The Social Science Review
A Multidisciplinary Journal
ISSN: 2584 – 0789
(Open Access, Peer-Reviewed, Refereed, Bi-Monthly Journal)
www.tssreview.in

A REVIEW OF THE MANGROVE FOREST'S SERVICES TO THE ECOSYSTEM AND ENVIRONMENT

[1]Dr. D. S. Narayankar and [2]Mr. Abhijeet Ghosal

[1]Assistant Professor, Department of Geography,
SSA College of Arts and Commerce, Solapur, Maharashtra, India
ORCID ID: *https://orcid.org/0009-0008-0398-0004*

[2]Research Scholar, Department of Geography,
Punyashlok Ahilyadevi Holkar Solapur University, Solapur, Maharashtra, India
ORCID ID: *https://orcid.org/0000-0003-3142-5995*

Abstract

Mangrove trees are valuable both economically and medicinally, but perhaps most critically, they provide special ecological functions. Three crucial ecological functions are: (a) providing a nursery for crabs, fish, prawns, and other animals; (b) preventing coastal erosion; and (c) managing carbon dynamics, which includes fixation, storage, and export. Based on recent studies conducted throughout the world, this paper critically assesses these responsibilities. There is no denying that mangrove forests provide a wide range of ecological benefits. However, the degree and scope of these environmental behaviors differ based on several variables. Certain factors include its biogeographical position, the extent of urbanization-related disturbance, aquaculture, tourism, the variety and richness of its flora and fauna, hydrological regimes, meteorological parameters (temperature, precipitation, tropical storms, etc.), and even the characteristics of nearby environments, etc. It is also clear that the main danger to the mangrove ecosystem itself and, consequently, to the ecological benefits that they offer is habitat damage brought on by urbanization, an overabundance of aquaculture, and tourism. Such an ecological evaluation's focus needs to be on the mangrove ecosystem's services and the most recent effects of climate change and global warming.

Keywords: *Mangrove, Ecological services, Climate change, Global warming*

Introduction

One of the planet's most unusual ecosystems is the mangrove forest. They can be found in tropical and subtropical areas' coastlines in the intertidal zones. Mangrove trees thrive in environments where the majority of other plants would probably perish. Plant life is continuously stressed by this type of habitat due to a number of factors, including high salinity, immersion, limited oxygen, and strong UV radiation. However, mangrove plants are survivors and fighters. They have several adaptive traits that allow them to grow, bloom, and procreate in spite of all these stressful situations. In addition, they possess significant economic and medical worth, but above all, they provide exceptional ecological benefits.

Mangrove research has seen a major boost in recent years. Additionally, the focus of this kind of study has shifted from studies of biodiversity to ecological services. Furthermore, the study's focus on the mangrove ecosystem has expanded from a local to a regional and ultimately global scale. The following factors were the main emphasis of this type of ecological evaluation: (a) fish, crab, prawn, and other fauna nursery; (b) protecting coastal erosion; and (c) carbon dynamics, which includes fixation, storage, and export/sequestration of carbon (Alongi, 2012).

Mangrove forests serve as a nursery for prawns, fish, and other fauna

In addition to a wide range of invertebrates, the mangrove environment serves as a home for vertebrates such as several fish species, reptiles, and even many mammals. Because it sustains an average greater number of individuals per area of land than other habitats inhabited by juveniles, it acts as a nursery for fish and crustaceans. Mangrove plants' distinctive root systems, the abundance of food that is readily available, and the high turbidity, poor visibility, and low-depth microhabitats that deter predators are all thought to be contributing factors to the greater conversion rate (Nagelkerken, 2009). The intricate root structure of mangroves significantly reduces the ability of larger creatures to prey on smaller prawns and fish. Prey-predator interactions are reduced to a low frequency by thick vegetation and turbidity. Additionally, shelled fauna receives a fair deal of protection during the ecdysis phase (Manson et al., 2005). There are others who question the beneficial function of mangroves in supporting fish and crustaceans. However, such figures mostly show a high incidence of juvenile fish and prawn capture rather than fatalities during the juvenile to adult-phase of the transition (Faunce & Serafy, 2006). Barbier et al. (2011) conclusively showed the important significance that mangroves have for reef fishes along Tanzania's coast. A comparable outcome was attained in the Caribbean. However, a less important function has been identified in the Virgin Islands of the Caribbean and the western Atlantic (Faunce & Layman, 2009). Therefore, the utility of mangroves as nurseries varies depending on the region.

