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IMPACT OF TSUNAMI ON MANGROVE FOREST COVER ALONG THE CUDDALORE COAST USING REMOTE SENSING DATA

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ABSTRACT

Mangrove forests form one of the primary coastal ecosystems in the tropical and subtropical region of the world. They are biologically diverse and have therefore traditionally been utilized for food resources, firewood, charcoal, timber and other minor products. However, mangrove ecosystems are very sensitive and fragile. In recent years, the pressures of increasing population, and the resulting expansion of agricultural land and industrial and urban development, have caused a significant proportion of the world's mangrove resource to be destroyed. In addition, significant areas of mangrove swamps in Indonesia and other regions of Southeast Asia have been developed to create ponds for the commercial production of fish and shrimps. The mangrove ecosystem forms as a natural barriers and protects the coast from natural disasters like, seasonal cyclones and tsunamis. Hence the present study aims to map the mangrove forest using optical remote sensing data during the pre and post Asian tsunami periods; and also to assess the impact of mangrove forest cover and how this has been a protective cover to the coast in Cuddalore coast zone. For this purpose Indian remote sensing digital data have been used to study the pre and post tsunami conditions and the mangrove ecosystem.

INTRODUCTION

Information is crucial in order to assess mangrove deforestation, to monitor the state of the remaining mangrove forests and ensure their sustainable management. In mangrove areas, the task of collecting information by ground inventory is extremely difficult, time consuming and, therefore, expensive. For this reason, remote sensing is an attractive means of obtaining data for defining deforested areas and updating management plans. In Indonesia, a serious drawback to using optical satellite images for mangrove monitoring has been the unavailability of cloud-free images at the time of interest. The advent of radar systems is expected to resolve this problem. Unlike optical systems, radar systems can be operated day or night and have all weather capability. They can therefore penetrate clouds cover, fog, rain and atmospheric dust. Furthermore, radar energy has the ability to penetrate tree canopies and some surface features. This paper describes research to compare three different radar satellite imaging systems (ERS-1, JERS-1, and Radar sat) and three types of optical satellite data (Land sat TM, MSS and Spot XS) for detecting and monitoring mangrove deforestation in the delta of the Mahakam River on the coast of East Kalimantan.

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Mangrove forest in Tamilnadu

The whole of the mangrove comprises about 51 small and large islands with their sizes ranging from 10 m^2 to 2 km^2. The mangrove soil usually consists of alluvium derived from the mangrove plants. About 40 Per cent of the total area is covered by water ways, 50percent by forest and the rest by mud flats, sandy and salty soils. There are numerous creeks, gullies and canals traversing the mangroves with a depth ranging from 0.5 to 1.5 m and discharging freshwater into the system. A major irrigation channel is mainly discharging agricultural waste water from the entire upper reaches to this mangrove. Pichavaram mangrove did not receive much attention during pre and post independence periods. A map published by the Cuddalore District authorities in 1882 is the document which was first made available to public. Then, only during the later part of 20th century (Thirumalairaj, 1959) explored the Pichavaram mangrove and Venkatesan (1966) listed the floral communities in the region in relation to environmental factors. French institute, Pondicherry is one of the pioneering institutes in exploring Pitchavaram and contributed several publications on the wealth of the mangroves (Blasco, 1975; Meher Homji, 1979)). The Centre of Advanced Study in Marine Biology, right from its inception in 1961 has been involved in various research activities in Pichavaram mangrove. Water quality, floral and faunal composition, micro flora, Ichthyofauna, bioactive substances from mangroves, fishery resources, larval development, heavy metals and Organochlorine residues, Methanogens, Cyanobacteria, wood Biodeterioration and UV - radiation are all studied extensively by this Centre. During 90s, M.S. Swaminathan Research Foundation (MSSRF), Chennai, India established a mangrove Genetic Resource Conservation Centre here by adopting 50 ha forest area. In addition, Centre for water Resources, Anna University, Chennai has remotely sensed Pichavaram forest with satellite imageries. The mangrove flora in India comprises 35 species under 16 genera and 13 families. Of these 33 species (16 genera and 13 families) are present along the east coast (Kathiresan, 1998). The east coast of India and Andaman and Nicobar Island shows high species diversity. Pichavaram mangrove is one of the rare mangrove forests in India and it represents 14 exclusive mangrove species (Kannupandi and Kannan, 1998). Avicennia marina alone constitutes nearly 30 per cent of the total population followed by Bruguiera cylindrica (17 per cent) and Avicennia officianalis (16 per cent).

