

TITLE: The 2004 tsunami in Aceh and Southern Thailand: A review on coastal ecosystems, wave hazards and vulnerability

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ABSTRACT:

In December 2004, a huge tsunami in SE Asia claimed many lives and caused catastrophic damage. This event has stimulated a debate about the role played by coastal ecosystems such as mangrove forests and coral reefs in protecting low-lying coastal areas. While some observers claim that these ecosystems play an important role, others are more sceptical and fear that financial resources may be diverted away from tsunami preparedness programmes to ecosystem rehabilitation schemes. Here, we review the role of coastal ecosystems in mitigating sea wave hazards. In particular, we examine the influence of coastal vegetation in severely affected parts of Aceh and Southern Thailand during the 2004 tsunami, and include direct observations made during two field visits in 2006. Numerous scientific studies illustrate that coastal ecosystems are important in protecting the coast against normal and extreme wind-driven waves, including cyclonic storm surges. However, much less information is available concerning the role of coastal ecosystems in protecting against tsunamis, and most studies have been too limited in scope to be able to generalise over large geographic areas and diverse conditions. In particular, few studies have taken account of the high variability in the energy and speed of tsunami waves along different coastline stretches, making it difficult to compare the role of ecosystems in different regions. Other aspects that have been little studied include the spatial patterns of impact, e.g. flow diversion and channelling as a result of hydraulic resistance, and the effects of tree breaking and flow debris. However, despite these limitations, some tentative conclusions can be drawn about the protection provided by ecosystems against tsunami waves: The most important predictor variables of the tsunami hazard (i.e. set-up and inundation) at the regional and landscape levels are distance to the tsunami source and coastal topography, in particular near-shore bathymetry. The influence of coral reefs on tsunami waves is complex. While closed, intact reefs can provide some protection, water may be accelerated through channels in fragmented reefs, causing even greater destruction on land. In contrast, seagrass beds appear to provide a more consistent buffering against tsunamis, though more data are needed to quantify this effect. In several locations (particularly farther away from the tsunami source), mangroves and other vegetation probably provided some protection against the 2004 tsunami; in numerous other locations, however, vegetation provided no protection or may in some cases even have increased the hazard (e.g. by contributing to flow debris, or by channelling water flows). It seems that whether or not vegetation does provide protection depends on many factors, including stand size, density, species composition, structure and homogeneity. Overall, the value of vegetation as a potential tsunami buffer is probably fairly minor, though it cannot be completely dismissed. Many more detailed spatial and hydro-dynamic analyses are needed before the hazard-vegetation interactions can be realistically modelled and visualised, e.g. on risk maps. Tsunami greenbelts should not be treated as alternatives to early warning systems. Greenbelts may only be considered as an economical (and multi-functional) means to provide relative hazard protection for material assets (e.g. infrastructure, agriculture). We recommend a more holistic view, with tsunami hazard mitigation being seen as one of several services provided by coastal ecosystems. Equally, the value of other ecosystem services may be seen within the frame of risk management as they foster social stability and, in case of disaster, robustness. To assess the overall value of these services and to develop more accurate indicators of risk will require much more transdisciplinary research.

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