

Importance of Conserving Wetlands in the Context of Climate Change and Adaptation Strategies

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Introduction

Wetlands are one of the most productive ecosystems on Earth that provide many important services to human society. These are transitional areas between aquatic and terrestrial ecosystems where the water table is at or near the surface, or the land is covered by shallow water. Wetlands cover 6% of the world's land surface, 4 per cent of the earth's ice-free land surface and 12% of the global carbon pool (Prigent, 2001). The wetlands encompass diverse and heterogeneous assemblage of habitats ranging from lakes, estuaries, river flood plains, mangroves, coral reef and other related ecosystems. Wetlands are important breeding areas and nursery for wildlife and provide a refuge for migratory birds. However, they are also ecologically sensitive and adaptive systems (Turner *et al.*, 2000). Floodplain wetlands are among the most important ecosystems on earth and function as the “kidneys” of the earth, which play an important role in maintaining ecological service functions. In Asia, sizable fishermen population is dependent on such fresh water ecosystems for their livelihood. Given likely climate warming scenarios, water problems in the river basins will increase and may be critical in terms of the ecosystem goods and services derived from these water bodies.

India has a wealth of wetland ecosystems that support diverse and unique habitats. In India floodplain wetlands are spread across 5.54 lakh ha area (Sugunan *et al.*, 2000, Pathak *et al.*, 2014) and the state wise distribution and other details have been shown in (Table 1). The majority of the inland wetlands are directly or indirectly dependent on the major rivers like Ganga, Bhramaputra, Narmada, Godavari, Krishna, Kaveri and Tapti. These wetlands support a rich diversity of fish and about



Fig. 1: A typical water stressed floodplain Wetland

85 belonging to 33 families is reported (Table 2). Other than biodiversity conservation these wetlands provide numerous ecological goods and services to mankind but are currently under tremendous stress due to overexploitation and degradation. In India, so far only 26 of these numerous wetlands have been designated as Ramsar Sites (Ramsar, 2013). However, many other wetlands which perform potentially valuable functions are continued to be ignored in the policy process. As a result many freshwater wetlands ecosystems are threatened and many are already degraded and lost due to urbanization, population growth, and increased economic activities (Central Pollution Control Board, 2008). The fishery potential and present production are depicted in figure 2. Globally, riverine floodplains are among the most biologically diverse and threatened ecosystems due to the impact of dams, levee systems, and other modifications to rivers. Global climate change is expected to become another important driver of loss and change in wetland ecosystem (MEA, 2005 and UNESCO, 2007). It is expected that India will lose about 84% of coastal wetlands and 13% of saline wetlands with climate change induced sea water rise

Table 1. Floodplain wetland resources of India
(Source: CIFRI, Barrackpore)

Sr. no	State	Area (ha)	Local names
1	Uttarpradesh	152000	Tal, Jheel
2	Bihar	240000	Maun, Chaur, Dhar
3	West Bengal	42500	Beel, Charha, Baor
4	Arunachal Pradesh	2500	Beel
5	Assam	100000	Beel
6	Manipur	16500	Pat
7	Meghalaya	213	Beel
8	Tripura	500	Beel
	Total	554213	

of 1m. High altitude wetlands and coastal wetlands (including mangroves and coral reefs) are some of the most sensitive classes that will be affected by climate change in India (Patel *et al.*, 2009). This communication deals with importance of wetlands, ecosystem goods and services provided by them, growing threats to wetland ecosystem with special reference to fisheries, climate change scenario in India, it's possible impact on these valuable resources and suggests mitigation and adaptation strategies for increasing their resilience to climate change.

Importance of Wetlands

Wetlands provide many valuable services at

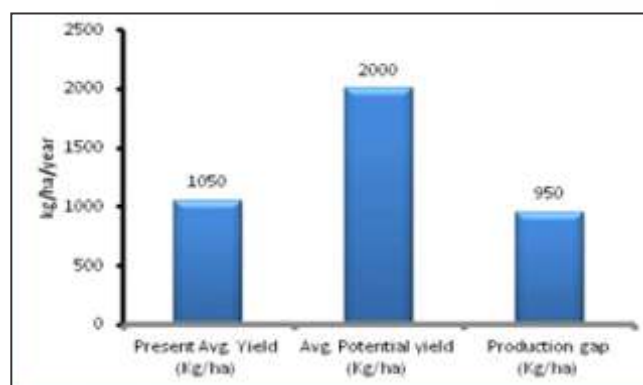


Figure 2. Present and potential fish yield from floodplain wetlands in India (Source: CIFRI, Barrackpore)

population, ecosystem and global levels. Their significant functions, values and attributes of wetlands are depicted in Figure 2, 3 and Table 2.

