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Chapter- 17

Wetland Ecosystem and Socio-Economics: Interdependence for Sustainability

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Keywords: wetlands, ecosystem, economy, sustainability, interdependent

Abstract:

Recent advances in environmental research have proved that wetlands are the most promising solution in controlling and managing environmental problems, with their unique property of enormous diversification in spatial, creation, water and sediment characteristics, and keystone species. While providing the natural habitat and breeding ground for about 40 percent of global wildlife, they also serve as vital sources of genetic medicinal resources, hydropower, food, raw materials and ecological services of flood mitigation, coast embankment protection and community resilience against disasters. The versatile study of wetland ecosystems and their contribution to large-scale environmental protection was undertaken by many scientists, and the concept progressed through numerous studies, mainly for tropical developing countries rich in wetlands like India. Their environmental importance was given global recognition at Ramsar convention held in 1971 where the wetland characteristics and functions were precisely defined along with the recommendations for wise use and its resource conservation in order to achieve sustainable development. Irrespective of variable sizes, wetlands' ecological and economic valuation is similar in significance and uniqueness. Because their services can be considered non-market goods, their economic valuation should be in monetary terms to get long-term benefits from investment upscaling for conservation. Wetlands also function as a unique, well-established system of waste treatment, recycling and resource recovery when the nutrients from waste are reused into fish culture and agriculture. The present environmental degradation of the system is affecting the livelihood of poor people who depend on the local wetlands. A model-based interactive approach will not only measure the interdependencies of the current situation of the ecological and social vulnerabilities but also will be able to predict future changes, thus bringing about sustainability.

Introduction:

Ecologists can never separate the functional attributes of a wetland ecosystem from its production potential and hence termed this ecosystem as 'valuable and productive' ecosystem in the world due to their effective and important services to human society. Their rich and high

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environmental production is due to their wide array of roles from the most efficient cradle of biological diversity to a global environmental 'stabilizer', 'filter', 'sink' 'flood control' etc. Economically, wetland services have a five times higher total economic value than tropical forests (Maltby and Acreman, 2011). Scientists and environmentalists worldwide are focusing more on the study of wetland ecosystem due to their rapid conversion due to human greed and need that prevents sustainable development. 1 billion people, depends on wetlands for their livelihood, making the wetland ecosystem a valuable and productive ecosystem in the world (Baral et al., 2016; Costanza et al., 1997; Mitsch and Gosselink, 2000).

Ramsar Convention was signed in 1971 at Ramsar, Iran which decided on the wetland conservation and its sustainable use. 'Wetland Health Card' has been decided to be issued by environment ministry to monitor the entire wetland ecosystem based on multiple parameters (The Economic Times, 2019). Concern for the wetland carrying capacity acts as a major challenge for sustainable development since it affects human life's social, political, and economic conditions (Costanza et al., 1993; Bassi et al., 2014). A meaningful sustainable development can be ensured with a proper analysis of the interrelationship and interdependency between ecological services and economic return.

Materials and Methods:

Nearly 500 research literature pertaining to research articles, review, short-communications, book-chapters, news-reports were reviewed for the collection of information on the title. Mostly peer-reviewed literature was consulted. The keywords used were wetland-ecosystem, sustainability, economics, wetland-degradation. The search engines employed were GoogleScholar, Researchgate, Pubmed, Scielo, CiteSeer X, SciTech Connect etc. After screening the papers, most relevant papers were finalised and the search results were categorised into the following groups.

Major Ecological Functions

Kidney of landscape

The filtering function of kidney is well exhibited by the wetlands which can absorb, dilute and transform nutrient wastes, suspended solids coming from adjoining terrestrial ecosystems by removing them from surface, thus filtering the pollutants and contaminants. Physical processes of sedimentation, sorption along with microbial nutrient transformations (Ramachandra and Aithal, 2015) and uptake by wetland vegetation (Fig-1) are primarily responsible for filtration activity. *Pistia stratiotes* could remove 70% ammonium and 59% total-nitrogen (Prajapati et al., 2017). 77%, 60% and 68% removal of TSS, nitrate-nitrogen and *E. coli* (Vymazal, 2007) respectively have been reported.

