National Conference on

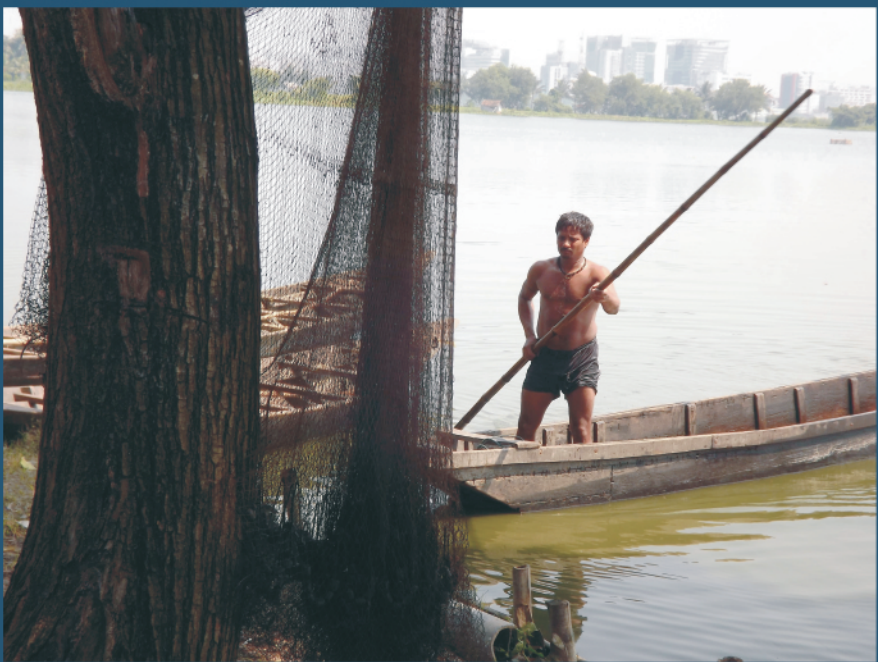
Mitigation and Adaptation Strategies in WETLANDS

A Community Leadership Perspective

1st to 2nd March 2014 at

CIFRI, Barrackpore, West Bengal

EXTENDED ABSTRACT



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Extended Abstract

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Preface

South Asian Forum for Environment and Central Inland Fisheries Research Institute welcomes you all in the national conference on "Adaptation and Mitigation Strategies on Wetlands" organized under the aegis of Indian Council of Agricultural Research, New Delhi. The conference secretariat greatly appreciates your worthy contribution in this coveted event.

Wetlands cover almost 6% of the Earth. They contribute to the livelihoods of millions of marginal farmers and fishers in Africa and Asia and are increasingly being used for agriculture as populations rise and upland areas become degraded. Despite the importance of this ecosystem in supporting rural communities, wetlands are often viewed as underexploited resources of waterand land or as wastelands that hinder development. Often, most of these tender ecosystems vanish under the tremendous pressure of anthropocentric development and those that are protected tend to be designated as 'nature sanctuaries', rather than valuable ecosystems that can also be used sustainably by communities.

Wetlands provide a diverse range of valuable environmental services. More than three billion people (around half the world's population) obtain their basic water needs from inland freshwater wetlands. A similar number of people rely on rice as their staple food, grown largely in natural and artificial wetlands. In places like the Kilombero Wetland in Tanzania, almost the entire local population relies on wetland cultivation for their livelihoods. Fisheries are also an extremely important source of protein and income in many wetlands. In addition to food, wetlands supply fiber, fuel and medicinal plants. They also help to reduce the damaging impact of floods, control pollution augment climate resilience and regulate the water regime.Wetlands are among the world's most productive environments. They are cradles of biological diversity, providing the water and primary productivity upon which countless species of plants and animals depend for survival. Many of these plants and animals have specially adapted to living in wet places. In the wake of climate change, wetland ecology is gradually taking the center stage owing to its immense potentials in carbon sequestration.

The international significance of wetlands is reflected in the Ramsar Convention on Wetlands, an intergovernmental agreement adopted on 2 February 1971 for the conservation and wise use of wetlands. An international report launched by the Ramsar Convention on 1 February 2013 entitled The Economics of Ecosystem and Biodiversity (TEEB) for Water and Wetlands, urges for a major shift in our attitudes to wetlands, to recognize their value in delivering water, raw materials and food essential for life and crucial for maintaining people's livelihoods and the sustainability of the world's economies". SAFE in collaboration with CIFRI, has successfully implemented the neo-economic paradigm of 'Biorights of Commons' in conserving the East Kolkata Ramsar Wetlands that compensates the opportunity costs of wetlanders and fishers in practicing wise-use of environmental resources in this Ramsar site and sustain the environmental services thereto. This has been cited as a best practice conservation method in the 4^{th} TEEB report of UNEP.

The ingression of urban development has rendered an alarming encroachment rate of 1.35% per annum on important wetlands of asia. Most critical are our Ramsar wetlands like East Kolkata Wetlands in West Bengal, Loktaklake in Manipore, DeeporBeel in Assom and so on. The scale mismatch in ecological process dynamics and pace of urban development is causing rapid habitat loss and loss of biodiversity. The vanishing endemic fishes of East Kolkata Wetlands or habitat destruction of Olive Riddley turtle in BhitarkanikaRamsar site in Orissa are burning examples. In some cases where the wetlands are not recognized as international sites or still remain unidentified, as for example in India-Nepal borders of Bihar, the conditions are still more serious.

The wetland inhabitants and end-users are least aware about the delicacy of the wetland ecosystem, whereas their dependence on the environmental services of wetlands is maximum. This leads to severe exploitation and unsustainable usage of natural resources. Policy supports are categorically missing though regimented regulations and action plans are immediately required for sustainable conservation. This needs strong decision support research that can justify the economic and ecological values of wetlands so that it can be persuaded to the decision making peer groups for the needful. In view of the complex dynamics of wetland ecosystem and its ecological overlaps on both terrestrial and aquatic ecology, detailed scientific discourse is still lacking. The available interfaces are delimited to fisheries, eutrophication and pollution, or else on ecotourism potential assessments. Wetlands have tremendous significance in water resource management, biodiversity hosting and disaster resilience. Moreover, in the climate change perspective, the carbon sequestration potentials of wetlands are immense because they appear as source and sink as well. However, research findings are sporadic and often contradictory failing to establish the significance of wetlands in conservation ecology. Economic valuation of wetlands and proper impact assessment are crucial for posing these tender ecosystems as national assets, as has happened in other countries. This would require strategic assessment of the economic values of the environmental services rendered by wetlands and output potentials in value added services, which leads to proper inventory preparation, biodiversity indexing, socioeconomic efficacy and usage of geospatial tools for analysis the changing land use patterns. Such structured studies are meager and sporadic. Initiatives are often lacking as these studies would demand interdisciplinary approaches and consorted efforts.

The National Conference on Wetlands organized by South Asian Forum for Environment [SAFE] and Central Inland Fisheries Research Institute [CIFRI] under the aegis of Indian Council of Agricultural Research [ICAR] will provide a platform to review advances in the ecological, biogeochemical, and social sciences as they relate to wetlands, especially in the context of climate change. The conference, with a theme Mitigation and Adaptation Strategies in Wetlands; A Community Leadership Perspective, would attempt to connect the community stakeholders, researchers and policy planners on conservation issues of wetlands and related climate concerns. This conference, therefore, seeks to share integrated solutions for sustainable management of wetland resources in a complex world, and to facilitate professional relationships at regional and national scales.

The conference provides an interdisciplinary setting for participants to review cutting edge science, create and renew partnerships, and discuss opportunities to collaborate and leverage resources to address national wetland conservation challenges in particular and global conservation issues in general. This conference will also deliver newer perspective on a wide range of socio-ecological and socioeconomic topics to help establish new collaborative partnerships towards change management.

On behalf of the conference secretariat and various other managing committees of the event, we express our gratitude and thanks to Indian Council of Agricultural Research to be the prime sponsor of this significant national event. We also thank State Fisheries Development Board for extending their support to make this event a grand success.

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Keynote address

GLOBAL PERSPECTIVE ON CONSERVATION AND SUSTAINABLE MANAGEMENT OF COASTAL AND MARINE BIODIVERSITY

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Background

Convention of Biological Diversity (CBD) was adopted at Rio Earth Summit in 1992 and has now 193 countries as its Parties. The three main objective of CBD are: i) Conservation of biological diversity; ii) Sustainable use of the components of biological diversity; and, iii) Fair and equitable sharing of the benefits arising out of the utilization of genetic resources. Cartagena Protocol on Bio-safety adopted under CBD, governs movement of living modified organisms (LMOs) resulting from modern bio-technology from one country to another. This supplementary Protocol to CBD entered into force on 11 Sept 2003. CoP is the governing body of CBD and Meeting of the CoP serving as MoP to the Cartagena Protocol on Bio-safety. CoP and MoP meet once in two years to take decisions for the implementation of CBD and is attended by member governments, international organizations, civil society, academia and research institutions, private sector, media and others.

Since India was incoming CoP President, became CoP President at Hyderabad which will stay for the next two years – thus, providing a unique opportunity to strengthen the voices of developing countries in the global biodiversity agenda. Biodiversity conservation has an important role in poverty alleviation, achieving equity, national economic growth and assured happiness of millions of people. On biological diversity conservation and management, India speaks from the position of strength on issues which affect the developing world.

India also proposed five issues for discussion during High Level Segment of CBD CoP-11 and these are as follows :

- Biodiversity and Livelihoods
- Integration of value of Biodiversity in National Planning and Accounting Process
- Strategy for Resource Mobilization
- Coastal and Marine Biodiversity
- Operationalisation of Nagoya Protocol

The Ministry of Environment and Forests (MoEF), Government of India (GoI) in October 2012, hosted the sixth meeting of the Conference of the Parties serving as meeting of the Parties (CoP-MoP 6) to the Cartagena Protocol on Bio-safety and eleventh Conference of the Parties (CoP 11) to the Convention on Biological Diversity (CBD) at Hyderabad, southern state Andhra Pradesh from October 1-19, 2012. These meetings were organized in collaboration with the Secretariat of CBD and State Government of Andhra Pradesh. Besides, the Ministry is also organizing a series of national and international events as run up to CoP-MoP 6 and CoP 11.

Given the fact that India was host to 11th Conference of Parties on CBD in October 2012, and that the decade of 2011 to 2020 has been declared decade of Biodiversity, as well as the decade on combating desertification and land degradation, an all inclusive communication strategy could not have found a better timing.

Biodiversity and Policy issues

It has been recognized that biodiversity contributes directly to poverty reduction by enhancing food security, ensuring health, sustaining income, reducing vulnerability and creating social safety net particularly during natural disaster through ecosystem components and services. This relationship is well recognized by Agenda 21 of the Earth Summit held in Rio de Janeiro in 1992, which declared that *combating poverty involves promoting sustainable livelihoods. To achieve this,* Agenda 21 calls for states *to integrate environment and development at the policy, planning and management levels*. However, recent assessment indicates that the total number of people living in poverty did not fall much below and a large proportion of poor people live in biodiversity rich areas.

The World Summit on Sustainable Development (WSSD) held in 2002 reaffirmed sustainable development as a central element of the international agenda and gave new impetus to global action to fight poverty and protect the environment. However, a study conducted by the Netherlands Environment Assessment Agency shows challenging situation; decreasing poverty usually coincides with decreasing biodiversity, creating a 'win-lose' situation. Overexploitation can lead to a collapse of the system and an increase in poverty with even more loss of biodiversity, and become a 'lose-lose' situation. Reducing poverty while conserving biodiversity - a 'win-win' can be achieved on a local scale. How to realize this win-win situation at large scale - at least at regional scale -is challenging.

Marine and coastal biodiversity and bioresearches

Marine and coastal areas, which include nearshore land and coastal waters up to continental shelf or to depth of 250m are rich in biodiversity and resources and play a key role in maintaining earth system functions including the regulation of weather, climate and hydrological cycle, as well as providing food materials and energy for human use. Coastal ecosystems such as the mangroves, coral reefs, sea grasses support a high diversity of species and are biologically productive. They act as bioshields and are the first line of defense in mitigating disasters.

It is a well-known fact that human settlements are highly concentrated in the coastal zone. The South Asian coastline alone is home to more than 400 million people, making it one of the most densely populated regions of the world. A large number of people, including poor communities, are dependent on the coastal and marine ecosystems for livelihood. There is intensification of resource use, driven by market pressures and rising consumption requirements.

These pressures are now being overtaken by large-scale land use changes and construction of infrastructure. There has been a rapid increase in the number of ports, offshore oil/gas exploration, thermal power stations, and manufacturing units. Large-scale commercial fisheries and agriculture too have exerted enormous pressure on the coastal and marine ecosystem. These activities can undermine the survival of coastal and marine ecosystems and the sustainability of services provided by the coastal and marine ecosystems. The threat is further compounded by the rise in sea level and occurrence of extreme weather events that have an adverse impact on the coastal populations leaving them vulnerable to disasters. As is often the case, it is the poor that have immense difficulties in coping with the impacts of natural disasters. Studies indicate that women and children are especially vulnerable.

In India, there are multiple governance frameworks and structures that administer the coastal and marine environment. While these are intended to have positive outcomes, overlapping jurisdictions, contradictory mandates and limited coordination hinders multiple agencies from working effectively in coastal India. Given this scenario, the challenge lies in reconciling livelihood needs and development vis-a-vis conservation.

Marine Biodiversity Conservation: National and International Issues

Though human impacts on marine and coastal biodiversity are less understood and publicized than those on terrestrial systems, their potential effects are no less threatening. The major direct threats to marine and coastal biodiversity can be divided into five interrelated categories: pollution (from land based and other sources), over exploitation of marine living resources, introduction of alien species, habitat degradation caused by coastal development, and global climate change and ozone depletion. Some of the harmful human impacts on marine biodiversity stem from ignorance and lack of understanding of the importance of marine biodiversity and how it can be affected, which put marine resources on a lower priority level *vis-à-vis* land biodiversity. Unregulated use of resources, increase in demand for the resources and rapidly expanding coastal development put the marine resources at considerable risk. The belated realization of the need for action after the damage becomes apparent (and often when it is too late) perpetuates this destructive cycle. Communities that depend on marine resources face the long-term challenge of sustainability yet are often confronted with immediate economic hardship. For the developing country like India, action is hardly ever preventive, but is usually undertaken only after irreversible damage has occurred.

In the face of this increasing uncertainty, the adoption of a precautionary approach is a *sine qua non* to the conservation of marine and coastal biodiversity. The precautionary principle, which is now widely recognized as the emerging part of customary international environmental law, requires that no harmful action be undertaken until all the effects on marine and coastal biodiversity have been clearly identified and weighed against the expected benefits. Moreover, this precautionary approach should cover all the activities of past, present and future, bearing in mind the cumulative impact that these activities combined will have on marine biodiversity.

The following are the important instruments with greatest potential for synergy with the Convention on Biological Diversity.

- United Nations Convention on the law of the Sea, Montego Bay, (UNICLOS). Agenda 21, Rio de Janeiro, 1992.
- UN Agreement on Straddling and Highly Migratory Fish Stocks, New York, 1995, and FAO Code of Conduct for Responsible Fishers, Room 1995.
- The UN General Assembly Drift-Net Resolution 46/15, 1991
- UNEP Conference on Protection of the Marine Environment from Land Based activities, Washington, 1995.
- Protocol on Substances that Deplete the Ozone Layer, 1987 (Montreal Protocol).
- The Framework Convention on Climate Change, Rio de Janeiro, (FCCC).
- United Nations Conference on the Sustainable Development of Small Island Developing States, Bridgetown, 1994.
- Convention on International Trade in Endangered species, Washington, 1973 (CITES)
- International Convention for the Prevention of pollution from Ships (MARPOL), 1973-1978.
- The Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter, London, 1972 (London Convention).

- Convention on Wetlands of International Importance Especially as Waterfowl Habitat, Ramsar, 1971 (Ramsar Convention).
- International Convention for the Regulation of Whaling, Washington, 1946 (ICRW).

Action under the Convention on Biological Diversity

The Conference of the Parties first addressed marine and costal biodiversity in a comprehensive way at its second meeting, establishing the "Jakarta mandate". Renewed efforts are needed now to implement the Programme of Work on Marine and Coastal Biodiversity. This will involve cooperation with various partners at multiple levels, including FAO and other UN-Ocean members, regional seas organizations and conventions, regional fisheries management organizations, and other partners, all consistent with the United Nations Convention on the Law of the Sea.

The Strategic Plan for Biodiversity 2011-2020 adopted at COP-10 includes the Aichi Biodiversity Targets, with specific commitments for marine and coastal areas, thus providing additional impetus for the action on marine and costal biodiversity. These include:

- *Target 6 on the sustainable management of fish and other marine organisms*

  By 2020, all fish and invertebrate stocks and aquatic plants are managed and harvested sustainably, legally and applying ecosystem based approaches, so that overfishing is avoided, recovery plans and measures are in place for all depleted species, fisheries have no significant adverse impacts on threatened species and vulnerable ecosystems and the impacts of fisheries on stocks, species and ecosystems are within safe ecological limits.

- *Target 7 on sustainable aquaculture*

  By 2020, areas under agriculture, aquaculture and forestry are managed sustainably, ensuring conservation of biodiversity.

- *Target 10 on the need to minimize, by 2015, the multiple anthropogenic pressures on coral reefs and other vulnerable ecosystems impacted by climate change or ocean acidification*

  By 2015, the multiple anthropogenic pressures on coral reefs, and other vulnerable ecosystems impacted by climate change or ocean acidification are minimized, so as to maintain their integrity and functioning.

- *Target 11 on the protection of at least 10% of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services*

  By 2020, at least 17 per cent of terrestrial and inland water areas, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes.

Livelihood and development vis-à-vis conservation

India's coastline is inhabited by 63 million people and the population is expected to rise to almost three quarters of the national population by 2020. At the same time, the coastline is pivotal to the country's economic development – there are a number of production activities taking place along the coasts for fisheries, aquaculture, agriculture, mining, tourism, ports, etc. It is well documented that these different resource uses have a negative impact on biodiversity. Considering the alarming rate of loss of biodiversity and increasing pressure on coastal resources, many management tools have been developed for the conservation and sustainable use of marine biodiversity. One of these tools is establishment of Marine Protected Areas and second major one is declaration of biodiversity rich areas as Marine Biosphere Reserve. These Protected Areas are declared under the Wild Life (Protection) Act, 1972 and the Wild Life (Protection) (Amendment) Act,

1991. Another tool is the declaration of biodiversity rich areas as Critically Vulnerable Coastal Areas (Ecologically Sensitive Areas) under the Coastal Zone Regulation Notification of 2011.

The Marine Protected Areas are not extractive in the sense community is not allowed to use any of the resources in these areas, whereas in ecologically sensitive areas communities are permitted to use resources, with certain conditions. At the same time, the number of MPAs in India is limited and do not adequately represent or cover significant coastal and marine biodiversity. In addition, legal frameworks are inadequate to cover the livelihood aspirations of people and weak to development pressure.

Challenges to conservation of marine and coastal biodiversity

The improved conservation and sustainable use of marine and coastal biodiversity presents a number of challenges:

- ***Habitat destruction*** **:** The driving force behind coastal degradation has been large development and infrastructure projects along the coast as well as unplanned and unregulated growth in coastal areas. Ecosystems and critical habitats that are constantly being challenged are mangrove forests, estuaries, mud-flats, coral reefs, small island ecosystems, coastal headlands and cliffs, coastal wetlands, sand dunes, etc.
- ***Over-exploitation of bio-resources*** **:** Living bio-resources found in the coastal zone are heavily exploited, and often the exploitation is unsustainable. This includes banned species such as sea cucumbers, molluscs and sea horses. There is practically no data available on the exploitation of any of these species.
- ***Pollution*** : The coastal zone receives waste generated by a number of point and non-point sources, especially sewage, industrial effluents, sediment, and agricultural chemicals, notably fertilisers and pesticides. These contribute to the degradation of the quality of coastal waters
- Reduce impacts of natural and anthropogenic pressures on Ecological and Biological Sensitive areas (EBSAs).
- Insufficient awareness by people of benefits they derive from marine and coastal biodiversity;
- Governance challenges due to sectoral and fragmented approaches including those associated with the management of common property resources;
- Poor integration of marine and coastal biodiversity concerns in the legal aspects of Environment Impact Assessment processes, and lack of awareness and sensitivity towards the issue of marine and coastal biodiversity among the judiciary, policymakers, decision-makers and administrators.
- Additional challenges due to governance gap on biodiversity conservation in areas beyond national jurisdiction;
- The inherent complexity of addressing multiple drivers of biodiversity loss with the spatial separation of causes and consequences;
- Multiple and often competing interests (eg: fishing; extractive industries; tourism; conservation; land-based industry and agriculture);
- Lack of capacity to address these challenges.

The Conference of Parties (CoP 11)

India hosted the Eleventh Conference of the Parties (CoP11) of the Convention of Biological Diversity (CBD) in Hyderabad, in October 2012 and the CBD identified the theme for the International Day for Biological Diversity in 2012 as "Marine and Coastal Biodiversity". The deliberations held during CoP 11 revolved around and addressed following specific questions:

- How the present tools of conservation marine and coastal biodiversity are effective in conserving biodiversity?

- Are these tools promoting integration of biodiversity conservation and livelihood enhancement?
- Are these tools based on an adequate understanding of the impact on biodiversity of industrial/extractive/urban growth?
- What are the current policy and governance challenges to coastal and marine biodiversity conservation? What is the role of community in the governance and management of marine protected areas and ecologically sensitive coastal areas?
- What is the challenge posed by industrial/extraction/urban growth to the coastal and marine ecosystems and what measures can be taken to balance such development with conservation?

CoP 11 also provided a platform to engage communities and policymakers on a range of issues that impact the coastal biodiversity. In this regard, the event focussed on the following themes :

- Policy and Governance
- Conservation
- Livelihoods
- Emerging Issues.

Outcome of CoP Deliberations:

The Conference of the Parties affirmed that the sustainable management of marine and coastal biodiversity is essential for the benefit of all humanity as well as critical for the livelihoods and well-being of the coastal communities all over the world. This was acknowledged by the all the parties in the discussions and the importance of greater international and regional cooperation towards this were emphasized upon.

The parties discussed following four major key questions and other related issues.

- How do we tackle poverty reduction with the ultimate goal of enhancing coastal livelihoods and well-being of local populations?
- How does on consolidate sustainable management of coastal and marine biodiversity?
- How do we strengthen the environmental and strategic impact assessment processes for coastal and marine areas?
- How can counties realize the Aichi Biodiversity Target commitment on establishment and management of the Marine Protected Areas?

The major challenges of conserving coastal and marine biodiversity as highlighted by the parties as well as other stakeholders were

- over fishing,
- ocean acidification,
- under water noise,
- marine debris,
- bulk commodity seabed mining, and
- issues pertaining to areas beyond national jurisdiction.

CoP 11 also highlighted that most of the pressure on sea and marine resources came from land based activities. There was a consensus among all the Parties on the need for regulating such activities while addressing the livelihood concerns of the coastal communities.

It was agreed that in order to reduce the pressure on coastal and marine biodiversity, the income of coastal communities needed to be enhanced. The Panel urged for a differential approach in dealing with artisanal and commercial fisheries and need for regulation, particularly of commercial fisheries in appropriate manner. It was felt that launching campaign at national, regional and global level would help in effectively addressing the issue. The issues regarding the unsustainable harvesting practices were highlighted and the need for enhancing awareness among the coastal communities on the above issues, including adverse impact of harvesting of juvenile fishery resources was emphasized. In this regard, education and training to various stakeholders was recommended.