Environmental Importance of wetlands

Wetlands store flood water and carbon:

Wetlands serve as a huge sponge storing 30% of freshwater on earth. During dry seasons, the water stored in wetland is discharged slowly towards nearby habitats to regulate the water levels. Plants near the wetlands can be safeguarded from wilting, and animals can access to water supply. In addition, aquatic plants absorb water and enhance the water storing capability of wetlands.

Table 2. Functions, values and attributes of wetland

Functions	Values	Attributes
<ul style="list-style-type: none"> Water storage Storm protection and flood mitigation Shoreline stabilization Ground water recharge and discharge Water purification Retention of sediments, nutrients and pollutants Stabilization of local climate particularly temperature and rainfall 	<ul style="list-style-type: none"> Water supply - maintenance of quantity and quality Fisheries Agriculture - through maintenance of water table Grazing Timber production Energy sources such as peat and plant matter Wildlife resources Recreation and tourism opportunities 	<ul style="list-style-type: none"> Biological diversity: wetlands support avifauna, especially waterfowl; fish, reptiles, and invertebrate species as well as several plant species, besides a variety of micro-organisms like plankton of both phyto and zoo origin Cultural heritage: open landscapes, wildlife and local traditions

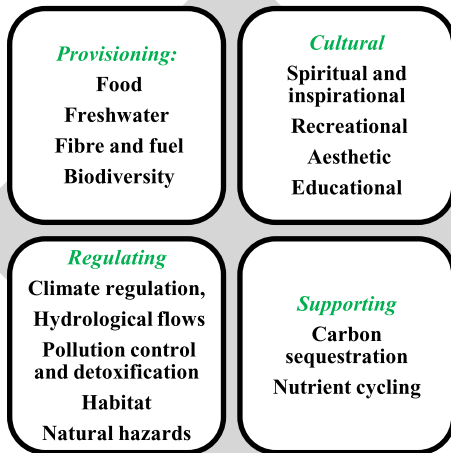


Figure 3. Goods and services provided by the wetlands

During monsoon season prolonged rainfall results in rise of water levels, causing rapid flow in rivers and flooding. Some wetlands such as the marshes and ponds, can store large amounts of water releasing the pressure of flooding. Naturally wetlands serve as a deterrent to the occurrence of flood and as opined by Boyd and Banzhaf, 2007.

Wetland store carbon: Wetlands act as the major carbon reservoirs in earth. They play an important role in the circulation of different resources. Plants in the wetland take up atmospheric CO₂ during photosynthesis and convert them into carbohydrates. In this way, atmospheric carbon dioxide will enter the food web and be consumed by other organisms. According to Ramsar secretariat about 1/3 of the world's terrestrial carbon is trapped and stored in wetlands, double of that of forests. As per the estimations, carbon sequestration potential of restored wetlands (over 50 year period) comes out to be about 0.4 tonnes C/ha/year (IPCC, 2001). Coastal wetlands in India especially the mangrove wetlands in eastern region and west coast serve as carbon sink sequestering approximately 1.5 metric tonne of carbon per hectare per year, and the upper layers of mangrove sediments have high carbon content, with conservative estimates indicating the levels of 10% (Kathiresan and Thakur, 2008).

Wetland sustain fisheries and wild life:

Wetlands are cradle of many lives They live in different types of wetlands and rely on them, either in their entire or part of life history. In tropical or sub-tropical areas, mangroves have developed complex root systems to adapt to the unstable environment. This provides ideal nurseries which attract many animals to live and breed in the mangrove swamps. The inland water bodies like lakes, wetlands, rivers and other freshwater bodies support a rich diversity of biota.

The wetlands are known for their rich biodiversity reserves in the form of wildlife, plants and animals but presently this significant characteristic is losing grounds at an alarming pace. Fisheries and aquaculture is a high priority area of economic gain and rural livelihood upliftment. This has lately suffered a great deal adversely affecting the rural economy. The wetlands of Ganga floodplain have been subjected to indiscriminate and disproportionate exploitation to the extent that many fish species have either become endangered or a number of them have already vanished from the habitat. Lopsided growth of fish food organisms affecting the food chains has engineered significant alteration in the composition of fish catch structure. The present trend of fisheries productions from wetlands may be attributed towards eutrophication, aquatic weed proliferation and sedimentation.