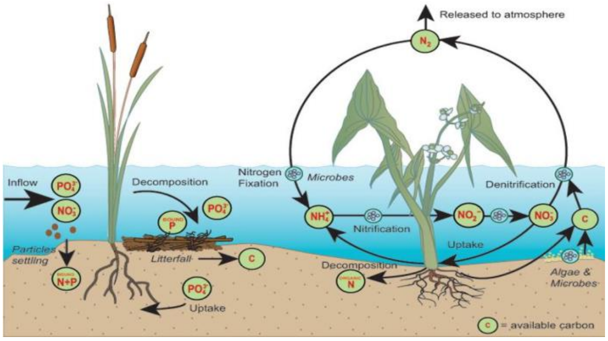

Figure 1.The kidney function of wetlands (modified from Kadlec and Knight (1996)

This pollutant filtering function of wetlands has been effectively used for the treatment of municipal and industrial wastewater by constructing artificial wetlands (Mitsch and Gosselink, 1993, Almuktar et al., 2018), the design of which has been upgraded to include many combined-hybrid models (Marzec et al., 2018). Aquaculture practice in wetlands has also induced the pollution removal process mainly through microbial-biogeochemical transformations (Ganguly et al., 2015; Lahiri et al., 2017). Livelihood through sewage-fed aquaculture is generated by implementing systems-ecology and employing ecological engineering techniques (Jana, 1998). Constructed wetlands can also efficiently remove cadmium while utilizing the organic waste for fish culture (Rana et al., 2011).

Biological supermarkets

Wetlands are rich in biotic diversity, providing unique habitats and extensive food-webs for a diverse range of plant and animal species. Enormous photosynthesis and nutrient recycling activities by the intricately diversified taxonomical wild living system can shape the uniqueness of wetland ecosystem. Besides serving as a food resource obtained from detritus, wetlands provide breeding and life-cycle habitats for many animals (Sandilyan et al., 2010) and help the weaker species hide from predators due to thick wetland vegetation.

Carbon sequestration

Sediments of tropical or sub-tropical swamps, mangroves, peatlands and marshes are a rich sink of carbon(Mitsch et al., 2013), storing nearly 20-30% of Earth's soil pool (Lal, 2009) and is suitable for carbon trading and climate change mitigation. Because of high organic matter, restricted decomposition and anoxic wet conditions, wetland soils (Fig-2) have sequestered 0.4 tonnes C/ha/year over 50 years. Sourcing 40% of global methane emission (Bloom et al., 2010) due to prolonged nutrient loading, the balance of CH_4 and CO_2 exchange can provide a global warming potential index.

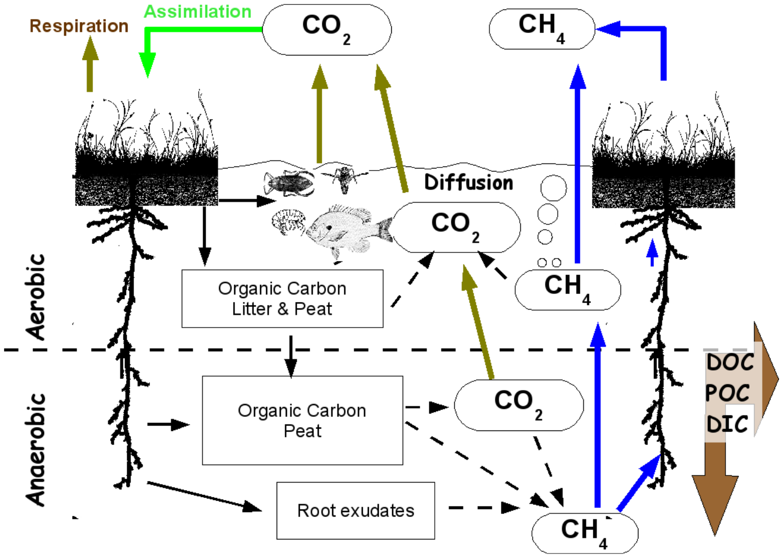

Figure 2.Carbon cycle helping in carbon sequestrationin wetlands (Van der Valk, 2006)

