

Climate resilient pen system in floodplain wetlands:

An adaptive strategy for fisheries enhancement and biodiversity conservation

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Inland capture fisheries has unique features of natural resource harvesting linked with global ecosystem process. Climate change and associated stressors are affecting wetland fisheries and livelihood of fishers. Therefore, innovative research programme on the biological, physical, climate variation issues, socio-economic and institutional factors influencing potential changes of the ecosystem and strategies for their sustainable restoration is essential. In this context, the primary emphasis should be on sensitizing fishers and demonstrating climate resilient technologies as a reliable tool for coping up with adverse impact of climate change. This kind of technological demonstration and adoption strategy by fishers can help to increase the innovative adaptive capacity of wetland fishers in changing climatic scenario.

Key words: Biodiversity, Climate Resilient Pen System, Conservation, Fisher, Floodplain wetland

INDIA is endowed with vast water resources under floodplain wetlands to the tune of 0.554 million ha especially in the eastern and north eastern parts of the country. Floodplain wetlands of India are biologically rich and very sensitive. They support unique aquatic flora and fauna and play a vital role in providing livelihood to a large number of fishers. Though the wetlands have a huge potential for increasing fish production, they have not been adequately utilized owing to several factors. During the last century, the country has witnessed considerable change in climate with increase in temperature in the range of 0.6°C, change in precipitation patterns and occurrence of extreme events. Climate change is projected to impact broadly across ecosystems, societies and economies thereby increasing pressure on livelihoods and food supplies, including those in the inland fisheries and aquaculture

sector. The impact of climatic variability on wetland fisheries includes changes in habitat, aquatic biodiversity, fish yield, aquatic weed proliferation, dominance of exotic species, etc. which has negatively affected the livelihood of fishers.

Central Inland Fisheries Research Institute (ICAR-CIFRI) studied the impact on some commercially important target fish species in Ganga river and associated wetlands. Among the two climatic variables *i.e.* temperature and rainfall, the latter imparts higher influence on fish assemblage pattern and breeding behaviour in natural open waters. Changes in rainfall pattern may have the most profound effect on gonadal maturation and breeding of spotted snakehead *Channa punctata* in Gangetic floodplain wetlands. Based on the changing precipitation pattern along Gangetic river basin of West Bengal, breeding of *C. punctata* is expected to strictly follow present

Table 1. Floodplain wetland resources of India

State	Area (ha)	Local names
Uttar Pradesh	152,000	Tal, Jheel
Bihar	240,000	Maun, Chaur, Dhar
West Bengal	42,500	Beel, Charha, Baor
Arunachal Pradesh	2,500	Beel
Assam	100,000	Beel
Manipur	16,500	Pat
Meghalaya	213	Beel
Tripura	500	Beel
Total	554,213	

monsoon schedule. The pre-monsoon and post-monsoon phase of breeding in the species as reported earlier from Indian waters were not observed in our present study. It is predicted that these breeding phases may have been hampered over the years due to non-availability of threshold rainfall, as evident from the decreasing rainfall pattern in the region during both

pre-monsoon and post-monsoon phases. This might have resulted or resulting in a narrower time frame available to breed. *Eutropiichthys vacha* and *Channa punctata* require special attention as they seem less climate change resilient in terms of reproductive potential although their thermal tolerance limits are high. These require further research over a considerable period of time. A positive indication of higher growth rate under enhanced thermal regime was also observed, which requires other conditions like water availability and disease susceptibility to be taken into consideration for drawing a conclusion. In this background, there is an urgent need to develop and demonstrate climate resilient adaptation techniques for livelihood security and biodiversity conservation of indigenous fishes in floodplain wetlands.

Impact of climate change on floodplain wetland

It is envisioned that India will lose about 84% of coastal wetlands and 13% of saline wetlands with climate change induced sea water rise of 1 m. Although similar assessment on the floodplain wetlands of India was not made, it is obvious that change in climate will bring about irreparable change in the ecology of the floodplain wetland also, as evident from a study on potential changes in floodplain inundation and connectivity between river and floodplain wetlands under projected future climates, conducted in the river catchment area in Western Australia. Any variations in climatic conditions specifically rainfall pattern and temperature have a great influence on the water spread, turbidity and aquatic vegetation of the wetlands. This is evident by the reduction in the water spread of wetlands from post-monsoon (77%) to pre-monsoon (39%) and aquatic vegetation from pre-monsoon (14%) to post monsoon (9%).

