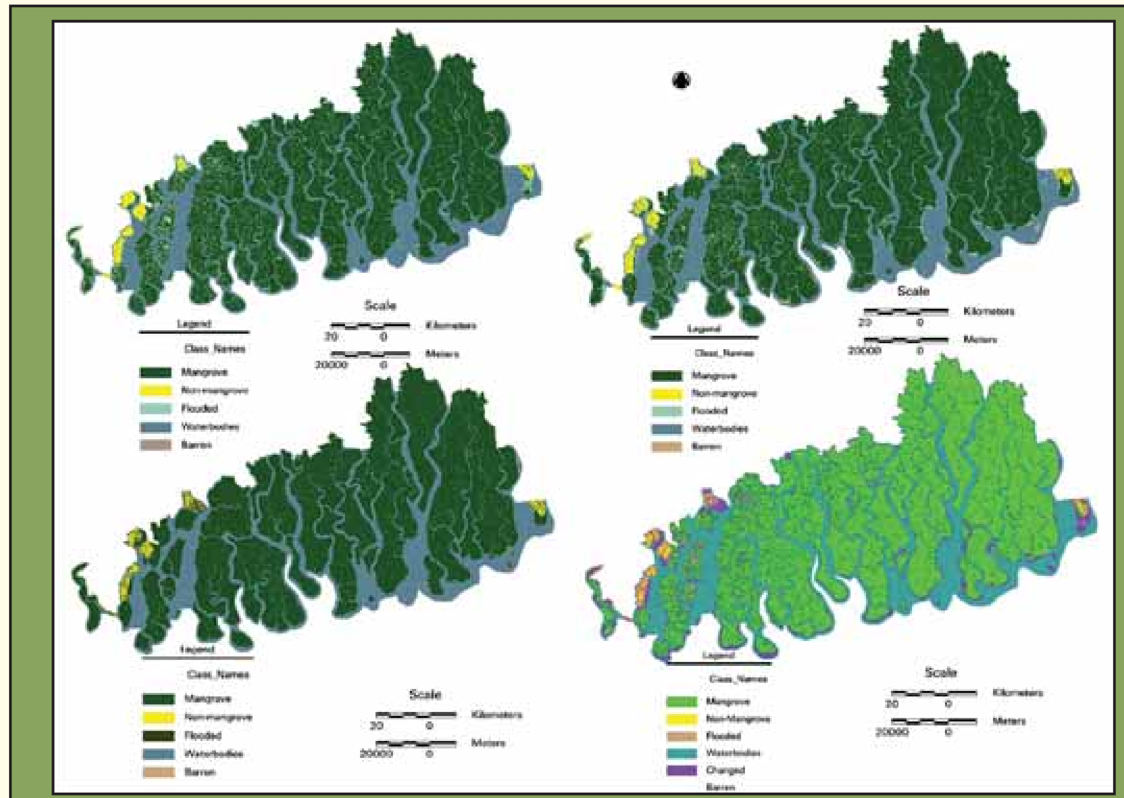
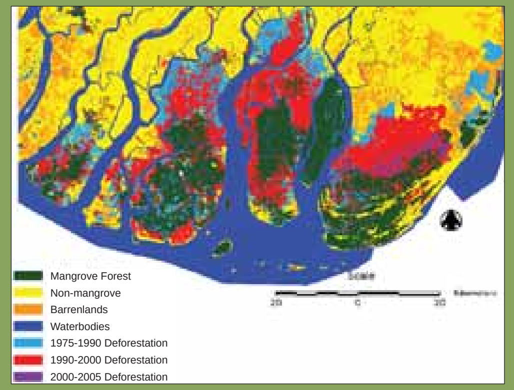
Mangrove Forest Distrubutions and Dynamics (1975-2005) in the Tsunami-impacted Region of Asia



Classification maps of (a) MSS, (b) TM, and (c) ETM+ data, and (d) change maps from the 1970s to 2000

The rate of deforestation was not uniform in both spatial and temporal domains. The annual rate of deforestation during 1975 to 2005 was highest (~1%) in Burma compared to Thailand (0.73%), Indonesia (0.33%), Malaysia (0.2%), and Sri Lanka (0.08%). In contrast during this period mangrove forests in Bangladesh (0.14%) and India (0.04%) expanded slightly.