Flood Control

Trees, vegetation and root spread of wetlands regulate stream flow by trapping and slowly releasing the flood waters (Rafiq et al., 2014) resisting large-scale erosion and dredging expenses. Further, their sponge character provides hindrance to the direct flow of suspended particles and nutrient load into rivers. Many characteristics of wetlands such as location, configuration, topography, soil structure and quality, influence the flood control function (Acreman and Holden, 2013).

Wetland ecosystem at risk

Despite a strong early bond between wetland and human communities, wetland conversion for non-wetland uses has been increasing historically. Since 1970, 35-50% of global natural wetlands no longer exists (Ramsar Convention, 2018) which is an alarming trend.

Major direct drivers are infrastructure advancement, land-conversion, excessive water-extraction, harvesting, pollution and eutrophication stress and invasive alien species introduction (MEA, 2005). Megatrends include climate change (Bates et al., 2008) and changing consumption patterns of enhanced land and water use (Kumar, 2013). Moreover, wetland siltation due to these stressors further alter the biological communities (Masese et al., 2012).

Alteration of carrying capacity of wetlands affects the positive and negative feedback mechanisms of the wetland ecosystem which act as the critical control systems (Gökçe, 2019) of the wetland ecosystem dynamics (Fig-3), thus achieving a non-steady state (Soto-Ortiz, 2015).