Wetlands are generally considered as resilient naturally to minor variations in climatic conditions, but rapid climate change may exceed the resilience threshold of wetlands. The impact of climatic variations on the

wetland ecosystems will greatly depend upon temperature and water availability through run-off in the inland fresh water bodies and on sea level rise and storm surges in coastal areas wetlands. The probable impacts of climate change on wetlands are envisaged as follows:

Impact on water volume dependent wetland function: The water volume in a wetland greatly influences the spread of the habitat available and also the water quality status available for organisms. Therefore, alteration in the precipitation pattern and runoff determine the seasonal dynamics of the water volume of a certain wetland and its species composition.

Alteration in hydrologic cycle: Wetlands, such as mangroves, salt marshes and floodplains, can play a critical role in the physical buffering of climate change impacts. An accelerated hydro-cycle predicted by IPCC (2014) has put closed wetlands under higher vulnerability over the open ones.

Changes in physical environment: Wetlands and shallow rivers are susceptible to change in temperature and precipitation. Water levels in such water bodies may drop to the point of drying out more completely in dry season. Increased temperature may lead to stronger; advanced and longer stratification of lakes and reservoir and greater de-oxygenation of bottom layers. Increase in atmospheric temperature may lead to enhance river runoff. Overall, an increase of 1°C in global temperature is expected to increase 4% in river

runoff. Change in flood areas, timing and duration of flood are also expected.

Changes in ecosystem and fish stock: Impact on aquatic ecosystems can be predicted with large scale change in temperature, precipitation, winds and acidification. Negative impacts on physiology of fish in predicted in localities affected by increase in temperature and limitation in oxygen transport. This will result in changes in pattern of distribution and population abundance of fish species, as well as species composition of marine and inland fish fauna. Climatic changes could have impact on physiological state of cultured stock also. This would not only affect productivity but also increase vulnerability to disease, impose higher risks and reduce return to farmers.

Changes in biological functions of fish: Any change in temperature of the habitat will significantly influence metabolism, growth rate, total production, reproductive efficacy, breeding season and susceptibility to diseases and toxins. Impact of climate changes are likely to disturb the natural rhythm of biological function of fish particularly reproduction and growth. The abundance and species diversity of natural fish population are predicted to be particularly sensitive to climatic disturbances, since lower water level and lack of rainfall may reduce the number of individuals able to spawn successfully.

Adaptation strategies

Considering the uncertainties of

Table 2. Pen culture technology packages

Technology packages	Species	Ratio	Stocking (Nos./ha)	Stocking size (mm)	Production/ha
Production of table size Indian major carps (polyculture)	<i>C. catla</i>	35	4,000-5,000	100-120	4,000-5,000 kg/4 months; 80% survival
	<i>L. rohita</i>	20			
	<i>C. mrigala</i>	45	30,000-40,000	60-80	1,500-1,600kg/4 months; 70% survival
	<i>M. rosenbergii</i>	—			
Production of table size crops and prawns (mixed culture)	<i>C. catla</i>	35	3,000-4,000	100-150	2,000-2,500 kg carps and 500-800 kg prawns/4 month 70-80%; survival
	<i>L. rohita</i>	20			
	<i>M. rosenbergii</i>	45	1,000-2,000	65-70	
Raising of carp fingerlings	<i>C. catla</i> ,	35	5-7 lakhs	15-20	600 kg/3 months; 70% survival
	<i>L. rohita</i> ,	35			
	<i>C. mrigala</i>	30			

Source: CIFRI Archives



Fig. 1. CRPS installed in wetlands

the climate change, it is necessary to develop climate resilient strategies that support both the general development and climate adaptation in the vulnerable ecosystem. Protection of wetland biodiversity and integrity are important activities to improve the resiliency of wetland ecosystems so that they continue to provide important services under changed climatic conditions. Location specific and innovative adaptation and mitigation strategies would bring community empowerment in the face of climate change

Pen enclosures

A pen is defined as a fixed enclosure in which the bottom is the bed of the water body and can be distinguished from the cage which in turn is defined as an enclosure with bottom and sides of netting or bamboo, *etc.* whether floating at the surface or totally submerged. The word 'pen' is also used synonymous with 'enclosure' as it is used in enclosure culture. Pen culture can be an ideal technology for enhancing fish production of 0.5 million ha shallow, macrophyte choked and multi-stake floodplain wetlands in states like Bihar, Asom, West Bengal,

Uttar Pradesh etc. This technology can be used for both table fish production as well as seed rearing for stock enhancement purpose in wetland eco-systems. CIFRI has standardized pen culture technology for

both seed rearing and table size fish production.