The population density of other species is poor and many of the species are on the verge of total extinction. According to a recent statistics, it is found that nearly 62.8 per cent of the Pichavaram mangrove forests were degraded between 1897 and 1994. Tissot (1987) investigated the change that has taken place in the vegetation of the Kaveri delta over a period of 2000 years. It has been found that the breadth of the beach protecting the mangrove areas from wave action at Pichavaram mangrove has reduced by 550 m between 1970 and 1992. The substantial reduction in the forest cover is due to frequent cyclones at least every alternate year which divested several mangrove species and reduced the total area from 4000 ha in the beginning of the century to nearly 1100 ha at present. As a result of this, many plants previously recorded from Pichavaram mangrove have completely vanished. For example, the pollen analysis of the sediments from Pichavaram showed that Sonneratia was abundant here in the past (Caratini et al., 1973), which is on the verge of extinction at present. Further, occurrence of Aegiceras flordium reported from this area by Krishnamurthy (1978) could not be confirmed by Muniyandi (1985). Certain species like Xylocarpus granatum, Rhizophora stylosa and Bruguiera gymnorrhiza which were once collected from this mangrove are not available at present (Kannupandi and Kannan, 1998). It is also found that most of the individuals of Rhizophora sp. are aged and the rate of reproduction is also low at Pichavaram mangrove. It seems to be on its way to extinction at this mangrove, being replaced by the much more dynamic Avicennia marina (Kannupandi and Kannan, 1998). From the Pichavaram mangrove ecosystem about 100 species of diatoms, 20 species of dinoflagellates, 40 species of tintinnids, 30 species of copepods, 30 species of prawns, 30 species of crabs, 30 species of mollusks and 200 species of fish have been recorded (Anon, 1987).

Impact of Tsunami on Mangrove ecosystem

A bout likely damage, made on this page, as follows: The impact of the recent Asian tsunami on ecosystems from Indonesia to East Africa will take a long time and significant resources to assess. The first major report Status of Coral Reefs in Tsunami Affected Countries: 2005 has just been completed and confirms the earlier predictions. There is likely damage to the structure and function of the coastal ecosystems (coral reefs, mangroves, sea grasses, estuarine mudflats): The physical structure has been damaged by the force of the wave itself, physical removal of flora and fauna and increased sediment load which will have killed sediment sensitive corals and sea grasses by smothering. The extent of this damage is being assessed and will likely vary considerably depending on the local topography and hydrology. Chemical changes have included saltwater intrusion, eutrophication (enrichment) of the water resulting from increased runoff, raw sewage and decomposition of flora and fauna including unrecovered bodies. There will be the slower decomposition of timber from mangroves, fishing boats and buildings. Non biodegradable waste such as plastics has contributed to a buildup in marine debris. Toxic wastes, which were inadequately stored, may have been dispersed, as has been reported on beaches in Somalia. Exotic (introduced) species used for aquaculture have escaped. Finally, the biological structure of the ecosystem could be disrupted as various species at different tropic levels were differentially removed. With the structure altered, ecosystem functions could be altered.

Study area description

Pichavaram is located 51 km north east of Chidambaram, Cuddalore district, Tamil Nadu, between latitude 11°20' to 11°30' north and longitudes 79°45' to 79°55' east. It is an estuarine type of mangrove situated at the confluence of Uppanar, a tributary of the Coleroon River. Fishing villages, croplands, and Aquaculture ponds surrounds the area. This mangrove environment is attracting large number of tourists The Pichavaram mangrove wetland has 51 islets and the total area of the Vellar-Pichavaram-Coleroon estuarine complex is 2335.5 ha of which only 241 ha. is occupied by dense mangrove vegetation. Nearly 593 ha, of this wetland are occupied by helophytic vegetation like Suaeda, 262.5 ha. Barren mud flats and 1238.5 ha. Barren high saline soil (Krishnamoorthy et al., 1994) out of the 2335.5 ha of this mangrove wetland only 1100 ha. Comprising the entire mangrove vegetation located in the middle portion of the Vellar-Pichavaram-Coleroon wetland has been declared as a reserved forest. Department of Forest, Government of Tamil Nadu, declared the Pichavaram mangrove as a Reserved Forest.

Problem of statement

Pichavaram is a zone of mangrove forest which is located near the Cuddalore coast. Distribution of these of these medicinal plants grows along the estuaries and also acts as a protecting agent off the coast during the high tide periods. Most of the studied indicate that the mangrove forests protect the coast even cyclonic disturbance as and tsunamis. The present study aims to analyze the pre and post tsunami conditions and how these medicinal plants have acted as protective agents against the giant tsunami waves.