Wetlands improve water quality: When water rushes down from upstream to downstream, it removes soil from the river bank, increasing the soil and suspended particles in water. However, when water flows through the aquatic plants, stems, roots of the plants act as a physical filter to trap the suspended particles and other pollutants to clean up the water. Nitrogen, phosphorus and potassium are essential nutrients for plant growth. However too much nutrient in water will cause pollution and trigger the rapid growth of algae. Aquatic plants growing in wetlands act like a filter, which uptake excessive nutrients and organic matter in water and remove pollutants including heavy metals.

Wetlands provide livelihood security: It has been observed that the pressure on fishing in these water bodies has increased many fold increase in population and changed land use patterns. This has

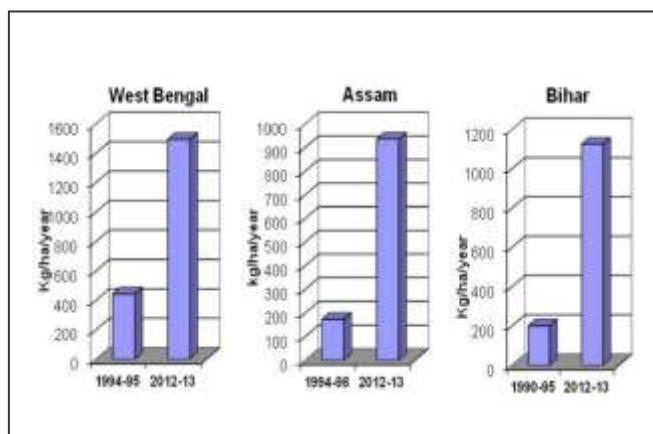


Figure 4. Improvement in fish yields due to culture based fisheries in wetlands of India (Source: CIFRI, Barrackpore)

led to a situation of over exploitation and accordingly once held popular belief that Wetlands are renewable source of energy in the form of fish biomass is losing its meaning very fast. The highly lucrative fish and fishery from such waters of earlier years has become almost a subsidiary occupation leading to large scale disguised unemployment.

Fisheries enhancement in Wetlands

Culture based fisheries: It is an effective management tool in enhancing fish yield from open waters when recruitment of desired species is lesser than the carrying capacity of the water body. It is solely based on the artificial stocking of fishes for their recruitment and recapture. Auto stocking of the desired fish species in most of the Indian wetlands is inadequate due to failure of breeding owing to habitat degradation and over fishing. Selection and stocking of right species of the right size at right time based on fish food resources

available in the system, and stocking density after assessing the production potential, growth and mortality rates are very critical. Harvesting at the right size and time can significantly greatly improve the fish production from both reservoirs and wetlands. Proper stocking and harvesting schedules, including staggered stocking and harvesting, allowing maximum grow-out period, taking into account the critical water levels will be beneficial in management of small open water bodies. The impact of culture based fisheries on fish production enhancement in Indian wetlands in presented in figure 4.

Pen culture: can be an ideal technology for enhancing fish production from shallow, macrophyte choked and multitasked floodplain wetlands in India. Pen is an enclosure that can be used for holding and producing fingerlings and table fish in open waters. Shallow and marginal areas of wetlands having water depth of 1-1.5m , retaining water at least 4-8 months in a year can be utilized for pen culture. Pens can be easily fabricated using locally available, cheap materials, which can be re-used. Cost benefit ratio of carp seed, table size carp and prawn production in pen are 1.34, 1.46 and 1.26, respectively. The following figure (figure 5) highlights some of the features of pen culture in wetlands.

