Did mangroves offer an effective barrier to the *Thane* cyclone surges?

Mangrove ecosystems support vital wetland communities of plants and animals. They are characterized by unique species of trees and shrubs that fringe the intertidal zone along sheltered coastal, estuarine and riverine areas in tropical and subtropical latitudes. Mangroves have played an important role in the economy of our coastal population for thousands of years, providing a variety of goods and services, including wood production, support for commercial and subsistence fisheries, aquaculture, salt production, and coastal erosion control. A mangrove ecosystem provides an ideal nursery and breeding ground for most of the marine and brackish water fish and shellfish, and is also important in the daily livelihood of local communities[1]. They are susceptible to lightning and hurricane disturbance, both of which occur frequently in the southeast coast of India. The main objective of this study was to assess the effectiveness of a mangrove barrier against cyclone, storm and strong tidal waves.

The Puducherry mangrove under study lies within lat. 11°90′107″–11°90′703″N and long. 79°80′547″–79°81′851″E. The mangrove exists as fringing vegetation over 168 ha distributed along the sides of the Ariankuppam estuary, which empties into the Bay of Bengal at Veerampattinam on the southeast coast of India (Figure 1). The channels in the mangroves are lined by a luxuriant vegetation of small salt marsh plants, trees, shrubs and thickets, totalling about 7 true mangrove species belonging to 3 families and 16 mangrove associate plants belonging to 12 families[1]. The *Avicennia* zone forms a small patch of *Avicennia marina* and *A. officinalis* dense stand at the mouth region of the estuary of Veerampattinam. The *Rhizophora* zone has four patches of *Rhizophora mucronata* and *R. apiculata* on the southern part of Thengaithittu and four patches of *R. mucronata* and *R. apiculata* near the mouth of the estuary.

Scare engaged coastal Puducherry as high tidal waves lashed the coast under the impact of cyclonic storm *Thane* which crossed the Indian coast between Cuddalore in Tamil Nadu and Nellore in Andhra Pradesh on 30 December 2011 and produced wind gusts of more than 140 km/h. According to India Meteorological Department (IMD), *Thane* was the strongest tropical cyclone of 2011 within the North Indian Ocean. Every year about 80% of tropical cyclones originate from world oceans[2]. Of these, about 6.5% develops in the Bay of Bengal and Arabian Sea[3]. While tropical cyclones can produce powerful winds and torrential rain, they are also capable of producing strong waves, damaging storm surges as well as spawning tornadoes. Climate change studies predict that while these storms may not become more frequent, they may become more intense with the warming of sea-water temperatures[3].

The *Thane* storm struck the coastline and inundated the shores with strong tidal waves, severely destroying and disturbing coastal life in Puducherry. Fishing boats anchored along the coast were either washed away or damaged due to the high tidal waves in several villages such as Kalapet, Veerampattinam and Thengaithittu. It had a large impact on the mangroves of Puducherry, with catastrophic destruction. Mangroves like *Rhizophora* spp. seem to act as a protective force against this natural calamity. Mangrove sites with no cryptic ecological degradation, or those well protected by distance inland and by *Rhizophora* spp. fringes, all experienced a low critical impact from the tsunami/storms[5]. Nevertheless, ground surveys and QuickBird pre-tsunami and IKONOS post-tsunami image analysis[5] covering the entire Tamil Nadu coast suggest less destruction of man-made structures located

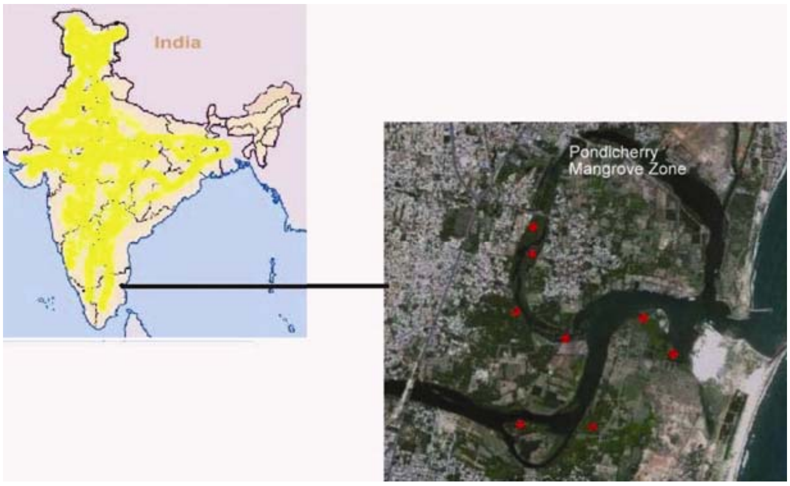

Figure 1. Study site of the Puducherry mangroves.

Figure 2. Mangrove forest struck by *Thane* cyclone 2011.

directly behind the most extensive mangroves. The above said resilient mangroves were extremely damaged by speed hit of *Thane* cyclone and damaged properties of the coastal people. Some 168 ha of mangrove habitat was present before the cyclone and approximately 70 ha (41.6%) was damaged by it (Figure 2). Over half of the salt marsh habitats (51%) was removed by the cyclone. Moreover, it is an invaluable loss and would take years to bring back the green cover. The ability of mangroves to reduce damage caused by tsunamis and topical storms is reportedly one of the most undervalued ecosystem services provided by such forests[4], but evidence supporting this claim is controversial. Studies were conducted after the Indian Ocean tsunami of December 2004, which revealed that mangroves acted as bioshields, and villages located behind them suffered lesser damage than those directly exposed to the coast[5,6]. On the other hand, reanalysis of data from different areas found no significant relationship between human mortality and the extent of mangrove forest fronting coastal hamlets[7–9].

Coastal vegetation, such as mangroves, can provide coastal communities with many valuable goods and services, and the protection and rehabilitation of these ecosystems is essential. Furthermore, the cost of mangrove restoration is relatively high and its effectiveness as a barrier against cyclones appears to be less when compared to the early warning systems. Conservation of mangrove forests is reported to prevent occupation of low-lying areas which are close to the coast[10]. However, in the absence of sufficient studies, the role of mangrove vegetation in protecting the coastal communities against strong storms remains an open question.

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P. SATHEESHKUMAR[1,]*
R. SIVA SANKAR[2]
D. SENTHIL KUMAR[3]
A. ATHITHAN[2]

[1]*Central Marine Fisheries Research Institute,*
Kochi 682 018, India
[2]*Department of Ecology and Environmental Sciences,*
Pondicherry University,
Puducherry 605 014, India
[3]*Kandaswamy Kandar Arts and Science College,*
Paramathi-Velur 638 181, India
**e-mail: indianscientsathish@gmail.com*