Thematic focus: Ecosystem management, Disasters and conflicts, Climate change

Mangrove forest cover fading fast

The uniquely adapted mangrove forests on the marine-terrestrial interface preserve coastline integrity by buffering wave energy from marine processes. The ecosystem services they provide and their support for coastal livelihoods worldwide are worth at least US $1.6 billion a year. Despite their global importance, mangroves are being lost rapidly and action is urgently needed to protect them.

Why is this issue important?

Mangroves are an important bulkhead against climate change: they afford protection for coastal areas from tidal waves and cyclones and are among the most carbon-rich forests in the tropics (Cornforth et al., 2013). In the face of rising sea levels and changing climates, coastal buffering against negative impacts of wave action will become critical and will play an important role in climate change adaptation.

Distributed in the tropical and sub-tropical regions of the world (Figure 1), mangroves provide shoreline protection and an array of ecosystem services. They support nutrient and organic-matter processing, sediment control for other inshore habitats (e.g. seagrass beds and coral reefs), and a source of wood for coastal communities. As a habitat for commercially valuable marine species (Walters et al., 2008), it is estimated that almost 80% of global fish catches are directly or indirectly dependent on mangroves (Ellison et al., 2008; Sullivan, 2005). Thus, the food security for many indigenous coastal communities is closely linked to the health of mangrove ecosystems (Horwitz et al., 2012). As much as 7% of the carbon dioxide reductions required to keep atmospheric concentrations below 450 ppm could be achieved simply by protecting and restoring mangroves, salt marshes and seagrass communities (Nellemann et al., 2009). Mangroves sequester up to 25.5 million tonnes of carbon per year and contribute more than 10% of essential organic carbon to the world's oceans (Dittmar et al., 2006).

Figure 1: Global mangrove forests distribution – 2000 (Giri et al., 2011). Map redrawn by UNEP/DEWA.

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What are the findings?

Mangrove ecosystems, which make up less than 0.4% of the world's forests (Spalding et al., 2010), are being lost at the rate of about 1% per year (FAO, 2007); in some areas, the rate may be as high as 2 to 8% per year (Miththapala, 2008). From 20% to 35% of the world's mangrove area has been lost since 1980 (FAO, 2007). The rates of loss are highest in developing countries where mangroves are cleared for coastal development, aquaculture, timber and fuel production (Polidoro et al., 2010). In as few as 100 years, the world's mangrove forests may become so degraded and reduced in area that they would be considered to have "functionally disappeared" (Duke et al., 2007). Figure 2 shows the areas where mangroves are already threatened in the world.

Figure 2: Proportion of Threatened (Critically Endangered, Endangered, and Vulnerable) Mangrove Species. (Polidoro et al., 2010).

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Importance of mangroves

(i) *Storm surge protection*:
Relatively small ocean waves are reduced in height from 12% to 66% over a distance of 100 metres of mangroves and 50% to 99% over 500 metres (McIvor et al., 2012). A number of factors determine the extent of wave energy reduction, including water depth, wave period, wave height, mangrove species, stand density, and trunk and root diameter (Mazda et al., 1997) (Figure 3). In southern Thailand, where 50% of mangrove forests have been lost since 1961, Thampanya et al. (2006) found that coastlines eroded by 0.01 to 0.32 square kilometre a year from 1967 to 1998. Sediment accumulation was observed only in coastlines with mangrove forests.

In the Red River Delta in Vietnam, it has been estimated that an earthen sea dyke with a rock face on the open ocean side would require repairs in about five years, whereas the same dyke would last about 50 years if the rock face were replaced by a 100-metre-wide protective mangrove belt (Macintosh and Ashton, 2004). In another project in Vietnam, the cost of planting and protecting mangroves was about US $1.1 million, and the project saved US $7.3 million a year in dyke maintenance. Moreover, during Typhoon Wukong in 2000, the project areas remained unharmed while neighboring provinces suffered major losses in lives, property and livelihoods. The Vietnam Red Cross estimated that some 7,750 families have benefited from mangrove rehabilitation (Reid and Swiderska, 2008).

(ii) *Provisioning value*:
In some cases, the provisioning benefits of mangroves may be worth even more than their coastal protection value. The 1,800 hectares of Ream National Park in Cambodia was valued at US

$300,000 for storm protection and erosion services alone. The additional provisioning services of the park, such as breeding grounds for fish, firewood, medicinal plants and construction materials, were valued at US $600,000 (Emerton et al., 2002). Moreover, the park’s ecosystem service benefits far exceed the value of clear cutting the area for timber and shrimp ponds (Horwitz et al., 2012).