It was also stressed that the importance of Traditional Knowledge (TK) should be taken into account as it formed the basis of relationship between coastal population and marine resources. Poverty reduction initiatives towards sustainable management of coastal and marine resources should include disaster risk management. The need for partnership between local self-governments, communities and Government to resolve certain issues was also emphasized.

The panel concluded that the key for consolidating sustainable management was through greater partnerships among the countries and stakeholders. The need for regional partnerships in conservation and management of marine resources was emphasized. Some Parties highlighted the important role played by the Regional Seas Program. As areas beyond national jurisdiction (ABNJ) represented more than 60% of the total marine and coastal areas of the world, the need for appropriate institutional mechanism was stressed upon. Suggestions were made to look at the outcomes of Rio + 20 on this issue. Participants also called for focus on issues of ABNJ within the context of CBD where possible.

Local community development approach and the recognition of the socio-cultural linkages was one of the most important tools that could be applied to make the sustainable use of resources. The participation of indigenous communities, women and all stakeholders in planning and managing the resources was emphasized. The importance of scientific knowledge on ocean and marine resources was stressed along with a suggestion to establish an international research center on ocean and marine resources to fill the knowledge gap. The idea of sharing best practices from successful experiences was also emphasized.

On the issues of strengthening the environmental and strategic impact assessment processes, it was pointed out that coastal and marine resource management should be dealt with in an integrated way and not on a case by case basis. The need for following a common code of conduct for conservation and sustainable management of coastal marine resources was stressed upon. The inadequacy of knowledge about the impact assessment has been highlighted and the need for blending tradition knowledge with scientific understanding of the resources for providing mitigation measures was emphasized.

Conclusion

It was concluded that the Parties were making significant progress in working towards achieving the Aichi Targets and aligning their national strategies with the Aichi goals. The challenge of implementation of these strategies lies not only in mobilizing the required financial resources but also in effectively managing these resources. The need for institutional mechanisms to ensure coordination among different agencies involved in coastal and marine resources management at national and regional level have therefore been emphasized.

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Content

Conservation and Management of Wetlands

Geomorphology, Hydrology and Hydraulics of Wetlands

National Conference 2014

Mitigation and adaptation strategies in wetlands

Conference Organizing Committee

South Asian Forum for Environment

Central Inland Fisheries Research Institute

The Central Inland Fisheries Research Institute, Inland Fisheries Society of India and South Asian Forum for Environment are jointly organizing a National Conference on " Mitigation and Adaptation Strategies in Wetlands : a Community Leadership Perspective" during March 01-02, 2014; the venue will be CIFRI, Barrackpore. The Director, CIFRI, has been pleased to constitute the following committees for smooth conduct of the Symposium:

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Climate Change

Adaptation & Mitigation

Conserving Wetlands in Urban Landscape for Climate Adaptation and Abating Anthropogenic Footprints : Study on East Kolkata Ramsar Site.

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East Kolkata Wetlands (EKW), Ramsar site in India is renowned as a manmade wetland for multiple use resource recovery system maintained by local commune, whichis currently facing threats of anthropogenic encroachment, habitat damage & biodiversity loss. 12,500 hectare wetlands, a niche of biodiversity and 52 endemic fishes, integrates 272 peri-urban lakes to make the only natural sewage treatment facility of Kolkata metropolis that supportdiverse human activities in wastewater fisheries to sustain livelihood of 80,000 wetland dwellers those are urban poor.

Conserving these unique peri-urban wetlands without compromising with community interests poses uneven challenges to long-term sustainable environmental development in the ruse of climate change. Present paper reviews the 'community-ecosystem' approach of conserving these wetlands in the urban landscapefor their carbon sequestration potentials and impact on anthropogenic footprints, through habitat evaluation, strategic impact assessment of anthropogenic interferences and further identifies an integrated optimal paradigm for development and conservation ensuring community participation and partnership.

Wetlands have the ability to accumulate significant amounts of carbon (C) and thus could provide an effective approach to mitigate greenhouse gas accumulation in the urban atmosphere. Wetland hydrology, age, and management affects primary productivity, decomposition, and ultimately C sequestration in wetlands, but these aspects of wetland biogeochemistry have not been adequately investigated, especially in created wetlands within urban landscapes. In this study we investigate the ability of created freshwater wetlands to sequester C by determining the sediment accretion and soil C accumulation. Perusal of results shows that created wetlands of EKW accumulated an average of 307 g C m^{-2} yr^{-1}, 74% more than a similar natural wetland in the region and 28% more than the projected rate estimated 5 years before this study. Soil C accrual accounted for 66% of the aboveground net primary productivity on average. Open water communities had the highest C accumulation rates in EKW. This study shows that created wetlands can be natural, cost-effective tools to sequester C to mitigate the effect of greenhouse gas emissions in the urban landscapes.

The Study also reflects that shrinking lake permanence index, vanishing biodiversity and habitat loss in EKW is correlated with lack of economic opportunity, awareness and wise-use of resources. Sustaining community based conservation effort in EKW needs adaptive management over time and spacealigned with pro-poor economic development. Such conservation paradigm can propound climate adaptive strategies for downscaling emission impacts in urban habitat.

Enhancing Ecosystem Goods and Services of the Wetlands of Indian Sundarban

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Wetlands are among the most productive ecosystems in the world providing valuable ecosystem goods like fishes and services like flood control or fresh water supply, recreation and tourism.In order to generate a high resolution data base of Wetlands (both fresh water and saline) of Indian Sundarban, a mapping exercise with IRS P6 LISS IV remote sensing data has been undertaken using advanced image interpretation techniques like band ratioing, estimation of NDWI,MNDWI, NDPI, NDTI etc.Later a knowledgebase classificationhas been performed to extract all wet land classes along with onscreen interpretation.It has been estimated that among the 36,000 wetlands of Indian Sundarban, around 18,000 Hectares can be utilized for aquaculture. Connectivity may be established for Wetlands existing in the course of dried up river channels for fresh water storage and supply for winter agriculture and other ecosystem services. Efforts for a more detailed inventory with estimation of depth measurement and enhancement, identifying the blockages and exploring modalities of regeneration and connectivity would be beneficial for livelihood generation and poverty alleviation in the Indian Sundarban delta.

Key words : Sundarban, Wetland, Remote sensing, livelihood

Marine Algae as Potential Factor in Carbon Sequestration in Costal Wetlands

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Mangrove swamps are one of the richest and most productive areas of organic detritus and form the base of the food chain. They are regarded as the “hotspots” of biodiversity and also for marine fungi. Marine fungi play an important role in nutrient regeneration cycles as decomposers of dead and decaying organic matter in the estuaries. For the sustainability of these ecosystems, it is therefore necessary to know this mycoflora.

Raigad, a coastal District in Maharashtra State along the Central-West coast of India possesses about 150 km long coastline along the Arabian Sea. An attempt was made to study the higher marine fungi from six different locations of mangrove wetlands in the said District.

71 fungal species of higher marine fungi were identified from amongst over 1600 samples collected during the study. Out of 71 species, 40 were reported in all three seasons while 05 species were restricted to two seasons and were usually absent in pre-monsoon season. Four species were restricted to only one season. Out of 71 fungal species, 50 species represented Ascomycota (70.42%), one Basidiomycota (1.4%), two from Mucoromycotina (2.8%), sixteen from Hyphomycetes (22.53%), and two from the group Coelomycetes (2.8%). This is the first time investigation of higher marine fungi from the coastal wetlands of Raigad district.

The current work is the first investigation of marine fungi along the coastal Maharashtra. Details of the work would be presented during the Conference.

Vetiver system as an integrated bioengineering tool for community based restoration of climate vulnerable coastline.

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In coastline restoration traditionalstructural localized rigid engineering measures are expensive, not compatible on erasable soft soils neither environment friendly.Bio-engineering with bamboo can not provide closed hedgerows. This paper converses about Vetiver, a fast growing noncompetitive noninvasive plant as potential tool for embankment stabilization for community based coastline restoration scheme.

Having small mean stem diameter,deep vertical rooting, tolerance to submergence, high root tensile strength and low above-ground biomass, Vetiver increases drainage and soil permeability,shear strength via apparent cohesion and decreasespore pressuresreducing chances of landslide. The tensile strength of roots hinders crack forming and pushing off soil aggregates.

Resultsshow that Vetiver shown on 40-60slopes with 1 meter vertical row space reduces 37% soil moistureup to 1.7 m depth.In high precipitation, 2.5% highergradient stabilizesdrainage outlets.Contour plantation traps surface runoffpreventing localized accumulation of surplus water and increased infiltration. Hedges planted in rows created hydraulic resistance of Class A with resistance decreasing with increased hedge spacing, suitable for highly erosive slope flow. While diamond-shaped plantations were in Class B resistance category and found suitable for slower flow rate, shallow slopes where sedimentation was high.Tensile strength increases with reduction in root diameter. Stronger fine roots provide higher resistance than larger roots.

Vetiver stands good as fuel and fodder, supports alternative livelihood and can earn carbon credits as the carbon sequestering ability is 15 MT per hectare. It can appear as a unique and comprehensive measure for alternative livelihood, especially for women in climate vulnerable coastal areas that can sustain home based industries on non-forest non-timber natural fibers, semi-processed organic active principles and also for processed fodder. Community based nursery and products prepared by skilled women can essentially augment economic and social security and as well enhance community resilience.

Carbon sequestration in wetlands

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Be definition wetlands are 'area of marsh, fen, peat land, or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish, or salty, including areas of marine water, the depth of which at low tide does not exceed six meters.' They are one of the most biologically productive ecosystems which will also be the worst affected by even small changes in climate and resulting changes in hydrologic regimes like sea level rise or decreased surface and ground water levels.

Wetlands are one of the largest biological carbon pool and important in global C-cycle. Their high productivity and presence of water gives them the ability to efficiently sequester carbon in the soil, serving as a potential tool to mitigate the net greenhouse effect of carbon emissions to the atmosphere and abate climate change. Despite covering 6-8% of the fresh water surface, wetlands are estimated to account for one third of the world's organic soil carbon pool. The major factors governing carbon cycling in wetlands are inputs, outputs, and storage capability. Inputs can occur as gas (photosynthesis by algae and macrophytes), solids (dust, water and soil erosion, and animal biomass), and dissolved substances (dissolved organic carbon, dissolved inorganic carbon). Outputs also occur in these three states: as gas through respiration (carbon dioxide, methane and nitrous oxide); as solids (e.g., harvesting of vegetation such as hay cropping); and as dissolved substances in water through surface and ground water flow (dissolved organic carbon and dissolved inorganic carbon). Carbon is stored in wetland sediments over the long term. Short-term stores are in existing biomass (plants, animals, bacteria and fungi) and dissolved components in the surface and groundwater. Modifiers of carbon storage in wetlands are numerous and include factors such as wetland class, vegetative zone, depth into sediment, north–south latitudinal gradient, salinity, climate cycles, temperature, hydrology and surrounding land use. Significant differences were found on carbon sequestration between wetland types in temperate and tropical regions, being consistently higher in the studied forested wetlands (260 ± 58 g C m^{-2} y^{-1}) than the riverine ones (113 ± 27 g C m^{-2} y^{-1}). The temperate wetlands were also consistently more efficient in sequestering carbon than similar tropical ones (230 ± 89 and 144 ± 57 g C m^{-2} y^{-1}, respectively). Wetland productivity and permanent anaerobic conditions are key factors in enhancing soil carbon sequestration. In the created wetlands carbon sequestration was strongly correlated with aboveground productivity. These temperate created wetlands sequestered 243 ± 24 g C m^{-2} y^{-1} after 15 years since creation, 26% more than the rate after 10 years (190 ± 7 g C m^{-2} y^{-1}) and 55% more than the similar natural wetland in the same region (140 ± 16 g C m^{-2} y^{-1}), implying that once created wetlands are fully functional and structured they can successfully sequester carbon, especially in their early years (http://senr.osu.edu/eventview.asp?eventid=5912).

Although wetlands can sequester carbon they can also act as source of greenhouse gases (GHGs). Drying and destruction of wetlands would ultimately entail release of CO_2 to the atmosphere by exposing the accumulated carbon in sediments for aerobic degradation. **Wetlands are a natural source of methane due to high rates of methanogenesis contributing about 25% of the global methane emissions. It was estimated that wetlands contribute between 109 - 145 TgCH_4/yr (20-26%) of the total 550 TgCH_4/yr methane emission**. As methane has a global warming potential of 21-23 times greater than that of CO_2, a small change in its concentration could have important impact on the climate.

Therefore, net carbon sequestration vis-a-vis GHG emission from wetlands is very complex issue which is only poorly understood. More comprehensive information is required to be generated from different types of wetlands under various agro climatic conditions. Efforts should be made from all sides to protect and restore the existing wetlands for enhancing carbon reserve and reducing GHG emission.

Keywords : Wetland, carbon cycle, sink, source

Sewage-fed wetland: a Model for Converting Waste to Wealth

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The East Kolkata Wetlands (EKW), a Ramsar site, is a complex of natural and human-made wetlands and spread over an area of 125 km^2 with multiple uses like vegetable cultivation, paddy cultivation, aquaculture and natural sewage treatment system. It consists of a series of nearly 300 numbers of freshwater bheries receiving 20-70 kg/ha/day of organic matter from sewage and wastewater of Kolkata city. Sewage fed wetlands (47.79 km^2) connected by major and secondary sewage canals are used for aquaculture using natural densely populated plankton as fish food. The nutrients present in sewage water are converted in to phytoplankton biomass, which is converted to fish flesh through aquatic food web. The wetlands are thereby termed as "Converter of Waste to Wealth". In order to understand the potential of these wetland to remove the sewage nutrients and convert it to fish food organism, the present study was conducted in one of the freshwater wetlands in EKW, Jhagrasia (22°59.872'N, 088°38.556'E) where aquaculture is practiced using fish species like grass carp, tilapia, IMCs etc. The water and sediment sample from both sewage inlet and wetland proper was collected during October and December, 2012 to analyze various indicators of nutrient removal and nutrient utilization. The nutrient load (specific conductivity, calcium, magnesium, phosphorous and silicate) in the sewage water was significantly reduced in the wetland proper while available nitrate level was increased. The water reaction shifted towards alkaline side with improvement of dissolved oxygen status in wetland. The nutrients are converted to phytoplankton mass as observed from significant increase of total chlorophyll and sestonic biomass in the wetland. Analysis of sediment attributes revealed decreased overall microbial activity, decreased carbon mineralizing potential and nutrients, while organic matter and microbial population increased. The wetland thus was capable of removing nutrients, and dissolved and particulate organic matters from the sewage water, improving the water quality, providing both conducible environment and food nutrients for cultured fish species. Periodic cycling of sewage with simultaneous stocking/ harvesting made the system sustainable and a good model for conversion of 'waste to wealth.'

Keywords : East Kolkata wetlands, sewage, nutrients, chlorophyll, carbon mineralization, microbial population, particulate organic matter

Coastal Wetland : Climate Impacts on Ecology and Related Services with Special Reference to Sunderbans, West Bengal

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Wetlands are among the most important life support system on the earth. India has a total of 27,403 wetlands of which 23,444 are inland wetlands and 3,959 are coastal in location. The coastal wetlands occupy an estimated 6,750 sq. Km. and are largely dominated by mangrove vegetation. About 80% of the mangroves are distributed in the Sunderbans of West Bengal and the Andaman & Nicobar Islands, with the rest in the coastal states of Orissa, Andhra Pradesh, Tamil Nadu, Karnataka, Kerala, Goa, Maharashtra and Gujarat. The entire Sundarbans is about 26,000 km^2, one-third of which falls in India. The Indian part of Sundarbans is comprised of 102 islands, of which 54 are inhabited by human where more than 45 lakhs people live and the rests are reserve mangrove forest. The Indian region is demarcated by the river Hooghly on the west, the Bay of Bengal on the south, the Ichhamati-Kalindi-Raimongal rivers on the east and the Dampier-Hodges line on the north. It comprises of 19 administrative blocks of which 6 are in North 24-Parganas and 13 in South 24-Parganas districts with total 190 Gram Panchayats and 1064 villages. Human settlement in Sundarbans started from 18^{th} century through clearing of mangrove forests and construction of earthen embankments for protection of the islands from tidal waters. The region is considered as one of the worst climate change hotspots that influences the lives and livelihoods of the inhabitants. The shallow and funnel-shaped Bay of Bengal intensifies cyclones and storm surges, flooding the low-lying plains of Sundarbans. Other climate-induced risks like sea level rise, salinity intrusion, temperature and rainfall variations, land erosion *etc.* also pose serious threats. The IPCC Fourth Assessment Report also predicts that the climate change will intensify extreme weather events such as cyclones and associated storm surges, especially along the Bay of Bengal. These will seriously affect the livelihood activities of the people like agriculture, animal husbandry and fishery (fishing and aquaculture) to great extents. The salient climatic variables in Sunderbans are air temperature, surface water temperature, rainfall and monsoonal pattern, salinity regimes, cyclonic storms & depressions, sea level rise, erosion & accretion and vulnerability of embankments. Changes in sea surface temperature and ocean acidification will have direct impact on phytoplankton populations, whose decline will severely affect fish production and diversity. Catch data from estuarine fisheries reveal an increase in the yield, but a decrease in the catch per unit effort. A steady decline in the fish catch per unit effort has been recorded in lower stretch of Hooghli-Matla estuarine system of Indian Sundarbans from 1984 to 2000. Increase incidences of cyclone, storm surge and sea level rise are causing erosion of land mass and saline water ingression in the inhabited areas resulting in loss of life, agriculture and fish crops. These are increasing stress, both biotic and abiotic, on lives and livelihoods of the people of Sunderbans. Developing policies and programs to improve the resilience of natural resources, through assessments of risk and vulnerability, by increasing awareness of climate change impacts and strengthening key institutions, may help the communities adapt to climate change.

Keywords : Sunderbans, climatic variables, threat, ecological services

Impacts, Vulnerability and Resilience of the Fisheries Sector to Climate Change in India

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Global warming and the associated climatic change has become a threat to the livelihood and economies of the countries dependent on the natural ecosystems of the earth including those in the fisheries and aquaculture sector. While the importance of fisheries and aquaculture is often less understood, the implications of climate change for this sector in India providing nutritious food, with high potential for rural development, domestic nutritional security, employment generation, as well as export earnings are difficult to ignore.

The Fishery sector has shown a steady growth in India and hence it is called the sunrise sector. Its contribution to the National GDP during 2009-10 is 0.96 %, to National Agriculture and allied activities is 5.41 %. The sector provides direct and indirect engagement to14 million people. India relies on fisheries for around 13.5% of its national animal protein intake and the average per capita fish protein consumption is 0.51 kg/capita/yr. But the contribution of fish to total animal protein consumption for the non-vegetarian population is much higher than the overall Indian average. Any potential direct or indirect effects of climate change will have immense implication on the food security of the country.

Climate change is evident in India as manifested by increased air temperatures, regional variation in the monsoon, frequent occurrence of droughts, and a regional increase in severe storm incidence in coastal states of India. The impacts are evident for freshwater fisheries and fishers of the River Ganga and the water bodies in its plains and deltaic areas. Analysis of time series data for 32 years at CIFRI from published literature and from current investigations showed a 0.99°C increase in the minimum water temperature recorded in the upper stretch of River Ganga and 0.5 to 1.4°C increases in aquaculture water on the Gangetic Plains of West Bengal. Rainfall showed a 1% increase in the post monsoon months of September-December. The impacts were evident in a geographic shift of warm water fish species such as *Glossogobius giuris, Xenentodon cancila* into the colder stretch of the River Ganga. The breeding of the Indian Major Carps (IMC) has been affected and a consequent decline in fish spawn availability in River Ganga recorded. However, a positive effect on breeding in fish farm hatcheries in the Gangetic Plains was observed in the advancement and extension of the breeding period for IMC by 45–60 days. A study on the impact of extreme climatic events like drought and cyclones in West Bengal, during 2009 was conducted The impact of drought revealed a rainfall deficits of 29% and 27% in the districts of North 24-Parganas and Bankura respectively in the fish breeding months of March–September and 92% of fish spawn hatcheries were affected. These districts recorded losses on average 61% to 73% of fish spawn during 2009 compared to the previous four years. The study on the potential impact of cyclones and storms on saline water inundation using a digital elevation model generated for coastal district of South 24-Parganas indicated the potential for 3% to 11% submergence of aquaculture areas in response to 1 to 2 meter rises due to sea water incursions. An assessment of people and the fisheries sector to climate change in 13 fish producing districts of West Bengal revealed inland fisheries in 5 districts of West Bengal to be highly vulnerable to climate change with the composite vulnerability index (VI) ranging from 0.61 to 0.53. The vulnerability profiles developed provide a frame work for assessing vulnerability of the fisheries sector to climate change in India

It is apparent that climate change can impact the aquatic ecosystems and fisheries already subjected to various anthropogenic stresses. These resources being common pool resources are important as they are vulnerable. Improper management and would affect poor people more if they are threatened. Thus appropriate adaptation strategies are needed for the fisheries sector to cope up with the impending threats. To achieve this goal a clear understanding of the ecosystem processes that govern the sector is essential. Without effective planning aquatic ecosystems, fisheries and aquaculture can potentially be affected by the adaptation measures undertaken by other sectors. A good beginning would be to harmonize fisheries and aquaculture into the national climate change adaptation strategies. To conclude it is felt that enhancing investments in fisheries and aquatic ecosystems is an investment in the 'liquid assets' of adaptation because this sector would buffer the society from climate- related risks.

Keywords : Climate change, gangetic plain, vulnerability, resilience

Marine Algae as Potential Factor in Carbon Sequestration in Costal Wetlands

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Coastal wetlands are sensitive to global climate change and may play an important role in the global carbon cycle .Coastal wetland ecosystems (salt marshes, mangroves, and seagrass beds) can store large quantities carbon for two reasons first their plants usually grow a lot each year, and in the process, capture (or sequester) large amounts of Carbon Dioxide (CO_2) and their soils are largely anaerobic (without oxygen) so carbon that gets incorporated into the soils decomposes very slowly and can persist for hundreds or even thousands of years (carbon storage).

The fate of photosynthetic carbon in marine ecosystems dominated by different types of primary producers is studied by scientists considering herbivory, autotrophic respiration, decomposition, carbon storage, and export rates as fractions of net primary production (NPP) in ecosystems dominated by different types of autotrophs (i.e., oceanic and coastal phytoplankton, microphytobenthos, coral reef algae, macroalgae, seagrasses, marsh plants, and mangroves). A large fraction (>40%) of, the NPP of marine ecosystems is decomposed within the system, except for microphytobenthos (decomposition, -25% of NPP). Herbivory tends to be highest for microalgae (planktonic and benthic, >40% of NPP) and macroalgae (33.6+4.9% of NPP) and is somewhat less for higher plants. Microphytobenthos export on average a much higher proportion of their NPP than do other microalgal communities, whereas marine macrophytes, except marsh plants, export a substantial proportion (24.3-43.5% on average) of their NPP.

The action of NPP stored in sediments is 4-fold greater for higher plants (10-17% of NPP) than for algae (0.4-6% of NPP). On average -90% of the phytoplankton NPP is used to support local heterotrophic metabolism (i.e. grazed or decomposed). This fraction is even higher in oceanic communities. Mangrove forests, and to a lesser extent seagrass meadows and macroalgal beds, produce organic carbon well in excess of the ecosystem requirements, with excess photosynthetic carbon (i.e. export rate plus storage) in these ecosystem; representing -40% of NPP.