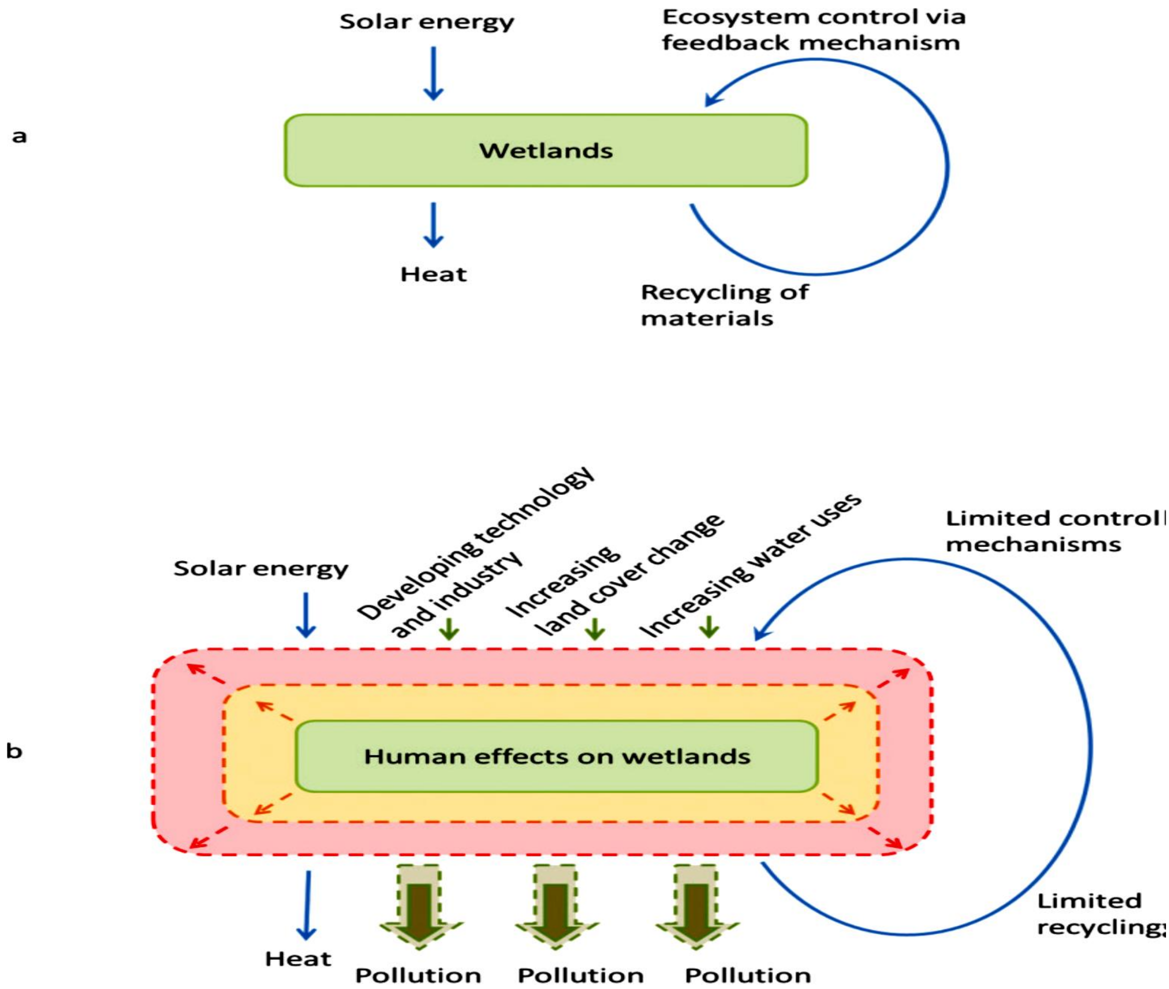

Figure 3.Wetland ecosystem dynamics (Gökçe, 2019)

Asia is the most affected area in comparison to its European and North American counterparts due to indiscriminate deterioration of water quality and widespread eutrophication.

In India, particular wetlands are considered as 'wastelands' by many decision-makers due to their easy accessibility for extraction without any imposed price. Moreover, water quality gets seriously degraded due to reduced inflows, pesticides runoff and sink for untreated effluents (Brinkman et al., 2020). The rapid change in land use and landcover due to fast urbanization is also decreasing India's wetland area, leading to a complex social–ecological transformation process.

Wetland Conservation and Management

Ramsar Convention as early as in 1971 ensured wise-use of wetlands for its 'sustainable utilization for the benefit of mankind in a way compatible with the maintenance of the natural properties of the ecosystem'. National Environment Policy (NEP), 2006, Wetland Conservation and Management Rules, 2017 were framed as a regulatory measure for protection of wetlands of India. Very recently, a notification prohibited setting up or expanding industries and disposal of construction and demolition waste within the wetlands.

In order to make this change temporary an ecosystem based management approach striking an appropriate balance between wetland conservation and socio-economic development can be the best option (Maltby, 2006). Wetland ecosystem indices offer a comprehensive framework for identifying, organizing, and analyzing the intricate factors that impact wetland ecosystems' living and non-living components. McCartney et al. (2005) developed the Working Wetland Potential (WWP) index, which utilizes a multi-criteria analysis to integrate wetland utilization's biophysical and socio-economic aspects. The conservation strategy may also involve activities such as wetland mapping and delineation, creating databases for temporal, spatial, and non-spatial information, establishing bodies for water quality monitoring, and conducting ecological health monitoring and socio-economic dependence analysis.

Wetland economic importance and assessment

Wetland valuation groups

Actual planned and possible use of wetlands by humans is designated as use-value in a Total Economic Valuation scheme whereas the unplanned, non-human interactive use gives non-use values (Tuan et al., 2008). Use-value is further grouped into direct and indirect use values which both together can be option value. Non-use-values can be existence, quasi and bequest values.