Threats to Wetland ecosystem

Wetlands have been under constant threat of environmental degradation due to natural as well as anthropogenic activities. Wetlands perform several economic, social, and ecological functions .The negative economic, social, and environmental



Figure 5. Pen culture activities in wetland. (a. a battery of pen, b. harvest of fingerlings from pen, c. harvest of table size fishes from pen)

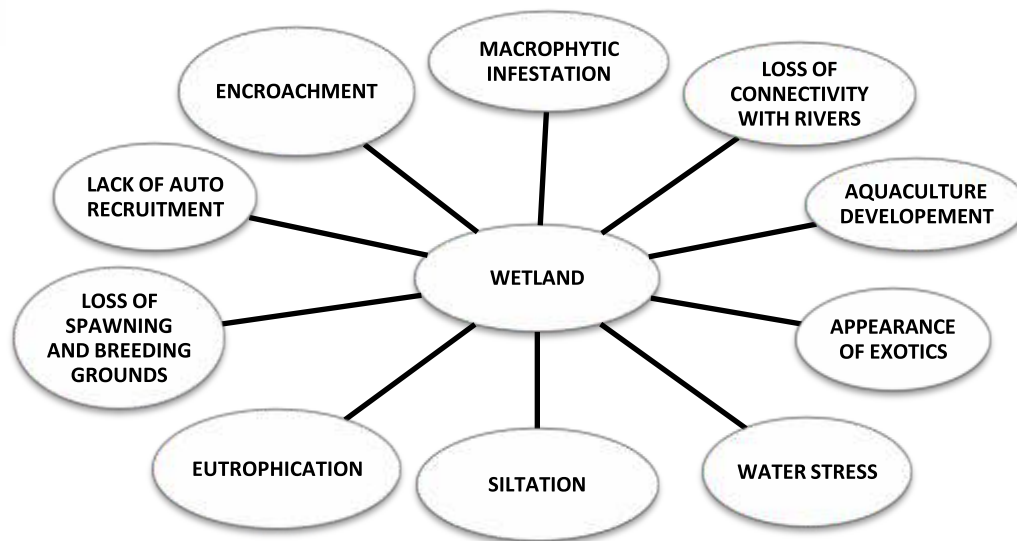


Figure 6. Threats leading to wetland degradation

consequences of declining water quality in wetlands are also an issue of concern for India. These freshwater bodies are often subject to changes in land use in their catchments leading to reduction in inflows and deteriorating quality of the "runoff" traversing through agricultural fields and urban areas. On the other hand, many of them act as the "sink" for untreated effluents from urban centers and industries. Encroachment of area for urban development, excessive diversion of water for agriculture is yet another major problem. Every one claims a stake in them, as they are in the open access regime, but rarely are willing to pay for this extractive use (Verma, 2001). Lack of conformity among government policies in the areas of economics, environment, nature conservation, development planning is one reason for the deterioration of these water bodies (Turner et al., 2000). Lack of good governance and management are also major reasons (Kumar et al., 2013). Some of the major threats faced by wetlands are given in the figure 6.

Climate change scenario and its impact on wetlands

India's large population depends upon climate-sensitive sectors like agriculture and forestry for its livelihood. Any adverse impact on water availability

due to recession of glaciers, decrease in rainfall and increased flooding in certain pockets would threaten food security, cause dieback of natural ecosystems including species that sustain the livelihood of rural households. The observed changes of climate in India as reported by Indian National Communication (NATCOM) to United Nations Framework Convention on Climate Change (UNFCCC) indicate an increase of 0.4°C in surface air temperature over the past century. Regional monsoon variations recorded though the monsoon rainfalls at the all India level do not show any significant trend. There is a trend of more frequent multi-decadal drought followed by fewer droughts and an overall increase in severe storm incidence especially in the states of Gujarat and West Bengal in India. There are indications of recession of some of the Himalayan glaciers which are the source of water for the perennial rivers such as Ganga, Indus and Brahmaputra, but the trend is not consistent across the entire mountain chain. In a developing country like India, climate change could represent an additional stress on ecological and socioeconomic systems like wetlands that are already facing tremendous pressures due to rapid urbanization and economic development. Investigations carried out by ICAR-CIFRI on impact climate change in major river basins have also reported shift in seasonal pattern of rainfall and changes in annual

Table-3. Summary of investigations on climate change across major river basins (Source: CIFRI, Barrackpore)