Net deforestation in the region peaked at 137,000 ha (approximately 1% per year) during 1990 to 2000, increasing from 97,000 ha (0.2% per year) during 1970 to 1990, and declining to 14,000 ha (0.06% per year) during 2000 to 2005. The rate of deforestation and forest re-growth was not uniform throughout the period and varied from country to country. The highest rate of deforestation during 1975 to 1990 occurred in Thailand (1.8%). The rate of deforestation of other countries was relatively low during this period. However, during 1990 to 2000, rate of deforestation was highest in Burma (2.9%) followed by Malaysia (1.3%). Similarly, deforestation rate during 2000 to 2005 was highest in Indonesia (0.75%) mainly because of increase in shrimp farming.



Spatial distribution of mangrove deforestation in Ayeyarwady Delta, Burma from 1975-1990 (cyan), 1990-2000 (red), and 2000–2005 (purple).


Satellite images showing shrimp farm bloom near Kutabagok in Indonesia

Abstract

The Indian Ocean Tsunami of 2004 and other natural disasters highlighted the importance of mangrove forests in saving lives and property. Following the aftermath, ambitious mangrove conservation and rehabilitation programs are being initiated. However, little is known about their current distributions, and the rates, causes, and dynamics of deforestation. Our analyses show that the region lost 12% mangrove forests from 1975 to 2005 to its present extent of ~1,670,000 ha. Rate of deforestation varied in both spatial and temporal domains. Burma experienced the highest rate of annual deforestation (1%), and the highest regional rate of deforestation occurred during 1990-2000. Major factors responsible for regional deforestation were agricultural expansion (81%), shrimp farming (12%), and urban development (2%).The information generated can be used to identify potential areas for conservation and rehabilitation.

Background

Mangroves forests, distributed circumtropically in the inter-tidal region between sea and land in the tropical and sub-tropical latitudes, provide important ecosystem goods and services. The Indian Ocean Tsunami of December 2004 and other natural disasters highlighted the importance of mangrove forests as a 'bio-shield' in protecting vulnerable coastal communities from natural disasters. Mangrove forests attenuated the Indian Ocean tsunami waves and protected coastal communities in Indonesia, Thailand, India, and Sri Lanka (Danielsen et al. 2005, Kathiresan and Rajendran, 2005). In some areas, mangrove forests suffered severe damage due to breaking and uprooting. Recent findings suggest that the continued destruction and degradation of many mangrove forests throughout the tropics over the past few decades has decreased the protective capacity of mangrove forest ecosystems and affected their ability to rebound from natural disasters. However, accurate and reliable information on the present extent of mangrove forests and the rate and causes of deforestation in the tsunami-impacted region of Asia was not available (UNEP, 2005). The information is needed to better understand the protective role of mangrove forests and learn more about deforestation dynamics, carbon fluxes, forest fragmentation, and other ecosystem goods and services.

Approach

We interpreted Landsat MSS, TM, and ETM+ data acquired in 1975, 1990, 2000, and 2005 using a hybrid supervised and unsupervised digital image classification techniques. Geometric correction was performed to improve the geo-location to Root Mean Square error of ± ½ pixels needed for the change analysis. Each image was normalized for variation in solar angle and earth-sun distance by converting the digital number values to the top of the atmosphere reflectance. Ground truth data collected by the research team and existing maps and databases were used to select training samples and also for iterative labeling. Change analysis was performed using post-classification approach. Change maps were generated subtracting the classification maps, 1975s-1990s, 1975s-2000s, 1975s-2005s, 1990s-2000s, 1990s-2005s, and 2000s to 2005s. The change areas were interpreted visually with the help of secondary data and ground truth information to identify the factors responsible for the change. Once the mangrove/non-mangrove areas were estimated for each period, the annual rate of change was calculated for the region and also for the countries. Classification results were validated with the help of local experts and high resolution satellite data to ensure high quality.

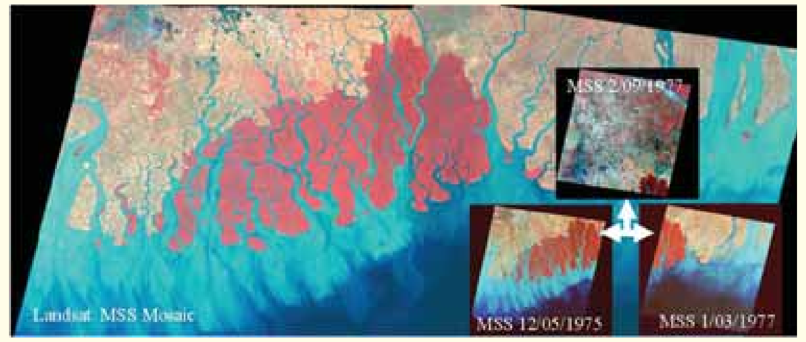


Figure : Three sets of Landsat images from 1975/1977, 1989 and 2000 were used to create mosaics corresponding to the three decadal intervals of the study.