Direct values: Widely known common services of wetlands used for direct consumption, sale, production, livelihood generation such as fish harvesting (Neiland, 2008), fuelwood collection, providing shelter, transport, water supply, agricultural crops (Emerton, 2016), recreation and other commercial and non-commercial activities in developing countries or for sport and recreation in developed countries (Barbier et al., 1997) are designated as direct values. Nearly 50% of a family's total income in a Zimbabewan village comes from direct use of wetlands (Mahlatini et al., 2020).

Indirect values: Wetland function-dependent uses have been valued to protect and maintain the balance of nature and the human system. The functional network is woven with ecological importance.

Option value: This includes uncertainty about future demand for wetland resource and/or availability.

Existence values: The inherent worth of wetland ecosystems and their constituent elements, irrespective of their present or potential utilization prospects – encompassing cultural, spiritual, aesthetic, and heritage importance.

Quasi-option value: The anticipated worth of the knowledge obtained from postponing the present wetland's utilization and transformation (Pascual et al., 2012).

Bequest values: Individuals who prioritize conserving tropical wetlands for future generations.

Considering the economic potentiality of ecological services of wetlands (Maltby et al., 2013) to human life, its valuation is based on non-market site-specific property based techniques (Table-1).

Table 1: Valuation methods of wetland services (Barbier et al., 1997)

Method	Applicable to	Description and importance
Market price method	Direct use values, specialty wetland products.	The value is estimated from the commercial market(law of demand and supply)
Damage cost avoided. Replacement cost or Substitute cost method	Indirect use values: coastal protection, avoided erosion. pollution control, water retention.	The cost of constructing and operating a water treatment plant can provide an estimate of the value of removing organic pollutants or any other pollutants. Similarly, the potential damage costs avoided in the event of flooding can help estimate the value of flood control measures.
Travel cost method	Recreation and tourism	The recreational value of a site can be determined by the amount of money individuals invest in visiting the location.
Hedonic pricing method	Future use and Non-use values.	This approach is employed when the value of wetlands impacts the cost of goods being sold. The presence of clean air, expansive bodies of water, or picturesque vistas will enhance the value of residential properties and plots of land.
Contingent valuation method	Tourism and non-use values.	One effective approach to estimate the Non-use values is by directly questioning individuals about their willingness to pay for specific environmental services. This method, known as the "stated preference method," is frequently employed as it allows for a more accurate estimation.
Contingent choice method	wetland goods and services	Estimate values by soliciting individuals to make tradeoffs among various sets of ecosystem or environmental services.
Benefit transfer method	General ecosystem services and recreational use	Economic values are estimated by applying benefit estimates from previous studies conducted in different locations or contexts.
Productivity method	For specific wetland goods and services; water, soil, air-humidity.	Calculates the monetary worth of wetland resources or benefits that contribute to the manufacturing of goods sold in the market.

Wetland economic assessment

Increasing exploitation and degradation of wetlands has an adverse impact on its economic values and so a number of economic assessment methods used by different economists has been synthesized to form an integrated wetland economic assessment framework. It involves analysis of wetland functions, policy and stakeholder along with wetland service valuations. The outcome needs to be communicated to all stakeholders and decision makers. Additional activities of expert consultation, multi-function use, total economic valuation and environmental impact assessment form the part of policy analysis. For management and policy measures, cost-benefit analysis, multi-criteria analysis need to be applied as component of trade-off analysis.

The economic assessment methodology calculates the option of wetland to either maintain its natural condition or undergo degradation or conversion to a different purpose, resulting in the acquisition or loss of certain values. Wetland values are frequently overlooked or undervalued in decision-making processes, resulting in degradation or complete destruction of these vital ecosystems (Dutta et al., 2014).

Wetland ecosystem *vs* socio-economics

The linkage between social and ecological systems (Masi et al., 2018) is of various types, which may be synergistic and co-evolutionary (Fig-4).