This variance results from variations in several characteristics that exist in two different mangrove ecosystems. These characteristics include the tidal amplitude, variations in hydrology, and the makeup of the flora and fauna. In order to survive, species that live in places that are left exposed when low tide relocate to an adjacent environment. Therefore, mangroves alone do not make up the nursery; rather, they are a component of a broader environment. Because of "trophic relay," the presence of such nearby habitat components and their physico-chemical characteristics are important. As a reservoir of resources that continually replace and augment at difficult periods like food shortages, such habitat connectedness is also required in permanently submerged mangroves (Drew & Eggleston, 2008). The survival and productivity of fish and prawns likewise rise with the quantity and diversity of nearby habitats, which eventually raises the mangrove's nursery value (Sheaves, 2005). Therefore, one factor influencing the nursery qualities of mangroves is also the entire landscape. The juveniles who remain in the mangrove habitat component develop better and have a higher survival rate as a result of these habitat modifications that lessen intraspecific competition. Those that are somewhat developed and less vulnerable to predators leave the nursery area and go to open seas (Mumby et al., 2004). Smaller organisms and those with shorter lifespans do not require as many different types of habitats.

Stable isotope tracers, or micro tags, have been used in recent studies to track several factors, including juvenile numbers, growth, survival, and migrations. Otolith microchemistry is another effective method for evaluating the function of mangroves as nurseries (Kimirei et al., 2013). Jones et al. (2010) used these creative methods to provide compelling evidence for the "Habitat Mosaic Hypothesis." According to molecular research, mangrove environments may be identified by host species via olfactory signals (Huijbers et al., 2012). It has been demonstrated that marine acidification-induced pH lowering adversely affects this kind of olfactory monitoring (Munday et al., 2009). To more precisely identify the significance of habitat connectivity, further research employing contemporary instruments and methodologies has to be conducted (Meynecke et al., 2007).

Mangroves: To Protect the Coast

Mangroves have long been believed to contribute positively to coastal protection, both via scientific research and circumstantial evidence. According to Zhang et al. (2012), several models have been put up that demonstrate mangroves' capacity to provide coastal defence against tropical storms with a moderate degree of ferocity. Fully developed mangrove vegetation considerably reduces a storm's speed as well as the wave energy it produces. According to several studies, mangrove forests act as a barrier between the adjacent coastal area and the sea (McIvor et al., 2012). A variety of factors across three hierarchical levels – species, community, and landscape – determine the extent of protection. The root system of mangrove plants varies widely, providing varying levels of protection. While mangrove trees are shown as cylinders in all storm surge resistance models, this is not the case in practise. These factors result in results that are less reliable (Iimura & Tanaka, 2012). The degree of protection is determined in part by the vegetation community's anatomy, species composition, density, and maturity level (Ohira et al., 2013). The kind of mangrove forest, the geomorphologic context, and the general landscape all play significant roles in this (Dahdouh-Guebas & Jayatissa, 2009).

