Public Works Department	**NEH**	North-East Hill
CRIJAF	Central Research Institute for Jute and Allied Fibres	**NFDB**	National Fisheries Development Board
DAHDF	Department of Animal Husbandry, Dairying and Fisheries	**NICRA**	National Innovations on Climate Resilient Agriculture
DARE	Department of Agricultural Research and Education	**NIRJAFT**	National Institute of Research on Jute and Allied Fibre Technology
DDE	Dichlorodiphenyldichloroethylene	**NMCG**	National Mission for Clean Ganga
DDT	Dichlorodiphenyltrichloroethane	**NPP**	Net Primary Productivity

Cont .....

ACRONYMS continued

DHA	Docosa Hexaenoic Acid	OTA	Over -time Allowance
e-DAS	electronic Data Acquisition System	**OUAT**	Orissa University of Agriculture and Technology
EHP	Enterocytozoon Hepatopenaei	**PFZ**	Potential Fishing Zone
eLDAS	electronic Length Data Acquisition System	**PME**	Priority setting, Monitoring and Evaluation
EPA	Eicosa Pentanoic Acid	**PUFA**	Polyunsaturated Fatty Acid
FCR	Food Conversion Ratio	**RAC**	Research Advisory Council
FEO	Fisheries Extension Officer	**REF**	Riverine Ecology and Fisheries
FL	Fingerling	**RFD**	Results-Framework Document
FREM	Fishery Resource and Environmental Management	**RGCA**	Rajiv Gandhi Centre for Aquaculture
FRL	Full Reservoir Level	**RS**	Research Station
FSSAI	Food Safety Standards Authority of India	**RRC**	Regional Research Centre
GADVASU	Guru Angad Dev Veterinary and Animal Sciences University	**RWF**	Reservoir and Wetland Fisheries
GaSI	Gastro-somatic Index	**SGR**	Specific Growth Rate
GEFC	Global Environmental Flow Calculator	**SHG**	Self Help Group
GIS	Geographic Information System	**SIF**	Small Indigenous Fish
GPP	Gross Primary Productivity	**Sring ab**	Srinagar Above Barrage
GSI	Gonado Somatic Index	**Sring bb**	Srinagar Below Barrage
Haridwar ab	Haridwar Above Barrage	**SSB**	Spawning Stock Biomass
Haridwar bl	Haridwar Below Barrage	**t**	Tons
HCH	Hexachlorocyclohexane	**Tehri ZP**	Tehri Zero Point
HPLC	High-performance liquid chromatography	**TDS**	Total Dissolved Solid
HRD	Human Resource Development	**TL**	Total Length
IARI	Indian Agricultural Research Institute	**TSP**	Tribal Sub-Plan
ICAR	Indian Council of Agricultural Research	**Vindh**	Vindhyanchal
ICDS	Integrated Child Development Scheme	**WBUAFS**	W.B. Univ. of Animal and Fishery Sciences
IHHNV	Infectious Hypodermal and Hematopoietic Necrosis	**WSSV**	White Spot Syndrome Virus

IMPORTANT CONTACTS

Dr. B. K. Das, Director,
ICAR-Central Inland Fisheries Research Institute ,
Barrackpore, Kolkata - 700120, West Bengal
033-25920177(O); 033-25920029(R)
033-25920388 (F); 033-25450997 (F)
director.cifri@icar.gov.in; director.cifri@gmail.com
http:/www.cifri.res.in

Dr. V. R. Suresh, Head
Riverine Ecology and Fisheries Division,
ICAR-Central Inland Fisheries Research Institute,
Barrackpore, Kolkata - 700120, West Bengal
033-25452060 (O); 033-25922808 (R)
0-9830108768 (M); sureshvr64@yahoo.com

Dr. B. P. Mohanty, Head,
Fishery Resource and Environmental
Management Division
ICAR-Central Inland Fisheries Research Institute,
Barrackpore, Kolkata - 700120, West Bengal
033-25452061 (O), 033-65355135 (R)
0-9230618153 (M); bimalmohanty12@rediffmail.com

Dr. U. K. Sarkar, Head
Reservoir and Wetland Fisheries Division,
ICAR-Central Inland Fisheries Research Institute,
Barrackpore, Kolkata - 700120, West Bengal
033-25935289 (O); 033-65226871 (R)
0-9800347666, 9051668588 (M)

Dr. R. S. Srivastava, Officer-In-Charge,
ICAR-CIFRI Regional Centre,
24 Pannalal Road, Allahabad - 211002, Uttar Pradesh
0532-2461529 (O); 0532-2460531 (O)
0532-2460531 (F); riverd@vsnl.net.in

Dr. B. K. Bhattacharjya, Acting Head,
ICAR-CIFRI Regional Centre,
Housefed Complex, Central Building,
4th Floor, Beltola Basistha Road,
Dispur, Guwahati - 781006, Assam
0361-2224893 (O); 0361-2228486 (O)
0-9435553274 (M); bkbhattacharjya@ ahoo.com

Dr. M Feroz Khan, Officer-In-charge
ICAR-CIFRI Regional Centre,
Hassarghatta Post, Bangalore - 560089,
Karnataka
080-28449889 (O);080-23564530 (R)
0-9845103137 (M); ferosekhan23@gmail.com

Shri. W. A. Meetei, Scientist-In-charge
ICAR-CIFRI Regional Centre
B-12, Hans Society, Harni Road,
Vadodara - 390022, Gujarat
0265-2486601 (O); 0265-2486601 (F)

Dr. (Mrs) A. Sinha, Officer-In-charge
ICAR-CIFRI Research Station,
CGO Complex, 2nd Floor, C-Wing,
DF Block, Salt Lake, Kolkata – 700064,
West Bengal
033-23379444 (O); 033-23379444 (F)
0-9433033950 (M); sinhaarchana@yahoo.com

Dr. Arun Pandit, In-charge,
Agricultural Economics Section
ICAR-Central Inland Fisheries Research Institute,
Barrackpore, Kolkata - 700120, West Bengal
033-25921190-91 Ext- 213 (O)
0-9903136521 (M); arunpandit74@gmail.com

Dr. (Mrs) Rani Palaniswami, Officer- In-charge
ICAR-CIFRI Regional Research Station,
CMFRI Campus, Ernakulan North P.O.,
Kochi - 682 018. Kerala
0484-2395973 (O); 0422-2648245 (R)
0-9995439629 (M); raanips@gmail.com

Dr. S. K. Manna, In-charge,
Prioritisation, Monitoring and Evaluation Cell,
ICAR-Central Inland Fisheries Research Institute,
Barrackpore, Kolkata - 700120, West Bengal
033-25921190-91 Ext- 233 (O)
033-25926356 (R); 0-9433475913 (M)
sanjibmanna@yahoo.com

ICAR

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

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