Objectives

- To map the mangrove forest areas using Remote Sensing digital data during pre and post tsunami periods,

- To assess the impact of tsunami on the mangrove forest cover and also to study how this acts as a protective agent off the coast.

Method of analysis

The Indian remote sensing digital data for the year 1971 (IRS-1C data) and 2005 IRS–1D data for the spatial resolutions of 23.5 m have been obtained from the NRSA for image analysis. The digital data for the above two time periods were subjected to digital image analysis using ENVI 4.1. The change detection tool in the ENVI software has delineated the presence of mangrove forest cover during the pre tsunami period of 1971 and the post tsunami periods of 2005. The comparative results were tabulated and the different maps were also derived for descriptive analysis.

Mangrove forest can reduce impact of tsunami

Dense mangrove forests growing along the coasts of tropical and sub-tropical countries can help reduce the devastating impact of tsunamis and coastal storms by absorbing some of the waves' energy, say scientists. When the tsunami struck India's southern state of Tamil Nadu on 26 December, for example, areas in Pichavaram and Muthupet with dense mangroves suffered fewer human casualties and less damage to property compared to areas without mangroves. But the scientists also warn that the unique coastal tropical forests are among the most threatened habitats in the world. This is due to population growth and unsustainable economic development including deliberate land reclamation for urban and industrial development, widespread shrimp farming, and chemical pollution."We have observed that mangroves often served as a barrier to the fury of water," says M. S. Swaminathan, so-called father of India’s 'green revolution', and head of the M. S. Swaminathan Research Foundation found that in October 1999, 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. More than 15 years ago, MSSRF launched a programme to restore India's vanishing mangrove forests.

One success story is the Joint Mangrove Management project, supported by the India-Canada Environment Facility with funding from the Canadian International Development Agency. Implemented in six mangrove areas along the east coast of southern India between 1996 and 2003, the project helped restore 1,447 hectares of degraded mangrove forest. The foundation adopted a three-pronged strategy. The first goal was to conserve and regenerate mangroves along India's east coast. The second involved identifying and transferring salt tolerance genes from mangroves species to crops like rice and mustard growing in coastal areas. Thirdly, the foundation has been raising awareness among local communities about impending storms and about safe fishing zones and days. Jeff McNeely, chief scientist of the Switzerland-based World Conservation Union (IUCN), also voiced concern this week about rapidly disappearing mangrove forests that offer protection against events like tsunamis.

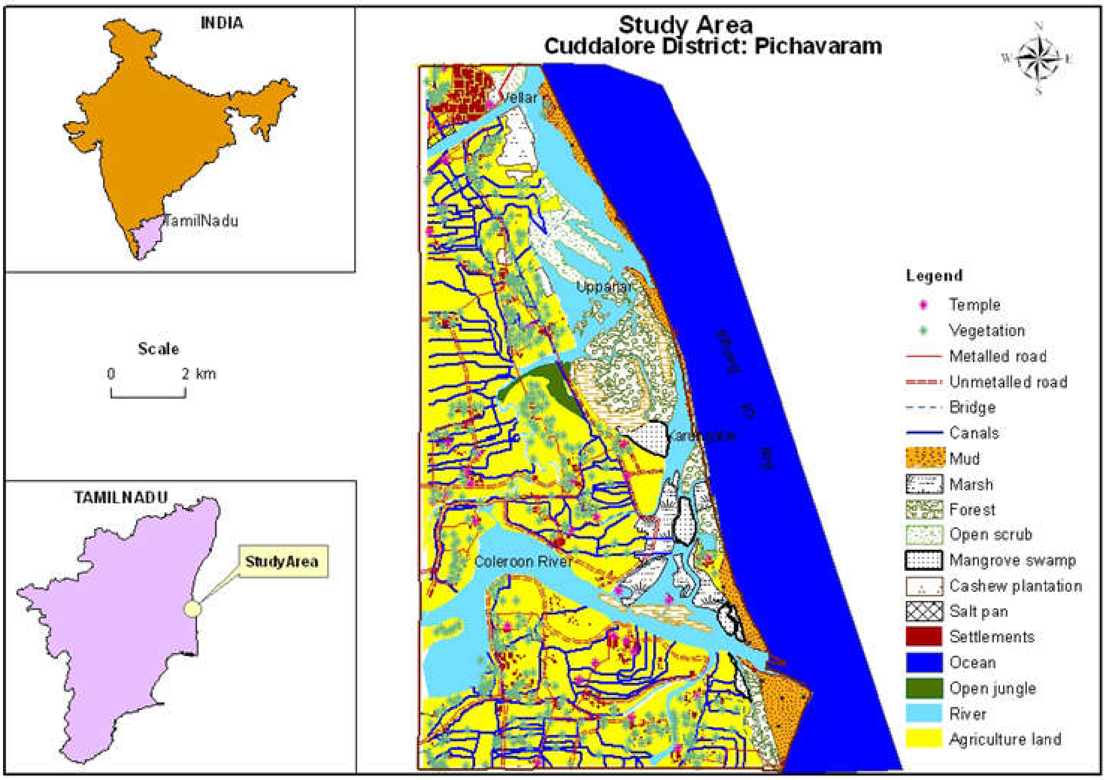

Figure 1.