There has been a good deal of interest in the potential of marine vegetation as a sink for anthropogenic C emissions (“Blue Carbon”). Marine primary producers contribute at least 50% of the world's carbon fixation and may account for as much as 71% of all carbon storage. We suggest that CO_2 acquisition by marine macroalgae can represent a considerable sink for anthropogenic CO_2 emissions and that harvesting and appropriate use of macroalgal primary production could play a significant role in C sequestration and amelioration of greenhouse gas emissions.

The fate of marine microalgae and macroalgae deals with their usage in carbon sequestration, biofuels and bioproducts potential.

Use of green and sustainable technologies for reclamation of wastewater: Mitigation and adaptation strategies for wetland conservation

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Increasingly high demand of water for multiple uses of human has been causing much concern due to depletion and uncontrolled pollution of surface and ground water sources. Despite the fact that vast wastewater resources could be utilized as a storehouse of fertilizers, there is heavy demand for chemical fertilizers for food security resulting in depletion of mineral reserves of the earth and degradation of water resources. Global warming has further aggravated the scenario of water crisis. It is most urgent to protect and conserve 20 – 60% of fresh surface water supplies, explore alternative sources of biogenic fertilizers as well as to mitigate the impact global warming on water resources. The ecological principles of holistic approaches using green and sustainable technologies are applied to respect the wastewater as resource and store house of fertilizers rather than ignoring its potentials and using it as to cause concern to sustainable environment. With a view to managing ecological poverty and downstream problems of contaminants and eutrophication with excess nutrient loadings in water bodies, living machines such as variety of macrophytes for nutrient removal, freshwater mussels and gastropods for heavy metal deprivation, herbivorous fish for algal bloom control, bottom grazing fishes and benthivorous animals for abnoxious gas and nutrient release from sediment have been examined. The benefits of wastewater reclamation cum fish culture in waste stabilization ponds were evaluated using the solar energy driven algal-microbial-heterotrophic complex processes. Nutrient management strategy with optimum CNP ratio and dose was used to augment carbon sequestration by microalgae and economically important crop water chest nut. Aquaponics of tomato plants and other vegetables were practiced in wastewater fed ponds for nutrient recovery and reducing water loss by evaporation especially during the summer months. The presentation aims to highlight and focus on these issues.

Community based intervention in Wetlands

Wetland a Fragile Ecosystem: Retrospect and Prospectus Towards Sustainable Management

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Wetland is attributed to aquatic and terrestrial environment, in which the soil is seasonally or permanently covered by shallow water of any type i.e. fresh, saline and brackish and the water table is close to or near the surface. India has a total of 27,403 wetlands, of which 23,444 are inland wetlands and 3,959 are coastal wetlands and directly or indirectly linked with major river systems. In India, out of an estimated 4.1 mha (excluding irrigated agricultural lands, rivers, and streams) of wetlands, 1.5 mha are natural, while 2.6 mha are manmade. The coastal wetlands occupy an estimated 6,750 sq km, and are largely dominated by mangrove vegetation. About 80% of the mangroves are distributed in the Sunderbans of West Bengal and the Andaman and Nicobar Islands, with the rest in the coastal states of Orissa, Andhra Pradesh, Tamil Nadu, Karnataka, Kerala, Goa, Maharashtra and Gujarat. Being, the most productive ecosystems, wetlands recognized worldwide for its imperative role in sustaining a wide assortment of biodiversity and provide goods and services for those which share aquatic and terrestrial ecosystems in general and riparian community in particular. Wetland, mangroves itself is amazing breeding and feeding ground for most of the migratory and resident aquatic animals including fish, shrimp, molluscans and many others. Energy and nutrients are assimilated and stored in leaves of mangrove trees. As a detritus-based ecosystem, leaf litter from these trees provides the basis for adjacent aquatic and terrestrial food webs. In tropical countries like India, function of mangrove wetlands critical in stabilizing shorelines, as India has a long coastline that is periodically battered by tropical storms and hurricanes. Moreover, freshwater wetlands are also important as a genetic reservoir for various species of plants including rice, which is a staple food for 3/4th of the world's population. Besides these wetland services include the control of flooding, maintaining the ground water level in lean season; used as region specific domestic water reserve across the country, for instance, wetlands in southern peninsular India, known as yeris (tanks), which are constructed in every village and provide water for various human needs, besides serving as nesting, feeding, and breeding sites for a large variety of bird species. In, northeastern states of India, wetlands locally known as baor / beel (West Bengal); chaur and maun (Bihar). However, despite their important role in maintaining the ecology and economy, wetlands in India are endangered by inattention and lack of appreciation for their role. At present, only 50 percent of India's wetlands remain. They are disappearing at a rate of 2% to 3% every year. Conversion of mangrove wetlands for agriculture, industrial development, human settlement and recently, shrimp farming are major threats to mangrove wetlands. Apart from these, severe degradation of mangrove wetlands also results from excessive extraction of wood for fuel and other purposes as well as unscientific management practices and reduction in fresh water flow. Increased anthropogenic activities such as indiscriminate disposal of industrial effluents and sewage wastes have altered the physical, chemical as well as biological integrity of the ecosystem. Moreover, climate change which attributed to increased air temperature; shifts in precipitation; increased frequency of storms, droughts, and floods; increased atmospheric carbon dioxide concentration; and sea level rise could also affect wetlands. Furthermore, excessive withdrawal of groundwater has led to salinization; construction of canals and diversion of streams and rivers to transport water to lower arid regions for irrigation has altered the drainage pattern and significantly degraded the wetlands of the region; unrestricted dumping of sewage and toxic chemicals from industries has polluted many freshwater wetlands; invasion of exotic introduced plant species such as water hyacinth and salvinia; those clog waterways and compete with native vegetation, are also aiding the value for wetlands distortions. The loss of wetlands leads to environmental and ecological problems, which have a direct impact on the socio-economic benefits of the associated populace. Serious consequences, including increased flooding, species decline, deformity, or extinction and decline in water quality could result. To retain very existing reserve and bring back the lost resource, efforts such as restoration process should include waste water treatment system, removal of over growth of invasive macrophytes and awareness among community and enhanced co-operation among government agencies to manage wetland. Management priorities should mainly include evolving sustainable managing strategies for maintaining water quality, control of invasive species, encroachment, drastic land cover changes in the catchment and identification of buffer zone, providing aquatic resources with adequate water quality and limiting the spread of exotic biota in a sustainable manner evolving managing strategies.

Key words : Wetland, Pollution, Buffer zone, Sustainable

Threats and Mitigations of Indian Wetlands

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India is blessed with vast wetlands coverage across the country ranging from small peat lands to coastal aqua econes. This wide spectrum of wetlands enchanting its functions and beneficial impact to society in terms of their socio-economic value, cultural benefits in particular and hydrological, biological, chemical function and others as general. However, despite of their potential, a less attention is paid towards their sustainable use and management. Therefore, as a consequence wetlands are continuously goes on deteriorating at a faster pace.Urbanisation, anthropogenic interference, pollution, invasion of macrophtytes, and uncontrolled abstraction of wetland and its entity to domestic as well as industrial purposes being the main factors responsible for their present status. Wetlands threats include some times the factor that may be beneficial from a pint but at the same time may be disadvantageous from biological and biodiversity point of view. For instance damming of a big wetland for flood control is excellent remedy but as biodiversity concern it's a huge blow for species diversity and their natural population. A number of such issues need to be promptly addressed on sustainable manner. Therefore, still scope is left for researcher and different stake holder to join their hands to bring wetlands into their very existence and to regain their lost occurred during the course of time. Otherwise days are not far when there would be no more wetlands for fitting in the mandate of wetland definition. The management measures must include the strategies by which the impact of different threats can be minimized.

Threats to wetlands

- *Urbanization and development* : Removing of vegetation and filling or draining wetlands for building sites sometimes indirectly impacts riparian wetlands through the installation of artificial stream stabilizing devices like rip-rap and bulk-heads that attempt to stop the natural meandering process which creates new wetlands and replenishes existing ones.
- *Infrastructure development and industrialization* : This process may lead to convert flood plain wetland to roads and railroads which also affect drainage from uplands onto the floodplains, and many are built on top of areas that once were wetlands. Such roads often create long, low-quality wetlands upslope of the road by interrupting surface and groundwater flows.
- *Grazing* : Overgrazing harms wetlands through soil compaction, removal of vegetation, and stream

bank destabilization. Wetlands offer some of the best forage for livestock as well as a water source and cover, so livestock tends to spend a disproportionately large time in wetlands.

- *Intensive Agriculture and allied activities* : Wetlands often have fairly flat areas of rich organic soil that is highly productive agricultural land if drained. For this reason many wetlands have been drained and converted to agricultural lands.
- *Mining* : It impacts wetlands in many ways: flood plain wetlands are gradually getting silted and continuous deposition of sediments would leads to the different water quality related concern if it closed wetland. Moreover, mining abstraction material will decrease the depth of water retention which in due course may lead to shrinkage of the total water area of a particular wetland.
- *Dredging* : The removal of material from a wetland or river bed. Dredging of streams lowers the surrounding water table and dries up adjacent wetlands.
- *Multipurpose draining* : Water is drained from wetlands by cutting ditches into the ground which collect and transport water out of the wetland. This lowers the water table and dries out the wetland.
- *De-vegetation* : Vegetation plays an important role in wetland ecology by removing water through evapotranspiration, altering water and soil chemistry, providing habitat for wildlife, and reducing erosion. Removal of vegetation can drastically and sometimes irreversibly alter wetland function.
- *Creation of dam for flood control* : Many ponds and reservoirs are constructed on wetlands. A flooded wetland cannot provide the same habitats and functions.
- *Invasion of macrophytes* : Presence of aquatic vegetation has been a concern of debate in reference to sustainable management of wetlands if it so, then how much coverage of wetland by floating and submerged macrophytes should be there?
- *Loss of river connectivity* : Wetlands function as whole the loss of river connectivity to a particular wetland, will impart a huge loss to its natural hydrological regime, biological characteristic, chemical functions and physiological appearances that all are attributed to loss of biodiversity of different aquatic plants and organism including fish in particular.
- *Inadequate institutional and administrative reforms* : It has been observed in many states that privatization of wetland and conversion of wetland into agricultural land or a site for establishing some industries on the cost of several fishers who have been directly or indirectly linked to that water body. This happens due to flexibility in regulation and up to some extent the biasness to a particular stake holder.

Mitigations

- *Mass awareness among rural folk* : It is a prime necessity to manage the wetland on sustainable manner. As this approach include do and don't key inputs to different stake holder which increase the early warning signals to particular threats.
- *Participatory management* : This is also one type of strategy which includes the local stake holder who may be the member of a cooperative society, belonging to a particular fishers group. This approach will help in managing the wetland in long term as it taking the experiences of local people in terms of species composition, behavior of wetland in different times, and many others which will facilitate the policy make processes in impressive manner.
- *Macrophyte eradication* : Although, this has to be the point of debate, however the advantages of wetlands macrophytes cannot be ignored. Therefore there is need to specify that how much coverage of macrophyes would be beneficial and vice versa, to support the wetlands services. In general study

conducted by CIFRI revealed that 20-30 % macropytes coverage will support the normal function of wetland in addition to count the particular benefits.

- *Minimize the mining activity in the vicinity of wetlands* : This approach would include the control over the abstraction activities taking place in the river beds and near the wetlands.
- *Improved institutional and administrative reforms* : This is the need of present time to save the wetland which is not possible without joining of hands of different stake holders let it be research institution, respective state departments and many other agencies. Here every agency has to play their role actively.
- *Ecosystem based fishery management* : There should be some regulation to sustain the natural stock in wetlands i.e. close season, artificial breeding ground for small fish indigenous of high importance rather increasing the stocking stress with alien species in view of to increase the fish production without taking the future course of invasion of such species.
- *Others* : It include some innovative ideas i.e. Encouraging wetland managers who improve the condition of wetlands; Preventing or limiting catchment activities that impact upon wetlands; maintain a minimum water of appropriate volume and quality to sustain normal functioning of wetlands and bridge the flow regimes that mimic natural conditions where ever possible.

Conclusion

There many issues which are of great concern either suitability or increasing the fish production point of view. These both are of arbitrary, so the strategies which are of capable enough to bridge this gap need to be popularized on sustainable manner i.e. ecosystem based fisheries management, participatory management and awareness and highlighting the benefits of wetlands in long term benefits. This is well know that these resources are unparallel to any other resources in country but in last decade's insignificant attention has been paid to acknowledge the benefits. There is an urgent need to pay due consideration and frame some policy documents on national level in reference to mass awareness, future prospectus and to demark future projections.

Keywords : Wetland, threats, mitigation options

Exotic Fishes in Open Waters and Their Ecological and Social Implications

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A species is defined as exotic (also known as introduced, non-indigenous or alien) in a certain geographical area, if that area is outside the species' natural distributional range. The impact of exotic fishes in open waters, whether introduced, stocked by humans or as natural invaders, has its implications, both on the ecosystem and socio-economics of the society. Invasive species is a phrase with several definitions. The first definition expresses the phrase in terms of non-indigenous species that adversely affect the habitats they invade. The second definition broadens the boundaries to include both native and non-native species that heavily colonize a particular habitat. The third definition is an expansion of the first and defines an invasive species as a widespread non-indigenous species. There is national and international concerns on the invasion of fishes beyond their natural range of distribution, as the issue of exotic fish species and implications of their invasion are worldwide concerns. The introduction of exotic fishes happens as part of deliberate attempts for developing angling/ sport fisheries, aquaculture, capture fisheries development, biological control, aquarium/ ornamental fish trade, etc. Maximum such introductions have happened in Asia for aquaculture and ornamental fish trade. However reliable information on their distribution, resource size, population structure and ecological and socio-economic implications in inland open water ecosystems of India is relatively less. In India, the introduction of exotic fishes has been through Aquaculture (31 species), larvicidal fishes (3 species), research purpose (1 species), pedicure (1 species), sport fish (8 species) and ornamental fish (≈ 300 species). Of all the exotic fish species in India, >211 species are expected to be breeding in the country (captive or otherwise) and >30% of them are among the world's worst 100 invasive species. There are also about seven hybrids of exotic-native species in India. Although most of these introductions are for commercial, socio-economic reasons, inadequate information on the ecological and social backlashes/ consequences of these species in our ecosystems, in most cases, impedes planning conservation and strategic initiatives on remedial/ control/ management measures. There are more than 15 exotic fish species in open waters, of this 10 have food value (*Hypophthalmichthys molitrix, Hypophthalmichthys nobilis, Ctenopharyngodon idella, Cyprinus carpio, Barbonymus gonionotus, Systomus tetrazona, Oreochromis niloticus niloticus, O. mossambicus, Clarias gariepinus, Piaractus brachypomus, Osphronemus sp.*) and 3 are of non-food value (*Pterygoplechthys disgunctivus, P. pardalis, Gambusia affinis, Barbonymus altus*). There can be several more as detection depends on intensive explorations and identification. The abundance index of exotic fishes in the open waters, so far assessed, ranges from 0.2 to 65% (Fig. 1). In some of the ecologically and socially sensitive waters like the Ganga, exotic species like *Cyprinus carpio* and *Oeochromis niloticus*, started appearing in the catches at Allahabad stretch of the river mostly and is on a continuous rise; currently contributing to about 35-40% of the total catch. The abundance index of exotics in the river ranged from 8-45%. The Indian major carps showed decline in their relative abundance (0.02-0.24), while the exotic fish species, *Cyprinus carpio* and *Oreochromis niloticus* show high relative abundance (3.3-17.4) in the middle stretch of the river. Availability of all size groups of the fish and adults with mature ovaries indicate presence of their self recruiting populations. Same is the case with tilapia along the stretch of the river. Other exotic fish species reported from the main stream of Ganges are *Hypophthalmichthys molitrix*, *Aristichthys nobilis*, *Ctenopharyngodon idella* and *Clarias gariepinus* as stray catch.

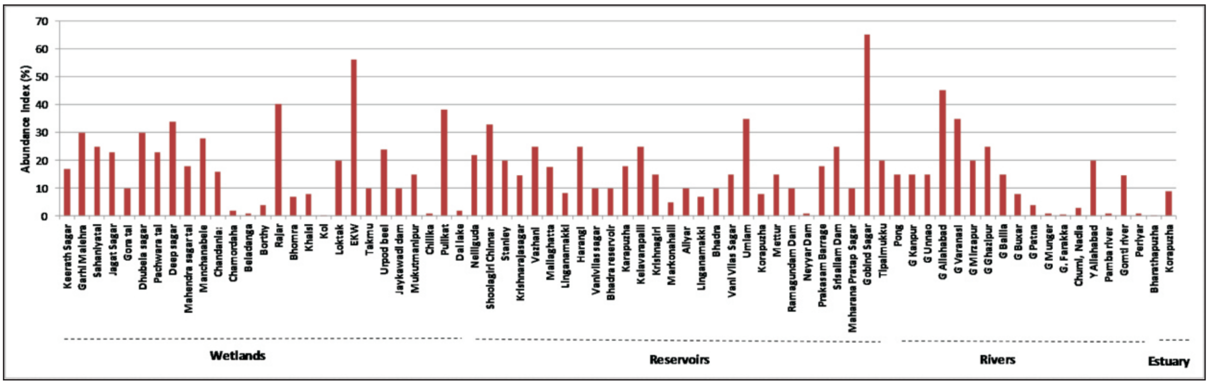

Fig . 1. *Abundance index of exotic fishes in open waters.*

While the appearance of exotics in the main channel of the river is more intense in some stretches, the presence of exotic fish species in open waters in the rest of the country are either as inadvertent entries or as part of aquaculture and culture based fisheries in wetlands and reservoirs, besides trade for aquarium purposes. In floodplain wetlands and several reservoirs in India, exotic fish species are stocked as part of culture based fisheries. The total fish catch during 2008 to 2010 from sampled wetlands along the lower Ganga basin ranged from 5400 to 65945 kg/year, of this the contribution of exotic fishes ranged from 6824 to 16561 kg/year; about 17 to 25% of the total production. In some cases *O. niloticus niloticus* formed 47-49% of the total production. In these wetlands, although the major source of fisheries income is indigenous species, the exotics play a vital role in providing additional income. The studies carried out in the East Kolkata Wetlands, undergoing extensive mode of culture and culture based fisheries, revealed sizeable presence of exotics. Of the exotic species encountered, the most prominent species with regards to catch was *Hypophthalmichthys molitrix* followed by *Cyprinus carpio*, *Pterygoplichthys* spp. and *O. niloticus niloticus*. Of these *H. molitrix* and *C. carpio* are part of the stocked fish along with the exotic food fishes are the main stay of the fisheries and income from these wetlands. Indian major carps, while *O. niloticus* and *Pterygoplichthys* spp. have formed self recruiting populations. *Pterygoplichthys* spp. has attained invasive proportions in the wetlands at an estimated resource size of 85 kg/ha, without any beneficial economic attributes. Taxonomic investigations indicated the existence of two species of the genera (*P. disjunctivus* and *P. pardalis*). Assessment of the food spectrum of the species and that of the other commonly occurring species in the wetland revealed general food item overlapping with most of the species and severe overlapping with that of *O. Niloticus niloticus*, *C. idella*, *C. carpio* among the exotics and *Cirrhinus mrigala*, *Labeo rohita* and *Anabas testudineus* among native species. The impact of these exotic fishes on the natural indigenous fish fauna is not clearly understood although attention is now being given for assessment of the stock and population structure and possible impact of these groups of fishes on the ecosystems, native species and socio economics.

Keywords : Exotic fish, abundance, distribution, inland open waters

Macrophyte : A Boon or Bane for Indian Wetlands

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The Indian sub-continent is flourishing in freshwater wetland resources and they transpire along river courses and low lying areas where precipitation exceeds the potential evapotranspiration leaving an accumulated water surplus. Mostly, the eastern and northeastern India is bestowed with cosmic stretch of wetlands, known as *beel*, *baor*, *maun*, *chaur*, peat lands, *hoar*. Most of the wetlands are infested with macrophytic vegetation which performs a key role in determining the structure and function of wetland ecosystems, where as some of them are completely weed choked due to which they have lost their very existence, *i.e.* Loktak lake (Manipur). Macrophytes, cover a wide diversity in term of their habitat *i.e.* submerged, floating, semi-floating and emergent, type of occurrence and stimulating and limiting factor responsible for their growth. In near future, it is going to be a considerable point of concern that whether, aquatic macrophytes should be totally removed or its presence must be there in wetlands if it is so then how to manage macrophytes for sustainability of the wetlands. For draw any conclusion, it is necessary to view the merits and demerits of macrophytic coverage in the wetlands, otherwise it would a rather wild thought that may not be substantial worthy. In this view, this abstract is being written to give insight to these issues and rationalize the prospectus of macrophytes in Indian wetlands.

Merits :

Generally, being aquatic vegetation, macrophytes are recognized to have their role right from biological, physiological chemical conditioning of the wetlands and what not.

- *Natural bioremediations* : Macrophytes act as biofilter, *i.e.* water hyacinth, as they intake large amount of organic as well as inorganic nutrients from the eutrophic water bodies/nutrient enriched pollutant through various dynamic processes: water cycle, nutrient cycle and food chain, therefore, known as '*Kidney of the Landscape*' or '*Biological Super Market*' in areas where the soil is saturated with water are crucial incubators known for high species diversity.
- *Water quality assessment* : Macrophytes and its associated flora and fauna as a whole , attributed to the ecosystem functions of the wetlands. As there is surplus of any type of fertilizer, chemical and other factor , parallel to this there will be change in the type, distribution and general physiological mapping of macrophytes which is attributed wetlands health in terms of water quality. As a general in wetland due to nitrogen excess there will be eutrophication so by visible observation it will give some indication in wetlands where, intensive stocking is tried.

- *Influx of essential nutrients into water body* : Wetlands are important to natural cycles involving water, nitrogen, sulfur and complex food chain. The nutrient rich soil and aquatic vegetation form buffer against global climate change, as it stores carbon instead of releasing it. By promoting carbon sequestration and nutrient conservation from the terrestrial landscape the high productivity of herbaceous plants, which is the major factor for maintaining ecosystem services, can be achieved.
- *Natural compost manuring* : Human activities, such as modern agriculture and aquaculture emphasized more involvement in wetland ecosystems, therefore, these less important plants of wetland apparently designated as 'weed'. The weed flora provides an indigenous source of chief fertilizers, which acts as soil conditioner, when utilized as compost manure.
- *Habitat to birds and aquatic animals* : The wetlands are also important for their importance in birds' migratory route as well as habitat to resident birds. Morefore, Wetland provide habitat for a diverse variety of plants and animals and provide necessary habitat for considerable numbers of endangered, threatened or vulnerable fishes and wildlife species. Wetlands plants communities are extremely productive and provide food and habitat for numerous animals. Diverse wildlife communities are important to the recreational and commercial hunting, fishing and trapping industries.
- *Rural livelihood* : Fishes like grass carp, some small indigenous fishes as mola, chanda, puntius spp., and many other are being macrphytes associated. Generally, fetch a good market price, so they are being caught on regular basis by rural people which provide them an alternate to agriculture in off season.
- *Improve water quality* : Floating macrophytes *i.e.* water hyacinth has been observed to absorb the incoming industrial effluents, domestic sewage and other run offs, to the wetlands (East Kolkata wetland). Thus, it favors a favorable environment to grow to fishes *i.e.* Tilapia, catfish and so many others low value fish being considered in very beginning but their market demand keep on increasing in domestic market.
- *Traditional and socio-economic use of aquatic vegetation* : Mainly aquatic plants develop simultaneously after decaying, plants (mainly weeds) grow along the margins and shore vegetation protect the edge from water current and rain flashing, provide food to human beings and used in different ailments as medicine in rural areas (Adhikari and Babu, 2008) . A significant number of plants are harvested in rural wetlands which can be consider as bioresources that aid to these resources socio-economic value (Mishra et al., 2009).
- *Others* : Some ornamental fishes *i.e.* are being observed as endemic to particular wetland (Jungle *beel*), so it can be a viable enterprise to rural folk to aware about the potential and trade of ornamental fish in India as well in foreign countries. Moreover, the wetlands also provide associated services like irrigation, horticulture, biodiversity repositories, habitat and breeding ground for migratory riverine small indigenous fishes etc, wild life sanctuaries, habitat for natural and migratory birds, conversion of waste to wealth (sewage fed fisheries), reclamation of eutrophic lakes, constructed wetlands particularly.

