CONSERVING WETLANDS – AN EFFECTIVE CLIMATE CHANGE ADAPTATION IN INDIA

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1. Introduction

Tropical wetlands of India encompass a wide range of inland, coastal and marine habitats. Among the most productive life support, wetlands have immense socio-economic and ecological importance. They are crucial to the survival of natural biodiversity. India has a wealth of wetland ecosystems distributed in different geographical regions. Most of the wetlands in India are directly or indirectly linked with major river systems such as the Ganges, Cauvery, Krishna, Godavari and Tapti. These ecosystems are often highly productive and harbour a unique assemblage of aquatic and terrestrial biodiversity and also provide a wide array of ecosystem goods and services (Wetlands Rules, 2010).The multiple services provided by wetlands include irrigation, domestic water supply, freshwater fisheries and water for recreation. They are also playing important role in groundwater recharge, flood control, carbon sequestration and pollution abatement. However, inland and coastal wetlands are being lost and degraded faster than any other ecosystem type in the world. This trend will considerably magnify in coming years and the degradation will be exacerbated by climate changes. The combined impact will make the poor fisher communities dependent on these wetland resources more vulnerable. Hence, when wetlands are affected, the ability of these communities to adapt to climate change will be greatly reduced. When wetlands are in healthy condition, they can greatly contribute to increasing our resilience to the impacts of climate change.

2. Wetland resource and types

The distribution of wetlands in India is widespread ranging from the cold areas of Ladakh to highly wet Manipur, the warm desert of Rajasthan and Gujarat to the monsoon drained Central India and humid zones of South India. Literally the wetlands include a wide variety of dynamic ecosystems from perennial rivers, streams, estuaries including mangrove swamps, natural depressions & marshes (locally known as beels, chaurs, dhars, pats etc.), ox-bow lakes, ponds & tanks and seasonally inundated floodplains.

The wetlands in India are classified as Himalayan wetlands which includes Ladakh and Zanskar Pangong Tso, Tso Morad, Chantau, Noorichan, Chushul and Hanlay marshes, Kashmir valley including Dal, Anchar, Wular, Haigam, Malgam, Haukersar and Kranchu lakes, Central Himalayas including Nainital, Bhimtal and Naukuchital and Eastern Himalayas having numerous wetlands in Sikkim, Assam, Arunachal Pradesh, Meghalaya, Nagaland and Manipur, beels in the Brahmaputra and Barak valley. Indo-Gangetic wetlands are the largest wetland system in India, extending from the river Indus in the west to Brahmaputra in the east. This includes the wetlands of the Himalayan terai and the Indo-Gangetic plains. Coastal wetlands contains the vast intertidal areas, mangroves and lagoons along the 7500 km long coastline in West Bengal, Orissa, Andhra Pradesh, Tamil Nadu, Kerala, Karnataka, Goa, Maharashtra, Gujarat and mangrove forests of Sunderbans, West Bengal and Andaman and Nicobar Islands, offshore coral reefs of Gulf of Kutch, Gulf of Mannar, Lakshwadeep and Andaman and Nicobar Islands. Deccan wetland includes a few natural wetlands, but innumerable small and large reservoirs and several water storage tanks in almost every village in the region.

3. Climate dependency of wetlands in India

Monsoonal variations 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%) as reported by Panigrahy *et al.* (2012).

4. Environmental importance of wetlands

4.1 Wetlands store flood water

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. The water stored in the wetlands also infiltrate into the soil and replenish the groundwater. This facilitates hydroponics.

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. Wetland plants growing within the streams and rivers act like barriers which slow down water currents. The root of the plants can hold the soil rigidly, preventing it from being washed away by water current and thus protecting the river bank. Naturally wetlands serve as a deterrent to the occurrence of flood and as opined by Boyd and Banzhaf (2007), wetlands can be considered as natural substitute for conventional flood control investments such as dykes, dams, and embankments.

4.2 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 CO_2 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 $1/3^{rd}$ of the world terrestrial carbon is trapped and stored in wetlands, double of that of forests.

Flood plain wetlands, swamps and mangroves play a significant role in carbon cycle. The wetland sediments serve as a long term store house of carbon whereas the plants, animals, bacteria and fungi serve as transitory stores of carbon (Wylynko, 1999).

