The Mangroves of Myanmar

16

Christoph Zöckler and Cherry Aung

Abstract

This manuscript describes the biogeography and composition of mangroves in Myanmar. It underlines the significant and ongoing decline of mangrove coverage, the importance to protect these ecosystems, and their roles for critically endangered species of flora and fauna. Reasons for mangrove habitat loss are analysed. The monetary value of mangrove ecosystem services for coastal people has been estimated. UNESCO Biosphere Reserves and Ramsar sites have been suggested as best options for the future conservation and management of Myanmar's mangroves. Developing community-based protected areas and forest management within the framework of the Man and the Biosphere Programme would cater for most of the management options that also involve local communities.

Keywords

Mangrove biodiversity · Ramsar sites · UNESCO Biosphere Reserves

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Introduction

Myanmar is the largest country in mainland Southeast Asia, with a continuous coastline of almost 3000 km, extending along the Bay of Bengal and Andaman Sea. The coastal habitats consist largely of soft marshes with mudflats and mangroves, interspersed with a few rocky outcasts and sandy beaches. In 2007 it held an estimated 437,000 ha of mangroves. It holds the 8th largest mangrove forest in the world (4% of the world mangroves) and stands 3rd largest in Southeast Asia (8.8% of Southeast Asia mangroves; Spalding et al. 2010) but is losing its mangroves fastest of all countries (Richards and Friess 2016), due to encroaching agriculture and aquaculture (Plate 16.1).

Distribution and Trends

Myanmar is the eighth largest mangrove nation with less than 500,000 ha mangroves left (Fig. 16.1).

Mangroves and adjacent mudflats are found in all coastal provinces and are widely distributed across the entire coastline (Figs. 16.2 and 16.3). The Central Delta region has been the most important for mangroves, which are concentrated along the southernmost parts of the Ayeyarwady Delta. However, in recent decades, the mangroves have been seriously depleted. Two other

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Plate 16.1 Mangroves near Myeik. (C. Zöckler)

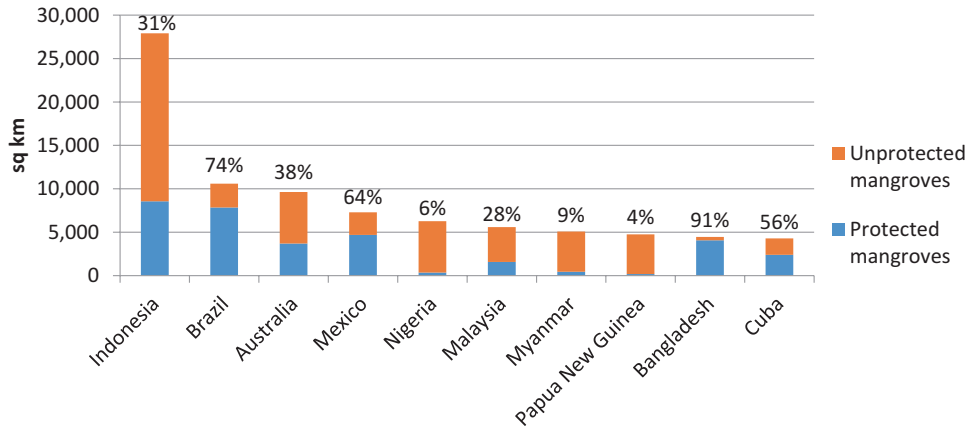

Fig. 16.1 Mangrove areas under protection for the ten largest mangrove nations. The estimates are based on the Global Distribution of Mangroves USGS (2011). Labels indicate the percentage of mangroves under protection

principal formations, along sheltered coasts in the Rakhine and Tanintharyi regions, are important. Figure 16.3 shows the current distribution of mangroves based on WCMC 2011 and updates from various sources (Zöckler et al. 2013; Harris et al. 2016; Bhagwat et al. 2016). The FAO (2010) report still mentions 437,931 ha, but recent data from Webb et al. (2014) show continued and strong decline in the Ayeyarwady Delta. All other regions suggest a strong decline since the 1980s in line with older assessments (FREDA and Actmang 2012). Richards and Friess (2016) estimated the overall loss from 2000–2012 to only 5.53%. While these identified losses continue through the regions, the losses in acreage seem less pronounced in the Tanintharyi Region. However, at closer look the level of destruction within the remaining mangrove stands is obvious and seems to continue even in protected sites, such as Meinmahla Kyun Wildlife Sanctuary (Yong 2016, Moses and Zöckler 2015, Zöckler 2016a). The degradation has been observed