McNeely told the Agency France Press news agency that over the past several decades, many mangroves have been cleared to grow shrimp ponds by, among others, outsiders granted concessions from governments to set up shrimp farms, which lacked the long-term knowledge of why the forests should have been saved. According to the US-based Earth Island Institute's Mangrove Action Project, mangrove forests once covered three-quarters of the coastlines of tropical and sub-tropical countries, but only half of that area remains intact today. In this analysis, Figure-1 shows the study area of Pichavaram along with all the physical and cultural landscape. The specific area of inters of mangrove forest has been clearly indicated. The Pichavaram land use pattern designed from the secondary information gathered from different sources. The road network with access to these forest cover. The drainage patter at the confluence stage near Bay of Bengal. Figure-2 and table-1 displays the pre and post tsunami implications along the mangrove coast of Pichavaram near Cuddalore.

shrimp farming projects without paying attention to social and ecological security, says the organization. Shrimp farming alone caused a loss of 65,000 hectares of mangroves in Thailand, according to a 2002 paper by V. P. Upadhyay an colleagues in the journal Current Science.

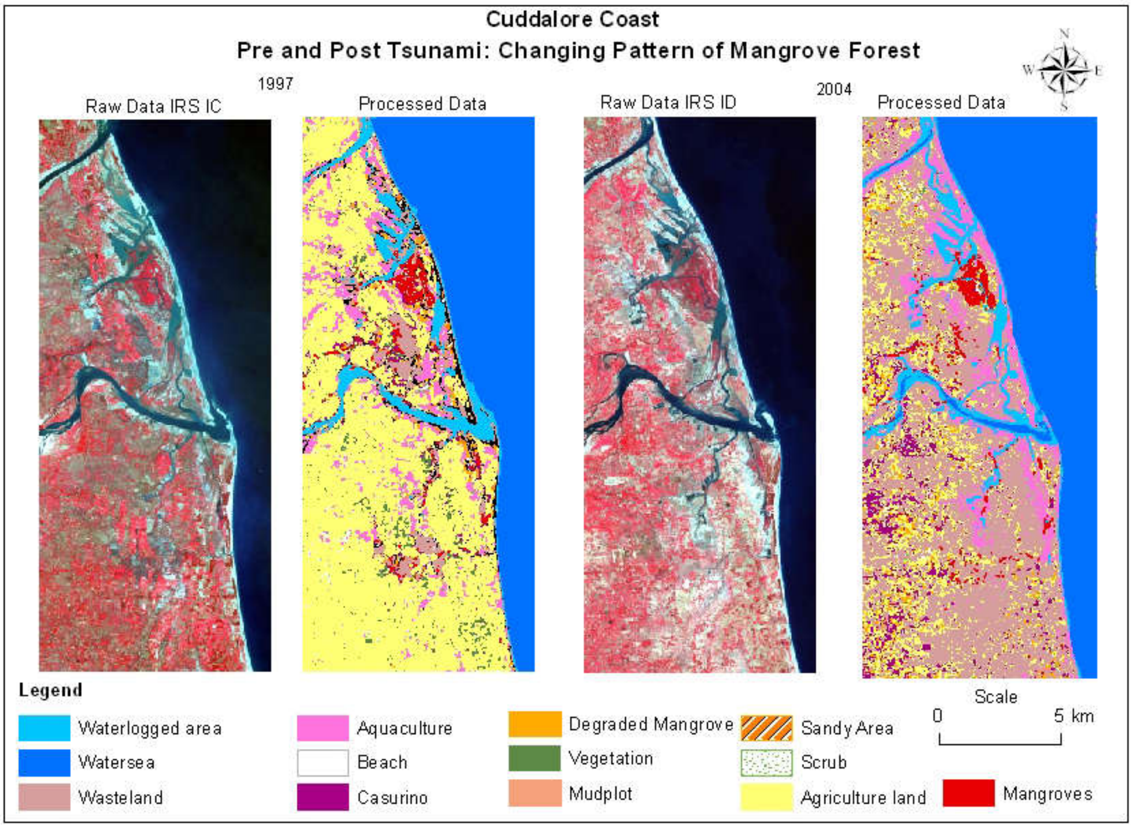

Figure 2.