Many studies on mangroves' capacity to defend coastlines were released following the 2004 Indian Ocean tsunami. Several criteria were important for determining the level of protection and harm. The protective capability of forest structure is diminished when grazing or tree cutting results in the creation of bare patches. Another important factor is the existence, biological state, and integrity of the mangrove forest's interconnected ecosystems. Therefore, in order for mangroves to continue their role as coastal protectors, the surrounding ecosystems need to be safeguarded and kept free from human interference, such as building harbors. Less damage was done to the settlements behind the mangrove forest. Mangroves were unable to provide enough defence against powerful occurrences like tsunamis. These kinds of woods managed hostile occurrences with a moderate amount of energy. Better defense against storms with cyclones and El Nino-generated excessive rainfall is provided, with these events happening every few months or years. However, because of the minimal amount of sediment accretion brought about by these tides, mangroves are powerless to stop erosion in the face of regular tidal occurrences. According to Bayas et al. (2011), the floating debris might act as an erosion barrier or perhaps even as its source.

According to Duke et al. (2007), forests of mangroves are continuing to disappear quickly as a result of growing human pressure. Remote sensing data makes it abundantly evident that the forest's continuity has been broken. These broken-up woods are less equipped to serve as protective environments. Mangroves are a good source of fuel, lumber, and medicinal materials. They are therefore frequently exploited without any corresponding sustainable management techniques. These woods' biological functions, such as protecting the shoreline, are being jeopardized in the course of fulfilling these commercial purposes. In addition to destroying the forest cover, human activity has a detrimental impact on mangroves' health and capacity to regenerate, which lowers the protective services that they provide (Wever et al., 2012). "Cryptic ecological degradation," in which the species mix has changed but the forest cover remains unchanged, is another significant cause. Since distant sensing cannot identify such items, they are typically ignored. In addition to causing losses in terms of money, time, and effort, unscientific plantation concepts have had negative effects (Lewis, 2005).

According to certain ecological models, mangrove plant habitat range alterations might result from climate change (Quisthoudt et al., 2013). Then, there's a chance that mangrove populations may grow along the coast and that mangrove-free coastline will be colonized. If such events do occur, there may be an improvement in coastal protection.

Carbon Dynamics: Export, Storage, And Fixation

Despite their limited species richness, mangrove forests are among the planet's most productive ecosystems. They fix atmospheric carbon through photosynthetic processes at a level that is more than enough for their continued growth and development. This opens up the possibility of exporting and storing. Mangrove ecologists frequently believe that mangroves "outwell," or export carbon to the atmosphere, on a net basis. Herbivory does cause some fixed carbon to be lost, however, estimates of this loss seldom go over 3% of all fixed carbon (Sousa & Dangremond, 2011). However, there is a hidden issue with these figures since they disregard their below-ground equivalent and are dependent only on biomass and above-ground production.

According to certain writers, such as Bouillon et al., there is a considerable amount of "inwelling" that results from the silt and organic material being trapped, which is further encouraged by the water current slowing down because of the intricate ground structure of the mangrove ecosystem. It appears that the detritus food chain processes the majority of the fixed carbon in mangrove plants. In addition to the aspect of quick mineralization, the amount of mangrove debris converted to faunal biomass is not as substantial (Kristensen et al., 2008).

Mangroves store carbon mostly because of two processes: (a) macro and microorganisms using the debris from the mangroves; and (b) changes in tidal amplitude that impact export and storage. The primary kind of carbon that macro consumers may use is leaf litter. However, the low levels of nitrogen (<1% N, high C/N ratio) & very refractory character of mangrove leaf debris present a significant disadvantage to this approach. Tracer isotope tests provide no evidence for the hypothesis either. Leaf litter is consumed by macro consumers, but they cannot live only on this high-carbon, low-nitrogen meal. The consumption idea is supported by the existence of cellulase, an enzyme, in both herbivorous and detritivores (Adachi et al., 2012). An alternative to supply the nitrogen need might be animal predation (Lee, 2008).

The consumption of detritus by gastropods, such as grabsid crabs, and the existence or occurrence of variables that facilitate detritus export are the two main factors that determine the quantity of detritus carbon stock. Tidal amplitude and river flows affect the amount of export. Increased rainfall encourages leaf litter outflow rather than storage. Increased cyclone frequency and intensity, which are thought to be a consequence of global warming, are changing the current export pattern.