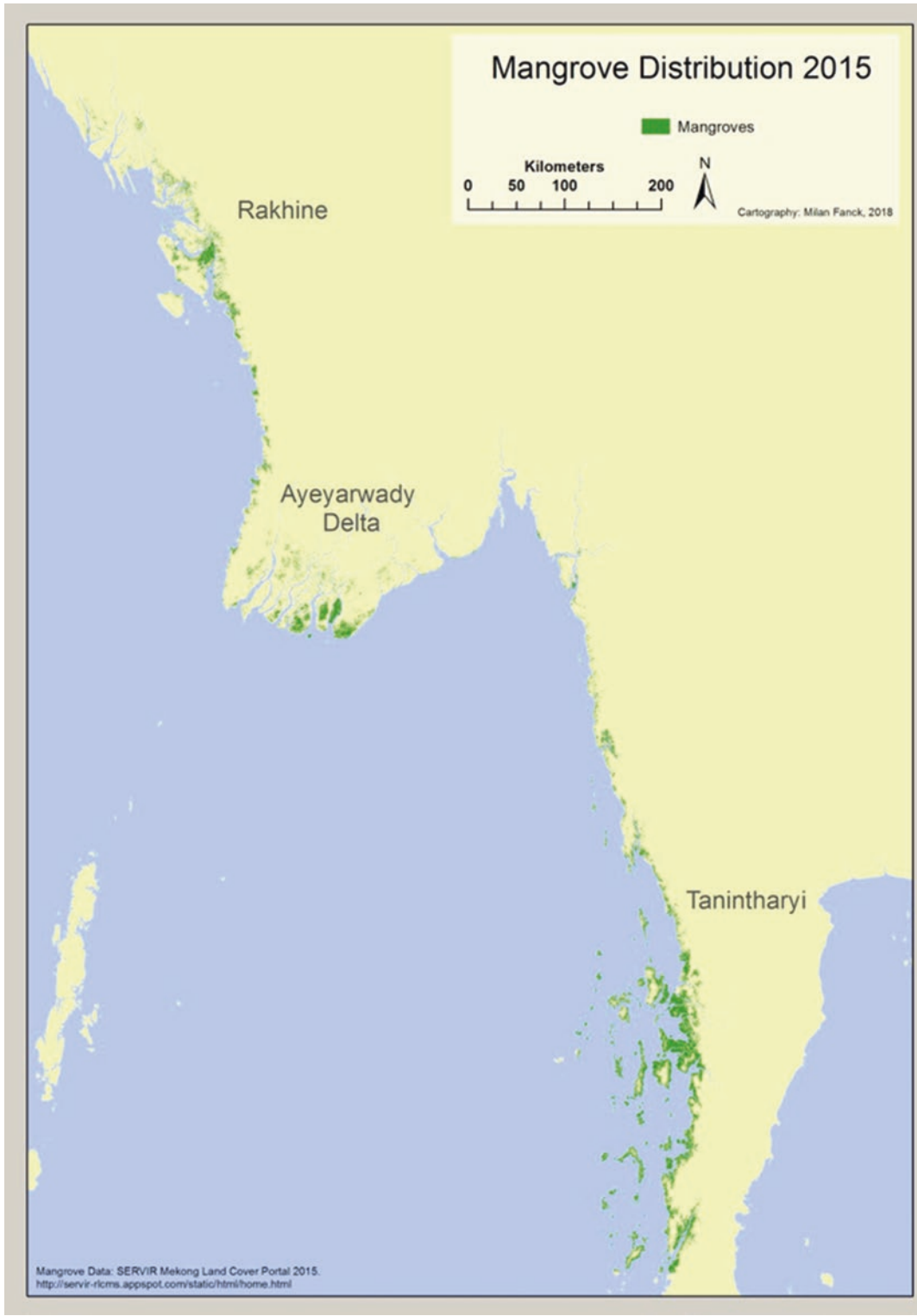

Fig. 16.2 Mangrove distribution by 2015 based on SERVIR-Mekong Land cover data. For updated information, see detailed regional maps

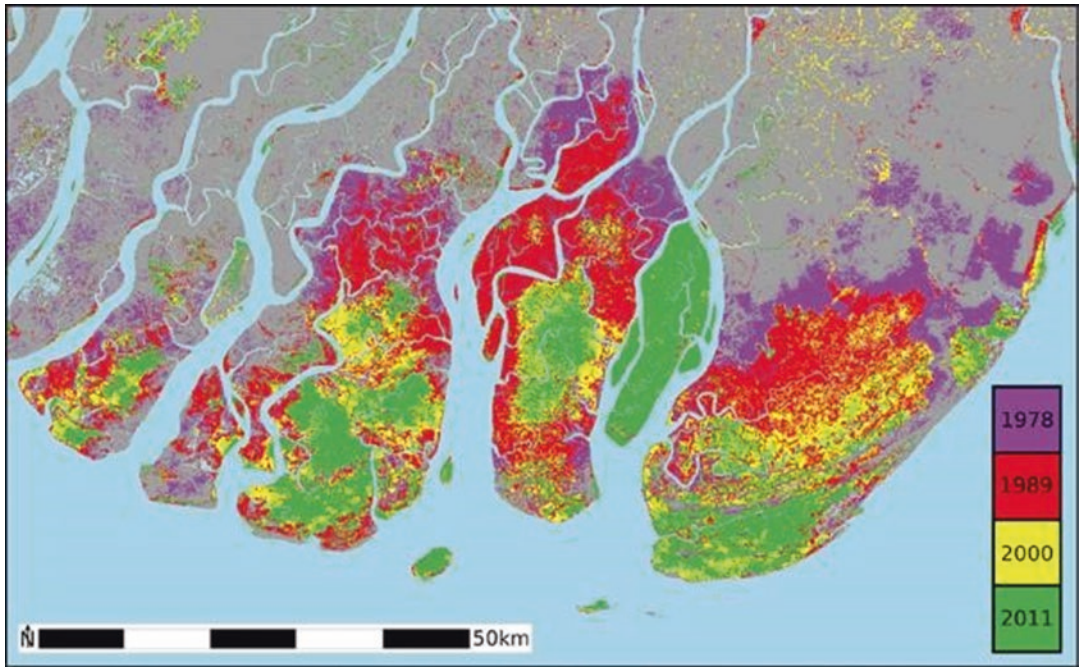

Fig. 16.3 Changes in mangrove forest cover between 1978 and 2011 in the Ayeyarwady Delta region. (Based on Webb et al. 2014)

Table 16.1 Mangrove distribution by region and loss in ha

Division	No. of tree spp.	1980	2002	2013	Loss in %
Rakhine	32	167,730	no data	102,840	>30
Ayeyarwady	29	274,781	138,341	45,048	>80
Taninthary	43	262,063	250,00	151,001	>40

FAO (2010), Cherry Aung (2016), Richards and Friess (2016), Bhagwat et al. (2016), and Webb et al. (2014)

across all areas in the vast remaining mangroves in Tanintharyi Region and has been unabated since (e.g. Zöckler 2016b).

