Exploration of canal resources as a potential source for fish production in the Indian Sundarbans

Archana Sinha, Aparna Roy, Pranab Gogoi, Tasso Tayung, Mitesh. H. Ramteke, Arunava Mitra, Subhendu Mondal and Basanta Kumar Das

ICAR-CIFRI, Barrackpore, Kolkata 700120, West Bengal, India. Email: sinhaarchana@yahoo.com

Making additional use of canal resources for fisheries and aquaculture can contribute to income generation and food security for rural people.

Canals are the second most important (26%) source of irrigation, covering about 17.0 million ha in India (Agricultural Census 2010- 2011). There are two types of canals viz., inundation canals and perennial canals. These canals can support fish productions at various levels. Canal water sources vary and may be from an associated reservoir, river, well, spring or lake. The type of water source is reflected by the natural flora and fauna in the canal and is also influenced by the chemicals used on the irrigated land within the catchment. Thus, the environment of canals differs from the surrounding natural waterways substantially. Usually, canals have flowing water but during the lean season it may have a static environment for a certain period of time. This tends to lower planktonic growth in comparison to static water bodies, because the nutrients and plankton are continuously flushed out of from the system.

The main autochthonous production in many flowing canals is in the form of aquatic macrophytes and not the phytoplankton community. Although the production of aquatic macrophyte biomass is very high in canals it is not immediately available to the fish, and frequently they are removed from the system during canal maintenance. This will limit the naturally available fish species in the canals as there are species such as grass carp that are able to directly utilise the plant materials. Thus, the trophic status and hydraulic characteristics of the canal habitats are significantly different from that of the natural waters.

Irrigation canals with suitable flow rates, water quality and depth, have considerable potential for fish production, especially in tropical areas where primary productivity is higher. Water bodies such as dams, lakes and rivers become part of irrigation system and have been extensively studied for their productivity and ecology. However, the canal systems themselves have been given little attention in terms of their potential fish production. Various studies have shown that channelisation or irrigation canals exhibit lower species diversity than nearby static water bodies which are influenced by temperature and low primary producers. In Thailand, there is extensive culture of bighead carp, grass carp and Nile tilapia in irrigation canals. Physico-chemical parameters

in canals are strongly correlated with the phytoplankton abundance. The NO_2, NO_3, SIO_3, HCO_3, PO_4, Ca and Mg are important variables in shaping the benthic assemblage in Upper Ganga Canal; zooplankton is primarily dominated by rotifers, cladocerans and protozoa in Ganga Canal. Limnological variations of the Sirhind feeder channel (Hanumangarh) are characterised by shallow, turbid, alkaline and well oxygenated water. Investigations on culture practices in Indian canals are scarce. Research is required to understand the ecology and development of suitable techniques in canal systems and to achieve sustainable production from these resources.

We conducted an exploratory survey was conducted in the canals of Indian Sundarbans, West Bengal for fisheries development and nutritional security of the community. Three canals in different areas of Indian Sundarbans were selected for the study and seasonal sampling was conducted for water, sediment, plankton and fish diversity.

Bishalakhi canal

The canal is located in Krishnanagar, Sagar Island and is tidally fed through its connection with the Mooriganga River. The total length of the canal is 2.5 km, and the width is 22 m (approximately), with a depth ranging from 90 cm to 3 m.

Bhetkimari canal

The canal is located in Madanganj, Namkhana and is tidally fed via a connection with the Hathenia and Dewania rivers. The total length of the canal is 1.5 km. It is approximately 30 m wide and has a depth ranging from around 1.2 – 2.7 m.

Bharua canal

The canal is located in Shibpur, Fraserganj. Like the other two canals it is tidally fed, through a connection to the Hooghly river. The total length of the canal is 2 km and it approximately 45 m wide, with a depth of around 90 cm to 2.4 m.

Ecology of the canals

The environmental parameter of canals in Sundarbans varies seasonally and temporally. Bhetkimari canal is a brackish water canal with a very high fluctuation of salinity from 1.26 ppt in monsoon season to 18.2 ppt in pre-monsoon. pH was slightly alkaline (8.1-8.4) and total alkalinity was moderate (110 mg/l). Dissolved oxygen ranged from 6.0-7.2 mg/l, suitable for fish culture practices. Nutrient parameters such as nitrate did not fluctuate much at Bharua and Bishalakhi canals, but in Bhetkimari canal the nitrate concentration was significantly diluted in the monsoon season (from 0.1 ppm to 0.01 ppm). Phosphate-P in Bhetkimari canal increased significantly during the monsoon with mixing of agricultural field run-off as the probable cause. Silicate was in conformity with other quality parameters; the highest silicate was observed during post-monsoon and in the pre-monsoon the concentration was much lower. The soil quality of the selected canals is mentioned below.