Demerits:

- *Disturbance to ecology* : In wetland ecosystem, the vegetation chiefly weeds are responsible for chocking, which do not allow water animals such as fish and turtle to move freely, reduce the productivity by preventing sunlight to reach down to bottom soil and depleting nutrients, lowering down the amount of dissolved oxygen and provide shelter to many organisms, e.g. pathogens and parasites.
- *High diurnal fluctuation of water parameters* : Floating and Submerged macrophytes release oxygen which adds to the dissolved oxygen content of the water in day time vice versa in nighttime that is

highly harmful for sensitive aquatic life. In wetlands dissolve oxygen attributed to change in different other parameters like alkanity, conductivity water temperature and pH which are very significant for aquatic life.

- *Reduction in scenic value of wetland* : Its common to rotten the dead macrophytes in shallow zone of the wetlands that lead to a unpleasant odor and appearance which may results in decreasing the scenic value of a particular wetland.

Conclusion :

Based on the study conducted by different institution particularly, Central Inland Fisheries Research Institute , Barrackpore, it could be concluded that considering the importance of wild wetland plants in local sustenance, it is suggested to protect their habitats, develop domestication protocols of selected species, and build programs for the long-term management of wetland areas by involving local people. Some medicinal plants may also be used to develop into modern medicines. However, coverage of 20-30 is only suitable for sustainable management of the wetlands, coverage more than this lead to numerous problems in Indian wetlands.

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Keywords : Wetlands, macrophytes, merits, demerits

Economic Valuation : a Tool for Conservation of Wetlands

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Wetlands like any other natural resources are complex, multi-functional and provide numerous goods and services to the mankind. They not only supply us a number of important resource outputs but also perform a large number of ecological functions which support economic activities. Though our life and livelihood would be jeopardized without these goods and services we continue to receive most of them for free as many of these services are not marketed because the support they provide to economic activity is indirect and therefore largely goes un-recognized in development decisions. Therefore, wetland resources are particularly susceptible to misallocation decisions (Barbier *et al.*, 1997). Undervaluing of wetlands can be a serious problem in the event of conversion of the wetland area. Development or conversion of the wetland tends to produce marketable outputs while maintaining/conserving the wetland usually leads to the preservation of non-market goods and services. Conversion or exploitation activities yield immediate commercial gains and revenues. Also, conversion activities generate revenue to the governments. Thus very often the decision-makers also support the conversion of wetlands to 'commercial' uses.

Economic valuation may provide decision-makers with vital information on the economic values of all the goods and services of wetland that would otherwise not be taken into account in development decisions. These quantitative data and information would be helpful for policy instruments to effective conservation of the environment including its biodiversity which could make a difference to livelihoods and national economies. Hence, valuation is a powerful tool which helps in shaping the policies governing conservation and sustainable utilization of these precious natural resources.

Goods and services from a wetland

A wetland provides numerous goods and services. Among them the *Provisioning goods are* production of fish and other aquatic animals/plants; water for domestic, industrial, and agricultural use; production of logs, fuel-wood, peat, fodder, medicine, ornamental species; preserving biodiversity etc. The r***egulating services include*** controlling greenhouse gases, temperature, precipitation, and other climatic processes; groundwater recharge and discharge; retention, recovery, and removal of excess nutrients and pollutants; flood control, storm protection etc. It has also got spiritual, inspirational, recreational and aesthetic values. Carbon sequestration and nutrient cycling are some of the *supporting services* provided by the wetland.

Significance of valuation

Economic valuation is assigning quantitative monetary values to goods and services provided by the resources. Everybody understands 'money'. Hence, when we put economic value to a resource everybody will realize the importance. Winpenny (1991) explained that the valuation allows measurement of the rate at which environmental resources are being consumed. Where environmental impacts can be quantified in monetary terms (i.e. valuated) they will carry more weight with decision-makers, who can then set this data alongside other quantitative information. In these circumstances, better decisions will be made. He further added that by assigning a tangible, comparable value to a resource it reduces the number of occasions where decisions have to be made based solely on the decision maker's judgment. Considering the importance and scarcity of wetland ecosystems, continuous valuation of these resources over time is very crucial to know about their exploitation, loss and sustainability. In absence of valuation environmental resources will continue to be exploited by other social or economic objectives that are mistakenly estimated to be more valuable to society. It is thus an important planning tool.

Valuation techniques

There are three major classes of valuation techniques-valuation using market prices, surrogate market approaches and stated preference methods. If the good/services are traded in markets - *market price* is used for valuation. In the absence of market prices, *surrogate price* can be used. These methods value a good using the price of a marketed substitute or the cost of producing the resource or its substitute. Of these methods, the *direct substitute price* method is widely applied. The *indirect substitute price approach* values a good by the opportunity cost of using another good as a substitute. Another approach is to value a related good by the opportunity costs of the inputs used to produce it. This is known as the *indirect opportunity costs approach*. Travel cost and hedonic pricing are examples of these classes of techniques. The *stated preference method* is based on directly seeking the consumers' stated preferences in terms of hypothetical payments by constructing hypothetical market situation. Here the consumer willingness to pay is elicited by posing direct questions. The most widely accepted stated preference method is *Contingent Valuation Method*.

Valuation as an instrument for conservation

A major reason for excessive depletion and conversion of wetland resources is often the failure to account adequately for their non-market environmental values in development decisions. By providing a means for measuring and comparing the various benefits of wetlands, economic valuation can be a powerful tool to aid and improve wise use and management of wetland resources. Now a days the open water resources are under immense threat and are being used for multiple purposes and have significant role in the livelihoods of the local people. Over the years, in many cases these Multiple Use Systems (MUSs) are getting converted into single use systems due to economic and social pressure from dominant stakeholders. The dynamic aspects of MUS are often not fully appreciated. The valuation tool will be of immense help to delineate the various gods and services and the associated economic importance. It provides the objective evidence of monetary and non nonmonetary benefits of the natural ecosystems to managers and public to obtain their support for conservation.

Loss of environmental resources is also an economic problem in addition to the ecological problem because important values are lost, some perhaps irreversibly. Each choice or option for the environmental resource – to leave it in its natural state, allow it to degrade or convert it to another use – has implications in terms of values gained and lost. The decision as to what use to pursue for a given environmental resource, and ultimately whether current rates of resource loss are 'excessive', can only be made if these gains and losses are properly analysed and evaluated. This requires that *all the values* that are gained and lost under each resource use option are carefully considered. If conversion options are chosen then all the direct, indirect goods and services are sacrificed, and these foregone values are additional costs associated with the conversion option. Therefore, governments and donors should consider the *total costs* – the direct costs plus the foregone benefits when choosing to develop the wetland. The failure to account the total economic costs of conversion or degradation of environmental resources is a major factor behind the design of inappropriate development policies (Barbier *et al.,* 1997). The result is too much conversion and over-exploitation of environmental resources. This failure occurs both in private and public projects concerning the use of environmental resources – particularly wetland resources – it is necessary to assess more fully the net economic benefits arising from different wetland uses. Thus, it is an important tool for environmental managers and decision makers to justify public spending on conservation activities and natural resources management.

Conclusion

Among the various goods and services, valuation of ecosystem services is difficult although they have profound impact on the ecosystem. Caution needs to be exercised while carrying out the valuation exercises. The interpretation also needs special attention and care. Since the value of wetland in ecosystem point of view is invaluable, the economic value arrived at would be under estimate and hence, may be termed as the minimum value. Thus, although monetary estimates of the wetland would be given, they should be regarded as approximations - at best, an order-of-magnitude indication of the actual numbers. Nevertheless, the valuation will be helpful in understanding the importance of the ecosystem goods and services which may help in shaping the policies for conservation of natural resources.

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Keywords : Wetland, valuation, significance, management tool

Wetland Fish Diversity and Conservation

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Wetlands are among the world's most productive environments. They are the cradles of biological diversity, providing the water and primary productivity upon which countless species of plants and animals depend for survival. The total number of animal species reported from India is 89461, out of which 17853 species depend on wetlands indicating wetlands support 19.9% of the biodiversity in the country. The wetland ecosystems are very rich in fish diversity. Globally, wetlands are home to about 40% of the 8500 species of freshwater fishes. In India, of 2546 species of fish reported 78.5% inhabit wetlands. Two hundred twenty three species of fishes are known to be endemic in Indian wetlands. The wetland ecosystems not only provide food for fishes, they also provide vegetated areas where fishes reproduce, hide from predators, and take refuge from inclement weather or other changes in the physical environment. These habitats are vital to fish populations because fishes depend on certain wetland processes. Wetlands filter out sediments and pollutants, providing the clean water for fish to live, and also reduce the effects of natural water quality changes on fish populations. The roots, stem and leaves of wetland plants slow down water flows, reducing stream bank and shoreline erosion. Minimizing erosion reduces the amount of sediment in the water that can clog the fish gills, or smother fish eggs. Despite all these ecosystem services they provide, wetlands are one of the most threatened habitats of the world. About 50,000 ha areas of wetlands are degraded every year in Asia. Freshwater fish diversity has witnessed a constant decline in recent years due to destruction of habitat on account of various natural and anthropogenic factors. Several endemic fish species in wetlands were either threatened or have become rare. For example, in the East Kolkata Wetlands which was declared as a Ramsar site in 2002, 52 endemic varieties of fish were listed, which has now been reduced to 22. Increased development and continued conversion of wetlands to other uses result in wetlands being degraded or destroyed. As a result, it becomes increasingly difficult for fish to find the habitats they need. A network of abundant and healthy wetlands is vital to the survival of the most of the fish species. Wetland destruction and its effect on fish populations are among the many issues forcing us to re-evaluate our activities on the land. Thus studies on wetlands require an integrated interdisciplinary approach as any alterations or disturbances in wetlands may have an adverse impact on the environment and fishery potential.

Keywords : Wetland, fish diversity, threats, conservation

Mangrove Estuarine Ecosystem of Sunderbans : Its Role and Conservation

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The 'Sunderbans' is situated in the southernmost tip of Ganga-Brahmaputra basin system and is home for wide diversity of fish, shrimp, crab etc., besides tigers, non-hammer headed sharks and crocodiles. The name 'Sunderbans' probably originated from the 'Beautiful Forest'. It perhaps finds its origin from the 'sea-evolved forest' of coastal Bay of Bengal. Yet another opinion is that the name originated from the 'Sundari' tree, *Heretiera fomes*. The vast expanse of the region ranges from the southern coastal areas of West Bengal and Bangladesh, which is the south-eastern part of the erstwhile Bengal Presidency. It falls in the southern part of a hypothetic line, known as D.H line (1831). The line is not perfectly horizontal, but leaning in the west from Kulpi (between Diamond Harbour and Kakdwip areas) to Basirhat in the east. The Sunderbans area is around 10,000 sq. Km, with about 1/3rd area lying in West Bengal (India) and the rest in Bangladesh. The area of the Indian part is approximately 4,264 sq. Km, of which mangrove forest covers about 2,195 sq. km. having arterial distribution of large and small rivers like Bhagirathi-Hooghly river, Muriganga (Battala), Saptamukhi, Thakuran (Jamira), Matla, Bidya, Guasoba, Harinbhanga, Kalindi, etc and innumerable numbers of canals. Recently, the mangrove area has been increased by 85 Sq. km due to large scale planting of mangroves by the state forest department, West Bengal. Out of the total area of 4,264 Sq. Km., about 2,585 sq. Km. is Tiger Reserve Area with 1,830 sq. Km. as the 'Core area.' Mangrove plants are typical halophytic in nature, capable of adaptation to various ranges of salinity. The local name(s) of some of these plants are Sundari (rarely encountered), Golpata, Poshu, Kholshe, Hizol, Bani, Geyo, Garan, Hental, Dhudul, Keora, Kankra, Harcouch, Dhanigrass etc. They are divided in three types: true mangroves, mangrove associates and obligatory mangroves. According to estimates the Sunderbans comprises of 30 true, 44 associates and 10 obligatory mangroves. According to other estimates, Sunderbans inhabit 70 species of plants of mangrove origin, of which 35 area true, 28 are associates and 7 are obligatory mangroves.

Sunderbans is a hot spot of aquatic diversity. About 18 types of shrimps and prawns, 34 types of crabs and 120 different species of fishes are encountered here. Among the fishes, only 28 species are commercially exploited and the rest do not have much commercial value. Total fish production is more than 40,000 metric tonnes of shrimps and fishes, of which inshore production is more than 20,000 metric tonnes with major share being contributed by the Hooghly-Matla estuarine system. This however, excludes the huge catch obtained from another source, the 'Bherry Fisheries' resources.

Conservation :

The mangrove ecosystem is extremely rich in shrimp and fishery resources, apart from 50 metric tones of honey, 19,000 tonnes of fuel wood, that are exploited from the region. The local fisher folk extract tannins, by boiling the bark of Garan tree, to color fishing nets brownish, and prepare boats from mangroves. They also use small logs, with soil, for construction of hutments. Among agricultural produces, the Sunderbans supply huge quantities of watermelons, red-chilies, sugar beats etc. All these require proper measures for their conservation and exploitation.

Mitigation Plan :

It is a fact that poor fisher folks catch export-quality shrimp seeds, mainly *Penaeus monodon*. After catch, *P. monodon* is separated out and a huge number of other small prawns of non-commercial nature and fishes are thrown on mud-banks and are thus destroyed. Unless, this enormous wastage is curbed by legislations, the important fsih and shrimp species will not survive. Additionally, mass plantation of mangroves be undertaken for sustenance of the mangrove ecosystem.

Keywords : Sunderbans, mangrove, biodiversity, conservation

Wetland Fish Diversity and Conservation

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Reservoirs are inextricable parts of our natural landscapes. These were constructed to meet a variety of human needs *i.e.* flood control, irrigation, hydroelectric power generation, drinking water supply, fisheries etc. Reservoirs provide essential infrastructure services, from the storage and delivery of water to the generation of power to the reduction of flood risk in downstream communities. Reservoirs have been the focal point of to cater the nutritional and livelihood security to millions of countrymen including resource-poor fishers. Innumerable species of fish and wildlife, too, benefit from the habitat that reservoirs provide.

Indian reservoirs having more than 3.15 million ha water area are spread over diverse agro-climatic regions. A total of 19,370 reservoirs (small: 19170, medium: 184 and large: 56) spreading across the nation. Out of which nearly 90% of the reservoirs are constructed on rainfed rivers. Around half of the small reservoirs are drying up during summer months. Multiple impairments are found in reservoir systems. These impairments, exacerbated by human population growth, industrialization, deforestation in the catchment area leading to siltation, climate change (erratic rainfall and rise in temperature), rise in water extraction, rise in hydroelectric projects etc. adversely affect fish, other aquatic species, and their habitats and diminish the quality of life for people. Erratic/inadequate rainfall during the *Kharif* season, forced to divert more water towards irrigation. The lowering of dead storage level affects the aquatic biodiversity, especially fisheries. Moreover, the total water holding capacity of the reservoirs is reducing day by day due to increase in sedimentation rate. Pollution is also being one of the threats prominent in wetlands, especially in small reservoirs. The ecological changes including species succession was evident in Indian reservoirs. The change in species diversity is assumed to be a potential threat in reservoir ecosystem. The loss/reduction of indigenous species drastically and increase in exotic population is evident presently. Stocking the reservoirs with hatchery produced seed has got serious genetic implications. Deforestation in catchment area compiled with increase siltation in basin, reducing living space for aquatic lives.

Conservation of reservoir systems is essential to maintain the quality of life. Effective management of these reservoir systems – maintaining their ecological function and biological health – is essential to the conservation of our nation's aquatic resources and their habitats. It requires that we minimize the adverse impacts of reservoirs on their watersheds and maximize their utility for aquatic habitat. Full participation of the local communities living in the reservoir area has been recognized to be a pre-requisite for the successful implementation of any fisheries development programs. Ideally, a participatory approach to fishery creates an integrated development strategy by fostering new relationships, ways of thinking, and structures and processes. A national collaborative partnership is need of the hour to promote the protection, restoration, and enhancement of habitat for fish and other aquatic species and communities in reservoir systems through cooperative and voluntary actions. It does this by facilitating, informing, equipping, and supporting a bottom-up approach to implementation of conservation – enabled, in turn, by the partnership's wealth of technical expertise. The development and strengthening of local grass-root institutions is the foundation for effective management of fisheries in the Indian reservoir.

Keywords : Indian, reservoir, threat, mitigation

Management Issues and Intervention for Wetland Sustainability

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Wetlands are unique ecosystem that represents a transitional area between terrestrial and aquatic systems where water table is at or near land surface and defined as being periodically or continually inundated by water with soils and vegetation characteristics of wet condition. Wetlands are among the most productive and diverse ecosystem in the world, cover an estimated area of 6% of Earth's surface and contribute 25% of global productivity. These aquatic resources are vast having huge productivity potential with multiporose use like irrigation, fishery, habitat for migratory birds, breeding ground for riverine fishes, flood control/ground water recharge, nutrient cycling, nutrient utilization /pollution remediation by sewage fed wetland through macrophyte and fish chain. In this way, wetland acts as repository of biodiversity (plants, fish, planktonic and benthic organism, microorganisms etc.), kidney of environment and livelihood support for riparian communities.

Issues

The sustainability of wetlands are linked to the degree of certain constraints/issues in-built to the nature of wetland like wide range of user, conflict among resource user, local political interference, social aspects causing barriers in technology diffusion, piecemeal approach for wetland management (wetland management vs. fisheries management) and treating wetland as revenue earner rather than resource providing ecosystem service and livelihood support. Moreover, certain issues like choking of wetland with floating macrophyte and drawdown of water table day by day due to poor rainfall and loss/ feeble connectivity to parent river cropped up recently hampering wetland health seriously.

Principles of management

Management interventions of wetland for sustainability can be ascertained by following certain principles which includes providing sustainable management rather than only exploitation of ecosystem goods/services, keeping ecosystem function and biodiversity intact, ecosystem development rather than fishery development, protecting interest of all possible user rather than fisherman only, protecting all biotic resources rather than fish only, protecting the interest of riparian population rather than contractor/ lessee, indentifying wetland specific problems/issues to address management strategy, suitable indicator for measuring/monitoring wetland sustainability etc. Above all, integrating all resource use, exploitation of wetland at sustainable level and providing livelihood support to all riparian communities involved in wetland services and goods is the key philosophy of sustainable wetland management.

Management Options

As wetland is multiuse and multistake natural resource, the very existence of the resource emphasizes the wetland management through need based application of principles of mitigation, management and conservation. Resource based maintenance/restoration of habitat for protecting all biotic communities including indigenous wild fish species could be achieved by application of technological, social and developmental module. Some of the options for its management and conservation are sustainable ecosystem based management, wise and integrated use of wetlands resource by establishing linakages among various level of resource users and managers, technological and social intervention for conflict management of stakeholders etc.

- *Stock replenishment :* Replenishing the depleted fish stocks based on food availability of wetland by stocking of seed of both wild and cultured species from land based hatchery / enclosure are among technological intervention for sustainable management of wetlands.
- *Management of macrophytes :* Floating leaved macrophyte can be managed by scientific removal that would create suitable environmental milieu so that biotic communities including small indigenous fishes inherent to wetland resources could be maintained.
- *Establishing connectivity :* Re-establishing the link channel of wetland to parent river and dredging the wetland could increase water carrying capacity and able to maintain water during dry season benefitting all the stakeholders.
- *Wise-use of wetland water :* Table fish can be produced in enclosure in wetlands having higher water table and low nutrient status.
- *Integrated use of resource users and managers :* Proper use of technological know-how and development activities for wetland sustainability involves integrating all the use (irrigation, fisheries, migratory birds, sewage remediation, groundwater recharge etc.), users and managers of wetlands including riparian community involved in wetland use, local *panchayat*, research institution, and central and state government department. Judicious use of central and state funded projects like RKVY, Livelihood improvement project, MGNREGA and Watershed development project etc. can be linked to wetland development with the cooperation of local bodies. Local governments and resource users need to be sensitized about the wise and sustainable use of wetland so that fund can be diverted for macrophyte management, dredging bottom organic sediment and reopening link channel, creating sluice gate, providing input for integrated use of wetlands (stocking materials).
- *Conflict management :* Water table in wetlands is gradually becoming shallow due to limited rainfall and loss/feeble river connectivity which create conflict among stakeholders regarding use of water for fisheries and irrigation. Irrigation for *Bodo* paddy cultivation makes the wetland almost dry where fisheries venture face a serious blow. This serious issue can be resolved by conflict management of all stakeholders by involvement of the local self government. Use of centrally fuded scheme especially MGNREGA for dredging the wetland in scientific manners could harvest rainwater facilitating the interest of both the people involved in fisheries and agriculture.
- *Participatory management regimes :* Application of need based co-operative/ co-management/ participatory management options for various types of wetland based on socio-economic condition of the riparian communities.
- *Using sewage fed wetlands for fish productivity :* Constructed wetlands and natural urban receives the nutrient rich sewage water from urban area. The wetlands are capable of decreasing the nutrient load and convert it to fish biomass via planktonic and detrital food chains.

- *Developing/applying sustainability indicators :* The degree of success of any management interventions towards sustainability needs standardization of sustainability indicators. Monitoring the changes in ecological regimes/integrity due to restoration of certain wetlands on case-to-case basis and managing fisheries of wetlands under culture-based regimes is very essential to understand the impact of intervention and develop future management norms. Therefore diagnostics in term of ecosystem health indicators need to be in place for detecting the changes happening in the ecosystem due to some anthropogenic/natural intervention, change in management regimes, technological regimes like hydrogical regimes, nutrient impaction, connectivity regimes, catchment variation, pollutant disposal, riparian zone variation, sewage fed fisheries, change in salinity etc. In Indian scenario, the effect of loss of connectivity, invasion of floating macrophyte and sewage feeding can be best explained by sediment nutrient cycling microbial enzymes, microbial population, organic matter and conductivity, macrophytic vegetation and invertebrate communities.
- *Model wetland development :* Developing model wetland by showcasing various wetland management technologies with participatory management by riparian community could build the awareness among the people and change in attitude of local government and policy makers towards sustainable use of wetland goods and services.
- *Developing policy framework :* Wetlands are natural resources. To maintain its natural resource characteristics, the wetland can be treated as a sustainer of livelihood to riparian communities and provider of ecosystem services. All the policies of wetland development should focus on conservation and management for optimizing wetland use rather than mere exploitation for maximum production and revenue generation.
- *Capacity building of wetland users:* Formation and smooth functioning of SHG/CIG as well as capacity building in technology use and conflict resolution are the prime social tools for wetland management.