Conclusion

In summary, there is no question that mangrove forests provide a wide range of ecological functions. The degree and scope of these environmental behaviors, however, differ based on several variables. Several factors contribute to the forest's characteristics, such as its size and isolation, biogeographical location, level of urbanization, aquaculture, tourism, richness and diversity of plant and animal life, hydrological regimes, climate variables (such as temperature, rainfall, and tropical storms), and the forest's synergistic relationship with neighboring habitats. It is also clear that the main danger to the mangrove ecosystem itself and, consequently, to the ecological services they offer is habitat degradation brought on by urbanization, excessive aquaculture, and tourism. The outflow of garbage from homes, farms, and aquaculture that mixes with mangrove detritus causes complex interactions.

References

1. Adachi, K., Toriyama, K., Azekura, T., Morioka, K., Tongnunui, P. & Ikejima, K. (2012). Potent cellulase activity in the hepatopancreas of mangrove crabs. *Fisheries Science, 78,* 1309–1314.
2. Alongi, D.M. (2012). Carbon sequestration in mangrove forests. *Carbon Management, 3,* 313–322.
3. Barbier, E.B., Hacker, S.D., Kennedy, C., Koch, E.W., Stier, A.C. & Silliman, B.R. (2011). The value of estuarine and coastal ecosystem services. *Ecological Monographs, 81,* 169–193.
4. Bayas, J.C.L., Marohn, C., Dercon, G., Dewi, S., Piepho, P.H., Joshi, L., Noordwijk, M. & Cadisch, G. (2011). Influence of coastal vegetation on the 2004 tsunami wave impact in west Aceh. *Proceedings of the National Academy of Sciences USA, 108,* 18612–18617.
5. Dahdouh-Guebas, F. & Jayatissa, L.P. (2009). A bibliometric review on pre- and posttsunami assumptions and facts about mangroves and other coastal vegetation as protective buffers. *Ruhuna Journal of Science, 4,* 28–50.
6. Drew, C.A. & Eggleston, D.B. (2008). Juvenile fish densities in Florida Keys mangroves correlate with landscape characteristics. *Marine Ecology Progress Series, 362,* 233–243.
7. Duke, N.C., Meynecke, J.O., Dittmann, S., Ellison, A.M., Anger, K., Berger, U., Cannicci, S., Diele, K., Ewel, K.C., Field, C.D., Koedam, N., Lee, S.Y., Marchand, C., Nordhaus, I. & Dahdouh-Guebas, F. (2007). A world without mangroves? *Science, 317,* 41–42.
8. Faunce, C.H. & Layman, C.A. (2009). *Sources of variation that affect perceived nursery function of mangroves.* In: Ecological connectivity among tropical coastal ecosystems (ed. by I. Nagelkerken). pp. 401–421. Springer, New York.
9. Faunce, C.H. & Serafy, J.E. (2006). Mangroves as fish habitat: 50 years of field studies. *Marine Ecology Progress Series, 318,* 1–18.
10. Huijbers, C.M., Nagelkerken, I., Lossbroek, P.A.C., Schulten, I.E., Siegenthaler, A., Holderied, M.W. & Simpson, S.D. (2012). A test of the senses: fish select novel habitats by responding to multiple cues. *Ecology, 93,* 46–55.
11. Iimura, K. & Tanaka, N. (2012). Numerical simulation estimating effects of tree density distribution in coastal forest on tsunami mitigation. *Ocean Engineering, 54,* 223–232.
12. Jones, C.G., Gutiérrez, J.L., Byers, J.E., Crooks, J.A., Lambrinos, J.G. & Talley, T.S. (2010). A framework for understanding physical ecosystem engineering by organisms. *Oikos, 119,* 1862–1869.
13. Kimirei, I.A., Nagelkerken, I., Mgaya, Y.D. & Huijbers, C.M. (2013). The mangrove nursery paradigm revisited: otolith stable isotopes support nursery-to-reef movements by Indo-Pacific fishes. *PLOS One, 8* (6), 1-8.
14. Kristensen, E. (2008). Mangrove crabs as ecosystem engineers; with emphasis on sediment processes. *Journal of Sea Research, 59,* 30–43.
15. Lee, S.Y. (2008). Mangrove macrobenthos: assemblages, services, and linkages. *Journal of Sea Research, 59,* 16–29.
16. Lewis, R.R. (2005). Ecological engineering for successful management and restoration of mangrove forests. *Ecological Engineering, 24,* 403–418.
17. Manson, F.J., Loneragan, N.R., Harch, B.D., Skilleter, G.A. & Williams, L. (2005). A broad-scale analysis of links between coastal fisheries production and mangrove extent: a case study for northeastern Australia. *Fisheries Research, 74,* 69–85.
18. McIvor, A.L., Möller, I., Spencer, T. & Spalding, M. (2012). *Reduction of wind and swell waves by mangroves.* Natural Coastal Protection Series: Report 1. The Nature Conservancy and Wetlands International, Cambridge, UK.
19. Meynecke, J.O., Lee, S.Y., Duke, N.C. & Warnken, J. (2007). Relationships between estuarine habitats and coastal fisheries in Queensland, *Australia. Bulletin of Marine Science, 80,* 773–793.
20. Mumby, P.J., Edwards, A.J., Arias-Gonzalez, J.E., Lindeman, K.C., Blackwell, P.G., Gall, A., Gorczynska, M.I., Harborne, A.R., Pescod, C.L., Renken, H., Wabnitz, C.C.C. & Llewellyn, G.