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).

4.3 Wetland sustain fisheries and wild life

Wetlands are a cradle of life, supporting algae, bacteria, plankton, eggs and larvae of aquatic organisms. 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. Many predators are also attracted to forage them. 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. One of the major factors for the low yield in fish biomass and the decline in fish species of wetlands is due to impaired auto-stocking, *i.e.* - poor ingress of riverine fish seed due to river valley modifications and loss of wetland connectivity through formation of levees at wetland mouths.

4.4 Wetland 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. Therefore, wetlands act as a sink for contaminants and serve as a low cost measure to reduce point and non-point pollution (Bystrom *et al*., 2000).

4.5 Wetlands provide livelihood security

The floodplains are known for their socio-economic values in rural India, specially in relation to agriculture and fisheries. During their early period of settlement the inhabitants extensively relied on natural resources such as forests, pastures and waters for food and other materials. Fishery continued to remain an important resource for landless or marginal farmers who earn their bread and butter through fishing from these wetlands. It has been observed that the pressure on fishing in these water bodies has increased due to many fold increase in population and changed land use patterns. This has 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.

The increased population and subsequent increase in efforts, in the face of diminishing biological resources, have resulted in conflicts amongst the various user groups. Gradual loss of wetlands, reduction in biodiversity including fishery, reduction in wildlife habitat etc. have led to a significant shift from wetland based human occupation to other petty jobs and as a result the wetland resource dominated areas have experienced a crunch in socio-economic front.

5. Conceptual approach to impact of climate change on wetlands

The degradation and loss of wetlands is a worldwide phenomenon primarily influenced by non-climatic factors such as drainage of wetlands, water withdrawal, deforestation, land reclamation, habitat fragmentation, discharge of sewage, eutrophication and pollution, overharvesting and overexploitation, and the introduction of invasive alien species (IAS). The impacts of climate change is expected to exacerbate the degradation of many wetlands because of the complex relationships and feedbacks between climate and wetlands though the hydrological cycle. It is widely acknowledged that global change will increase the likelihood of potentially abrupt changes in wetlands, which can be large in magnitude and difficult, expensive, or impossible to reverse (Millennium Ecosystem Assessment, 2005).

5.1 Resilience of wetlands: Wetlands are generally considered as resilient in maintaining particular ecosystem services as conditions change but rapid climate change may exceed the resilience thresholds 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 area wetlands (Poff *et al*., 2002).

5.2 Role of temperature: Temperature play an important role in the biological processes of organisms. Temperature alterations due to extremes and seasonal rate of changes can directly influence the metabolic rate, behaviour and habitat preference of aquatic organisms. Changes in temperature can produce shifts in species composition that in turn, can affect the overall metabolism and productivity of wetlands (IPCC, 2002).

5.3 Geographic shift of species: Global warming is expected to shift the potential geographic ranges of species. However the ability of species to migrate into the new areas will depend on both the habitat availability and the capability to move along dispersal corridors. However, both circumstances will largely depend on wetland type and on the habitat fragmentation (Dale, 1997). Climate change pose an additional threat to wetland imposing newer pressure for adjustment.

5.4 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 . Therefore, a change in climate that alters the existing hydrologic regime has the potential to greatly modify habitat suitability for many species and cause significant ecological changes (even if the thermal regimes would remain unchanged). IPCC (2014) has raised concerns on high intensity-short duration seasonal precipitation and frequent events of non-seasonal precipitation in regions of South East Asia.

5.5 Hydrologic cycle alteration: Climate variations manifested by alterations in the freshwater flow, rise in sea level and increases in storm surges will result in the enhanced erosion of shores and coastal habitats, salinization of groundwater and estuaries, altered tidal ranges in rivers and embankments, changes in sediment inputs and nutrient loadings, increased coastal flooding and, consequently in a decrease of freshwater availability for humans and ecosystems in coastal areas. Wetlands such as mangroves, salt marshes and floodplains, can play a critical role in the physical buffering of climate change impacts (Scavia *et al.*, 2002). An accelerated hydro-cycle predicted by IPCC (2014) has put closed wetlands under higher vulnerability over the open ones.