Table 1. Pre and Post Tsunami Implications Results of Digital Image Analysis for Mangrove Forest Cover

No	Categories	1997 Pixel	Km^2	2005 Pixel	Km^2	Differences
1	Beach	31962	1.96	32973	2.02	+0.06
2	Sandy Area	65149	3.99	34090	2.09	-1.9
3	Degraded Mangrove	8055	0.49	209542	12.85	+12.36
4	Mangrove	11813	0.72	32497	1.99	+1.27
5	Water logged Area	53574	3.28	47923	2.94	-0.34
6	Water/Sea	669596	41.08	586785	36.00	-5.08
7	Agricultural land	510090	31.29	241209	14.80	-16.49
8	Vegetation	169123	10.37	32887	2.01	-8.36
9	Mudplot	19782	1.21	135667	8.32	+7.11
10	Scrub	230558	14.14	149335	10.16	-3.98
11	Waste land	35816	2.19	283401	17.38	+15.19
12	Aquaculture	79404	4.87	86122	5.28	+0.41
13	Casurinos	55592	3.41	36344	2.23	-1.18

Source: Results from Digital Image Analysis

The first image is the raw digital data of IRS 1C (17th February 1997) and the digitally processed data which gives different land use classifications of water logged wasteland, land put to use for aquaculture, sandy beach, causurino plants, degraded mangroves, vegetation cover, mudflats, scrubs, agriculture land categories and mangrove forest cover. The 1997 data implies the pre tsunami conditions of these land use categories. Similarly for the year 2005 (29th February 2005), that is after the great impact of tsunami along the Cuddalore coast with particular reference to the mangrove forest zones indicates small changes than the previous time period. The Mangrove Action Project says vast tracts of mangroves have been cleared to make way for shrimp farms in developing countries, and that national governments have been unable to adequately regulate the industry. Multilateral agencies are also supporting

In Indonesia, Java has lost 70 per cent of its mangrove area, Sulawesi 49 per cent, Sumatra 36 per cent. Globally the rate of decline in mangrove forest cover is 2-8 per cent each year, said the paper. In India, large stretches of mangrove forest have been severely degraded in almost all areas where they are found. As well as acting as a barrier against tsunamis, cyclones and hurricanes, mangrove forests provide society with a range of other 'ecological services'. These include preventing coastal erosion, protecting coral reefs from silting up, and providing a source of timber, food and traditional medicines.

Conclusion

Mangroves are important because they: Support commercial and recreational fish species that depend on mangroves.

Mangroves provide shelter and food for juvenile fish of many species. Including commercially important fish such as, king and banana prawns, mud crabs, barramundi, mackeral, mullet, threadfin salmon, bream, whiting, luderick, and flat head are parts of a complex coastal wetland system that recycle nutrients. Mangroves provide basic inputs of carbon to estuaries primarily in the form of dead leaves and branches. Mangroves are not usually eaten directly by herbivores, except by some insects and crabs (for example: sesarmid crabs), which eat the fallen mangrove leaves and seedlings. Most mangrove debris is subject to breakdown by bacteria and fungi before it is made available to the food chain of aquatic animals help stabilise and protect the coastline from wind, storm surges, currents, waves and tides and pollution. Mangroves protect coastal land by absorbing the energy of storm-driven wave and wind action - creating in effect a natural breakwater that helps stop erosion. A mangrove community may also provide a buffer between polluted areas and nearby marine environments.

- Protect coastlines against erosive wave action and strong coastal winds, and serve as natural barriers against tsunamis and torrential storms.
- Prevent salt water from intruding into rivers.
- Retain, concentrate and recycle nutrients and remove toxicants through a natural filtering process.
- Provide resources for coastal communities who depend on the plants for timber, fuel, food, medicinal herbs and other forest products.
- Can be harvested sustainably for wood and other products.

A re an important breeding ground for many fishes, crabs, prawns and other marine animals, essential for sustaining a viable fishing industry. Malaysia's mangroves are more diverse than those in tropical Australia, the Red Sea, tropical Africa and the Americas. About 50percent of fish landings on the west coast of Peninsular Malaysia are associated with mangroves. It is evident from the present analytical study to analyze the impact of tsunami on the coastal mangrove forest cover did not have any adverse impact. This means that mangrove forests acts as a protective agent and protecting the coastal environment. This suggests further plantation of this medicinal plant for multipurpose activities in future, in this region.

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