River Basin	Station/Place	Observations
Ganga	Haridwar	The annual mean minimum water temperature in the upper colder stretch of river Ganga at Haridwar during the period 1980-2009 increased by 0.99°C
	Allahabad	Percentage of total rainfall in the monsoon period and declined by 7% whereas it increased by 4% in the post- monsoon period at Allahabad
	Patna	The rainfall pattern a decreasing trend in the last four decade. The annual rainfall has decreased by 52.58 mm during time period 1976-2015. The seasonal rainfall pattern has decrease from 6.22% to 4.30 % in the January- April months, increased from 66.96% to 74.94% during May-August whereas decreased from 26.82% to 20.76% during September - December in last four decades 1976-2015. The mean maximum temperature has increased by 0.54°C and minimum increased by 0.66°C last three decades
	Farraka	The seasonal pattern at Farakka shows changes in rainfall pattern has decrease from 78.34% to 74.80% during the months in May - August, but during the pre and post monsoon season months rainfall shows increasing trend from 7.33% to 8.19 in January to April and 14.33% to 14.01% in September - December during the last four decades 1985-2014. The mean maximum temperature at Farakka has increased by 0.32°C and minimum temperature increased by 0.54°C last four decades (1972-2014)
Brahmaputra	Assam	Alterations in the seasonal rainfalls resulting in sudden high floods and drought-like situations in recent years have been observed for this river basin
Mahanadi	Odisha	The maximum temperature is decreasing across the districts where as the minimum temperature is increasing. The maximum temperature has decreased by 1.24% (0.73°C) whereas the minimum temperature has increased by 0.86% (0.19°C). The average yearly rainfall variation in the Odisha state is about 667mm among the districts. In river Mahanadi basin a decrease in rainfall has been evident in majority of the districts during the monsoon months and an increase in rainfall in the post monsoon period
Cauvery	Karnataka	Mean maximum surface air temperature in January decreased in river basin by 0.6°C in 100 years while mean minimum temperature increased by 0.12°C. Mean maximum and mean minimum air temperature in June increased by 0.8° and 0.16 °C respectively. Increasing trend in monsoon and post monsoon rainfall has been observed for the period 1901-2005.

trends in mean minimum and maximum temperature at various stations in major rivers basins. The major observations are listed in table 3 and figure 7.

Climate change is an important driver of loss and change in wetland ecosystem. Changes in temperature and precipitation trends across major river basins will have direct impact on wetlands. It is

expected that climate change will have a pronounced effect on wetlands through alterations in hydrological regimes. Climate induced rising temperature and declining rainfall pattern in Indian subcontinent presents a potential danger to the already disappearing wetlands in the Gangetic plains. Decreased precipitation will aggravate water stress and hence alter the freshwater inflows to

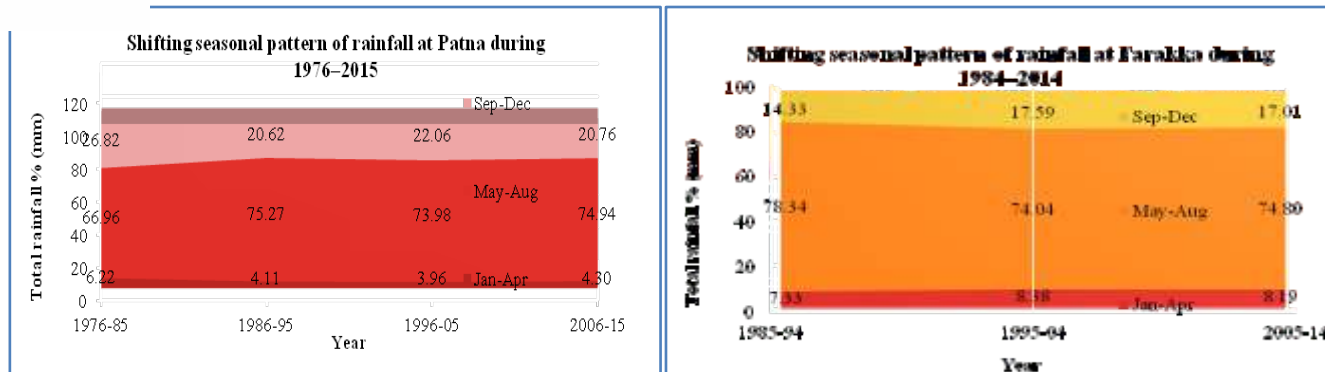


Figure 7. Shifting seasonal pattern of rainfall at Patna (1976-2015) and Farakka(1984-2014).