6. Climate change predictions in India

Some of the recent assessments on global warming and climate change having the potential to impact the wetland ecosystem are:

Surface air temperature: At the national level has increased by 0.4°C over the past century.

Rainfall: While the observed monsoon rainfall at the all-India level does not show any significant trend, regional monsoon variations have been recorded.

Extreme weather events: Trends observed in multi-decadal periods of more frequent droughts, followed by less severe droughts. There has been an overall increasing trend in severe storm incidence along the coast of West Bengal and Gujarat and a rising trend in the frequency of heavy rain events,

Rise in sea level: A sea level rise between 1.06-1.75 mm per year. These rates are consistent with 1-2 mm per year global sea level rise estimates of IPCC.

Impacts on Himalayan Glaciers: The Himalayas possess one of the largest resources of snow and ice and its glaciers form a source of water for the perennial rivers such as the Indus, the Ganga and the Brahmaputra. The available monitoring data on Himalayan glaciers indicates that while recession of some glaciers has occurred in some Himalayan regions in recent years, the trend is not consistent across the entire mountain chain.

Limited analysis on the impact of climate change on wetlands in India suggests that high altitude wetlands and coastal wetlands (including mangroves and coral reefs) are some of the most sensitive resources that will be affected by climate change (Patel *et al.*, 2009). Recent investigations carried out by ICAR-CIFRI in some floodplain wetlands of West Bengal reveal that inland floodplain wetlands are facing threats from climate change events like recurring water stress and erratic precipitation pattern leading to subtle but gradual changes in wetland eco-geomorphology (unpublished). In case of the coastal wetlands such as Indian part of Sunderbans mangrove, rising sea surface temperature and sea level rise due to thermal expansion, could affect the fish distribution and lead to the destruction of significant portion of mangrove ecosystem. Further destruction of the Sundarbans mangroves would diminish their critical role as natural buffers against tropical cyclones resulting in loss of lives and livelihoods (UNESCO, 2007). Climate change induced rising temperature and declining rainfall pattern presents a potential danger to the already disappearing lakes in the Gangetic plains (Sinha, 2011). Decreased precipitation will exacerbate problems associated with already growing demands for water and hence alter the freshwater inflows to wetland ecosystems (Bates *et al.*, 2008; Erwin, 2009), whereas, rise in temperature can aggravate the problem of eutrophication, leading to algal blooms, expansion of aquatic macrophytes, fish kills and dead zones in the surface water (Gopal *et al.*, 2010). Also, seasonality of runoff in river basins (such as Ganges) will increase along with global warming, that is, wet seasons will become wetter and dry seasons will become drier (IPCC, 2014). This would have severe adverse impact on affected populations, especially if the seasonality of runoff change would be out of phase with that of demand. As per estimates, India will lose about 84% of coastal wetlands and 13% of saline wetlands with climate change induced sea water rise of 1 m (Blankespoor *et al.*, 2012). As a result there will be adverse consequences on wetland species, especially those that cannot relocate to suitable habitats and migratory species that rely on a variety of wetland types throughout their life cycle. However, it must be noted that projections about the extent of loss, degradation and shrinking of wetlands are not yet well established as climate models used for such predictions are not robust. It is not clear how region specific temporal and spatial variability in rainfall gets captured by these models. Further, there is tendency to attribute hydrological regime changes in wetlands to climate change, rather than trying to find the real physical and socio-economic processes responsible for such changes (Kumar, 2013).

7. Potential impacts of climate change and role of wetlands in climate adaptation/reducing climate risks/mitigation

7.1 Increased frequency and magnitude of fresh water floods

Impact

- Physical damage /loss of property and life and loss of ecosystems
- Water pollution
- Decreased (food) production through damage to production systems and agricultural areas

Adaptation potential

Protect life,property,production systems and ecosystems

- Lakes and floodplains can reduce peak flows by delaying and storing flood waters
- Lakes and floodplains can detain polluted waters
- High land peats can regulate river flows releasing flood flows slowly over time

7.2 Increased frequency and magnitude of droughts

Impact

- Decreased food production due to freshwater shortage
- Waterways unavailable for transport

- Loss of ecosystems and biodiversity
- Contamination of freshwater sources through saltwater intrusion

Adaptation options

Provide resilience against drought by replenishing freshwater aquifers and providing sources of water during drought