Table 16.1 depicts the distribution of mangroves in the three main regions of coastal Myanmar, with Rakhine in the northern coastal area, Ayeyarwady in the delta and adjacent regions, and Tanintharyi encompassing the southern coastal strip.

Ayeyarwady Division

Mangroves have been covering the vast majority of the delta area of the Ayeyarwady Basin. They can reach as far as 60 km inland. Originally, the most extensive mangroves in Myanmar of over 270,000 ha were found in the Ayeyarwady Delta. High human population pressure has led to the loss of over 64% of mangrove cover over the past 35 years, more than 80% (Webb et al. 2014).

In protected areas such as the Meinmahla Kyun Wildlife Sanctuary, groundwork suggests that mangroves are suffering from precipitous degradation and rarely reach maturity (Moses and Zöckler 2016; Yong 2016).

Restoration efforts between 1980 and 2004 resulted in re-planting of 14,000 ha with mangroves in the delta region, mostly on old rice paddies and abandoned agricultural sites. The damage caused by the tropical storm Nargis has been estimated at 35,000 ha of mangrove forest

Plate 16.2 Mangroves at Meinmahla Kyun Wildlife Sanctuary. (C. Zöckler)

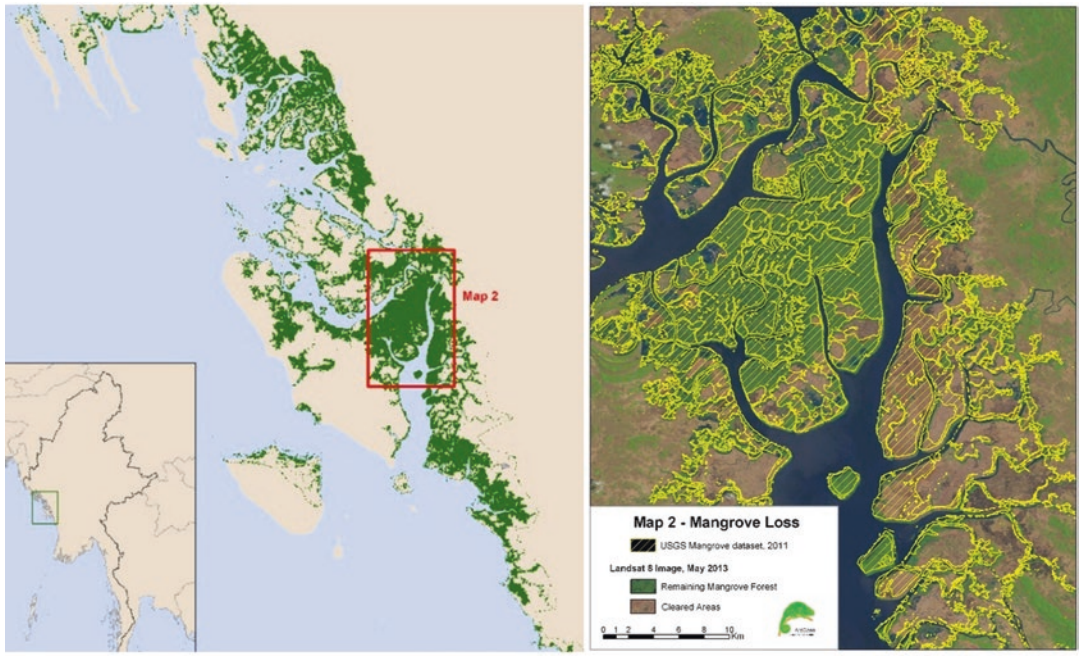

Fig. 16.4 Mangrove loss in the Wanbike area near Ramree Island in Rakhine region between 2001 and 2013. (Zöckler et al. 2013)

in two divisions of the delta region (FREDA and ACTMANG 2012). Comparison of satellite images between 1974 and February 1995 in the Ayeyarwady Delta area indicates mangrove losses from 32.2% to 5.8% of the forest area in Laputta and from 51.9% to 19.5% in Bogalay (Plate 16.2).

Rakhine State

Pressure on the Rakhine mangrove forest habitat is still increasing according to our own research on the ground, with new developments planned for deep sea ports, gas pipelines, infrastructure projects, and hotels (see Fig. 16.4). Adverse

anthropogenic impacts on mangroves are expected to become even more pronounced as Myanmar opens its doors to increased foreign investment in agriculture and development (Zöckler et al. 2013).

In other parts of Rakhine, an additional threat is posed by shrimp farming. The mangrove degradation in the Rakhine region between 1974 and 1995 has been documented by Myint Pe (2002), showing a loss of ca. 30%; however, more recent data are not available. An analysis of the Wanbike area illustrates the loss of mangroves over the last 10–12 years (see Fig. 16.4), due to land conversion into rice paddies and aquaculture farms.

Tanintharyi Region

The Tanintharyi Region still holds large areas of mature mangroves, including the largest remaining mangrove area in Myanmar with >150,000 ha. However, this area has also decreased from 262,000 ha in the 1980s.