Keywords : Wetlands, issues, management options

Development of Computational Model to Map Mangrove Wetlands

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Mangrove wetlands provide valuable ecosystem goods and services such as carbon sequestration, habitat for terrestrial and marine fauna, and coastal hazard mitigation. The Knowledge of the dynamics of mangrove ecosystems is therefore important in the context of global change. To obtain this knowledge, use of satellite remote sensing to map mangroves has become widespread as it can provide accurate, efficient, and repeatable assessments. Yet it poses challenges by not able to accurately map fringe mangroves and true mangrove species due to relatively coarse spatial resolution and/or spectral confusion with landward vegetation. This demands development of new ways to improve classification accuracy.

We observe that high resolution satellite data acquired from use of the new Worldview-2, Quickbird, Ikonos and FORMOSAT-2 sensors, can improve the spatial resolution for discriminating land-cover features. However, the data acquired from these satellite sensors have limitations, such as high cost of data acquisition and historical data constraints associated with the changes of mangrove forest over the past decades. A number of techniques have been developed for land-cover classification, which are highlighted below:

Neural Networks Methods: These methods classify the mangrove area by partitioning the data set into two types training data set and testing data set. The classification based on neural network shows higher accuracy than classification with conventional statistic method such as maximum likelihood for land cover classification.

Tree (DT) and Support Vector Machine (SVM): Here, two classifiers are used to classify satellite image; Decision Tree (DT) and Support Vector Machine (SVM). The Decision Tree rules are developed manually based on Normalized Difference Vegetation Index (NDVI) and Brightness Value (BV) variables. The classification using Support Vector Machine (SVM) method is implemented automatically by using four kernel types; linear, polynomial, radial basis function and sigmoid. The study indicates that the classification accuracy of SVM algorithm is better than DT algorithm.

Object-based image analysis (OBIA): Object based image analysis approach is the approach to image analysis combining spectral information and spatial information, so with object base approach not only the spectral information in the image will be used as classification information, the texture and context information in the image are combined into classification as well.

Artificial Immune Algorithm: In this approach, multiclass co-evolution is combined with clonal selection to determine the best cluster centers for various land cover types in parallel.

Current Paper discusses, outcome of a few representative studies conducted using above-said techniques, which shed a promising light on mapping mangroves, and can lead to a paradigm shift in remote sensing fields.

Adaptive Climate Mitigation through Sustainable Livelihood Alternatives in Vulnerable Deltas : A Case Study from Indian Sundarbans.

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Adverse climate impacts and fragility of ecology often restrict rural livelihoods to mainly traditional economic activities which mostly involve unsustainable exploitation of natural resources leading to habitat destruction and loss of biodiversity. With the growing demand of Tiger Prawn (Penaeus monodon) farming in Southern West Bengal, collection of Tiger Prawn seeds from the brackish estuarine water has been adopted by a large section of rural people of climate vulnerable deltaic Sundarbans. while economic returns from such traditional livelihood is reducing these years, lack of eco-friendly alternative livelihood are forcing poor communities to remain engaged in this activity. Perusal of results show that untrained rural people annually segregate Tiger Prawn seeds and throw the major portion of haul to the mudflats allowing them to perish. On an average amount of Tiger Prawn seeds to the total catch are 2.5%. Indiscriminate exploitation of these seeds leads to drastic reduction of the species concerned and other associated communities from the estuaries. The present paper assess upon a case study from Indian Sundarban investigating the mode of seed collection from the rivers and direct ecological impacts. Further, it estimates the economic feasibility of this livelihood and suggests eco friendly alternatives to sustain livelihood and promote conservation. The study suggests that to restore ecological balance in Sundarban's ecosystem community-ecosystem approach and adaptive managements in alternative ecofriendly livelihoods needs to be incorporated.

Post cyclone changes in community structure of plankton in Chilika Lagoon

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Phailin, a 'severe cyclonic storm' crossed Odisha coast on 12th October 2013 causing heavy rainfall leading to floods (IMD, 2013) and widespread devastation (Froberg, 2013). Chilika, Asia's largest lagoon, spread over Puri, Khurda and Ganjam districts of Odisha, between Lat. 19? 28'- 19? 54' N and Long. 85? 06'- 85? 35' E had to face the consequences of cyclone Phailin (Mohanty, 2013). In a related study the lagoon was investigated for plankton dynamics before the cyclone during 22-27 September 2013. To investigate the post cyclone changes, a study was conducted after the cyclone during 11-16 November 2013. The information collected was also compared with the same period of 2012.

The study examined post cyclone changes in the taxonomic diversity, abundance and community structure of plankton along 13 stations in Chilika Lagoon. Due to the heavy rainfall and floods, followed by the cyclone, the average salinity range of the lagoon dropped from 4.7 ppt (September 2013) to 1.9 ppt (November 2013); that is otherwise unusual for this period. This change in salinity was reflected in both the diversity as well the abundance of plankton in the lagoon. The plankton diversity showed significant difference ($p = 0.01$) between the pre and post cyclone samplings. The total number of phytoplankton and zooplankton recorded in September 2013 was 61 and 30 respectively, which decreased to 48 and 26 species in November 2013. The corresponding period of 2012 had recorded 66 and 28 species of phytoplankton and zooplankton respectively, indicating a decline in the plankton diversity post Phailin. The average phytoplankton abundance (units/m^3) of the lagoon was 4624123 and 568078 in September and November 2013 respectively. The average zooplankton abundance (no./m^3) stood around 10563 and 150225 in September and November 2013 respectively. Although the total abundance of plankton across the stations in November 2013 did not vary significantly ($p = 0.17$) with that of September 2013, the abundance of the same period in the previous year showed a significant difference ($p = 0.004$). The plankton community structure of the lagoon showed considerable change between the sampled months. Among phytoplankton Bacillariophyaceae dominated the Northern sector (40- 60%) and Southern sector (30- 95%) both in September 2013 and in the corresponding period of 2012. The trend changed in November 2013, wherein the group was restricted mostly to the Central sector and Outer Channel (45- 70%) of the lagoon. The dominance of Cyanophyaceae in Northern, Southern and Central sector in November, 2013 (60- 80%) can be attributed to abundance of *Microcystis aeruginus* (222263 unit/m^3), which were considerably low in September 2013 (971.38 unit/m^3) and not encountered in the corresponding period of 2012. The abundance of dinoflagellates remained relatively low post Phailin but the occurrence of resting dinocysts of species like *Gonyaulax* sp. and *Protoperidinium* sp. (2641unit/m^3) were recorded for the first time from the lagoon. The abundance of copepods increased to 87634 no./m^3 in November 2013 from 41499 no./m^3 in September 2013 and 4543 no./m^3 in the corresponding period of previous year.

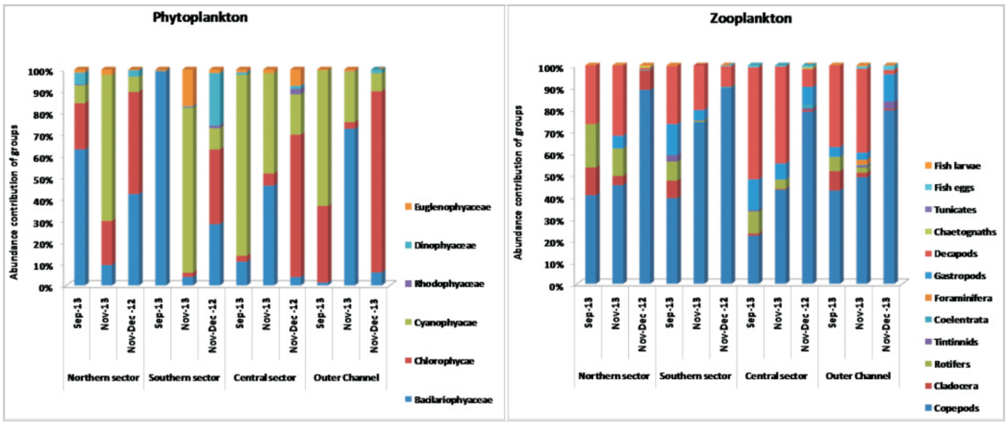

Fig. 1. *Percentage composition of phytoplankton and zooplankton during November- December 2012, September, 2013 and November 2013 of Chilika lagoon.*

Their contribution to the total zooplankton during post Phailin period (45%- 75%) was higher than September 2013 (20- 50%) but lower than previous year (80-90%) as shown in Fig. 1. The cyclopoida to calanoida ratio remained 1: 0.5 in September, whereas 1: 1.8 post phailin. The zooplankton community of the lagoon also showed decrease in marine speices of rotifers, cladoceans and veliger larvae. The outer channel that otherwise used to be dominated by marine species showed presence of freshwater species like *Pediastrum simplex, Closterium setaceum*, *Pandorina* sp., freshwater polycheates and nematodes. Thus the study indicated changes in the diversity, abundance and community structure of the plankton in the Lagoon after the cyclone, which probably will soon regain to its original state.

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Floodplain Wetland Fisheries and its management strategies

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Wetlands are areas of critical ecological significance that support rich biodiversity including a large variety of plant and animal species adapted to fluctuating water levels. Wetlands are the ecotones or transitional zones between permanently aquatic and dry terrestrial ecosystems. They are one of the most productive ecosystems and play crucial role in hydrological cycle. The production potential of such water bodies is extremely high and therefore it is a source of valuable aquatic flora and fauna and thus utilized for harvesting of commercially important food and ornamental fishes, crustaceans, aqua-vegetables etc. Ecological features of various floodplain wetlands are quite different, so the fish faunal diversity is also not identical with in them. Therefore, floodplain wetland always demand appropriate conservation measures to protect the fish species diversity.

Floodplain wetlands are potential sources of endemic carps, catfishes, snakeheads, featherbacks, herring, gobies, perches, needlefish, mud eel, spiny eel, loaches, puffer fish and prawns, and therefore means of livelihood for fisherfolk. However, the very existence of these unique resources is under threat due to developmental activities and population pressure. Thus, their identification and protection becomes very important. Since, an updated geospatial database of these natural resources is the pre-requisite for effective management and conservation planning. Creating an updated and accurate database that supports research and decision-making is the first step towards this. Use of advanced techniques like satellite remote sensing and Geographic Information System (GIS) is helpful in acquiring and creating accurate and timely spatial database of large areas.

Scientific validation of perceived special flavours of certain wetland fishes of Assam, India: Will it help in conserving the wetlands harbouring them?

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Floodplain wetlands *(beels)* associated with the Brahamaputra and Barak river system forms the mainstay of fishery resources of Assam, India. The state has the second largest area (c 100,854 ha) covered by *beel*s in the country. There are 1,392 enlisted *beel*s, which comprise 423 registered (30.4%) and 969 unregistered *beel*s (69.6%). Together, they cover approximately 72.45% of the total lentic areas of the state. Rapid, random field studies conducted by CIFRI in 38 selected *beel*s located in 12 districts of the state during 1996-99 revealed that their natural fish yield ranged from 14-488 kg $ha^{-1}yr^{-1}$ with an average of 173 kg $ha^{-1}yr^{-1}$, which was substantially higher than that of the manmade lakes and other lentic ecosystems of the country. In recent years, high fish yield rates (up to 1350 kg $ha^{-1}yr^{-1}$) have been reported from certain beels of the state where culture-based fisheries have been practised. The *beel*s of the state has a special role in conservation of natural fisheries including indigenous fish species, which support nutritional and livelihood security of a sizeable riparian population. Studies conducted in over a hundred *beel*s located in all the five agro-climatic sub-zones of Assam during 1996-2013 showed that these beels supported 96 fish species belonging to 64 genera under 24 families and 11 orders. They constituted as much as 44.2% of fish species reported from all the water bodies of Assam. Only five of the recorded species were exotics (*Cyprinus carpio, Ctenopharyngodon idella, Hypophthalmichthys molitrix, Aristichthys nobilis, Clarias gariepinus*). All the species recoded in the beels have food value except for four species (*Chaca chaca, Aplocheilus panchax, Badis badis* and *Tetraodon cutcutia). Traditionally, people of the state have been holding certain* indigenous fishes occurring in selected beels in high esteem. These fishes are believed to be of special quality as far as their taste and flavour are considered. For example, people of Barak valley of Assam vouch for the special taste of chapila machh (Gudusia chapra) caught from Baskandi anoa, Cachar district. Same is the case with air machh (Sperata seenghala) from Dholi beel, Karimganj district. Similarly, people from lower Assam relish the special taste of *kowe machh (Anabas testudineus) of* Kapla beel, Sarthebari, Barpeta district and guji machh (Sperata aor) from Dohor Jogra beel, Dhuburi district. In the same way, *koroti machh (G. chapra) and lachim-bhangon machh (Cirhinus reba)* caught from Samaguri beel, Nagaon district are regarded as very tasty. People of Assam relish fish and are ready to pay higher prices for fishes with special taste and flavour. Naturally, there is room for unscrupulous traders/ vendors passing fishes caught from other beels as that from the special ones for getting higher profits. Thus, there is a need to scientifically ascertain whether certain indigenous fishes occurring in selected *beels* of the state indeed have special taste/flavour commensurate with their high consumer preference and market value. Such studies can eventually help in special packaging and marketing of the selected *beel*-specific fishes. Such efforts are likely to help the consumers in getting best value for their money as well as passing on the benefit of higher consumers' price to the respective *beel* fishers. It may eventually pave the way for assigning Geographical Indications (G.I.) to selected beel-specific fishes of the region. Geographical indications are usually place names used to identify the origin and quality, reputation or other characteristics of products and are important in this IPR (intellectual property rights) era not only for high forex earning but for species prioritization (for aquaculture) and conservation. More importantly, scientific validation of the perceived special taste and flavour ascribed to certain indigenous fishes occurring in the selected beels would be helpful in eventual conservation of the wetlands harbouring them. Such an approach is worth giving a trial considering the fact that even though concerns are being voiced by many a quarters over the shrinking area, degradation and reclamation of most wetlands of the state, very little concrete action has been initiated to ensure effective conservation of these precious natural resources.

Conservation and Management of Wetlands

Modeling of Wetland for Sustainable Management Through System Dynamic Approach

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System dynamics is one of the most widely known and widely used methods of modeling. It has emerged as the most common and computer-aided approach for studying and managing complex systems which change over time. Constructing system dynamics modeling techniques allow managers and researchers to see in advance the consequences of actions and policies in environmental management. Using this approach researchers can understand the behaviour of complex systems over time. It deals with internal feedback loops and time delays that affect the behaviour of the entire system. Any dynamic systems characterized by interdependence, mutual interaction, information feedback, and circular causality. The "dynamics" in system dynamics refers to the fundamental patterns of change such as growth, decay and oscillations. System dynamics models are constructed to help us understand why these general patterns occur. They are not constructed to predict the exact value of the system at a specific time in the future like any forecasting model, but, an ecologist uses these models to understand general properties such as persistence, stability, resilience or efficiency. Ecosystems are subjected to highly random inputs, so it does not make suitable to construct predictive models when basic inputs cannot be measured or predicted. It makes more helpful to use models to improve our general understanding and to guide further research.

Ecology has advanced human understanding, dynamic of natural systems considerably over the course of this century. Ecologist studying patterns of change have developed the metaphor of patch dynamics, which is defined as continuous change in community structure and its species abundances due to disturbance, creating shifting and mosaic patchiness. Ecologists discuss the reversibility of change in terms of natural systems' resilience. Resilience is the ability of a system to maintain its structure and patterns of behavior in the face of disturbance. Geology also plays a critical role in understanding wetland dynamics. There are three characteristics i.e. vegetation, soils, and hydrology make a wetlands unique.

Hydrology may be the single most important factor in the establishment and maintenance of specific wetland types. Wetlands receive water from various sources precipitation, surface water runoff, and groundwater. Each source is characterized by a certain water chemistry, which in turn affects the type of vegetation and diversity of species. The permanence of a water source determines the type of soil that develops, which also influences the type of vegetation present. Understanding the hydrology of a wetland is important to decisions involving its future and to evaluating trade-offs involved in protection, development, and mitigation.

There are a large variety of software tools currently available for developing simulation model. This model will be helpful for planners to understand nutrient dynamics and ecology of the wetland.

Keywords : Wetlands, modeling, system dynamics, ecology, hydrology, tools

Sustainable Development as a Measure to Minimize Eutrophication in Brackish Water Fisheries

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Global warming has an impact on the algal communities of water bodies. Brackish water is more productive than fresh water as well as sea water and many fisheries of North 24-Parganas, West Bengal, India are dependent on brackish water. Our study showed that these fisheries are suffering severely from eutrophication *i.e.* vigorous growth of cyanophycean algae. The nutrient loads that cause anthropogenic eutrophication result from run-off from farmlands, wastewater treatment plants or untreated human and animal waste. However, cause and effect of eutrophication of brackish water is one important subject which requires special attention. Eutrophication is mainly correlated with nitrogen. Another factor for eutrophication is the abundance of phosphate the level of which is mainly increased due to waste disposal. Eutrophication is a serious threat to the brackish water fisheries which directly affect fish production. Sustainable development such as organic agriculture may be one approach to minimize eutrophication.

Keywords : Eutrophication, nutrient, management, brackish water

Time Series Analysis and Forecasting Techniques Applied on Fish Seed Collection in Hooghly Estuary

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Time series analysis techniques Structural Time Series Models (STS), **Unobserved Component Models** (UCM) and Seasonal Autoregressive Integrated Moving Average (SARIMA) models were used to forecast daily and monthly fish seed and tiger shrimp seed collection recorded from the Hooghly river estuaries (1995-1998). The techniques were evaluated based on their efficiency to forecast and their ability to utilize auxiliary environmental information. Applying a "stepwise modeling" technique, namely by adding stepwise predictors and comparing the quality of fit, certain inferences concerning the importance of the predictors were made. The influence of temperature and salinity on collection data was mainly investigated by applying UCM models for monthly forecasting data, which predicted the monthly landings with high precision ($R2$ = 0.99), even when incorporating in the model exclusively monthly water temperature and salinity. They combined the information of both environmental and monthly collection data time series, namely the monthly mean temperatures and salinity and the monthly seasonality of the seed collection. The impact factors estimated from the model have the form of time series representing the temperature effect and salinity. The results reveal that the monthly collection of seeds can be predicted .The trend plus cyclical models were used to estimate lunar effects, trend and seasonality from daily collection data and can also be applied for forecasting of future values.

Two-Way Random-Effects Model for cross sectional time-series data (6 rivers of Hooghly estuaries) has been developed where time invariant variables included. River-specific patterns implied by the fitted model were studied. It was done by using the smoothed estimate of *Trend-Plus-Reg*, with its 95%confidence limits.

Keywords : Fish seed, forecasting, time series models, Hooghly estuary

Abundance and Seasonal Succession of Plankton in a Floodplain Wetland in West Bengal, India

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Abundance and seasonal succession of plankton community was studied by collecting samples from a floodplain wetland, *Duma baor* (an ox-bow lake) in North 24-Parganas district of Gangetic West Bengal during 2005-2006. The area of the wetland was 293 ha with 72% water spread. The wetland is a cut off meander of River Ichhamati maintaining a connection with main river channel. The average annual depth recorded was 6.0 m with estimated macropyte coverage of 32%. The catchment was found to be inhabited by human settlement and intensive agriculture with multiple cropping was the characteristic land use pattern. Average water quality parameters were: transparency 140 cm, water temp. 27°C, DO 8.7 ppm, pH7.6, alkalinity 146 ppm, hardness 136 ppm, free CO_2 from trace to 6 ppm, NO_2 from trace to 615 ppb, PO_4 50 – 180 ppb, silicate 4.1 – 15.4 ppm and sediment character was sandy loam with pH7.2, organic carbon 4% and available P 5mg/100 gm soil.

The average plankton count during in pre-monsoon, monsoon and post monsoon period were213, 246 and 993 individuals per litre, respectively. Zooplankton dominated throughout the year with 75.59%, 54.88% and 64.35% in pre-monsoon, monsoon and post monsoon respectively. Among zooplankton rotifers dominated in pre-monsoon (54.04%) and post monsoon season (83.41%) while in monsoon copepods population was marginally high (46.67%) over rotifers 45.93%). Copepods contributed 43.48% and 7.8% in pre-monsoon and post monsoon months whereas the cladocerans were the third dominant group with 2.48%, 7.41% and 8.3% in pre-monsoon, monsoon and post monsoon collections. Among phytoplankton, Cyanophyceae dominated in pre-monsoon (76.92%) and monsoon (96.4%) season while in post monsoon Bacillariophyceae dominated with 83.62%. Other groups of phytoplankton observed in this wetland are Chlorophyceae with 21.15%, 1.8% and 0.85% in preponsoon, monsoon and post monsoon. Bacillariophyceae in pre-monsoon and monsoon collection contributed 1.93% and 0.9%, respectively. Dinophycean alga (*Ceratium hirundinella*) were recorded only in monsoon season (0.9%) and euglenids were in the samples of post monsoon (1.41%) season only.

Keywords : Wetland, plankton, abundance, succession

Statistical Application in Wetland Assessment and management

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Several functionalities emerge towards multiple directions in wetland ecosystems. Diversity and uncertainty are integral part of any wetland ecosystem. Scientific assessment and formulating management under such uncertainty become very complex. In addition assessment benefits of multiple stakeholders depending upon wetland further aggravate the problem. This kind of scenario prevails on almost all the wetlands spread over India. This leaves huge challenges to scientific community to recommend suitable management plans for optimal use of wetlands. In this regard statistical tools play some key role to help in decision making under such diversity, complexity and uncertainty. In this article I delineate some statistical tools that could be effective in framing up prudent management action plans.

Wetland Classification

The ultimate goal of classification is to reduce variation within classes to enable detection of differences between reference and impacted condition within classes as cost-effectively as possible. There are two different approaches to classification of aquatic resources, one that is geographically based, and one that is independent of geography but relies on environmental characteristics. The goal of geographically based classification schemes is to reduce variability based on spatial covariance. Geographically independent or environmentally based schemes include those derived using watershed characteristics such as land use and/or land cover, hydro geomorphology, vegetation type, or some combination of these. It is possible to combine geographically based with hydro geomorphic and/or habitat-based approaches.

Geographical classification scheme

The present geographically classification scheme is based on administrative boundaries such as State, District or block. This was done mainly due to convenience with less emphasize on ecological similarities. Some improvement was made on the basis of Agro climatic zone assuming wetlands belonging to same zone will be similar. However in India ecologically similar zone coined as "ec0-region" has not been introduced so far. The idea behind it is that wetlands are classified considering aquatic ecology as prime parameters of importance. The eco-region system can subsequently be overlaid on "component maps" for land use, potential natural vegetation, land-surface form, and soils. The final map will be more useful for planning.

Environmentally Based Classification Systems

Hydrogeomorphic classification system for wetlands, based on geo morphic setting, dominant water source. Internally seven classes have been described: riverine, depressional, slope, mineral soil flats, organic soil flats tidal fringe, and lacustrine fringe. However, it may differ from country to country. So the creating of similar classes in Indian contest could be a area of research. Here Multivariate analytical tools l will be very useful for object classification on hydrogeomorphology.