- Marshes,lakes and floodplains can maintain river base flows by releasing wet season flows slowly during drought period
- Pen culture and cage culture as non consumptive use of water
- Groundwater aquifers can be recharged during water rich periods ensuring ground water sources during drought
- Income diversification during drought period providing alternative sources of food and water for people and biodiversity
- Mangroves and other coastal wetland ecosystems can guard against salt water intrusions when coastal freshwater areas dry up

7.3 Increased frequency and intensity of storms affecting coastal zones

Impact

- Physical damage/loss of property and life and loss of ecosystems
- Pollution and damage to ecosystems and health
- Decreased (food) production through damage to production systems and agricultural areas

Adaptation options

Protect life, property,production systems and ecosystems

- Mangroves other forested coastal and delta ecosystems and reefs can disseminate storm power
- Coastal wetlands like mangroves can assist the recovery of local community livelihoods after storms by providing sources of food and building materials
- Forest and reefs provide havens for biodiversity during and after storms

 

7.4 Melting of glaciers

Impact

- Increased floods after heavy precipitation in mountain regions, leading to floods
- Less freshwater flows from glaciers fed rivers during periods with little precipitation. This is leading to fresh water shortage

Adaptation options

Provision of and maintain resilience of freshwater sources :

- Marshes and lakes can store excessive precipitation just like glaciers used to do
- Marshes and lakes will release water in a reliable flow just like glaciers used to do

7.5 Coastal inundation as sea levels rise

Impact

Loss of coastal fishery productivity

- Loss of coastal agricultural areas, cities and other economically important areas
- Loss of coastal ecosystems as land is lost
- Loss of agricultural production and increased fresh water shortage through saline intrusion

 

Adaptation options

Protection and maintenance of coastal zones and their ecosystems (mangroves, reefs and other coastal ecosystems)

- Build and maintain the resilience of natural coastal defences through alluvial plain accumulation
- Provide nurseries for coastal fisheries
- Protect freshwater sources from saline intrusion

8. Conclusions

Tropical wetlands of the world are of great interest because of the numerous ecosystem services at risk and the extensive greenhouse gas emissions that arise from land conversion. These ecosystems both affect and are affected by climate change. Hence synergising mitigation and adaptation strategies and measures in tropical wetlands is a key approach. Given the large carbon stocks of tropical wetlands, and the array of tropical wetlands ecosystem services at risk, it makes sense to include them in the global, national and local climate change adaptation agendas. Coastal wetlands such as mangrove ecosystems have proven their value as buffers. They reduce vulnerability of low-lying coastal zones to damage from storm surges, tropical cyclones, and casualties from tsunamis, to some extent. Likewise, peat swamp forests function as 'landscape sponges' reducing flooding during wet seasons and releasing water during dry seasons.

The management of floodplains in the different river basins is of crucial importance for the economic development and livelihood security of the region. The tropical wetlands and their dependent people are mostly affected by the climate impacts of sea-level rise, increasing soil salinity, changes in temperature and rainfall patterns, increasing severity of cyclones, and increasing frequency severity of El Nino Southern Oscillation events. Adaptation strategies specific to these wetlands are needed to protect ecosystem services for future generations. Mitigation procedures that preserve ecosystem resistance and resilience to climate change are also recommended as cost-effective and ecologically sound adaptation strategies.

Adaptation to the impacts of climate change must be mainstreamed into the economic development planning and implementation process. Adaptation and mitigation strategies would enhance the benefits to communities that are the most vulnerable to climate change. Addressing the potential of wetland restoration in agricultural systems, the IPCC (2000) noted that such land use change would result in the accumulation of 0.4 t ha^{-1} y^{-1} of carbon. As with terrestrial farming, there may be opportunities for aquaculture operators to restore wetland areas and make a commitment not to convert existing wetlands for further aquaculture development. Conservation, restoration and wise use of wetlands can be a cost-effective strategy for climate adaptation with strong benefits for poverty reduction and biodiversity conservation. Conversely, we believe that strategies for climate adaptation and development that do not address the continuing crisis in wetland loss and degradation will have strong limitations. Local level planning and management strategies also have to be evolved for comparing various alternative options suitable at different conditions.

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