Decline in Mangrove Quality

In addition to the actual loss in mangrove area, there is also a deterioration of the remaining mangroves. The rapid assessment tool was also applied in the southern Tanintharyi Region (see Fig. 16.5). The rapid assessment method is being described elsewhere (Zöckler and Wodehouse in prep.), including factors such as logging, cutting, clear-cutting, fire, and the intensity of the impact.

Mangroves as Habitats

Plants and Vegetation

Myanmar hosts 44 species of mangrove trees of which species of the genus *Rhizophora*, *Sonneratia*, *Avicennia*, *Bruguiera*, *Ceriops*, *and Xylocarpus* spp. (Table 16.2) are dominant. This is within the range of expected 60 species in SE Asia (Yong 2016). Eight of these species are considered as globally threatened (Polidoro et al. 2010), and two are critically endangered (*Sonneratia griffithii* and *Bruguiera hainesii*). The former has been found with few individuals (<200) in Meinmahla Kyun (Yong 2016) and also a few in Kyaikkhami area, Mon State. The latter still remains with a few (<1000) in the Gwa region (Rakhine). Six plants of *Bruguiera hainesii* were found in the Magyi (Shwe Thaung Yan) mangrove area (Htoo Lwin Aung 2016). *Pemphis acidula* is one of the rare species, and it only occurred near Kyaikkhami, Mon State (Cherry Aung 1999), and in Lampi Island (San Tha Tun et al. 2008) (Plate 16.3).

Animal Biodiversity

The mangroves in Myanmar are supporting a wide range of vertebrate and invertebrate species, including several globally threatened mammal and bird species. Among the mammals these are, for example, fishing cat *Prionailurus viverrinus* (EN) and smooth-coated otters *Lutrogale perspicillata* (VU) that have been regularly observed in the Tanintharyi Region (Plate 16.4). Also dhole *Cuon alpinus* (VU) has been recorded in the delta region (Zöckler and Kottelat 2017). Quite prominent and possibly unique for Myanmar and its coastal habitats is the good numbers of Irrawaddy dolphins *Orcaella brevirostris* frequenting the mangrove channels and coasts near the mangroves in all three mangrove regions (Rakhine, delta region, and Taninthary). In the latter region, the globally near-threatened (NT) Indo-Pacific humpbacked dolphin, *Sousa chinensis*, is still present in good numbers (Moses and Zöckler 2016) (Plate 16.4).

A total of over 230 species of birds were observed in Myanmar's mangroves (Zöckler et al. 2018). The lesser adjutant stork *Leptoptilos javanicus* (VU), mangrove pitta *Pitta megarhyncha* (NT), and brown-winged kingfisher *Pelargopsis amauroptera* (NT) are characteristic flagship species and still present in good numbers in the southern mangroves in Tanintharyi but scarce in the delta area and largely missing in the Rakhine region. Mangroves and associated