Empirical Classification Scheme

Classification should be viewed as an iterative approach, involving the initial choice of a framework as a hypothesis, validation with univariate and multivariate statistical techniques, and subsequent modification to create new classes or combine existing classes. Best professional judgment can be used to generate a hypothetical set of classes using techniques such as the Delphi approach. The Delphi approach is a process to ex-tract the collective intelligence of a group of experts who may have a wide range of backgrounds, expertise, and opinions. To produce a more objective framework, it is possible to sample a suite of reference wetlands randomly, and then classify sites based on physical, chemical, and/or biological characteristics after the fact through parametric techniques such as cluster analysis, discriminant function analysis, detrended canonical correlation analysis (DCCA), and/or non-parametric techniques such as nonmetric dimensional scaling (NMDS). Cluster analysis is an exploratory technique that groups similar entities, e.g., by community composition, in a hierarchical structure. Discriminant function analysis can be used to objectively define those attributes of groups responsible for intergroup differences. Detrended canonical correlation analysis is a parametric multivariate technique for relating multiple explanatory variables such as site characteristics to multiple response variables such as species abundances, or metrics within an index of biological integrity. It corrects for the "arch" effect of regular canonical correlation analysis (CCA) that results from the unimodal distribution of species along environmental gradients. NMDS is a nonparametric technique (i.e., does not rely on the normal distribution of underlying data) that can be used to order sites along gradients based on species composition differences, then independently determine which environmental variables significantly vary with community gradients. Although these techniques can be used in an exploratory fashion, they can also be applied with a second set of data to confirm an initial classification scheme. Numerous examples of the application of empirical classification schemes for other aquatic ecosystem types can be found in the literature. Multivariate analysis techniques are available in common statistical packages such as SAS (SAS Institute 1979), SPSS, R, BMDP. In addition, more specialized software exists that is specifically geared towards the analysis of biological community data, including CANOCO, PAST, PC-ORD.

Integrated Assessment of Wetlands

After the classification of the wetlands, most similar wetlands can be taken up for integrated assessment for management. Multiple objectives certainly emerge due to multiple uses of the wetlands. Here the choice will be multi-objective decision analysis. It is an integrated framework in which multi-objecitive optimisation has been used successfully in other countries. So this can be implemented in the Indian context. It essentially requires systematic delineation different components with separate objectives. This is useful for the assessment of the impact of different management alternatives on wetland functions. A geographical information system is used to translate the assessment scores to performance maps. Comparison of the alternatives is supported using a multi-criteria approach. The approach is flexible, easy to use and uses a combination of quantitative and qualitative data combined with expert judgement. Necessary data can be obtained through a limited field survey complemented with interviews with experts. Therefore implementing the tool in other wetland areas will be relatively easy. This will make it possible to combine management alternatives in the individual areas into an overall management alternative for the entire region.

Keywords : Statistical tools, canonical correlation, assessment, management, wetlands

Phosphorus Dynamics in Wetlands : Sustainability Perspective

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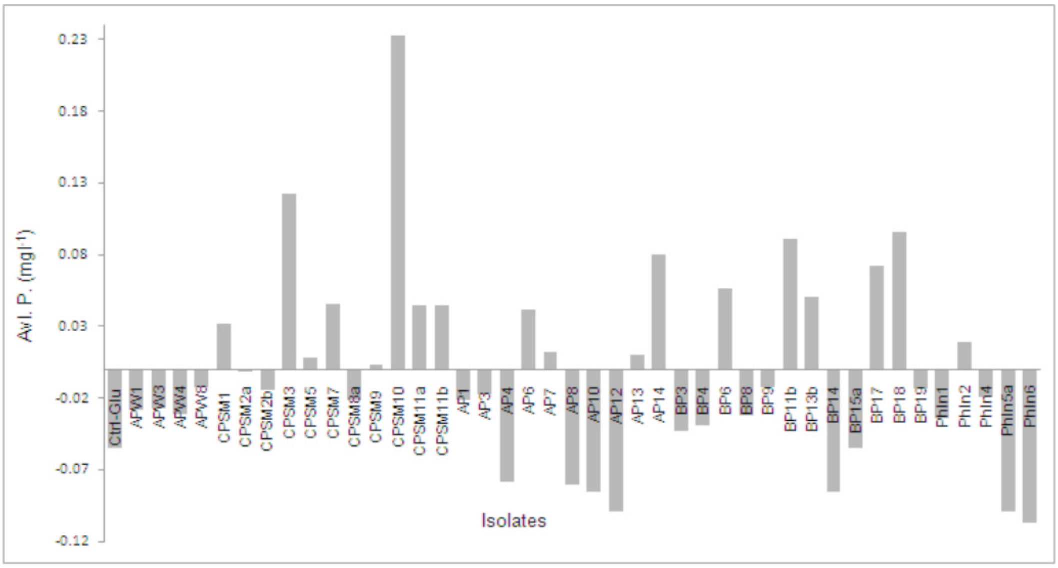
Phosphorus (P) as a deficient growth limiting micronutrients in most freshwater ecosystems limits aquatic productivity. Phosphate fertilizers are often used to combat P deficiency; however, about 90% of the applied P fertilizers get buried in the sediment to unavailable forms (Jana, 2007). P geochemical cycle based on redox potential change of sediment, along with oxidized/ reduced state of iron contributes to the P chemistry of sediment (Einsele, 1938; Mortimer, 1942). Further, microbial cellular P release under anoxic state and microbial decomposition has been studied to play roles in internal P loading in lakes (Gächter and Meyer, 1993). Bacteria are known to release phosphorus from various organically and inorganically bound forms. Phosphate solubilizing bacteria (PSB) are known to solubilize soil calcium-bound P (Ca-P) and are potential candidates for enhancing P availability in aquatic system; phytate mineralizing bacteria mineralizing phytate have also been investigated in soil, but meagerly in aquatic system. Beside release, bacteria uptake P, sometimes in luxury, limiting the actual P release for phytoplankton and making the aquatic P cycle complicated.

Floodplain wetlands are hot spots of biological activities, playing essential functions like water reserve and recharge, flood control, purification, supporting biological diversity etc. These wetlands are also breeding ground of fish fauna and provide substantial fish food for a nation. India has 0.88 million ha wetland area rich in endemic fish species and are considered productive with fish production potential of about 1000-1500 kg/ha. However, actual production from these wetlands is often <200 kg/ha, excepting in some well managed wetlands, where production has exceeded 800 kg/ha (Vinci 2003). The low productivity is mainly due to improper management and distribution in terms of content related imbalances of P and N (Das 2003).

In the present environment there is growing concern about the anthropogenic phosphorus input, including P fertilizers, in water bodies that trigger acute eutrophication. On the other hand, use of bio-fertilizers may enhance water P level, through release of sediment bound P, in a benign and sustainable manner. For this purpose inorganic phosphate solubilizing, and organic P (phytate) mineralizing bacteria were isolated from fresh water environments, studied their activity in culture media and in simulated microcosm system to examine their survival and activity in real freshwater ecosystem. Our observations indicate wide presence of phosphorus releasing bacteria in varied aquatic niches, with highest load in sediments. The sediments were P rich with total P loading ranges between 5-8 g kg^{-1}, of which majority was organically bound, followed by Ca bound form. However, compared to the isolates from terrestrial/agricultural soil, the aquatic bacteria have low to moderate phosphorus releasing activity. However, about 42% of the isolated bacteria were effective in

P regeneration, up to the level of 0.233 mg l^{-1} in sediment, indicating their bio-fertilization potentiality in freshwater systems. Several strains possessed both the PSB and PSM activities, which might arm the strains with capability to use both inorganic and organic forms of sediment P. Further our whole genome study of selective isolates showed presence of nucleotidase, phosphatase, ATPase, DNAse etc. in aquatic bacteria, rendering them as potential bio-fertilizers for nutrient management of inland waters.



The P solubilizing activity of the isolates in Microcosm system

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Keywords : Wetland, phosphorus, sediment, level, fraction, transformation, microbes

Ecological Integrity of Wetland Ecosystem : Pollution and Contamination Perspective

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A revolutionary technique of sewage-fed fisheries is practiced in the eastern outskirt of Kolkata, wherein a huge amount of nutrient rich raw city effluents are utilized as input. Out of the total fish consumed in Kolkata, such farming system contributes a significant portion. Since raw sewages are used in the production process, there is always a risk of accumulation of toxic substances like heavy metals in various components of the aquatic ecosystem including final produce, the fish flesh. The observations made on the residues of organochlorine pesticides in water and fish tissues of a sewage-fed fish farm of Kolkata are presented here. In order to compare the residue levels, studies were also made in a floodplain wetland (*beel)* of West Bengal. The selected *bheri* of the Kolkata sewage fed wetland system was 4 no. *Matsyajibi Samaby Samiti* with 75 ha culture area. The closed *beel* Bhomra of district Nadia, WB was the other water body. It was carried out during 2003. The study indicates presence of higher amount of DDT and its metabolites in water to disturb the aquatic life processes. The fish flesh residue levels were found insignificant and may not cause any harm on human consumption.

Studies on total organochlorine pesticide residue content in water of the *beels* Saguna and Bansdah during April, 2003 to March, 2005 indicated that in the Saguna water the residue level was much higher. The observed total organochlorine pesticide range was 64 – 153 ppt at Saguna while 12 – 70 ppt at Bansdah. Although Bansdah beel is surrounded with agricultural fields, the pesticide residue levels were found low compared to municipal and industrial area dominated Saguna *beel*. The detailed data of individual pesticides indicated that significantly higher content of DDT and its isomers in Saguna *beel* (range 49 – 141 ppt; F = 20.90, p 0.001) were responsible behind higher content of total organochlorine pesticides (F = 11.25, p 0.006). For the other pesticides, the difference was insignificant. The aquatic life has certain levels of risk due to the residues of organochlorine pesticides.

Like the water phase, in the fish tissues of Bansdah *beel* the observed pesticide residue levels were low (range of total organochlorine pesticides 5.9 – 11.7 ppb. Two fish samples of the Saguna *beel* were analysed for pesticide residues. In one sample, *C. mrigala* of winter, 2005, the total residue content was found 286 ppb. The DDT and its metabolites dominated the residue (280 ppb). As a whole, the residue contents were found meagre with respect to the permissible limits of these pesticides for human consumption.

In some pond and floodplain wetland of West Bengal, unusually high content of methyl parathion (85000-2113000 ppt) and monocrotophos (535000-4410000 ppt) were detected (Chowdhary *et al*. 1994). Although the water sources were near the paddy fields receiving these pesticides, more such study can strengthen the findings.

The routine organochlorine pesticide residues in fishes from east Kolkata wetlands were found not very alarming, but one study has informed significantly higher level of polychlorinated biphenyls and as a potential source to its consumers (Someya *et al*. 2010).

Although green revolution was a success story, introduction of high yielding varieties with *ad libitum* application of fertilizers and pesticides are responsible for their higher residues in the fishes of the floodplain wetlands. Very limited study was undertaken to measure the pesticide residues in such environments. The residues of endosulfan were found high (490-2390 ppb) in the fishes from pond and floodplain wetland of West Bengal. In some ponds and floodplain wetlands of West Bengal relatively high content of endosulfan (670-8350 ppt) was reported by Chowdhary *et al*. (1994).

Like the water, only a few studies on the residue of organophosphorus pesticides in fish are available. Chowdhary *et al*. (1994) observed very high accumulation of methyl parathion (10250 - 10850 ppb) and monocrotophos (320000-523500 ppb) in the fishes collected from pond and floodplain wetland of West Bengal (Chowdhury *et al*. 1994). Agricultural applications were the source behind such unusual accumulation.

Kaushik *et al*. (1999) studied the heavy metal status in the water of Motijheel, Surajkund and Ranital of Gwalior region (M.P.). The concentrations of Cu, Zn, Ni, Co, Pb, Cr and Cd ranged between 17-34, 65-120, 1-4, 3-9, 2-9, 20-48 and 9-10 ppb respectively. Lowest and highest values of all the metals were recorded during summer and rainy season. The levels of Cu, Pb and Cd were above the permissible limit for aquatic life. Shrivastava *et al*. (2003) reported that the mean concentrations of Cr, Ni, Zn and Ph in the water of Shapura lake that received untreated sewage from residential areas in Bhopal city were not within acceptable water quality limit. Saha and Mandal (1998) estimated the concentration of Zn, Cu, Fe and Mn in the water of twelve sewage-fed ponds, eight at Bantala, located in the eastern fringe area of Kolkata and four at Khardaha, 24 parganas (North), receiving Kolkata city sewage and Titagarh Municipality sewage effluent respectively. The concentration of Zn, Fe and Mn were below the toxic limit whereas Cu in most of the pond water was above the acceptable limit. The mean values were Zn 34.0, Cu 20.0, Fe 230.0 and Mn 150.0 ppb.

Shrivastava *et al*. (2003) recorded mean values of Cr 18.0, Co 7.0, Cu 87.3, Ni 38.0, Zn 0.028 and Pb 0.019 ppm in the sediment of Shahpura Lake, Bhopal. According to USEPA Cu is categorized as heavy pollution and Ni as moderate pollution. Saha *et al*. (2003) studied the status of Zn and Cu in the sediment of forty eight beels spread over fifteen districts of Assam. In most of the beels Cu (16.3-59.0 ppm) was in the level of moderate pollution while except a few beel, level of Zn (67.0-128.5 ppm) was in non-polluted category.

Metal concentrations in the fish flesh of Shahpura lake, Bhopal were Cr 0.33, Co 2.06, Cu 1.96, Ni 2.97, Zn 9.67 and Pb 6.0 ppm on wet weight basis (Shrivastava *et al*. 2003). The detected metal levels in *Labeo rohita* flesh of the Kolkata sewage-fed wetlands were Cu 3.4, Zn 30.2, Mn 20.3, Pb 2.3, Cd 0.4 and Cr 0.8 ppm on dry weight basis (Adhikari *et al*. 2001). In the other study of Maiti and Banerjee (2003) on the Kolkata sewage-fed wetlands, the detected metals in the fish fleshes were Zn 7.2 - 35.0, Cu 2.0 - 5.3, Cd 3.0 - 4.5 and Pb 39.4 - 59.3 ppm on dry weight basis.

As a whole, the wetland systems are at various stages of anthropogenic stresses due to the pesticide and metal contaminants and the aquatic health is under stress. With respect to human health the situation is somewhat better since the associated permissible limits are exceeded in some occasions only.

Keywords : Wetlands, heavy metals, pesticides, occurrence, levels

Community Structure and Seasonal Variation of Benthic Macro-invertebrates in a Floodplain Wetland in West Bengal, India

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Community structure of benthic macroinvertebrates was studied in a floodplain wetland, Jaleshwar *beel* (ox-bow lake) in North 24-Parganas district of gangetic West Bengal during 2004-2007. The water spread of the wetland is 45 ha with an average annual depth of 2.56 m and estimated macrophyte coverage of 38%. The wetland is an open ecosystem and connected to river Ichhamati through a tributary. The catchment is inhabited by human settlement and intensive agriculture with multiple cropping is the characteristic land use pattern. Agriculture using wetland water and fisheries exploitation through stocking and fishing are the major anthropological activities around the wetland. Water of the wetland is slightly saline with average transparency 66 cm, water temperature - 25.5°C, DO - 6.9 mgl^{-1}, pH7.6, free CO_2 - trace to 2 mgl^{-1}, total alkalinity -140 mgl^{-1}, Hardness - 114 mgl^{-1}, Nitrate - trace to 180 μgl^{-1}, phosphate - trace to 80 μgl^{-1} and silicate - 3.2 mgl^{-1}.

The biotic community structure was studied by collecting 45 samples from three selected sites over the period of three years. The benthic community was represented by members of 23 gastropod taxa (Class: Gastropoda), 5 bivalve taxa (Class: Pelecypoda), 4 dipteran taxa (Order: Diptera) and one oligochaete taxa (Class: Oligochaeta). The study revealed the density of benthic community as 6079, 4659 and 6520 nos/m^2 in summer, monsoon and winter seasons respectively. Gastropoda dominated in all the three seasons with 98.19%, 97.9% and 96.69% in summer, monsoon and winter, respectively. Oligochaetes were the second dominant group in summer (0.97%) and winter (2.87%), while dipterans (1.09%) were dominated in monsoon season. Bivalves contributed 0.29% (winter), 0.43% (monsoon) and 0.67% (summer) to the total zoobenthos.

Species richness of different benthic animals was almost similar in different seasons. However, *Gabbia orcula* was the dominant gastropod with 41.97%, 41.22% and 47.19% and *Gyraulus convexiusculus* was the second most dominant invertebrate with 36.22%, 25.61% and 23.62% throughout the study period in summer, monsoon and winter seasons respectively. Decrease in gastropod population led to reduction in total benthic macro-invertebrate density during monsoon.

Keywords : Floodplain wetland, macrobenthos, community, succession

Ecology and Fisheries of Majihar wetland in Raebareilly District of Uttar Pradesh

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Wetlands are among the most productive aquatic habitats in the world. Majihar wetland spread in 48.00 ha in the Raebareilly district of Uttar Pradesh was studied for ecology and fishery parameters. Depth of the wetland varied from 2.0 to 3.2 m. The wetland had luxurious growth of macrophytes, particularly towards periphery and about 35% of the wetland is covered with weeds like *Typha angusta, Eicchornia crassipes*, *Ceratphyllum* sp., *Nelumbo nucifera*, *Trapa bispinosa*, *Hydrilla verticillata*, *Pistia stratiotes, Potamogeton* sp., *Ipomea* sp., *Azolla caroliniana, Cyperus* sp., *Marsilea* sp., *Alternanthera philoxeroides*. The centre zone of the wetland is also infested with *Eicchornia crassipes* which causes havoc for fishing operations and boat navigation in the wetland. A total of 21 fish species, including stocked fishes were recorded in the wetland. The fishery is mainly comprised of IMCs and murrels, but *Amblypharyngodon mola* was dominant by number. Soil and water quality investigation revealed the wetland to be moderately productive. The surface water pH ranged from 6.65 to 7.21 and alkalinity varied from 115.0 to 188.0 mgl^{-1}. Soil was rich in organic carbon. Abundance of plankton ranged from 280 to 950 $ul^{-}1$, with Bacillariophyceae being the dominant group. Observation on biotic and abiotc parameters indicated high fish production potential in the wetland, although the current yield was low. Siltation, macrophyte infestation and improper management are the principal reasons of poor fish production. Adoption of scientific practices like pen culture, and proper stocking of fish species with higher percentage of detritivour fishes will enhance fish production, income and livelihood of the fishers in the locality.

Key Words: Majihar wetland, ecology, fish diversity, macrophyte, Uttar Pradesh

Environmental Water Allocations : Need of Hour for Wetlands Conservation

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Wetlands receive water from precipitation, groundwater, water flowing over land surface or tidal influxes and are characterized as fresh, brackish or saline. Freshwater wetlands are closely associated with rivers and therefore are the most likely to be affected by river flow regulation. As most of the rivers at present are heavily regulated by a large number of dams causing irretrievable changes to the river ecology, the hydrological regime and the ecology of wetlands are at stake. Freshwater wetlands are listed among the most impacted and degraded of all the ecological systems and accounts over 60% of the world's wetlands that have been lost. This scenario is being resulted from many factors including conversion to agriculture or aquaculture farms, rapid urbanization, siltation or closure of wetland mouths, and climate change resulting into a ghost ground from the cradle of life for many aquatic flora and fauna including indigenous fish, shrimp, crabs, weeds, plants, birds and reptiles, thereby, affecting the livelihood of millions. Therefore, the need of the hour is to protect these precious natural resources by conserving the native flora and fauna through environmental water allocation to the wetlands. To estimate the water or ecological flow requirement, it is paramount to understand the natural hydrological regime and ecosystem behavior of native flora and fauna. Hydrological regime of wetlands include extend (area inundated), depth (minimum and maximum), seasonality, rate of rise and fall, size and frequency of floods, duration of dry periods and variability. These fluctuations in water level provide variable conditions for germination, establishment, growth and reproduction of native flora and fauna of wetlands. Though several models such as Digital elevation model (DEM) and simulation hydrodynamic model (MIKE 21) computing water depth and velocity on a 30 m grid, flood inundation and connectivity model have been developed for water budgeting in wetlands, integrating environmental flows assessment methods for rivers into wetlands would be of water regime recommendations for wetlands conservation.

Key Words : Ecological flows, wetlands, conservation

Effect of Cyclone (Phailin) on Water Quality of Chilika Lagoon

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The 'Very Severe Cyclonic Storm' Phailin occurred over east central Bay of Bengal during 8 to 14 October 2013, resulted in heavy winds and gushing to Chilika, the largest brackish water lagoon in Asia. A maximum of 38 cm (24 hr cumulative) rainfall was reported in the area during this period resulting in widespread floods in the lagoon. This run-off resulted in massive change in overall water quality of the lake post cyclone during November 2013, as compared to pre-cyclone period (November 2007, '08, '09, '11 and '12). Analysis showed that, a number of water quality parameters differed significantly with data of those parameters during the same period of previous years.

Water depth, transparency, specific conductivity, dissolved oxygen, total alkalinity, salinity, phosphate and silicate of the water changed significantly after the cyclone. On the other hand, parameters like water temperature, pH and available nitrate did not differ significantly. Water depth increased (av. 224 cm) at all the stations as compared to that in previous years (av. 158 -182 cm) during the same period. The salinity dropped to 4.7 ppt at Station 2 in southern sector, while it was 15 to 18 ppt during the same period in previous years. Water transparency, dissolve oxygen, total alkalinity and available phosphorus were significantly low (av. 50 cm, 6.85 ppm, 73.3 ppm and 0.021 ppm, respectively) after the cyclone as compared to the values for the corresponds period for the last five years (av. 68-88 cm, 8.18-9.20 ppm, 98 -112 ppm and 0.047 – 0.066 ppm, respectively).Whereas, the value of silicate increased after cyclone (av. 15.43 ppm) as compared to previous years (av. 2.19 – 6.53 ppm), apparently due to influx through run-off. As a whole, post cyclone, there has been significant difference in almost all water quality parameters.

Effects of Pollutants in Inland Open Water Ecosystems

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Contaminants such as heavy metals, petroleum hydrocarbons and pesticides can cause direct toxic effects when released into aquatic environments. Fish species may be impaired by sub-lethal effects of the pollutants, and this ecological alteration may initiate a trophic cascade or a release from competition that secondarily leads to responses in tolerant species. Contaminants may exert direct effects on keystone facilitator and foundation species, and contaminant-induced changes in nutrient and oxygen dynamics may alter ecosystem function. Thus, populations and communities in nature may be directly and indirectly affected by exposure to pollutants. While the direct effects of toxicants usually reduce organism abundance, indirect effects may lead to increased or decreased abundance. Studies of accidental contaminant release, chronic contamination and experimental manipulations have identified indirect contaminant effects in pelagic and benthic communities caused by many types of pollutants. Contaminant-induced changes in behavior and competition can alter species abundances or community composition, and enhance, mask or spuriously indicate direct contaminant effects. Further, endocrine disrupting chemicals found in water creates problems in fishes by sex change and may affect the fish biodiversity in the aquatic ecosystem.

