A brief review of Merits and Demerits of Coastal Bio-shielding

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Prepared by	Reviewed by	Approved by
Sd/-	Sd/-	Sd/-
Ms. Parvathy S Junior Research Fellow HVRA Cell	Dr. Sekhar L. Kuriakose Head (Scientist) HVRA Cell	Prof. Dr. Keshav Mohan Director ILDM

Hazard, Vulnerability and Risk Assessment Cell
Department of Revenue and Disaster Management, Govt. of Kerala
2nd Floor, Institute of Land and Disaster Management
PTP Nagar, Thiruvananthapuram 695038
Tel/Fax: 0471-2364424
Email: hvracell.gok@gmail.com

Introduction

Bio-shields are strips of trees and shurbs along the coasts to protect coastal areas from high velocity winds and waves. They serve as sandbinders and also reduce wind speed during cyclones. Bio-shields can prevent the entry of seawater into the mainland during the cyclones and tsunami. During December 2004 tsunami the Pichavaram mangrove forest protected about 6000 people living in the hamlets from the tsunami (MSSRF, 2001).

Mangroves are considered as an excellent bio-shield since they have many advantages. They are the most productive and bio diverse wetlands on earth. These marine tidal forests are the most luxuriant around the mouths of large rivers and in sheltered bays and are found mainly in tropical countries where annual rainfall is fairly high. Mangrove plants possess a number of unique adaptive features to grow in saline and oxygenless soil. The most striking adaptation is the aerial roots, which are otherwise called breathing roots. Many environmentalists have the opinion that mangroves form a natural buffer between land and sea and can prove as a ravage of nature.

Merits

Mangroves are defined by the presence of trees that mainly occur in the intertidal zone, between land and sea, in the subtropics. The intertidal zone is characterized by highly variable environmental factors, such as temperature, sedimentation and tidal currents. The aerial roots of mangroves partly stabilize this environment and provide a substratum on which many species of plants and animals live. Above the water, the mangrove trees and canopy provide important habitat for a wide range of species. These include birds, insects, mammals and reptiles. They possess mechanisms to deal with intense sunlight rays and solar UV-B radiation. This ability of mangroves makes the environment free from the deleterious effects of UV-B radiation (Moorthy and Kathiresan, 1997).

They stores and process huge amounts of organic matter, dissolved nutrients, pesticides and other pollutants and by absorbing excess phosphates and nitrates prevent the contamination of coastal water. In doing so they play a vital role in protecting coral reefs and sea grasses from siltation and eutrophication (Moorthy and Kathiresan, 1997).

Mangroves are biogenic systems that accumulate sedimentary sequences, where cores can provide records of mangrove species variation in distribution with past climate change and sea-level change. Fossil evidence used for palaeoecological reconstruction is based on organic remains that preserve identifying features so that they can be identified to generic levels atleast. Anaerobic conditions in mangrove sediment allow the long-term preservation of these fossil records (Kathiresan, 2008).

They can also be used for carbon sequestration ie the process of capturing and storing atmosphere CO_2 while releasing O_2 back to the atmosphere. The process is considered as crucial step in mitigating impacts of climate change as CO_2 emission is one of the key contributing factors to global warming (Kathiresan, 2008).

Mangrove extracts are used in indigenous medicine for example Bruguiera species (leaves) are used for reducing blood pressures and Excoecariaagallocha for the treatment of leprosy and epilepsy. Extracts from mangroves seem to have a potential for human, animal and plant pathogens and for the treatment of incurable viral diseases like AIDS (Kathiresan, 2000).

Mangrove forests are also important in terms of aesthetics and tourism. Many people visit these areas for sports fishing, boating, bird watching, snorkeling, and other recreational pursuits.

Mangroves ecosystems are important nursery areas and habitats for commercially valuable shrimp, shellfish, and fish species. To cite an example 40000 fishers get an annual yield of about 540 million seeds for aquaculture in the Sundarban mangroves of West Bengal (Chaudhuri and Choudhury, 1994). Harvestable benefits of mangroves include wood for fuel, furniture and construction, a source for charcoal, paper, dyes and chemicals, honey and incense. For instance, the Sundarbans provide employment to 2000 people engaged in extracting 111 tons of honey annually and this accounts for about 90% of honey production among the mangroves in India. So it acts as a source of livelihood to the local communities for eg, commercial species such as bamboos can be sold when it reaches end of its working life. The foliage of mangrove species is used to feed livestock and several mangrove plants are used for traditional medicines.

Mangrove systems offer protection to the coastline against the flood which often caused by tidal waves or due to the heavy rainfall associated with storms. The serious flood disaster of 1991 in Bangladesh would certainly minimized, had the $300km^2$ mangrove area not been cleared for shrimp farming and rice cultivation earlier. The ability of mangroves in flood control is due to the response of their root system to have a larger spread out in areas prone to tidal inundation and their roots to promote sedimentation (Kathiresan, 2008).

Besides flood control, the mangroves prevent the entry of seawater inland and thus protect from ground water salanization. Often very sharp changes have been noticed in salt concentration of groundwater at the interface between salt flats and mangroves. This suggests that the mangrove system can modify the salinity of the groundwater by lowering it drastically (Ridd and Sam, 1996).