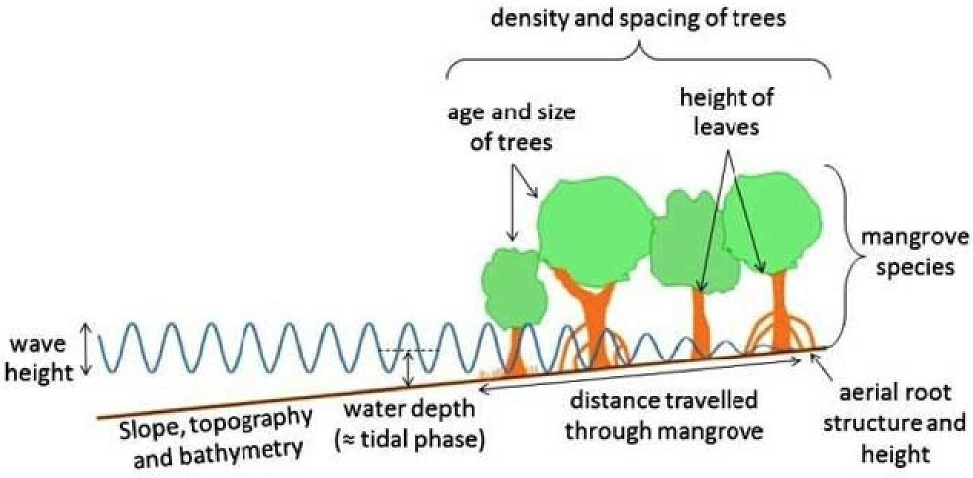

Figure 3: Factors affecting wave energy in mangroves (McIvor et al., 2012).

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Threats to mangroves

(i) *Conversion of mangrove forests* :
Increasing population in coastal areas has spurred the widespread clearing of mangroves (Polidoro et al., 2010). Over-exploitation for fuelwood and timber production has degraded about 26% of mangrove forests around the world (Valiela et al., 2001). Shrimp aquaculture has contributed to about 38% of global mangrove loss and other types of aquaculture account for approximately another 14% (Ellison, 2008; Figure 4). In India, more than 40% of the mangrove area on the western coast has been converted to agriculture and urban development (Upadhyay et al., 2002). While direct anthropogenic impacts are the biggest threat to mangrove ecosystems, changing climates probably will pose even greater risks in the future (Gilman et al., 2008).

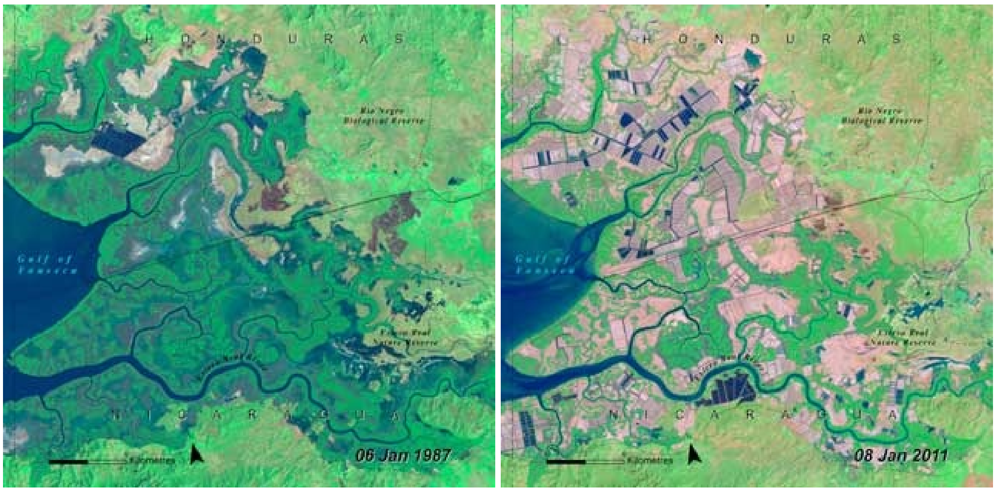

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Figure 4: Satellite images showing an increase of shrimp farms in the Gulf of Fonseca, Honduras. The shrimp ponds appear as blue and pink rectangles near the water line scattered across the mangrove delta in the 2011 image, a period of 24 years since 1987.

(ii) *Global temperature rise*:
While mangroves often show resistance and resilience in the face of disturbances, the additional stresses brought by climate change may cause sudden and irreversible losses at many sites (Huxham et al., 2010). Warmer temperatures will increase evaporation rates and salinity in the sediments on the landward fringe of a mangrove forest. This may cause a die-back of mangroves or a reduction in diversity (Huxham et al., 2010).