Keywords : Pollution, impacts, fish, population, trophic level

Fisheries management in wetlands of Uttar Pradesh and scope for further yield enhancement

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Uttar Pradesh is blessed with plenty of water resources in the form of wetlands owing to geomorphic characteristics and presence of vast network of criss–crossing rivers. Total area under floodplain wetlands in the state is estimated at 152,000 ha. Twenty two wetlands situated in different regions of the state were studied for ecological and fishery parameters. The water spread area ranged between 21.0 and 900.0 ha. About 30 fish species were recorded from these wetlands, besides the stocked fishes. Most of the wetlands were leased out for fish production, but majority of them were underutilized as far as proper fishery development is concerned. In general, fish composition in the wetlands recorded dominance of miscellaneous fishes followed by catfishes and Indian major carps. Exotic species were also recorded from majority of the wetlands. Fish yield varied from 30.0 to 520.0 kg ha-1yr-1, while the estimated potential is multifold. Lesser fish yield could be attributed to weed infestation, sedimentation and succession, excessive organic load, injudicious stocking, presence of predatory fishes, uncertainty in water availability and also litigation issues in some of the wetlands. Fish yield from these wetlands could be modestly enhanced up to 3-4 times from the present average production of 180.0 kg ha-1 yr-1. To harness maximum benefits, some of the suitable wetlands could be utilized as multifaceted resource for practicing intensive culture fishery in the pens installed on marginal areas; cages in deep areas and traditional capture fishery or sport fishery in open central portions. Besides fish production enhancement there is also scope for integration of duck, poultry, dairy, horticulture and development of fishery based eco-tourism (FBET) in few wetlands.

Key words : Wetlands, piscine diversity, composition, yields, fishery enhancements, Uttar Pradesh

Ecology and Fisheries of Majihar Wetland in Raebareilly district of Uttar Pradesh

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Wetlands are among the most productive aquatic habitats in the world. Majihar wetland spread in 48.00 ha in the Raebareilly district of Uttar Pradesh was studied for ecology and fishery parameters. Depth of the wetland varied from 2.0 to 3.2 m. The wetland had luxurious growth of macrophytes particularly towards peripheral region and around 35% of the wetland is covered with weeds like *Typhaangusta, Eicchorniacrassipes*, *Ceratphyllum*sp, *Nelumbonucifera*, *Trapabispinosa*, *Hydrillaverticillata*, *Pistiastratiotes, Potamogeton*sp, *Ipomea* sp., *Azollacaroliniana,Cyperus* sp. *Marsilea* sp., *Alternantheraphiloxeroides*. The centre zone of the wetland also infested with*Eicchorniacrassipes* and created havoc for the fishing operations and boat navigation in the wetlands**. A** total of 21 fish species were observed from the wetland including stocked fishes. The fishery mainly comprised by IMCs and murrels but *Amblypharyngodonmola* was dominant by number. Soil and water quality investigation revealed the wetland in moderately productive nature. The surface water pH ranged from 6.65 to 7.21 and alkalinity varied from 115.0to 188.0mgl^{-1}. Soil was rich in organic carbon. Abundance of plankton ranged from 280 to 950 ul^{-}1, Bacillariophyceae being the dominant group. Observation on biotic and abiotc parameters indicated high fish production potential in the wetland although current yield was low. Siltation, macrophytes infestation and improper management might have led to the poor fish production. Adoption of scientific practices like pen culture and proper stocking of species with higher percentage of detritus feeder willenhance fish production, income and livelihood of the fishers in the area.

Key Words : Majiharwetland, ecology, fish diversity, macrophytes, enhancement measures, Raebareilly

Conservation and Management of Deepar Beel – A Ramsar Site of North East India- with Special Emaphasis on its Fisheries

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Deepar beel is an important floodplain wetland (beel) of North-eastern India with a water spread area of 10.1 sq. km extending upto 40 sq. km during flood. It is a prominent Ramsar site located near Guwahati city of Assam (90°36′ E; 26°05′ N). This perennial wetland receives water from River Brahamaputra through a 5 km long canal as well as from Basistha stream. Geographically the wetland is formed of a part of Shillong plateau of Precambrian age. The major part of the wetland consists of black clay soil except on the western part which is with light yellowish lateritic soil. The wetland experiences moderate climate with average air temperature ranging from 15° to 30° C. Water of the wetland was characterized by moderate temperature (23.7° - 36.1°C), high Secchi disc visibility (40.8 – 55.4 cm) and high turbidity (7.5- 20.4 NTU). Water of beel was neutral to alkaline in nature (pH 6.8 - 8.3), had fluctuating dissolved oxygen (3.2 - 10.1 mg l^{-1}), moderate total alkalinity (78.3 - 174.3 mg l^{-1}), total hardness (61.2 – 62.1 mg l^{-1}) andmedium to high BOD (2.6 - 5.2 mg l^{-1}). The beel receives nutrient rich waters from its catchments and also sewage with moderate nitrate-N (0.14 - 0.41 mg l^{-1}), phosphate – P concentration(0.30 -0.50 mgl^{-1}), silicate- Si (3.02 – 3.10 mg l^{-1}) and DOM (3.84 - 3.9 mg l^{-1}). It also had considerable sulphate (4 – 90 mg l^{-1}) and chloride (34.6 – 35.1 mg l^{-1}) levels. The wetland has rich floral and faunal diversity including 234 birds (e.g., *Phalacrocorax niger, Anas acuta, Pelecanus philippensis)*, 24 mammals (e.g., *Elephas maximus, Muntiacus muntjak, Hystrix brachyuran)*, 67 finfish (e.g., *Chitala chitala, Labeo rohita*), 33 reptiles (e.g., *Lycodon aulicus, Xenochrophis piscator, Python molurus)*, 11 amphibian species (e.g., *Haplobatrachus tigerina, Rana syanopyletes, Rana tytleri*), 3 prawns (*Macrobrachium dayanum M. assamensis and M. lamerri)*, 2 crab species (*Paratelphus aeduntula and P. guirini)*, 25 aquatic insects (e.g., *Ranatra filiformis*, *Nepa apculata*), 5 molluscans (e.g., *Bellamya bengalensis, Pila globosa, Corbicula assamensis)* and 5 bryozoans species (e.g., *Hislopialacustris moniliformis, Plumatella emarginata*). The wetland supports 18 globally threatened vertebrate species. Birdlife International, UK included Deepar as an *Outstanding*Important Bird Area for threatened birds. The beel supports considerable natural fisheries. A total of 67 finfish species belonging to 21 families have been recorded from the wetland so far. These include primarily riverine species like *Labeo rohita, L. calbasu, L. gonius, Catla catla, Cirrhinus mrigala, Chitala chitala, Speretta seenghala, Ompok pabda, Mystus vittatus* and exotic carps (*Cyprinus carpio, Ctenopharyngodon idella, Hypothalmichthys molitrix*). The estimated average fishing from the beel was low (2.4 kg ha^{-1}). Fishing methods/ gear used in the beel includes both commercial (e.g., brush fishing, cast net, gill net, dip net) and subsistence fishing gear (bamboo traps, bamboo gear etc.). Discharge of municipal garbage of Guwahati city and continuous siltation of the wetland, encroachment, reclamation of marginal areas, newly constructed railway line passing through the south-east part of the wetland, construction of brick kilns in the periphery of the wetland are the major factors adversely affecting the ecology and fisheries of this important Ramsar site of Northeastern India. Most of the issues and threats concerning conservation of Deepar beel are similar to those faced by wetlands all over the globe. However a few threats like construction of the new railway track dissecting the wetland are specific to this particular wetland. Considering the techno-socio-economic issues concerning conservation and management of the wetland, a few conservation strategies have been proposed for the wetland.

Keywords : Wetland, sustainability, conflict management, participatory approach

Economical, social & Enviornmental services of East Kolkata Wetland (EKW)

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The EKW is famous for its unique services for environments, upliftment of social and economical status (blending with traditional wisdom and technology) of people working and living there. EKW supports more than 2 lakhs people and its economical value is more than Rs 9168 million/yr. The practice of EKW for production and livelihood, low cost sanitation and environmental protection are exemplary for underdeveloped countries and can be replicable according to the situation.

Govt. can generate revenue from different services and through modification of land policy. Utilize the same for survival of EKW and other wet lands. Interrelation of wetlands and human civilization need to reassess in different angles for sustainable functioning.

Community Based Intervention in Restoration of Mangrove Forestsfrom Anthropogenic Pressure- Developing Resilience for Sustainable Wetlands in Coastal Sundarbans

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In coastlines of India and Bangladesh, mangroves provide critical habitat for biodiversity and supports as well, world's highest coastal population near to a biodiversity hot-spot. The conservation status is extremely vulnerable because of anthropocentric pressure owing to deforestation and massive forest degradation through agricultural expansion, pasturing, logging, fuel and fire wood, along with commercial activities accounting for greenhouse gas emissions. Reducing Emissions from Deforestation and Forest Degradation (REDD Plus) is a global effort to create a financial value for the carbon stored in forests, offering incentives for developing countries to reduce emissions and invest in low-carbon paths to sustainable development.

This paper presents REDD plus conservation paradigm, developing a community sustained mangrove nursery and reforestation as a means of alternative livelihood for the people of coastal Sundarbans. It incorporates Vetivar cultivation and introduction of solar appliances towards substituting non-timber forest products. The project supported by UNEP is located in remote captive islands of sundarbans with more than 700 economically challenged beneficiaries of tribal origin. It inculcated communityawareness in protecting mangrove forests as a social tool in adopting REDD plus interventions for alternative economic opportunity and also for policy implications. Further, it aims to assess and account Carbon Stock volume (CSV) earned through reforestation and reduction in emission by prevention of forest degradation as a fiscal analysis to compensate the opportunity cost of the community. Perusal of results reveal that efforts have not only helped habitat and biodiversity restoration as evident through diversity indices, Strategic EIA and hydrogeochemical studies, but have brought substantial impact on social and financial inclusion and empowerment of tribal communities of coastal Sundarbans.

REDD plus interventions in climate vulnerable areas of Sundarbans redefines anthropocentric conservation paradigm in coastal zone management policy in the global south as well.

Key Words : Mangrove, REDD Plus, Sundarbans, Carbon Credit, Reforestation

Potentials of algaculture for biological carbon capture and storage in saltwater inundated coastal wetlands

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Introduction

Saltwater inundated coastal wetlands and marshes are home to several hundred species of microalgae and numerous attached or drift macro-algae (Montague &Wiegert, 1990; Wiegert & Freeman, 1990). While the total biomass of vascular plants in coastal salt marshes and wetlands outweighs that of many algal species, algae may be more productive as a whole, thereby having a great potential for quick capture of biological carbon and its storage. Algae growth and decay are more rapid, and organisms can assimilate energy from algal communities more quickly than vascular plants (Adam 1990). In addition to providing a habitat and food source for fishes and invertebrates, algal flora also plays an important role in salt marsh ecosystems. A variety of filter feeders and zooplankton feed on phytoplankton, and benthic diatoms and cyanobacteria form mats that stabilize sediment on mud flats, possibly allowing subsequent colonization of salt marsh vegetation (Coles 1979). Saltwater inundates coastal wetlands and marshes during high tides, with dry seasons and high evaporation further increasing salinity. Salinity gradients, caused by these processes, contribute to zonation in marsh plants based on salt tolerance among species. Most angiosperms have a limited ability to thrive in saline waters, and diversity of vegetation decreases along with a substantial drop in primary productivity in coastal wetlands with increasing salinity (Odum, 1988; Odum & Hoover, 1988). Even seeds and seedlings of mangroves, too, are vulnerable to salt stress, further contributing to zonation in mangrove plants. The present paper attempts to assess both ecological and economic potentials of cultivating native algal flock in saltwater-inundated wetlands of Indian Sundarbans, towards downscaling climate impacts in such vulnerable coastal areas.

The Indian Sundarban (21°13/ to 22°40/ N and 88°85/ to 89°00/ E), located on the southern fringe of the state of West Bengal and declared as 'Sundarban Biosphere Reserve', covers an area of 9630 sq. km. The area has a rich depository of flora and fauna owing to its extremely dynamic physico-chemical nature that supports a marvellous gene pool of micro and macro biotic community in which the mangrove vegetation occupies a special status (Guha Bakshi et *al.*, 1998). However, sustainable environment development is meagerly warranted as general tendency of conversion of mangrove forest into agricultural land by the farmers prevails in Sundarban in order to increase arable land thereby increasing yield from single cropping of paddy in dearth of fresh water resource for agriculture. More recently saltwater intrusion, owing to sea level rise, has inundated many agricultural lands and during last two decades, 'cash crop' aquaculture by shrimp farming has become an important alternative livelihood in Sundarban. Though profitable on a short term basis, even such intensive aquaculture has been identified as the source of long term hazards promoting degradation of the ecosystem.

While it remains mostly unexplored, the Indian Sundarban is also a rich and resourceful area of abundance of 148 algae species (Sen and Naskar, 2003), found both in the lentic and lotic aquatic environment in Sundarban, which play vital roles for the sustenance of the ecosystem and are economically valued species as well. Their potential in carbon sequestration through eventual assimilation as organic carbon is equally relevant in the milieu of climate change and after their death and degradation, the biomass adds as organic carbon to clay. Strategic assessment of ecological impacts of algal cultivation and its economic potential as an alternative livelihood is therefore a matter of serious concern in Sundarbans in the present context.

Materials and Methods

A. Study site & Collection of Seed materials

The experiments were designed and implemented in Gosaba block of Sundarbans Biosphere Reserve wherein 2 ponds measuring 0.2 to 0.5 acre and having a mean depth of 1.5 m, connected to tidal water resource, were selected for integrated fishery with algae. While mixed varieties of native self recruiting species of fishes naturally inhabited the experimental ponds, *Enteromorpha intestinalis*, a native alga that has economic potential, is collected from its natural habitat for cultivation in inundated salt waters and cultured using the following techniques.

B. Culture Technique

1. ***Single Rope Floating Raft (SRFR) Technique :***

The technique (Fig 1) has been developed by Central Salt & Marine Chemicals Research Institute (CSMCRI), Bhavnagar, Gujarat, India. It is suitable for culturing seaweeds in wide area and greater depth (Khan and Satam, 2003) . A long polypropylene rope of 10 mm diameter is attached to 2 wooden stakes or bamboo poles which are anchored by suitable polypropylene cables having a length of twice the depth of the aquatic body (3 to 4 m). The long polypropylene rope is kept afloat with synthetic floats at required intervals. The polypropylene cultivation ropes of 1 m long x 6 mm diameter are hung as rafts from the main floating rope. A stone is attached to the free lower end of the cultivation rope to keep it in a vertical position. The distance between two cultivation ropes is kept at 2 m. Generally 10 fragments of algal species are inserted on each cultivation rope.

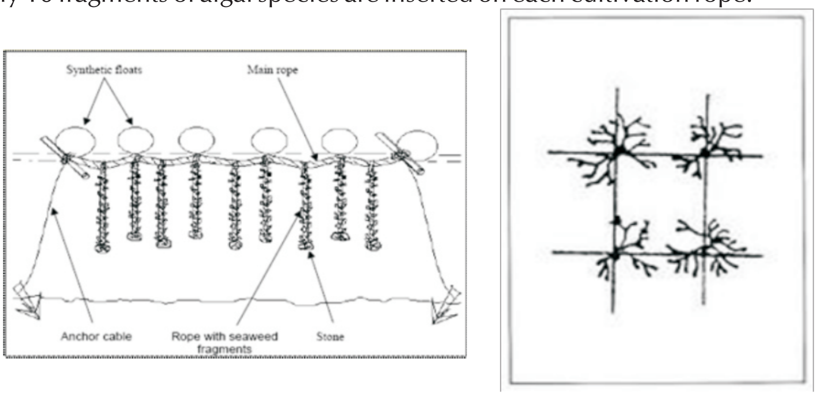

Fig: 1: *Diagrammatic representation of the Single Rope Floating Raft (SRFR) technique*

3. *Modifications of Classical Culture Technique:*

The classical SRFR technique has been modified to suit the pond ecology in Sundarban. Grazing of the different algal species by the pond fishes is inevitable. In some field experiments, each culture rope encased within a fine meshed nylon net bag (0.5 m length x 0.1524 m diameter) tied with nylon rope at the top has effectively prevented such grazing. This improvisation not only has prevented consumption of algae by pond fishes, it has also helped in their propagation as well.

2. *Net culture Technique (NCT):*

A floating net of 1 m^2 area is used as the substratum for algae in this culture. Nets were supported by bamboo side frames. The framed net is kept afloat near the water surface with the help of bamboo poles or anchor, holding at the four corners of net. The algae along with holdfasts are introduced into the twist of the coir ropes of the net.

C. Experimental Set-Up

Five different initial fronds viz. 50g, 75g, 100g, 125g, and 150g were tried for the present study. In modified SRFR set-up the length of the main rope was taken as 10 mts with side ropes tied at 1mt intervals. Well branched good quality seed materials was inserted in single braid knot (20 braid knots/single rope); thus 400 seed materials were prepared out of 20 ropes in a single raft. Approximately 30, 40, 50, 60 and 70kg of seed materials were inserted in a single raft; the distance between each tied rope was 100 cm; finally the raft was tied at both comers of another raft. Stones were used for anchoring the raft. Floats were used. Usually 10mm breadth and 10m length ropes were used.

D. Limnological data

For routine limnological studies, Dissolved Oxygen (DO) was measured by Winkler's titrimetric method and Salinity by argentometric method. Temperature and pH were measured by using the probe (EI Water & Soil analysis Kit, Model 191 E).

E. Seasonality

The experiment was conducted for three different seasons viz., post-monsoon, summer and pre-monsoon from January to September 2006. During monsoon season, culture experiment was washout within 5 days due to heavy rain fall and fresh water flow. Daily growth rate was calculated at every 15 days interval.

F. Daily Growth Rate (DGR)

Daily Growth Rate % was calculated using a formula (Dawes et al 1993) DGR% = ln (W_f / W_o) / t X 100; wherein t is the number of culture days. W_o is the initial fresh weight (g) and W_f is the final fresh weight (g) after culturing for t number of days.

G. Carbon Mitigation Potential

Algae have the ability to fix carbon dioxide efficiently (Richmond 2000, Benemann 1997). Carbon dioxide fixed through photosynthesis is converted to carbohydrates, lipids, proteins and nucleic acids. The carbon content varies with algal strains, media and cultivation conditions. The CO2 fixation rate can be calculated by applying law of conservation of mass:

Biomass molecular formula: $CO_{0.48}H_{1.83}N_{0.11}P_{0.01}$

$M_{Biomass}$ = 23.2 gram/mol: M CO2 = 44 gram/mol

$4CO_2 + \text{nutrients} + H_2O + hv \rightarrow 4\,CO_{0.48}H_{1.83}N_{0.11}P_{0.01} + 3.5\,O2$

Rate constant K = $MCO_2/M_{Biomass}$ = 44/23.2 = 1.89.

Total CO_2 fixation = K × biomass productivity X fixation efficiency

F. Statistical Analysis

Data were analyzed statistically using Analysis of Variance (ANOVA) to determine the differences in seasonal Daily Growth Rate with different initial seed density along with various seasons of culture period.

Results and Discussion

The limnological parameters of the culture ponds have been seen to vary seasonally and a comparison (Fig 2) of such parameters during pre-monsoon, monsoon and post-monsoon period in experimental ponds shows that water salinity ranges from 12.01 PSU in pre-monsoon to 17.27 PSU in monsoon season, whereas pH and DO demonstrate a more consistent curve showing minimal seasonal changes. Ambient temperature is maximum during pre-monsoon phase and minimum during winters, showing a negative correlation with salinity. A comparison of variability in DGR% in both modified SRFR and NCT across these seasons and other limnological parameters show direct positive correlation of DGR with salinity. A similar study has reportedly been found in Cyanobacteria that can tolerate higher osmotic stress until salinity reached a PSU of 16 with enhanced growth and synthesis of zeaxanthin (Liua et al, 2010; Chakraborty et al, 2011). Though, greenalgae and cyanobacteria from freshwater system shows considerable acclimation towards fluctuating pH, the variability of pH in this case was not as dramatic as salinity. Consistent curves of pH and DO hint a sharp compensation of CO_2 release and its utilization buffering the pH with bicarbonates and subsistent release of oxygen through photosynthetic activities (Chakraborty et al, 2011; Chi Z et al, 2011). These findings are environmentally relevant to understand the likely impact of salt water intrusion and pH variation on phytoplankton communities in a tropical freshwater system in general and for fish cum algae culture in particular wherein stabilized pH and DO are significant for getting better yield.

Trends of biomass growth in both modified SRFR and Net culture across the three seasons has been illustrated (Fig 2a &Fig 2b). In both cases the growth is maximum during post monsoon season and minimum in premonsoon season. Yield has been observed higher in net culture than that in modified SRFR culture. In case of net culture, yield is approximately 2.2 kg from 1 kg seed after a period of 15 days of culture. Whereas in case of raft culture, the yield is 1.5 Kg from the same amount of seed and period of cultivation.But, in spite of lower yield, the Net Primary Productivity (NPP) of the water of the ponds under raft culture technique has been observed to be twice higher than that of the ponds under net culture technique (Barik et al, 2011).

Perusal of result show that initial stocking volume of 100 gms/m^2 shows the best growth rate in net culture technique where as in modified raft culture initial stalking volume of 50 gms/m^2 provides the best growth rate. The production has been found to be maximum in the post monsoon season when the salinity is comparatively higher and temperature is at the minimum. This explains the limits of carrying capacity of maintained culture frame which is significant for commercial production. However, the range of variability in the rate of biomass production is highly dependent on seasonal ambience and found to be varying maximum during pre monsoon season as observed in both the culture techniques. The same trend has been observed in both the culture techniques. However, production in net culture exceeded that of modified raft culture in all the three seasons. The enhanced growth in post monsoon period in post monsoon period is attributed to the increased salinity as explained earlier.

The annual average biomass productivity and carbon mitigation potential of cultivated algal stock was calculated from incoming solar radiation and photosynthetic efficiency of the algal species (Sudhakar & Premlatha 2012). The maximum possible energy conversion to organic biomass was estimated theoretically and optimum efficiency was found to be at 11.42% (Williams et al 2010). Thus assumed, the seasonal changes in carbon mitigation potential, illustrated in Fig 3, showed that the maximum optimistic CO_2 fixation capacity is 117 Tons per hectare per year, obtainable in NET culture technique during post monsoon season, whereas it is lowest in SRFR technique during pre-monsoon season nearing to 57 Ton of CO_2 per hectare per year only. However, this estimate is drastically higher than carbon fixation capacity of terrestrial plants (Ravindranath & Bhatt 1997). Despite any discrepancies among approaches, all estimates affirm the productive potential of algae as a sustainable source of carbon sequestration and energy production. Considering the CO_2 fixation ability of cultivated algae, it would be ideal to locate algae production plants next to stationary emitters as a carbon capture and storage (CCS) option. It is therefore evident that the accrued biomass through algal growth is a direct evidence of carbon capture by aquatic flora in inundated waters. As evidence earlier (Campbell P K et al, 2010; Chi Z et al, 2011; Kaladharan et al, 2011) green seaweeds has been found to utilize 100% of CO_2 towards carbon fixation from ambient water having a concentration gradient of

CO_2 at 15 mg/Lt in a low temperature conditions whereas microalgae can utilize only 27.7% of the dissolved CO_2 in similar condition. It is estimated that seaweed biomass along the Indian coast is capable of utilizing 9052 t CO_2/day against emission of 365 t CO_2/day indicating a net carbon credit of 8687 t/day. This suggests the photosynthetic efficiency and carbon storage that has been already noticed in the present study and explained earlier. The potential of algal culture in low cost carbon stocking has also been explored by using bicarbonates to capture CO_2. The relevance of this study therefore reveals the suitability of fisheries in combination with algal culture in inundated waters as an alternating farming in coastal plains and its ecological significance as a pronounced method of carbon capture in the area.