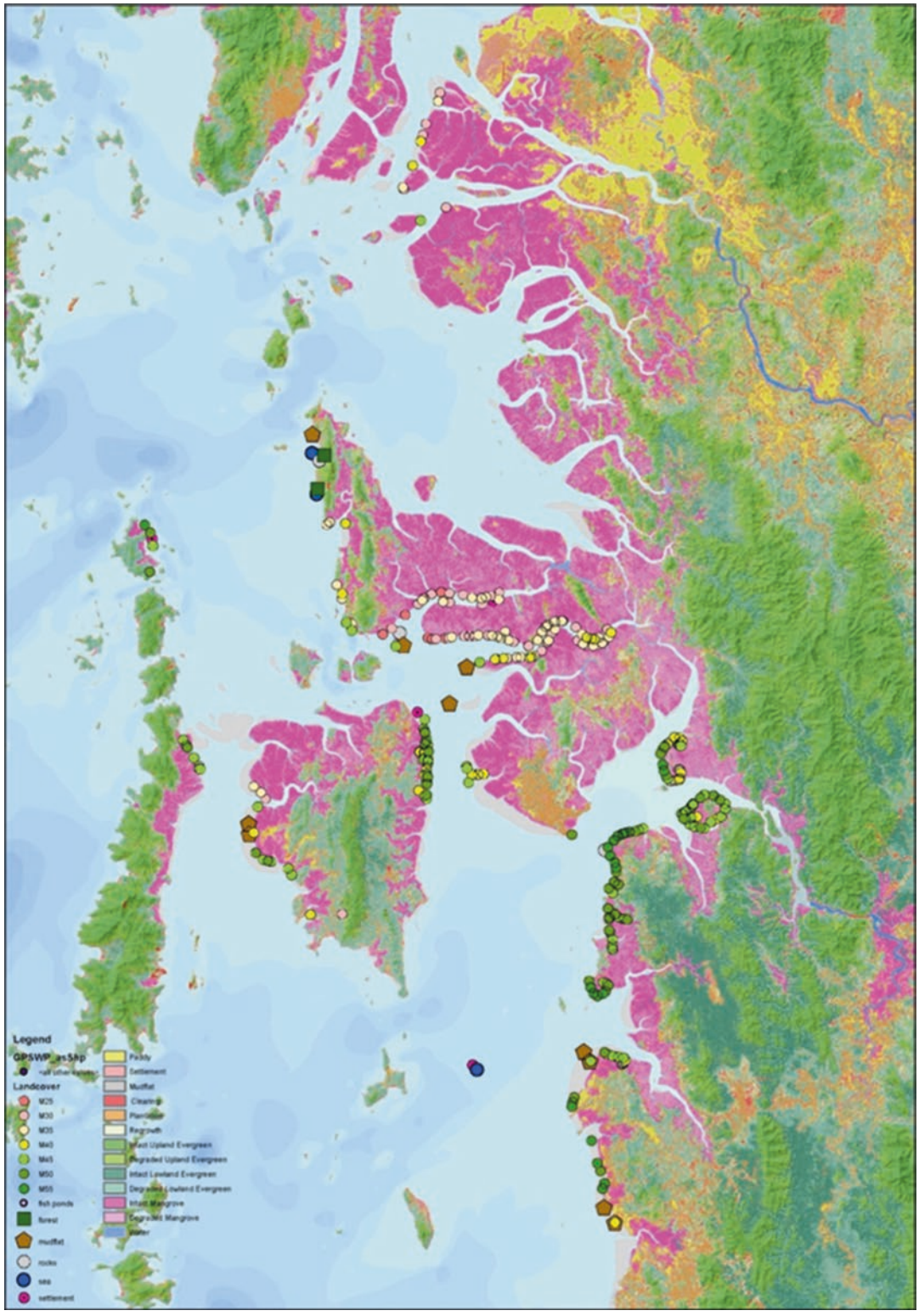

Fig. 16.5 Coastal habitats in the southern Tanintharyi Region, mangroves in pink, mudflats in grey, depicting the level of mangrove deterioration on a scale of M25 (heavy deterioration)–M55 (intact mangrove stands). (Zöckler 2016b)

Table 16.2 A list including the conservation status of the "true" mangrove species and hybrids observed during these studies in Myanmar

	Species	Family	Conservation status
1	*Acanthus ilicifolius*	Acanthaceae	LC
2	*Acanthus ebracteatus*	Acanthaceae	LC
3	*Acanthus volubilis*	Acanthaceae	LC
4	*Acrostichum aureum*	Pteridaceae	LC
5	*Acrostichum speciosum*	Pteridaceae	LC
6	*Aegiceras corniculatum*	Myrsinaceae	LC
7	*Aegialitis rotundifolia*	Plumbaginaceae	NT
8	*Aglaia cucullata*	Meliaceae	DD
9	*Avicennia alba*	Acanthaceae	LC
10	*Avicennia marina*	Acanthaceae	LC
11	*Avicennia officinalis*	Acanthaceae	LC
12	*Brownlowia tersa*	Malvaceae	LC
13	*Bruguiera cylindrica*	Rhizophoraceae	LC
14	*Bruguiera gymnorhiza*	Rhizophoraceae	LC
15	*Bruguiera parviflora*	Rhizophoraceae	LC
16	*Bruguiera hainesii*	Rhizophoraceae	CR
17	*Bruguiera sexangula*	Rhizophoraceae	DD
18	*Ceriops decandra*	Rhizophoraceae	NT
19	*Ceriops tagal*	Rhizophoraceae	LC
20	*Cynometra iripa*	Fabaceae	LC
21	*Dolichandrone spathacea*	Bignoniaceae	LC
22	*Excoecaria agallocha*	Euphorbiaceae	LC
23	*Heritiera fomes*	Malvaceae	EN
24	*Heritiera littoralis*	Malvaceae	LC
25	*Kandelia candel*	Rhizophoraceae	LC
26	*Lumnitzera littorea*	Combretaceae	LC
27	*Lumnitzera racemosa*	Combretaceae	LC
28	*Nypa fruticans*	Arecaceae	LC
29	*Phoenix paludosa*	Arecaceae	NT
30	*Pemphis acidula*	Lythraceae	LC
31	*Rhizophora apiculata*	Rhizophoraceae	LC
32	*Rhizophora mucronata*	Rhizophoraceae	LC
33	*Rhizophora stylosa*	Rhizophoraceae	LC
34	*#R* x *annamalayana*	Rhizophoraceae	EN
35	*#R* x *lamarckii*	Rhizophoraceae	VU
36	*Scyphiphora hydrophyllacea*	Rubiaceae	LC
37	*Sonneratia alba*	Lythraceae	LC
38	*Sonneratia apetala*	Lythraceae	LC
39	*Sonneratia caseolaris*	Lythraceae	LC
40	*Sonneratia griffithii*	Lythraceae	CR
41	*Sonneratia ovata*	Lythraceae	LC
42	*#Sonneratia* hybrids/spnov	Lythraceae	EN
43	*Xylocarpus granatum*	Meliaceae	LC
44	*Xylocarpus moluccensis*	Meliaceae	LC

Based on Cherry Aung (2016), and Yong (2016)
LC least concern, *DD* data deficient, *NT* near-threatened, *VU* vulnerable, *EN* endangered, *CR* critically endangered

Plate 16.3 Flowering mangrove tree *Lumnitzera racemosa* (Myeik). (C. Zöckler)

Plate 16.4 Smooth-coated otters *Lutrogale perspicillata* near Kan Maw (Myeik). (C. Zöckler)

mudflats are also home to a number of migratory waterbirds. A total of more than 20,000 migratory waterbirds have been counted regularly in winter in the southern Tanintharyi mangroves and mudflats alone. Among these are several globally threatened waterbirds (Zöckler et al. 2014, in prep.).

Among the reptiles such as snakes, crocodiles, and lizards, the most prominent examples are the estuarine crocodile *Crocodylus porosus* and the mangrove monitor lizard *Varanus indicus* (Thorbjarnarson et al. 2000). Several species of marine and freshwater turtles live exclusively in the mangroves, for example, the mangrove terrapin *Batagur baska*. However, this has no longer been observed in Myanmar's mangroves since early 2000 (Platt et al. 2008).