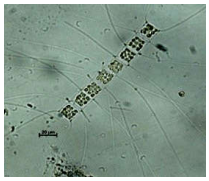
Plankton availability

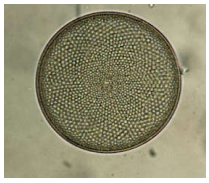
The plankton population exhibited significant seasonal variation. The mean phytoplankton abundance was 2.32 x 10^3 (± 1.0 x 10^3) ml^{-1}, with four major algal groups dominating the sampling stations. Among microfloral elements, cyanophyceae dominated in terms of abundance and bacillariophyceae in diversity. The phytoplankton community in the Bishalakhi, Bhetkimari and Bharua canal was distributed across 62 species (54 genera), 77 species (66 genera) and 71 species (63 genera) respectively during the overall study period. The richness and Shannon diversity were found to be >2.95 in all canals indicating a moderately rich phytoplankton diversity of the systems. The zooplankton community was mainly dominated by crustacean naupliii (26%), followed by calanoida (24%), cyclopoida (14%), cladocera (6%) and rotifera (3%). The most zooplankton was recorded in Bharua canal (1,918 ± 97 individuals/l) followed by Bishalakhi (661 ± 142 individuals/l) and Bhetkimari canal (547 ±138 individuals/l).

Fish diversity in Bishalakhi canal

A total of eighteen finfish species were recorded under ten families, of which twelve were small indigenous fish species. Two species of prawns were recorded (one penaeid and one non-penaeid) contributing 8.6 % of the total catch. Seasonal diversity was observed to be highest during the post-monsoon season (15 species). The family-wise percentage relative abundance of fishes revealed the dominance of family Cyprinidae (88%) followed by Polynemidae (5.75%), Ambassidae and Channidae (5.1% each), Mugilidae (4.3%) and Bagridae (2.7%). Small indigenous fishes were found to be the major component of the fish catch in Bishalakhi canal contributing 76% of the total catch whereas other species contributed only 24%.


Oscillatoria princeps


Chaetoceros loranzianus


Coscinodiscus centralis


Planktionella sol


Ditylum brightwelli


Bacillaria paradoxa


Helediaptomus sp.


Oithona sp.

Fish diversity in Bhetkimari canal

The fish diversity of Bhetkimari canal was lower than that of Bishalakhi canal. A total of sixteen finfish species under nine families were recorded during sampling, thirteen of which were small indigenous fish species. Five species of prawns were recorded (three penaeid and two non-penaeid) contributing 10% of the total catch. No exotic fish species were recorded. The seasonal diversity observed was highest during the monsoon season, with thirteen species sampled. Analysis of catch structure revealed the dominance of family Cyprinidae (60.5%) followed by Mugilidae (9.2%), Anabantidae (8.4%), Aplochelidae (5.6%), Polynemidae (4.2%) and Bagridae (3.3%). In Bhetkimari canal small indigenous fishes were also found to be the major component of fish catch contributing 83%.

A canal net partition system.

Fish diversity in Bharua canal

A total of sixteen species were recorded under seven orders and ten families. The canal was dominated by fish of family Cyprinidae (60%) followed by Bagridae (13%), Ambassidae (9%), Channidae 97%), Notopteridae (4%), Gobidae (2%), Mastacembelidae (2%), Anabantidae (1%), Megalopidae (1%), and Schilbeidae (1%). The major component of the fish catch was contributed by small indigenous fishes. The seasonal diversity was observed to be highest during the monsoon season.

Status of fish diversity in Sundarbans canals

The fish diversity in Bharua canal was highest in terms of the Shannon Wiener diversity index (H') and Margalef's richness (d') value (2.32 and 2.62 respectively) followed by Bishalakhi canal (1.88 and 2.4). The lowest was recorded in Bhetkimari canal (1.026 and1.02). The highest Pielou'sevenness index (0.85) was recorded in Bishalakhi canal followed by Bharua canal (0.73) and Bhetkimari canal (0.52). The common fishes recorded in the selected canals were *Puntius sophore*, *Puntius ticto*, *Amblypharngyodon mola*, *Salmophasia bacaila*, *Macroganthus pancalus*, *Mystus gulio*, *Mystus vittatus*, *Rasbora daniconius*, *Glossogobius giuris*, *Chanda nama*, *Channa punctata*, *Channa striata*, *Anabus testudineus*, *Notopterus notopterus*, *Chelon parsia*, *Terapon jarbua*, and *Boleopthalmus boddarti*.

Gear used in the canals

The following gear was used to sample fauna in the canals:

Bishalakhi canal

- Seine net: 10.5 m length, 2.1 m height, mesh size 0.5 cm.
- Cast net: mesh size 0.5 cm.
- Bamboo trap: Locally named as *atal*. Large: About 80 cm height, 104 cm length with a 30/30 cm opening; small 40 cm height, 30 cm length and 20/20 cm opening.

Bhetkimari canal

- Bag net: 10 m length, 4 m width, 1.2 m height and mesh size: upper panel 2 cm, middle panel 1.5 cm, lower panel 0.5 cm.
- Seine net: 10 m length, 1.5 m height, mesh size 1 cm.
- Traps: Locally named as *banki*, small in size and made of bamboo. It is triangular in shape and usually placed between two nets.

