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Coastal protection function of mangrove ecosystems: a case study from Sri Lanka

Wasana de Silva[1] · **Mala Damayanthi Amarasinghe**[1]

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Abstract
The Indian Ocean tsunami in 2004 revealed the inferiority of hard engineering solutions in coastal protection and provided sound evidence over the potential of coastal vegetation, particularly mangroves in protecting the coast against erosion, tropical storm surges, and occasional natural calamities like tsunamis. The present study was initiated therefore to determine the extent to which mangroves could be used to protect the coasts against damage by tsunamis. The structure of mangrove vegetation at Kirinda, Kalametiya, and Rekawa in Sri Lanka that resisted tsunami waves for varying extents in 2004 was studied in detail to discern the wave attenuation function of mangrove vegetation. Vegetation structure is a salient factor that contributes to reduction of the impact of natural disturbances to which mangrove ecosystems are vulnerable. The current study highlights that mangrove parameters such as canopy, trunk, and complex root system and wave parameters such incident wave height and inundation distance play vital role in mangroves-induced wave attenuation. The study found that tsunami run-up height and tsunami inundation distance were negatively correlated with tree volume, forest width and tree height whereas that was positively correlated with porosity of the mangrove vegetation. Depth of sedimentation caused by tsunami waves decreased across the mangrove vegetation from the proximal end (in relation to the advancing wave) to the distal end at all mangrove study sites indicating the progressive dissipation of energy of the wave. The mangrove plant communities comprised of *Avicennia marina, Ceriops tagal, Excoecaria agallocha* and, *Rhizophora mucronata* evidently, have served as natural coastal barriers and contribute to mitigate impacts of natural disturbances such as tsunamis and tropical storms. As such our study revealed that the effectiveness of coastal bio-shields is based on the make-up of the coastal forests.

Keywords Mangrove ecosystem · Vegetation structure · Wave dissipation, coastal protection · Tsunamis · Tropical Storm surges

Introduction

The coast is of utmost importance to an island like Sri Lanka as it forms the boundary between land and sea where unique resources are located, on which humans depend for their livelihoods. Ensuring protection of the coast, therefore, is a national priority of Sri Lanka. Sri Lanka is an Island state in the Indian Ocean, Sri Lanka has faced numerous disastrous events throughout the past years. Indian Ocean tsunami in 2004 took more than 150,000 lives and innumerable physical destruction to infrastructure and economic activities (Jayasuriya et al. 2005). This massive tsunami waves in 2004 was an eye-opener for Sri Lanka and other island nations to assess the efficacy of existing coastal protection strategies.

Analysis of aerial photographs made on tsunami-affected areas on the southern coasts on the island indicated that coastal vegetation both cultivated and natural, has served a protective function to a certain degree, against destructive forces of high tidal waves (De Silva and Amarasinghe 2021a). Furthermore, it was evident that hard engineering structures have failed to withstand the destructive forces of the tsunami wave but the patches of mangroves and the other coastal vegetation, comprised mainly of mangroves and *Pandanus odoratissimus* have resisted them (Alongi 2008; Hettiarachchi et al. 2013; Wijetunge 2014; Satyanarayana et

✉ Wasana de Silva
wasanaldes@gmail.com

[1] Department of Plant and Molecular Biology, Faculty of Science, University of Kelaniya, Kelaniya, Sri Lanka

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