Fish, Crustaceans and other Invertebartes

Mangroves serve as nurseries for many marine and estuarine fish species, shrimps, and crabs. Several species that are associated with mangroves are listed as vulnerable, near-threatened,

Plate 16.5 Mudskipper Periophthalmus spp. Are prominent fish species in all mangrove ecosystems. Photo Stefan Pfuetzke

or (critically) endangered on the IUCN red list, such as the shovelnose ray, lemon shark, smalltooth sawfish, goliath grouper, and rainbow parrotfish.

Mudskipper fish *Pterophthalmus spec* are very common in Myanmar's mangroves (Plate 16.5). More details on fish species in the Ayeyarwady Delta are listed in Zöckler and Kottelat (2017).

Brachyuran crabs are common mangrove epifauna, of which the *Sesarmidae* and ghost crab *Ocypode* are dominating. Some Sesarmid crab species are specific to host plants. For example, *Sesarma intermedia* prefers to live among the *Nypa* palm trees. The gastropod *Littorina scabra* is a prominent species on the mangrove trees, especially on *Avicennia* species. Many different species of *Sipunculids*, *Echiurids*, worms, bivalves, and some crustaceans are dwelling in the mudflats. The peanut worm (phylum: *Sipunculida*), the prominent and mysterious *Sabellid polychaete* (Plate 16.6), the ancient Cambrian Brachiopod *Lingula anatina*, the small crab *Dotilla*, the slug *Onchidium* sp., and the insect larvae (Fly Fam: Dolichopidae) are just a few examples of the rich diversity of the mangrove and mudflat benthos. They also provide an important food sources for fish, crabs, shrimps, and many birds. Fireflies (Lampyridae) are well known to prefer the *Sonneratia caseolaris* trees. Many different bee species are visiting flowering mangroves, and mangrove honey is highly valued.

Mangrove Ecosystem Services

The Nargis storm in 2008 highlighted the need to emphasise the critical ecosystem services of high-quality mangroves, mainly in protecting coastal communities from storm surges. Moreover, Myanmar's mangroves are highly important for storing carbon and providing vital fish, crab, and shellfish nurseries.

Mature mangroves provide wood for boat-building, construction, firewood, charcoal, furniture, and fish traps, as well as non-timber forest products such as mangrove honey, fruit, medicine, and even wine, and nypa palm thatch for roofing and are also used to make syrup, juice, wine, and vinegar. Mangrove honey – with its subtle sweetness and tinge of saltiness – is becoming a valuable commodity in coastal communities.

The density and rot resistance of some types of mangrove wood and a corresponding ability to withstand exposure to saltwater are the reasons this timber is used in boat-building and often for construction of docks, fences, and fish traps. The wood of *Rhizophora*, *Bruguiera*, and *Ceriops* species is a heavy hardwood with tannin-rich barks and is often used as building material for homes, for railroad ties, and in the leather industry. Mangrove leaves are used as animal fodder for buffaloes, sheep, goats, and camels. In some locations, certain mangrove species are used in traditional medicine to treat a range of ailments

Plate 16.6 Sabellid polychaete with "bouquet" using mangrove leaves and sticks. (C. Zöckler)

from toothache to leprosy and tuberculosis (Govindasamy and Kannan 2012).

In the past, Ayeyarwady mangrove was famous for its *Ceriops* and *Bruguiera* trees. After World War II, a lot of *Ceriops* and *Bruguiera* mangroves were produced for charcoal. *Ceriops* charcoal is of excellent quality and exports from Ayeyarwady are famous. The palm *Phoenix paludosa* has been used for bridge and house construction (Cherry Aung 1999).

The mangrove seaweed *Catenella nipae* is another mangrove product. It grows at the trunks and pneumatophores of the plants in Kyaikkhami, Mon State. It provides good income for the local people that collect the seaweed and sell it for human consumption in the form of a salad.

Supporting and regulating services that mangrove habitats provide include nutrient cycling, carbon storage, flood control, water quality maintenance, shoreline stabilisation, sediment balance, land accretion, and the buffering of both land and marine habitats from the ravaging impacts of storms and rising sea levels (Nellemann et al. 2009; McIvor et al. 2012). As human habitation along the coasts has increased, the rich ecosystem services provided by mangroves have also grown.

The value of mangroves has been estimated in the range of 200,000–900,000 USD annually per km^2. Considering a remaining mangrove forest in Myanmar of about 300,000 ha (see Table 16.1), this would mean a total value of mangroves of 150–400 million USD per year, depending on the ecological functioning of the mangrove systems. Values include coastal protection, fisheries, coral reefs, and tourism (Costanza et al. 2008).

Causes of Mangrove Forest Degradation

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 2010); in Myanmar the rate is as high as 5% per year (Richards and Friess 2016). Between 20% and 35% of the world's mangrove area has been lost since 1980 (FAO 2010). The rates of loss are highest in developing countries where mangroves are cleared for agriculture, coastal development, aquaculture, and timber and fuel production (Polidoro et al. 2010). Webb et al. (2014) listed agriculture expansion for rice production as the main driver for loss in mangrove area. Conversion for paddy cultivation of rice is a major threat to mangrove conservation, particularly in the Ayeyarwady Delta area. Agricultural expansion into mangrove areas to meet the requirements of regional food security is also common in the other two coastal regions, espe-

cially in the Rakhine region. Figure 16.5 showing mangrove loss between 2001 and 2013 overall depicts agricultural land replacing former mangrove areas (Zöckler et al. 2013).