(iii) *Rising sea levels*:
The global sea level has already risen 12 to 22 centimetres over the course of the 20th century due to global warming and sea-level rise could be the greatest threat facing the future of mangroves

(Gilman et al., 2008). If local conditions restrain mangroves from adapting to rising sea levels through inland migration, they will become increasingly submerged. Even in circumstances in which inland migration could occur, there may still be negative impacts on people, since it is the seaward fringes, and not the inland margins, that provide the most valuable environmental services for fisheries and coastal protection (López-Medellín et al., 2011).

(iv) *Storms and natural disasters*:
High levels of damage may be inflicted on mangroves during storms. A massive loss of mangroves following a hurricane in Honduras led to peat collapse, which reduced recovery rates (Cahoon et al., 2003). Furthermore, mangrove ecosystems can be converted to other types of ecosystems as a consequence of storm impact. For example, mangrove forests in Everglades National Park in Florida have been converted to intertidal mud flats following the impacts of hurricanes Andrew in 1992 and Wilma in 2005 (Smith et al., 2009).

Progress in the conservation and restoration of mangroves

Since the 2004 Indian Ocean tsunami, there has been a general increase in the awareness of the importance of mangrove ecosystems; efforts to conserve, protect and restore them can be seen in Bangladesh, India, Indonesia, Myanmar, Seychelles, Sri Lanka, Pakistan, Thailand and Vietnam (Macintosh et al., 2012). The Ministries of Environment and Natural Resources of Guatemala, Honduras and Nicaragua, in collaboration with the UN Environment Programme, have embarked on sustainable mangrove management, raising awareness of the critical role mangroves play in areas that are constantly threatened by the risk of hurricanes and sea level rise (UNEP, 2012).

What are the implications for policy?

As the negative impacts of climate change, including rising sea levels, become more evident, the economic value of coastal wetlands for protection will also increase as the need for their buffering services becomes more critical (Costanza et al., 2008). While market pressures push for mangroves to be cleared for aquaculture and urbanization, coastal land managers must consider not only the value of the services that mangroves provide, but also their potential value in the future (see Box 1).

Box 1: Successful Management: The Matang Mangrove Forest Reserve
The Matang Mangrove Forest Reserve in the State of Perak, Malaysia, is arguably the best example of a sustainably managed mangrove ecosystem and demonstrates that an effective balance can exist between the harvest of natural resources and conservation (Lavieren et al, n.d.). The existing management plan regulates forestry, fishing, and aquaculture activities and only non-destructive practices are permitted. Harvesting of mangrove timber for poles, firewood, and charcoal production, occurs on a 30 year rotation cycle (Chong, 2006). Selective felling is carried during year 15 and year 20 and then a final clear-felling occurs during year 30. When necessary, re-vegetation programmes are implemented two years after the final felling. The annual value of charcoal between 2000 and 2009 was estimated to be RM 27.2 million (equivalent to approx. US$ 8.9 million) while the annual value of poles was estimated at RM 2.6 million (equivalent to approx. US$ 847 thousand). Fisheries in the Matang Mangroves are also an important contributor to the Malaysian economy. Fish cage and cockle aquaculture are allowed, and cockle farming is estimated to have an annual market value of RM 32.45 million (equivalent to approx. US$ 10.7 million). Most of the natural resources obtained from the forest are exported to markets in the states of Selangor, Penang, and Kedah. This case provides evidence that mangrove forests can be conserved and enjoyed while still providing reliable long-term but reasonably high economic return for local and larger communities. It shows that when well-managed, mangroves can ensure sustainable yields of products (numbers are from the Malaysian Timber Council, 2009).

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Mangrove conservation and management

Curbing deforestation may be more effective than reforestation. In the last decade, a study in Thailand found that the cost of restoring mangroves was US $946 per hectare, while the cost for protecting existing mangroves was only US $189 per hectare (Ramsar Secretariat, 2001).

Framework policy and legislation established at national levels, and integrated into a broader spatial framework of coastal zone management, should cross all sectors and involve all stakeholders to prevent piecemeal loss and degradation (Lavieren et al., 2012). For example, countries such as Tanzania and Malaysia have placed all mangroves in forest reserves under state ownership. In some locations in Australia and the United States, local policies of “no net loss” have placed specific limitations on future mangrove clearance. These strategies will be effective in the long term if backed by strong political will, enforcement measures and penalties for noncompliance.

An array of market-oriented strategies have been proposed to curtail the conversion of mangrove areas to other land uses. The fact that mangrove forests are increasingly recognized as a valuable source of revenue should in theory make it easier to entice those who benefit from mangroves to make payments for the ecosystem services that they generate (Lavieren et al., 2012). Furthermore, because mangrove forests store significant amounts of carbon and are threatened by the economic allure of conversion, they could be ideal targets for carbon financing. Such initiatives and investment funds provide exciting new opportunities to better protect natural capital, benefit communities, and utilize cost-effective green technologies to address the challenges of climate change.

Acknowledgement

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