Table 4. Mitigation and adaptation strategies for coping up climate change in wetlands

Mitigation	Adaptation
<ul style="list-style-type: none"> De-silting of wetlands, Opening and widening of linkage channels Prevention of additional anthropogenic stress Maintaining hydrology Control of exotics Ecosystem approach for wetland management 	<ul style="list-style-type: none"> Pre-summer enclosure Deep pool based fishery Refuge/weed based fishery Submerged branch pile based fishery

wetland ecosystems while rise in temperature will intensify the problem of eutrophication, algal blooms, fish kills, and hypoxia in the wetlands. It is expected that India will lose about 84% of coastal wetlands and 13% of saline wetlands with climate change induced sea water rise of 1m. Direct and indirect impacts will be the alterations in temperatures, hydrology, and increased heat stress in wildlife, pest and disease vectors, soil erosion, and flood runoff resulting in a decreased recharge of floodplain aquifers (Sarkar *et al*, 2016). It is expected that in future wetlands and their functional capacity within most ecoregions will decline and the geographic location of certain wetlands may shift. Under currently predicted future climate scenarios, the spread of exotics will probably be enhanced, which will increase pressure on watersheds and ecosystems.

Adaptation and mitigation strategies

Wetland habitat responses to climate change and the implications for restoration need to be realized on a regional and mega-watershed level with specific restoration and management plans. Considering the uncertainties of the climate change it is necessary to introduce climate resilient development strategies that both support general development and climate adaptation in the vulnerable region. Protection of wetland biological diversity and integrity are important activities to improve the resiliency of wetland ecosystems so that they continue to provide important services under changed climatic conditions. Some of the strategies for adapting to impending threats of climate change are suggested in table 4 and figure 8.

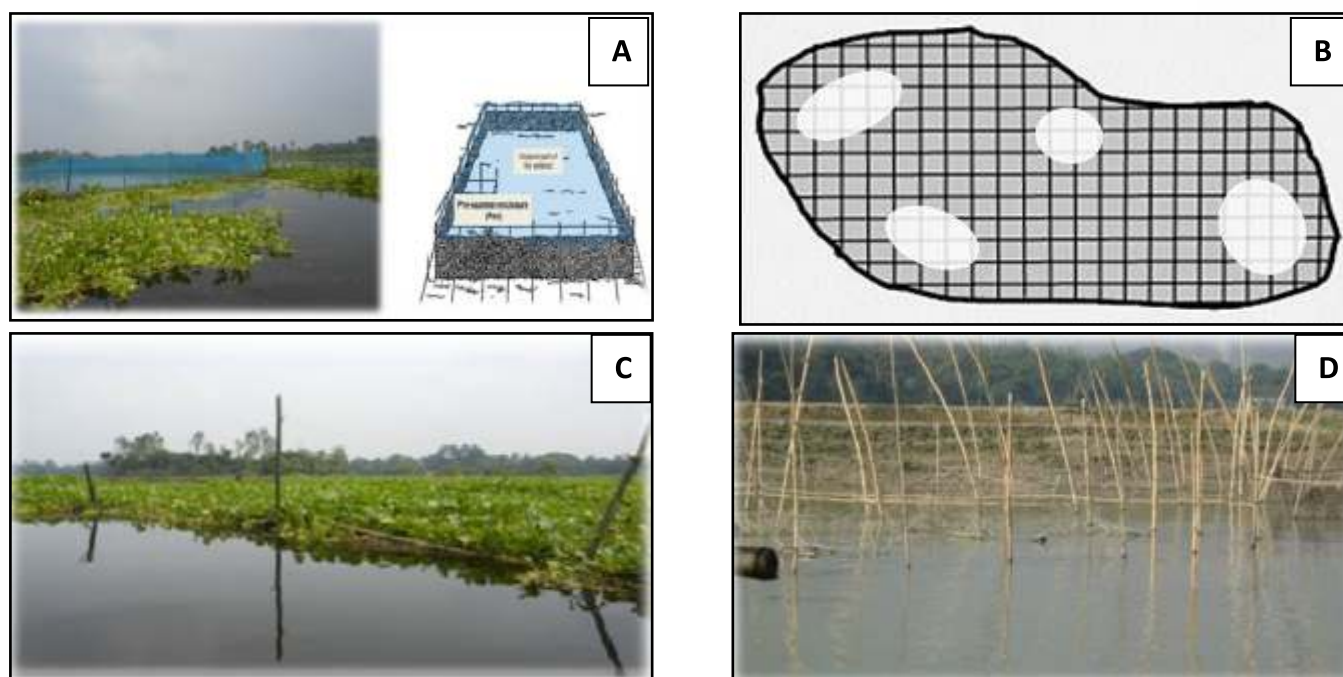


Figure 8. Climate change related adaptation strategies for wetland fisheries [a. Temporary pre-summer enclosure, b. Deep pool refuge based fishery, c. Weed refuge based fishery, d. submerged branch pile based fishery.]