Over-exploitation for fuelwood and timber production has degraded about 26% of mangrove forests around the world (Valiela et al. 2001), and similar figures are likely to apply with mangrove loss in Myanmar. Shrimp aquaculture has contributed to about 38% of global mangrove loss, and other types of aquaculture account for approximately another 14% (Gilman et al. 2008). For example, the Setse mangrove in Mon State was totally converted into shrimp farm in 2003 (Cherry Aung 2016). A similar scenario was observed in the Ayeyarwady and Rakhine region while the southern mangroves in Tanintharyi Region so far remained unaffected by aquaculture.

While direct anthropogenic impacts including coastal development comprise the biggest threat to mangrove ecosystems at present, climate change is another factor of concern regarding changes in mangrove ecosystems (Gilman et al. 2008).

Over-exploitation of Firewood and Charcoal Production

For at least a hundred years, the Ayeyarwady mangrove forests had provided firewood and charcoal to Yangon, the capital city of Myanmar, and other towns in the delta area. The annual firewood requirement for Yangon is about 700,000 tons, and this demand is increasing steadily due to dynamic population growth (Myint Pe 2002). However, the Ayeyarwady Delta firewood production, of about 432,200 tons per year, is no longer sustainable since the 1980s, and the mangrove forest is diminishing fast, due to over-exploitation of the forest for charcoal production.

A similar development is taking place in the Tanintharyi Region. Especially in the past 5–8 years, an acceleration in charcoal production and mangrove degradation has been observed. This is largely due to the increasing demand and export to Thailand and the cheap import of cheap chain saws (Zöckler 2016b).

Aquaculture Development

Throughout their biogeography, mangroves and intertidal mudflats are exposed to aquaculture development. In Myanmar, aquaculture in mangroves was introduced in 1980 as a pilot scheme in the northern part of Rakhine (see photos). Later, in the southwestern part of the Ayeyarwady Delta area, mangroves have been converted into brackish shrimp ponds, and this development is still continuing (FREDA and ACTMANG 2012) and adding to the loss from agricultural conversion.

The culture of tiger prawns (*Penaeus monodon*) using traditional methods was initiated in 1975 and increased from about 28,000 ha in 2000 up to about 49,000 ha in 2002 (Myint Pe 2002). There has been no further increase after 2003 because there was a severe disease problem affecting shrimp ponds such as white spot virus around 2001–2002. The shrimp business declined in those days because of decreasing market demand. Cyclone Nargis in 2008 destroyed a lot of shrimp farm in Yangon and Ayeyarwady Region, and many shrimp farmers left the job, but recently they started to rebuild with foreign aid support from, e.g. Germany and Japan (FREDA and ACTMANG 2012).

Coastal Development

Myanmar is one of the least developed countries in Asia and only recently opened for foreign investment. This, in turn, leads to coastal development activities in some coastal areas. In Rakhine, oil and gas terminals have been constructed alongside with roads. These have heavily impacted the existing coastal mangrove areas on the Ramree Island. Similar plans exist for the northern Rakhine Province near Dawei, where a major coastal development project encroaches into mangrove habitats. Further south

in the Myeik region the industrial zone has been expanding north into mangrove areas.

Plastic and Fishing Nets

Another problem for mangroves in particular is the pollution with macro-plastic, including ghost nets, damaging and sometimes uprooting young mangroves plants.

Mangrove Protection and Restoration

Protected Areas

With an ever-increasing pressure on the remaining mangroves, there is an urgent need to safeguard the remaining mangrove forests of Myanmar. However, only a small fraction of the mangroves in Myanmar are currently protected inside the Meinmahla Kyun Reserve and in the Lampi Marine National Park covering a total of <1% of Myanmar's overall mangrove stands. No further extensions are planned at present (NBSAP 2015). A priority task should be to expand the existing protected area network in Myanmar. Strengthening the legislative framework applicable to protected area management will enhance law enforcement as well as providing incentives for restoration of degraded mangrove areas.

Meinmahla Kyun

Meinmahla Kyun Wildlife Sanctuary, 13,000 ha in size, was established in 1993, protected and managed by the Forest Department. No villages or settlements are within the area of the sanctuary, but villagers are still allowed to go fishing and also cutting mangroves. A new management plan has been drafted that will reduce fishing and harvest of timber. In 2017 the area was extended to include adjacent intertidal mud- and sandflats and islands, increasing the total protected area to about 50,000 ha in total, and the site was designated as Myanmar's third Ramsar site.

Lampi Marine National Park

The Lampi Island Marine National Park (MNP) is a demarcated marine national park located in Myeik Archipelago. It was designated in 1996 and comprises Lampi, the biggest island of the park and the core of the site, and 20 smaller islands in its surroundings. It protects a rich diversity of habitats including mangrove, beaches, dunes, coral reefs, and sea-grass beds.

Ramsar Sites

In 2017 Myanmar designated for the first time two coastal wetlands. In addition to the above mentioned Meinmahla Kyun site, parts of the Gulf of Mottama were designated as Ramsar site adding another 90,000 ha of intertidal mudflats as coastal protected areas. The Ramsar protection tool is particular valuable to cover intertidal mudflats that host important numbers of migratory waterbirds.