$$R = \left(\frac{1}{t_2 - t_1} \right) 1n\left(\frac{Ai_2}{Ai_1} \right)$$

Where,

R = Annual rate of deforestation

Ai_1 = area of class i at an initial time t_1

Ai_2 = area of class i at a later time t_2

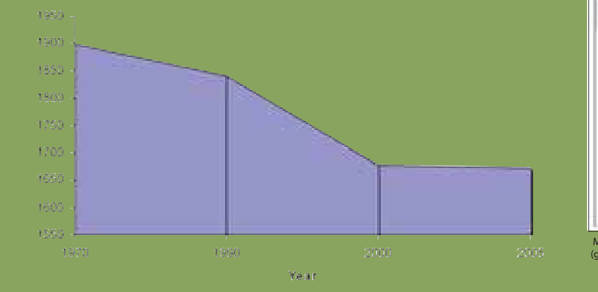
Source: Puyravaud (2003).

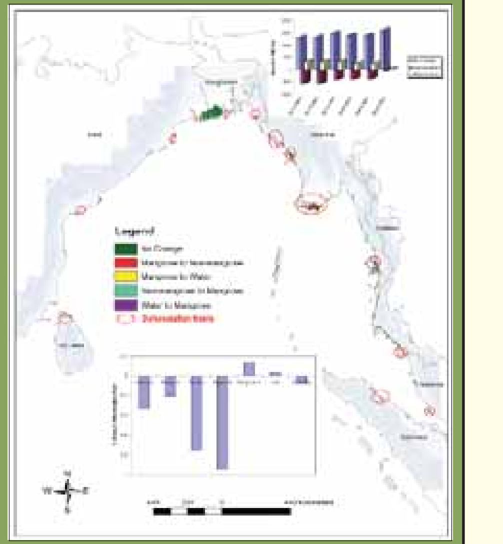
Results/Conclusions

Our analysis revealed that the remaining mangrove forest in the region is approximately 1,670,000 ha. We determined that among the tsunami-impacted mangrove in the region (our study area), the largest amounts are located in Burma (33%) followed by Bangladesh (27%), India (21%), Thailand (10%), Malaysia (4%), Indonesia (4%), and Sri Lanka (1%). The largest remaining contiguous mangrove forests are located in Sundarbans (along the boarder between Bangladesh and India); Ayeyarwady Delta, Rakhine, and Taninthayi (Burma); Phangnga and Krabi (Thailand); and Matang (Malaysia).


Mangrove distribution in 2005

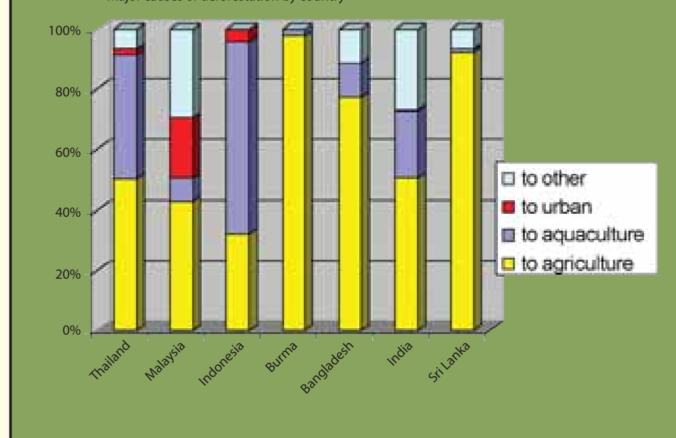
Time-series analysis revealed a net loss of 12% of mangrove forests in the region from 1975 to 2005. The regional deforestation rate is lower than the country average for Thailand, Malaysia, or Indonesia. This is primarily because the mangrove forests along the Andaman coast is relatively well protected compared to other parts of these countries. For example, 80-90% of mangrove forests in the Gulf Coast of Thailand disappeared in the last 30 years. In contrast, the regional deforestation rate is higher than the country average for India, Bangladesh, and Sri Lanka because large part of mangrove deforestation in these countries occurred prior to 1975.




Mangrove forest cover change from 1975 – 2005 (Map), total deforestation and afforestation (graph in top right), and annual deforestation rate by country (graph, bottom).

Urban expansion near Kuala Lumpur Malaysia

Our analysis identified that the major factors responsible for the deforestation are conversion of mangrove forests to agriculture (81%), shrimp farming (12%), urban development (2%), and other factors (5%). The causes of deforestation vary with countries and also with time.



Remaining mangrove forest areas (in green) in Matang Mangrove Forest Reserve, Malaysia

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