The mangrove systems minimize the action of waves and thus prevent the coast from erosion. The reduction of waves increases with the density of vegetation and depth of water this has been demonstrated in Vietnam. In the tall mangrove forests, the rate of wave reduction per 100 m is as large as 20% (Mazda et al., 1997). Another work has proved that mangroves form live seawall and are very cost effective as compared to the concrete seawall and other structures for the protection of coastal erosion (Harada et al., 2002). The mangrove forest of 100 m width protected the sea dyke, lying behind for more than 50 years. In contrast, the rock fencing protected the sea dyke for only about five years. This is because of the fact that the rock fencing is not long resistant to wave damage, as compared to mangrove forest. The planting of mangrove has cost of US$1.1 million but has helped reduce maintenance cost of the seadyke by US$7.3 million per year (World Disaster Report, 2002).

MSSRF (M.S Swaminathan Research Foundation) in Oct 1999 observed that, mangrove forests reduced the impact of a super cyclone that struck Orissa on India's east coast killing at least 10,000 people and making 7.5 million homeless. Despite such tangible merits, the mangroves area in India reduced to about 411 ha from 1165 ha within a period of 60 years (1930 to 1994). "Mangroves for the Future (MFF)" is a regional initiative, being coordinated by UNDP and IUCN. It focuses on tsunami-hit countries such as India, Indonesia, Maldives, Sri Lanka, Seychelles and Thailand. MFF adopts a new approach by promoting partnerships to stimulate investment, thereby moving from reactive responses to proactive activities. These activities include raising awareness and capacity for secured livelihoods, disaster preparedness and resilience-building, as well as climate change adaptation measures.

Criticism

Based on the studies conducted in Thailand (Yanagisawa et al., 2009) a numerical model was proposed which shows that with a density of 0.2 trees/m^2 and a stem diameter of 15 cm in a 400 m wide area can reduce the tsunami inundation depth by 30% when the incident wave is assumed to have a 3.0 m inundation depth and a wave period of 30 min at the shoreline. Also certain analytical models show that 30 trees/100m^2 in a 100m wide belt may reduce the tsunami flow pressure by more than 90% (Hirashi and Harada, 2003).

Several studies criticized these findings as being simplistic, incomplete and over eager in interpretation. These studies indicated that the impact of the tsunami was highly dependent on topography, distance from the shore and other physical factors and vegetation contributed little protection to coast (Dahdouh-Guebas et al., 2006; Vermaat & Thampanya 2006; Wolanski, 2007). In a classic review on mangrove forests, Alongi (2008) points out that mangroves may offer limited protection from tsunamis; some models have suggested marked reduction in tsunami wave flow pressure for forests that are at least 100m in width. He also draws attention to the fact that the magnitude of energy absorption is determined by several biological and geological factors like tree density, stem and root diameter, shore slope, bathymetry, spectral characteristics of incident waves and tidal stage.

The CRZ notification 1991 had the potential to protect mangroves as it stated that all mangroves were to be classified as CRZ I. At the time of the notification in 1991, coastal plantations may not been identified as an activity requiring its own regulation under this law or even posing a threat to other coastal ecosystems. Nor did the question of coastal plantations as an effective protection measure arise. Therefore the CRZ offers little by way of policy guidance for such activities on the coast; in fact it allows these activities just as it allows seawalls (Mukherjee et al., 2008).

Demerits

However, a vegetation barrier cannot completely stop a tsunami and its effectiveness depends on the magnitude of the tsunami as well as the structure of vegetation. Local communities have diverging opinions about coastal plantations. Access to and visibility of the seashore and sea is crucial for fishermen in their daily decision making a part of the fishery livelihood. In addition, the beach is also used for fishing activities such as fish drying and mending of nets.

An open gap in the forest can channel and amplify a strong current by forcing it into the gap; it is one of the demerits of coastal forests. Another demerit is floating debris from broken trees also can damage surrounding buildings and hurt people. However some of these demerits can be overcome with proper planning (Kathiresan, 2008).

Conclusion

Bio-shielding can prevent coastal erosion to a large extent but is not the only suitable method for coastal protection or tsunami impact reduction. Hence it is not appropriate to implement bio-shielding all along the Kerala coast and before doing so a detailed study on the topography, geology and coastal erosion processes prevailing in the area has to be carried out. A replicable case of efficient coastal protection using bio-shielding was implemented by NARBONA Society and Kerala Forest and Wildlife Department (Social Forestry Wing) along the Punnapra coast of Alappuzha.

Based on the above review it is recommended that the merits of bio-shielding as against structural measures for coastal protection and thereby reduction of the magnitude of the impacts of coastal hazards may be brought to the attention of Dept. of Irrigation and Harbor Engineering and a collective effort for implementing similar projects along Kerala coastline at stretches found suitable for bio-shielding based on the local topography, geology and coastal erosion processes that are active may be coordinated by the State Disaster Management Authority in collaboration with the respective departments.

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