Conclusion

Wetlands provide multiple services to mankind such as water for irrigation, domestic supply, fisheries, recreation etc and also play important role in ground water recharge, flood control, carbon sequestration and pollution abatement. They are being lost and degraded faster than any other ecosystem type in the world due to anthropogenic activities. This trend will magnify in coming years and degradation will be further exacerbated by climate change. The combined impact will increase vulnerability of the poor to climate change that

depends on these resources for their nutritional and livelihood security. Timely implementation of mitigation and adaptation strategies is necessary for increasing resilience and adaptive capacity of the stakeholders. Conservation, restoration and wise use of wetlands will be a cost effective strategy for climate change adaptation with strong benefits for poverty reduction and biodiversity conservation. Public awareness and capacity building of stakeholders on climate change will aid in effective implementation of the policies and to respond effectively to the threats or opportunities posed by climate change.

References

- Boyd J. and Banzhaf, S., 2007. What are Ecosystem services? The need for standardized environmental accounting units. *Ecol. Econ.* 35(2-3): 616-626.
- Central Pollution Control Board (CPCB), 2008. Status of water quality in India 2007. Central Pollution Control Board, Ministry of Environment and Forests, Government of India, New Delhi
- IPCC, 2000, Climate Change 2001: The Scientific Basis. Intergovernmental Panel on Climate Change: Working Group I. Cambridge University Press, Cambridge, UK.
- Kathiresan, K. and Thakur, S., 2008. Mangroves for future: National strategy and action plan, India. Ministry of environment and Forests, New Delhi
- Kumar S., Merwade V., James L. K. III, Dev Niyogi, 2013. Evaluation of temperature and precipitation trends and long term persistence in CMIP5 Twentieth-Century Climate Simulations. *J. Climate*, 26: 4168-4185.



- Millennium Ecosystem Assessment, 2005. Ecosystem and human well-being: wetlands and water. Synthesis. World Resources Institute, Washington, DC. 155pp.
- Patel, J. G. Murthy, T.V.R. Singh, T. S. and Panigrahy, S., 2009. Analysis of the distribution pattern of wetlands in India in relation to climate change. In Panigrahy, S., Shankar R. S. and Parihar, J.S. (Eds.), Proceedings of the workshop on impact of climate change on agriculture. Ahmedabad, India, 17-18 December. International Society for Photogrammetry and Remote Sensing, Ahmedabad.
- Prigent, C., E. Matthews, F. Aires, and W.B. Rossow, 2001: Remote sensing of global wetland dynamics with multiple satellite data sets. *Geophys. Res. Lett.*, 28, 4631, doi:10.1029/2001GL013263.
- Ramsar Secretariat, 2013. The List of Wetlands of International Importance. The Secretariat of the Convention on Wetlands, Gland, Switzerland.
- Ramsar, 2013. Ramsar Sites
- Turner, R.K., Van der Bergh, J.C.J.M., Soderqvist, T., Barendregt, A., van der Straaten, J., Maltby, E., van Ierland, E.C., 2000. Ecological-economic analysis of wetlands: scientific integration for management and policy. *Ecol. Econ.* 35 (1), 7–23.
- UNESCO, 2007. Case studies on climate change and world heritage. UNESCO World Heritage Centre, pp. 1-80.
- Verma, M., 2001. Economic valuation of bhoj Wetlands for sustainable use. [EERC Working Paper Series: WB-9]. Indian Institute of Forest Management, Bhopal.
- Sugunan, V. V., Vinci, G. K., Bhattacharjya, B. K. and Hassan, M. A., 2000. Ecology and fisheries of beels in West Bengal. Bulletin No. 103, Central Inland Capture Fisheries Institute, Barrackpore. 53 pp.
- Pathak, V., Tyagi, R. K. and Balbir Singh, 2014. Ecological status and production dynamics of wetlands of Uttar Pradesh. Bulletin No. 131. Central Inland Capture Fisheries Institute, Barrackpore. 44 pp.
- Sarkar, U. K., Nag, S. K., Das, M. K., Karnatak, G. K., and Sudheesan, D., 2016. Conserving wetlands - An effective climate change adaptation in India. Bulletin No. NICRA/CIFRI/2015-16/2. Central Inland Capture Fisheries Institute, Barrackpore. 9 pp.