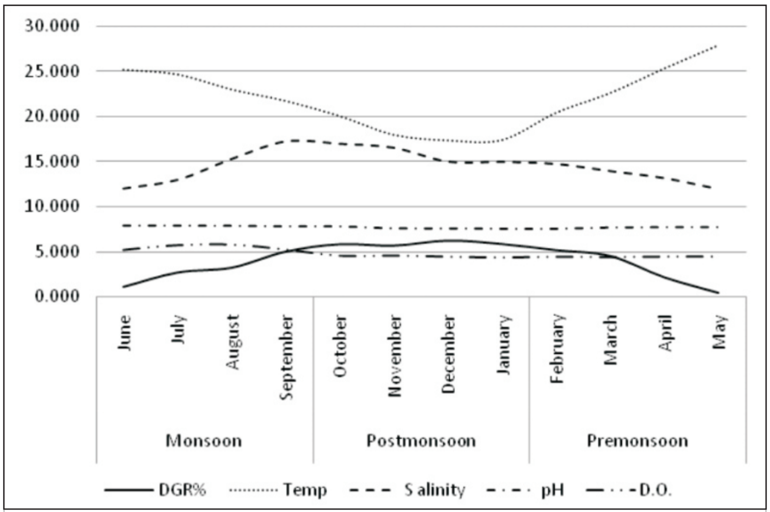

Fig 2: *Changes in DGR% (100mg / m^2 in Net Culture) Changing Limnological parameters*

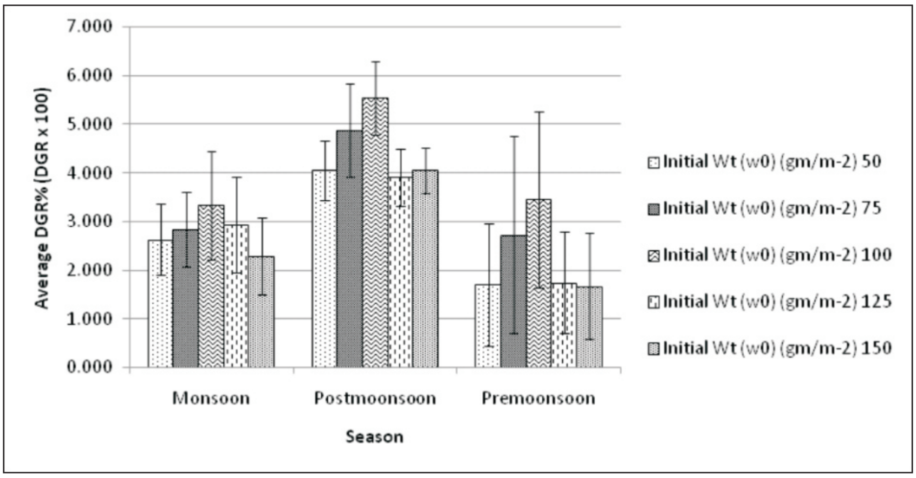

Fig 2a : *DGR% in Net Culture Technique*

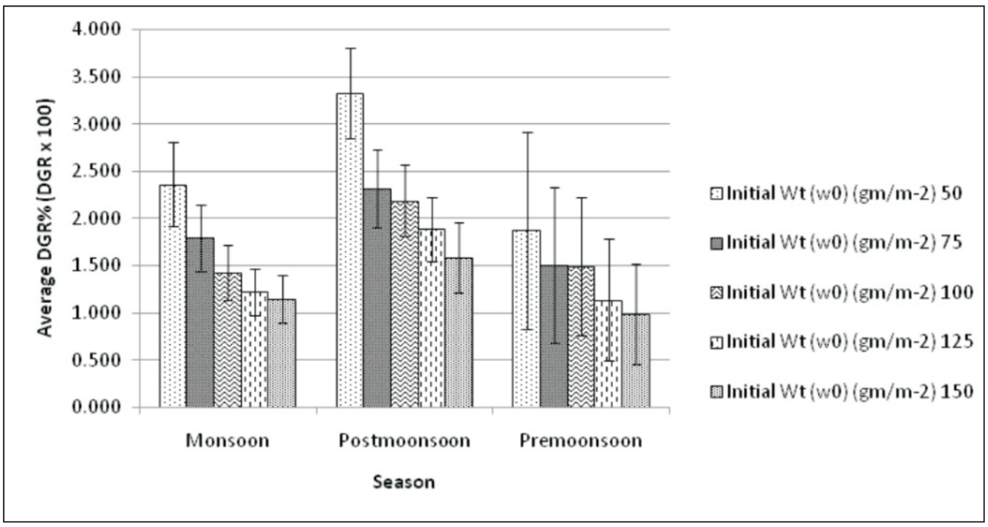

Fig 2b : *DGR% in Modified Raft Culture Technique*

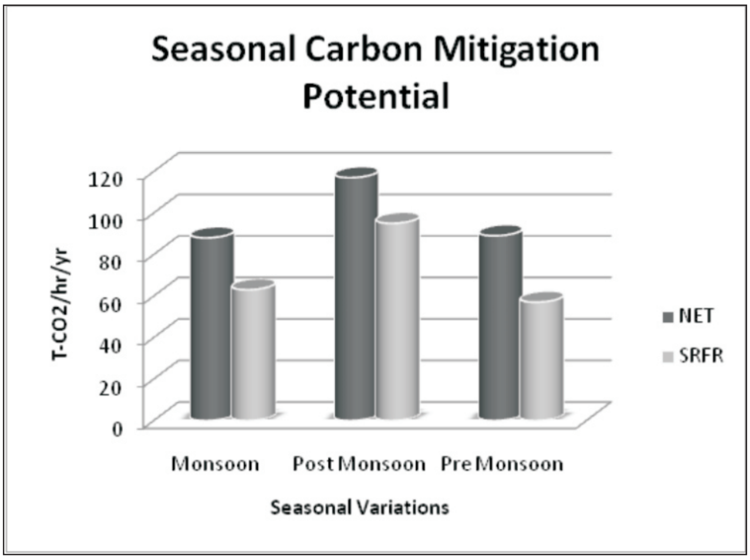

Fig 3 : *Seasonal Carbon Mitigation Potential in cultivated algae using NET culture and SRFR culture techniques.*

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Key Words : Algal culture, salinity, inundated wetlands, carbon capture, climate adaptability

Geomorphology, Hydrology and Hydraulics of Wetlands

Small Indigenous Fish: An Alternative Source to Improve Rural Livelihood and Nutritional Security in Coastal Zone of Sunderbans, India

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India has the largest number of endemic fish species, contributing 27.8% of the native fish fauna. Of 765 freshwater fish species, about 450 species could be classified as small indigenous fish species (SIFS). SIFS found in the vast inland water resources, provide not only nutrition but also livelihood opportunities and income to a large number of fishers. Studies in India have shown that the profit accruing to fishers is actually higher in the case of SIFS when compared to those from large cultured species. SIFS are traditionally known to contribute to the nutritional security of people living in the vicinity of water bodies. They are also known to play important roles in supporting the livelihoods and incomes of poor fishers, contributing to poverty alleviation. These species are also vital in sustaining biodiversity and maintaining environmental balance. However, due to growing urbanization and the indiscriminate use of pesticides and insecticides in agriculture, such freshwater fish species are being threatened and their habitats destroyed and limited. Deltaic Sundarban, India and Bangladesh combined, embraces the world's largest brackish water **mangrove wetland.** This is the largest nursery of marine finfish and shell fish juveniles and also the breeding ground of numerous mangrove faunal species, benthic and pelagic. With change of time during the last four to five decades lot of environmental characteristics also changed, may be due to commissioning of Farakka barrage, global warming, the anticipated threat of sea level rise and increase sea surface salinity. Those fishes like Sea basses, Mullets, Thread fin fishes, Milk fishes and prawns were once abundant near the estuarine water of Kadwip, Sagar Island and Namkhana, are now found to be totally disappeared. They have shifted far south in the Bay.

A survey was conducted in collecting peri-urban and rural fish markets of Sunderban area. Ukiler bazaar (Village market), Dasmile market (Village market), Namkhana bazaar (peri urban market), Kakdwip market(peri-urban market), which are located near to natural waters of Southern part of West Bengal. The main consumer groups of these rural and peri-urban fish markets are the villagers, businessmen and service holders of the respective localities. Market survey was conducted for a year in the rural and peri-urban markets of Sunderbans. The supply of SIF of fish in the rural and peri urban fish markets during the study period found to be 1.5 to 28.5 kg per month in average normally. During the month of April - June SIF has maximum supply in the fish market because of their higher availability in natural water. Average monthly supply in the selected markets is 11.92kg. So, the contribution of SIF in market is very low compare to the IMCs and other Marine fishes. Maximum contribution in the market is *Mytus gulio (29.39%)* followed by *Clarias batrachus (10.86%), Anabus testudineus (10.43%), A. mola (10.22%), Puntius ticto (6.38%) H. fossilis (5.53%)* and others.

On 25 May 2009, cyclone *Aila* unleashed its fury on this tidal country and for the 3.5 million people residing on the islands of the Indian side of the Sundarbans, home to the world's largest mangrove forest and the Royal Bengal Tiger, the cyclone changed their lives forever. The worst calamity in living memory left about 150 people dead and over 40,000 homes razed. This has also affected the fish resources and livelihood of the villagers. Return to normalcy is happening slowly, and most people said they were not sure if it would ever be possible to go back to their pre-*Aila* life. Construction of embankments has started in some places. A field survey was conducted regarding the status of small indigenous fishes after *Aila* in Sunderbans region, particularly in Namkhana block, which was badly affected by cyclone *Aila* in the year 2009. Hundred people of various age groups ranging from 27 -65 years and involved in various occupations were interviewed personally to know about the present status of small indigenous fishes in that zone after *Aila*. Survey in selected areas of Sunderbans revealed drastic reduction in native fish species, *e.g. Ompok pabda, Wallago attu, Heteropneustes fossilis, Clarias batrachus, Glossogobius sp., Anguilla bengalensis, Amblypharyngodon mola, Colisa fasciata, Notopterus notopterus, Mystus vittatus, Channa marulius, C. striata, C. punctata, C. gachua, Mastacembelus armatus, Macrognathus pancalus, Puntius sarana, P. ticto, Chanda nama, Nandus nandus, etc*. It was reported by 60% of the respondents that there is significant reduction in availability of *Amblypharyngodon mola* and *S. bacalia*. About 70% of the respondents reported that availability of *Mystus vittatus, Puntius sarana, Nandus nandus* in the water channels of Sunderbans has drastically reduced. It was stated by almost every respondents that people of Sunderbans particularly people of Namkhana block think that availability of *Colisa fasciata, Colisa lalia, Mystus cavesius* almost nil after *Aila*. Both natural and man-made catastrophes, degradation of aquatic environment have resulted in the disappearance of many suitable habitats for the SIFs in Sunderbans. Most of the SIF available in the natural water bodies have high nutritional value. The people of rural Sunderbans, particularly the women depend on these SIF for their livelihood. So, there is an urgent need to conserve SIF in Sunderbans areas.

Keeping these issues in background, an initiative was taken to conserve selected SIF species in Sunderbans area. A conservation and demonstration site has been developed in Madanganj, Namkhana for SIFs. The village community pond is developed as demonstration centre for the small indigenous fishes. Fishes were collected from the rain fed canals of local area and were stocked in the village community pond for ensuring the community participation in conserving the small indigenous fishes two Farmer Interest Groups (FIGs) has been formed with six members in each groups. The groups are monitored by the Madanganj Matsya Chasi Samiti, Madanganj, Namkhana. SIF, namely, *Anabus testudineus, Mystus vittatus, Amblypharyngodon mola, Puntius ticto, Xenentodon cancila, Glossogobius giuris, Mastacembelus pancalus, Channa punctatus, Chanda nama, Chanda ranga* collected from the canal of Madanganj area were stocked in the village community pond. Significant increase in number and weight was observed. The paper dealt with the details of soil and water quality, plankton availability, fish growth and species preference recommendation for rapidly growing population in coastal zones of Sunderbans.

Keywords : Small indigenous fish, diversity, Sunderbans, livelihood

Participatory Approach: a Potential Tool to Sustainable Wetlands Management

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Since the beginning of the 20th century Indian wetlands have been degraded due to siltation, loss of river connectively, draining and conversion to arable land, dumping of refuse etc. Furthermore, many wetlands have been degraded through nutrient enrichment, the main sources being sewage effluents and agricultural fertilizers. Such eutrophication interferes with the important ecological functions of water bodies and is jeopardizing the use of water resources by man. In India, extensive floodplain wetlands in the form of ox-bow lakes (*mauns*, *chaurs*, *jheels*, *beels* - as they are locally called), especially in the states of Assam, West Bengal, Bihar and Eastern Uttar Pradesh, bear special significance in the inland fisheries of India because of their magnitude and support to livelihoods of millions. Wetlands perform a myriad of functions: recharge and discharge groundwater, flood control, retain sediment, toxins and nutrients, biodiversity conservation, export biomass etc. Wetlands can also generate products such as forest, wildlife, fishery, forage and agricultural resources, as well as water supplies. Thus wetland is a natural resource with immense ecological and economic importance. Wetland resources are fundamental to rural livelihoods and the rural economics dependent on wetlands are diverse, dynamic and adaptive. Wetland economies involve a wide profile of natural resources, with livelihood strategies adapting to environmental change, both seasonally and annually. The viability of these resources depends on this diversity, dynamism and adaptability. Since many wetlands are common resources they tend to be of particular importance to poorer sections of the society who have less access and control over private resources. Significant threats to livelihoods come from wetland degradation, and privatization of common areas to the exclusion of local people. Keeping these issues in view sustainable management of wetlands is necessary for livelihood security of the people depending on the wetlands.

A participatory approach for sustainable wetland management helps in creating 'win–win' situations by providing efficient and equitable solutions to the challenges of natural resource management. Participatory approaches are believed to produce more effective result by incorporating knowledge of local resource users and ensuring higher compliance since these are devised by stakeholders. In case of wetlands, peoples' participation or community participation is recognized as fundamental principles of wise-use by the Ramsar Convention (Ramsar Convention Secretariat 2004b; Ramsar Convention Secretariat 2004a).

For community participation stakeholder analysis is the most important thing to be done in priority. Stakeholders can be defined as the people who either

- will be potentially affected by the management of wetlands;
- will be involved by one way or another in the implementation of management activities;
- who are likely to support or oppose the research, development or the policy at stake.

Usually, the expected outcomes of stakeholder involvement in natural resources management are: a better understanding of people concerns leading to solutions which are more adapted to their needs. The integration of their knowledge in management options leads to reduction of potential conflicts among stakeholders. For conflict resolution application of Analytic Hierarchy Process (AHP) could also be useful. The main theme of AHP is the decomposition by hierarchies and synthesis by finding relations through informed judgment (Saaty 1996).

Promoting participatory planning and management approaches and consultation with local people particularly with the poor and vulnerable, strengthening networks of local resource users across ecosystems and their capacity to represent their interests, securing access to and control over resource and information, and communities presence in decision making arenas will help in wetland management in better way. Strengthening of local community and building capacity to manage natural resources, particularly common property resources will make sure conservation and rehabilitation of wetland resources, particularly the fisheries resources. Women and girl children play important roles within the household in managing natural resources particularly fisheries. Interventions should also be targeted to empower women taking into account their needs. Finally, for sustainable management of the wetland participatory monitoring and evaluation should also be ensured.

Participation is seen as a goal in itself. This goal can be expressed as the empowering of people in terms of their acquiring the skills, knowledge and experience to take greater responsibility for their development. People's poverty can often be explained in terms of their exclusion and lack of access to and control of sources, which they need to sustain and improve their lives. So, participation is an instrument of change and a potential tool for sustainable wetland management.

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***Keywords**: Wetland, sustainability, conflict management, participatory approach*

Community Based Intervention and Institutional Arrangement for Sustainable Management of Fisheries Commons

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India is endowed with extensive multi-use water bodies in the form of rivers, floodplain wetlands (*beels*), reservoirs, swamps, canals and tanks. Fishing in these waters dates back to time immemorial and still plays a fundamental role in sustaining the livelihoods of millions of the rural poor, providing food and nutritional security and opportunities for diverse categories of income and employment generation.

In the last decade of twentieth century the role and relevance of social and institutional structures in connection with the whole field of contemporary environmental management has gained substantive importance. Institutional innovations for common property resources fisheries management refers to the understanding how governments, communities and entire fishing communities change their habitual behavior and institutional roles in managing common water bodies for fisheries. To gain insights of this issue it requires a study of laws, rule making, policies, fishing rights etc. The public trust doctrine allows government to lease, grant, and sell public resources as long as it does not unduly harm public interests. Lease of fisheries means assigning rights (property, use) to individuals, groups, cooperative, or communities. Property is composed of a bundle of rights (access, withdrawal, exclusion) that can be allocated to users.

Analysis of the open water fisheries institutional reforms in carried out following the institutional analysis framework that has included both theoretical and analytical frameworks. Theoretical frameworks explain fisheries institutional evolution and change. Analytical framework involves quantitative changes over a period. The time lines were developed to explore the nature and evolution of institutional innovations for open water fisheries management in India. The fisheries institutional arrangement has been analysed in light of the underlying foundation of the state's philosophy of balancing economic growth with welfare and sustaining vital resources, highlighting the role of the state in explicating the political economy of inland capture fisheries in open water fisheries resources.

The objectives of this study are to i) review the institutional arrangement, ii) formation of ownership and allocation rights, iii) various case studies of community based intervention in wetland resources of India, and iv) identify the major issues, challenges, concerns and choices for sustainable management of fisheries. Various case studies of community based intervention in wetland fisheries management are also discussed.

Keywords : Common resources, sustainability, institutional arrangement

Table Fish Production Through Pen Culture in Baraila *Chaur*, Vaishali, Bihar

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Low lying, flat, shallow, water logged area with massive growth of vascular plants is locally called *chaur* in Bihar offers potential for fisheries management. Such resource in Bihar is lying in derelict condition, traditionally being exploited by marginal fishers' for their subsistence with estimated yield of 25-40 kg/ha/yr. The low fish yield from these water resources could be attributed to cumulative impact of floods, dense macrophytes, predators, ownership impasse and poor technological back up. Attempts were made to improve productivity *vis-a-vis* livelihood of fishers through knowledge up-gradation, social and technological intervention in one such water body. Fish culture in pen was considered the most appropriate, simple and inexpensive technique for production enhancement in such ecosystem which will ensure livelihood opportunity of fishers with least ecological modification. A Fish Production Group (FPG) comprising 10 fishers was formed in Dulaur village and trained at CIFRI on this method of farming. A pen made up of HDPE net was fabricated and installed covering 1.0 ha area.Considering the ecological condition and trophic structure the pen was stocked with 400kg (11660 nos.) fingerlings of **catla,** rohu, mrigal, grass carp, common carp and big head carp. To avoid predation, advanced fingerlings (average weight 30 gm) were stocked in pen. Macrophytes were not cleared and no supplementary feed was given. During four months culture period, a total of 7170 fishes corresponding to 2.7 ton fish biomass were retrieved from pen with survival rate 61.49%. Final weight and % survival was highest in grass carp and lowest in mrigal. The B:C ratio was found to be 1: 2.33.

Keywords : Wetland, Bihar, livelihood, pen culture, group approach

Fisheries Management in Wetlands of Uttar Pradesh and Scope for Further Yield Enhancement

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Uttar Pradesh is blessed with plenty of water resources in form of wetlands, owing to its geomorphic characteristics and presence of vast network of criss-crossing rivers. Total area under floodplain wetlands in the state is estimated at 152,000 ha. Twenty two wetlands situated in different parts of the state were studied for ecology and fishery. The water spread area of wetlands ranged between 21.0 and 900.0 ha. About 30 fish species were recorded from these wetlands, besides the stocked fishes. Most of the wetlands were leased out for fish production, but majority of them were under-utilized as far as fishery development is concerned. In general, fish composition in the wetlands is dominated by miscellaneous fishes, followed by catfishes and Indian major carps. Exotic fish species were also recorded from majority of the wetlands. Fish yield varied from 30.0 to 520.0 kg $ha^{-1}yr^{-1}$, while the estimated potential is multifold. Low fish yield could be attributed to weed infestation, sedimentation and succession, excess organic matter, inappropriate stocking, presence of predatory fishes, uncertainty in water availability, and also conflicts in some of the wetlands. Fish yield from these wetlands can be modestly enhanced 3-4 times from the present average production of 180.0 kg $ha^{-1}yr^{-1}$. To harness maximum benefit, suitable wetlands can be utilized as multifaceted resource for practicing intensive culture fishery in pens installed in marginal areas, cages in deep areas, and traditional capture fishery or sport fishery in open central portions. Beside fish production, there is also scope for integration of duck and poultry, dairy, horticulture, and development of fishery-based eco-tourism in few wetlands.

Key words : Wetlands, fish yield, fishery enhancement, Uttar Pradesh

Ecological Goods and Services : Wetlands Perspective

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Wetlands are lands transitional between terrestrial and aquatic eco-systems where the water table is usually at or near the surface or the land is covered by shallow water. Wetlands are generally highly productive ecosystems, providing many important benefits to society. These benefits sometimes described as 'goods and services', or functions or uses of wetlands The various beneficial functions of wetlands like sustaining life processes, water storage protection from storms and floods, recharge of ground water, water purification, storehouse of nutrients, erosion control and stabilization of local climate help in maintaining the ecological balance. In addition, wetlands are important feeding and breeding grounds for wild life and migratory birds, and are important natural habitat supporting diverse flora and fauna species. Despite their important roles in maintaining the ecology and economy of the region, there are growing concerns worldwide about their destruction and degradation. Wetlands are almost in an engendered state due to various anthropogenic activities. The extinction of such wetlands due to urbanization and other factors can cause unnoticed climatic hazards in future.

The present paper is an attempt to define various goods and services provided by wetlands. The basic difference between services and functions of different wetlands are discussed with case studies.

Keywords : Wetland, Ecological, Goods, Services, Functions, Stakeholders

Land Conversion Scenarios of East Kolkata Wetland – a Geo-informatics Appraisal

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The East Kolkata Wetlands is the world's largest sewage fed aquacultural system located in the eastern fringes of Kolkata Metropolitan city. With numerous species of floral and faunal assemblages this wetland has become highly enriched ecosystem and provides several ecosystem services to the environment and community. This wetland has been designated as "wetland of international importance" under the Ramsar Convention on August 19, 2002. For conservation and proper management of this wetland a continuous monitoring is very much needed. Application of Geo-informatics is the best means of technique in terms of time as well as cost effectiveness. In this study Multi temporal satellite imageries of LANDSAT (Multispectral optical) has been used of the years 1990, 2001 & 2014. The main objective of this study is to understand the land conversion scenarios within the wetland. The wetland has been extracted from the satellite imageries using several techniques. Normalized Difference Water Index (NDWI) has been applied to extract the water bodies, Soil Adjusted Vegetation Index (SAVI) and Normalized Difference Vegetation Index (NDVI) has been applied to extract the vegetation cover within the wetland boundary. Finally a knowledge based classification has been adopted with the training sets collected from the field to generate the Land Use Land Cover of the study area. Then the changes have been assessed using the change detection technique. From the analysis it is prominent that though the area is under conservation rule an increasing trend of land conversion has been identified. The main conversion noticed is conversion from water body to filled up agricultural area and Built-up land. To understand the future scenario of the wetland a hybrid technique of spatio-statistical analysis has been applied. Using CA-Markov chain analysis it has been noticed if the rate of conversion remain the same the conservation of the wetland will be difficult. It is not too far that the sustenance of the wetland as ecosystem and its related ecosystem services in the near future will be in question

Key Words : East Kolkata Wetlands, Land Conversion, SAVI, NDVI, NDWI, CA-Markov chain.

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