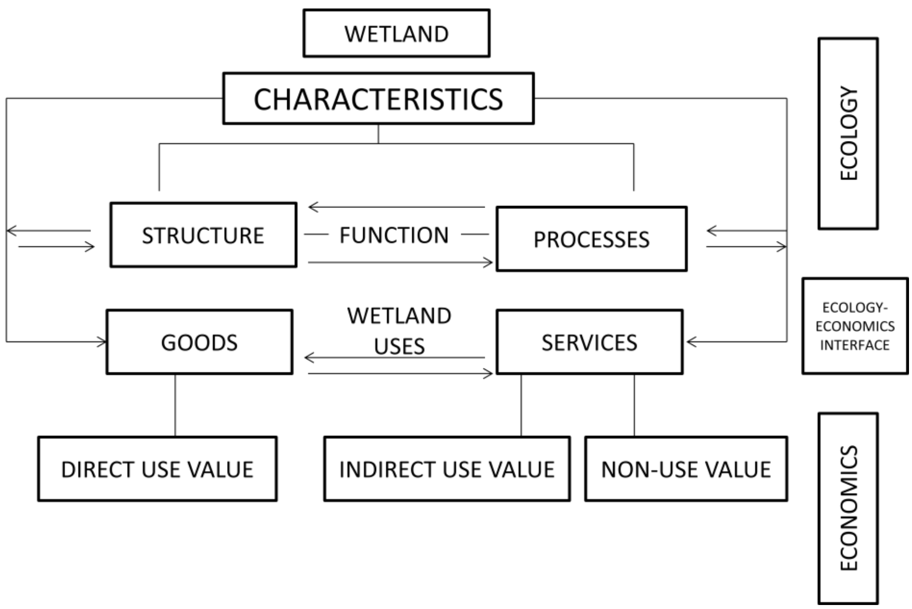

Figure 4. Ecology-economics interface of the wetland uses

However, any damage to the environment results in social vulnerability when people get exposed to that environmental stress. This may vary according to the human capacity to cope with the stress (Dey and Banerjee, 2018).This gives rise to the phenomenon of 'environmental criticality' referring to circumstances where the degree or speed of environmental decline prevents the maintenance of existing utilization methods or standards of human welfare, taking into account possible adjustments and societal capacities to react (Patra & Madhu, 2009). This social vs ecological conflict may be caused by overlooking certain cultural contexts and local technical knowledge while considering equity and economic efficiency when it comes to the sustainable use of natural resources (Ghosh et al., 2017; Gogo et al., 2023). This is because the local communities are resource-dependent and their social levels, economic position and stability are a direct function of their resource production and localized economy (Machlis et al., 1990).

In order to achieve wetland ecosystem dependent social resilience or vice-versa, a more definite and concrete relationship needs to be formulated considering the quantitative contribution of influencing factors and the magnitude of social and ecological damage.

Discussion and Conclusion:

Transitional ecosystems such as wetlands show unique ecological properties which are not only different from their individual mother ecosystems of aquatic and terrestrial but also highly dependent on both due to their interactive mode of functioning. A number of international forums have focused on the multidisciplinary aspects of wetland ecosystem degradation among others. Irrespective of variable sizes, wetlands' ecological and economic valuation is similar in significance and uniqueness. The main reason behind anthropogenic destruction of wetlands is that they do not value the services of wetlands in economic and monetary terms. This is because they do not understand or give importance to the valuable, interactive ecological processes of the wetlands capable of generating livelihood. Thus an interactive situation between ecology and economy of wetlands is required for resilience and sustainability.

The economic values of non-market goods and services such as that from wetlands, should be measured in monetary terms to recognize true economic contribution, maximize long-term benefits, and increase investment in conservation. Therefore, it is required to integrate ecological and economic modelling and analysis in order to assess the potential future impact of this ecosystem-dependent socio-economic condition of an area, helping to meaningful adoption of policies.

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