Concept of CRPS

The pen is designated as Climate resilient pen culture (CRPS) as it has high tensile strength HDPE net material, provision to withstand flood, wind action and resilient indigenous species are being stocked in this system. Sufficiently reinforced and structurally superior net enclosures using the latest net fabric is employed for making the net wall. The net pens were dual-partitioned in the middle resulting three compartments within the same pen (Fig. 1). The net wall of the enclosures had minimal split bamboo and maximum 'only net' composition to facilitate better water exchange. The height of the pen wall is decided based on highest depth encountered during peak monsoon. In this study initiated by ICAR CIFRI in CRPS, the pen height was kept to the tune of 11 feet to contain the stocked fishes even during peak monsoon. Provisions have also been kept to roll-down the excess net during lean season when the water depth inside pen also recedes following the depth of the wetland. The entire net-pen structure was constructed leaving 5m gap from

the bank/bundh of the wetland so that the effective water area inside the pen is not compromised during pre-monsoon when the wetland banks tend to dry up. However, to counter the opposite effect during monsoon (i.e. marginal water is deep enough), provisions were kept to fence the gaps with net material to prevent escape of stocked fishes.

Potential species

Within each compartment, a combination of locally important fish and/or shell fish species with high commercial value can be stocked in polyculture model. These stocks can be further supplemented with 'conservation priority' of local indigenous fish species like *Amblypharynx godonmola*, *Puntius sarana*, *Mystus tengra*, *Ompok pabda*, *Gudusia chapra*, *Nandus nandus*, *Labeo bata*, etc. Seeds of commercially important fishes/shell fishes like Indian major carps and Chinese carps are also ideal for stocking. CRPS can be used to – (a) examine the growth and reproductive pattern of stocked fishes, (b) temporal variations in such patterns, (c) production potential and economic yield of such unique combination of species, (d) scope of commercial utilization and insitu ranching of SIFs (small indigenous fishes) simultaneously, and (e) storm and flood-level withstanding capacity of the installed pens etc.

CRPS for clam farming

Pen (38 m × 3 m) was constructed using bamboo poles as framework and HDPE netting panels as walls. Bamboo poles of 3m length were used for the frame. The poles were fixed into the lake bottom at 1m intervals to make a rectangular pen. Poles were tied horizontally across the vertical poles to support the frame. The netting panel was tied to the poles using ropes. The bottom end of the net was fixed into the sediment. The pen was divided into two compartments having 30m² and 84m² area. Black clam (*Villorita cyprinoides*) of average length 15mm was stocked in the larger compartment @ 5000 no./m². Larger clams of average length 22mm was stocked in the smaller compartment



Fig. 2. *Amblypharynx godonmola*



Fig. 3. *Gudusia chapra*



Fig. 4. *Catla catla*



Fig. 5. *Cirrhinus mrigala*



Fig. 6. *Labeo bata*



Fig. 7. *Ompok bimaculatus*



Fig. 8. Pen installed for clam rearing



Fig. 9. Black clam (*Villorita cyprinoides*)

of the pen @ 2000 no./m². These pen can be stocked with regionally important fish species like mullets, pearlspot, seabass, etc.

Advantages

The CRPS has got many advantages in the context of changing climatic scenario as mentioned below:

- Protection from adverse climatic events like flood, heavy wind action, etc.
- Suitable for seed raising as well as table fish production
- Insitu breeding of indigenous fishes for conservation and propagation
- Resilience to fluctuating water levels in wetlands
- Better biosecurity compared to normal pen enclosures
- Tapping of natural productivity (food)

- Environmentally viable and cost effective
- Low maintenance cost and high shelf life
- Intensive utilization of space and ease of harvest.

Conclusion

Inland capture fisheries have unique features of natural resource harvesting linked with global ecosystem processes. Climate change and associated stressors are affecting wetland fisheries and livelihood of fishers. Therefore, innovative research programme on the biological, physical, climate variation issues, socio-economic and institutional factors influencing potential changes of the ecosystem and strategies for their sustainable restoration is essential. In this context, the primary emphasis should be on sensitizing the

fishers and demonstrating climate resilient technologies as a reliable tool for coping with adverse impact of climate change. Stocking of high value SIFs along with IMCs has been initiated by ICAR-CIFRI in CRPS including 3 States for evaluating whether additional income can be accrued from the system in the face of climatic vagaries. This kind of technological demonstration and adoption strategy by fishers can help to increase the innovative adaptive capacity of wetland fishers in changing climatic scenario.

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