(2004). Mangroves enhance the biomass of coral reef fish communities in the Caribbean. *Nature, 427*, 533–536.

21. Munday, P.L., Dixson, D.L., Donelson, J.M., Jones, G.P., Pratchett, M.S., Devitsina, G.V. & Doving, K.B. (2009). Ocean acidification impairs olfactory discrimination and homing ability of a marine fish. *Proceedings of the National Academy of Sciences USA, 106* (6), 1848–1852.
22. Nagelkerken, I. (2009). *Evaluation of nursery function of mangroves and seagrass beds for tropical decapods and reef fishes: patterns and underlying mechanisms. Ecological connectivity among tropical coastal ecosystems.* (ed. by I. Nagelkerken), Springer, New York, 357–399.
23. Ohira, W., Honda, K., Nagai, M. & Ratanasuwan, A. (2013). Mangrove stilt root morphology modeling for estimating hydraulic drag in tsunami inundation simulation. *Trees – Structure and Function, 27*, 141– 148.
24. Quisthoudt, K., Randin, C.F., Adams, J., Rajkaran, A., Dahdouh-Guebas, F. & Koedam, N. (2013). Disentangling the effects of climate and land-use change on the current and future distribution of mangroves in South Africa. *Biodiversity and Conservation, 22*, 1369–1390.
25. Sheaves, M. (2005). Nature and consequences of biological connectivity in mangrove systems. *Marine Ecology Progress Series, 302*, 293–305.
26. Sousa, W.P. & Dangremond, E.M. (2011). *Trophic interactions in coastal and estuarine mangrove forest. Treatise on estuarine and coastal science* (ed. by E. Wolanski and D.S. McLusky), Elsevier, Waltham, MA. 43–93.
27. Wever, L., Glaser, M., Gorris, P. & Ferrol-Schulte, D. (2012). Decentralization and participation in integrated coastal management: policy lessons from Brazil and Indonesia. *Ocean and Coastal Management, 66*, 63–72.
28. Zhang, K., Liu, H., Li, Y., Xu, H., Shen, J., Rhome, J. & Smith, T.J. (2012) The role of mangroves in attenuating storm surges. Estuarine, *Coastal and Shelf Science, 102*–103, 11–23.