Bharua canal

- Cast net: mesh size 0.5 cm.
- Seine net: 10 m length, 1.5 m height, mesh size 1 cm.

Above, below: Indian major carps from the net partition system in Bharua canal, Fraserganj, captured together with prawn and small indigenous fishes (overleaf).

- Gill net: 7.5 m length, 1.8 m height, mesh size 2 cm.
- Traps: Large *atal* 80 cm in height, 104 cm in length with a 30/30 cm opening and banki/i, a small trap of 40 cm height, 30 cm length with a 20/20 cm opening.

Net barrier partition system as a tool to enhance fish production from canals of Sundarbans

On the basis of suitable water and soil quality, plankton availability and the productivity of canals, Bharua canal in Shibpur, Frasergunj and Bishalakhi canal on Sagar Island of Sundarbans were selected for raising fishes in net partitions. This was done to enhance production for the improvement of local stakeholder livelihoods and social status. A Memorandum of Understanding was signed between the local stakeholders and ICAR-CIFRI regarding culture of fishes in these canals. The net barrier partition system, a new form of enclosure culture, was used as a tool to enhance fish production and livelihoods. The canal was partitioned by installing HDPE net screens as a barrier across with the help of bamboo poles. These were installed with community participation. The partitions were made with locally available poles, net screens and mosquito nets to reduce construction cost. Three net partitions were constructed with dimension of 50 m length × 45 m width each, covering a total area of 2,250 m^2. Indian major carp fingerlings *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala* were stocked in addition to the native fishes of the canals. Different stocking ratios, feeding rates and strategies were tested. The best result was observed with stocking @ 2 individuals / m^2 using a stocking ratio of 50 : 40 : 10 *C. catla* : *L. rohita* : *C. mrigala* respectively.

After six months of culture, the maximum sizes reported were 1.2 kg for *C. catla*, 1.0 kg for *L. rohita* and 0.8 kg for *C. mrigala*. A good quantity of small indigenous fishes such as *Puntius sophore*, *Puntius ticto*, *Amblypharngyodon mola*, *Salmostomo bacaila* and freshwater prawn *Macrobrachium rosenbergii* were also harvested. Freshwater prawns were eye catching. The total harvest was 250 kg of fish including 10% share of indigenous fishes available in the canal.

Harvested fishes were sold in local markets at a high price. The results of this project have encouraged the community to culture fish in canals of Sundarbans.

Perception of the beneficiaries and non-beneficiaries regarding canal fisheries development through net pen barrier

A perception-based study was conducted with the objective to identify the people's attitude and perceptions regarding canal fisheries development in that area. A three-point continuum scale (agree, neutral and disagree) with the scores 3, 2, 1 respectively was used to assess the perceptions. Both beneficiaries (30) and non-beneficiaries were taken as respondents. We found that the perception towards canal fisheries development differed between the beneficiaries and non-beneficiaries. More than 50% of the sampled beneficiaries (86%) and non-beneficiaries (56%) perceived that the initiative of canal fisheries development would enhance production and that it would help in income improvement, although they opined that it could create conflict between fisheries and aquaculture.

Above, below: A good quantity of prawns and small indigenous fishes from the net partition system in Bharua canal, Fraserganj.

Beneficiary going to sell fish at the local market.

Governance mechanism for sustainable canal fisheries

Co-management and community-based management are the most viable options for governing irrigation water bodies for livelihood improvement through fish production. Group-based approaches can be the best option to govern the canal fisheries and will facilitate the exclusion of outsiders. For sustainable canal fisheries, environmental, social and economic aspects should be taken into consideration and equilibrium should be maintained.

Canals are important for both capture and culture-based fisheries. Conceivably, the major limitation to fisheries development in canals is assurance of a regular flow of water throughout the culture period. Since canals are made primarily for agricultural purpose, a conflict may arise between the stakeholders. In aquaculture, the question of ownership of the cultured fish is quite clear. But, in the case of canal fisheries, ownership of fish may be set in participatory mode before the canal fisheries starts.

Conclusion

The canals of Indian Sundarbans have been proven as a potential source of fish production with community participation using net barrier partition systems as a tool to enhance fish production. However, the adoption of viable technical interventions for the fisheries development needs to address the potential for conflicts among various stakeholders as part of the planning and design process. Viable options for better governance and people's participation were identified by conducting participatory rural appraisals and an awareness programme to boost canal fisheries.

We identified that awareness and sensitisation to canal fisheries would attract the local populace towards enhancement of fish production. People also perceived that group-based approaches may help to amplify community participation in canal fisheries development. Moreover, better linkages and improved coordination among research institutes, state departments, village panchayats, self-help groups and fishers will support canal fisheries development in that particular area. More emphasis on the field demonstrations, training and capacity building programmes and extension will help in diffusion of the knowledge and practice of canal fisheries. Consequently, sustainable canal fisheries will be achieved by amalgamating management and strategies across social, ecological, biological, political and economic dimensions.