UNESCO Man and Biosphere Reserves

Developing community-based protected areas and forest management within the framework of the Man and the Biosphere Programme would cater for most of the management options that also involve local communities. It could create a vital platform for the long-term protection and restoration of mangroves along the Myanmar coast. A good showcase can be the southern Myeik Archipelago, mangroves, and mudflats in the Tanintharyi Region (see Fig. 16.6). Here we still have a large area of mature mangrove stands, raising pressure on the existing natural resources and an open-minded community, interested in jointly developing scenarios and to redress further mangrove loss. Establishing a large

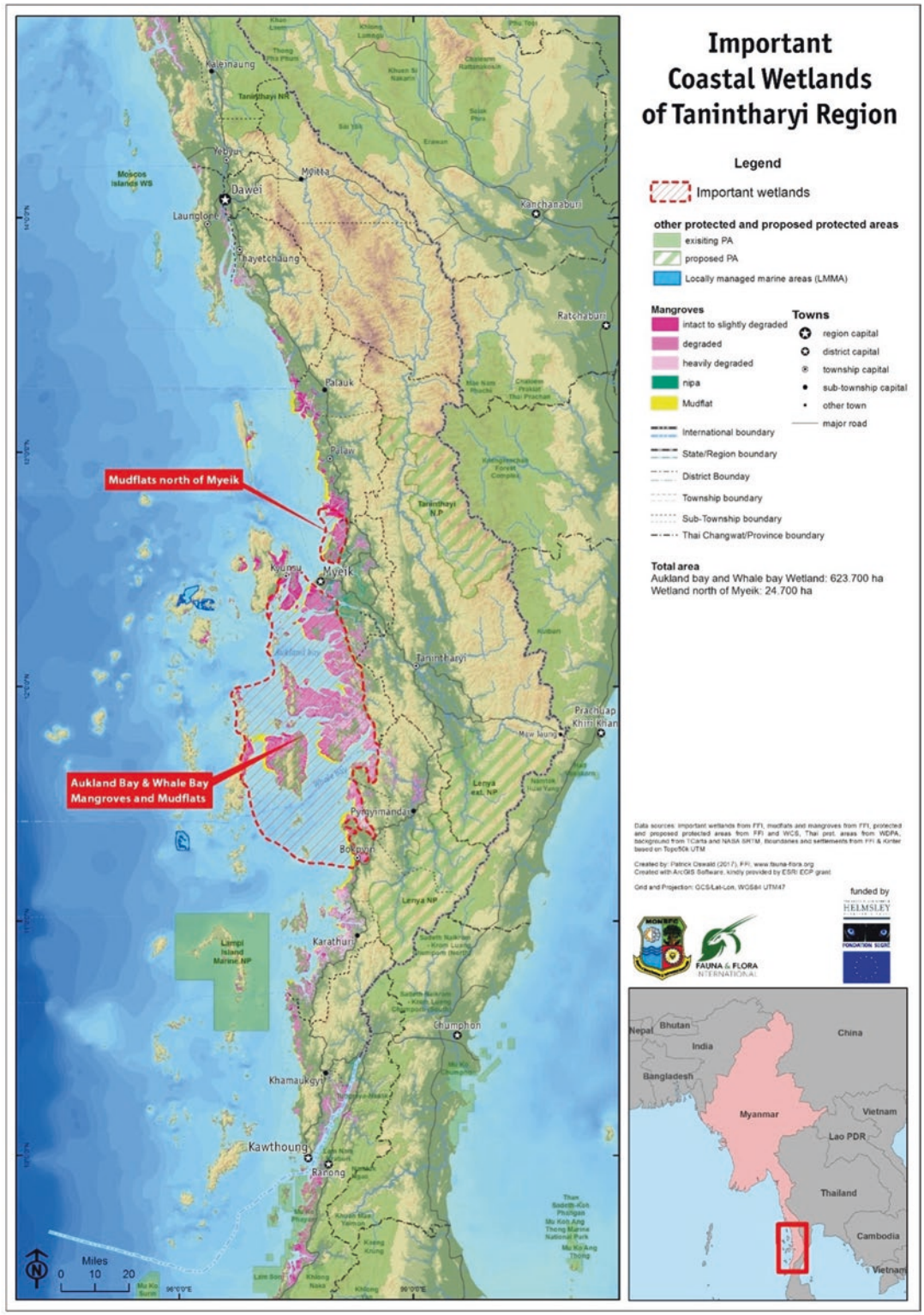

Fig. 16.6 Key coastal biodiversity areas that could be protected as biosphere reserve and as Ramsar sites. (Zöckler et al. 2018)

biosphere reserve with several core areas as protected sanctuaries, combined with Ramsar sites, buffer, and development zones, where nature conservation in reconciliation with sustainable human development and good land use practices can be tested and applied, is being proposed.

Restoration

Recent restoration activities involving local forest user groups pointed the way towards successful government-NGO collaborations to curb further mangrove degradation. Restoration efforts have been taking place in the Ayeyarwady Delta since the 1980s, and a total of 13,000 ha has been restored.

Curbing mangrove deforestation is an urgent conservation priority. 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).

Some areas of the mangroves in the Ayeyarwady Delta have been improved by the Forestry Department's rehabilitation programmes, including reforestation and the protection of natural mangroves in Ayeyarwady and Tanintharyi regions.

Establishment of a mangrove plantation programme with suitable mangrove and other forest-growing species has been launched in degraded and abandoned lands.

The Ministry of Natural Resources and Environmental Conservation is cooperating with Denmark on a mangrove conservation project in Rakhine and Tanintharyi regions. The project started in August 2018.

It would be important to coordinate these laudable mangrove conservation and restoration efforts, including with the establishment of a combination of UNESCO Biosphere Reserves and Ramsar Wetlands. This will be major contributions to redress the ongoing mangrove habitat loss and involve the local communities to safeguard the continuous provision of essential ecosystem services provided by intertidal ecosystems.

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