SOBA 4.6: AQUATIC HABITATS IN THE AYEYARWADY BASIN AND THEIR BIODIVERSITY

AYEYARWADY STATE OF THE BASIN ASSESSMENT (SOBA)

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Prepared by:
Dana Lee and Christoph Zöckler

Disclaimer
"The Ayeyarwady State of the Basin Assessment (SOBA) study is conducted within the political boundary of Myanmar, where more than 93% of the Basin is situated."

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LIST OF ABBREVIATIONS

ADB	Asian Development Bank
BANCA	Biodiversity and Nature Conservation Association
DEC	declining
DoF	Department of Fisheries
EIA	Environmental Impact Assessment
EN	endangered
FAO-NACA	Food and Agriculture Organization and Network of Aquaculture Centres in Asia-Pacific
FCZ	Fisheries Conservation Zones
FFI	Fauna and Flora International
ha	hectare
INC	increasing
IADS	Integrated Ayeyarwady Delta Strategy
km	kilometer
km^2	square kilometers
km^3	cubic kilometers
LC	least concern
m	metre
masl	meters above sea level
mg/L	milligrams per litre
mm	millimetres
m^3s^{-1}	cubic metres per second
MECF	Ministry of Environmental Conservation and Forestry
NT	near threatened
NWRC	National Water Resources Committee
ppt	part per thousand
SOBA	State of the Basin Assessment
STA	stable
VU	vulnerable
WEPA	Water Environment Partnership in Asia
WWF	World Wildlife Fund

EXECUTIVE SUMMARY

This document provides a description of the general freshwater habitats found throughout the Ayeyarwady Basin. With a wide range of riverine and wetland habitats and high levels of species biodiversity, the Ayeyarwady River remains an ecologically important area and one of the world's biodiversity hotspots. However, the habitats of the Ayeyarwady River, from the mountain's rivers in the Eastern Himalayas to the Outer Delta Islands, are increasingly being subjected to intense and growing pressure from habitat loss, degradation and fragmentation, and over-exploitation of natural resources. Almost all of the wide ranges of riverine and wetland habitats illustrated in this report are under extreme pressures from human activities, ranging from deforestation, mining, and over-exploitation of natural resources. The level of pressure varies, but it is clear that the current form of protection is inadequate to address the major challenges of all wetland and riverine habitats. The protection of these habitats and its biodiversity can only be possible if there is close collaboration with the local communities and they are provided an alternative vision for their future.

1 INTRODUCTION

1.1 Overview

An estimated 8.1 to 8.2 million hectares (ha) of rivers, lakes, and wetlands comprise Myanmar's inland freshwater assets. Myanmar's major rivers include the Ayeyarwady (Irrawaddy) River, the Salween (Thanlwin) River, and the Sittaung River (Table 1 and Table 2).The Chindwin River is a 1,200-km long tributary of the Ayeyarwady River.

Table 1 - Catchment area and surface flows of major rivers in Myanmar

River basin	Catchment area (km^2)	Average discharge (m^3s^{-1})	Length (km)
Ayeyarwady River	413,000	13,000	2,150
Salween (Thanlwin) River	158,000	4,500	2,800
Sittaung River	34,400	1,500	450

Notes: km^2 = square kilometres m^3s^{-1} = cubic metres per second km = kilometres

Table 2 - Catchment area and surface flows of minor rivers in Myanmar: Area includes 3% of the Mekong Basin (Water Environment Partnership in Asia [WEPA], 2014; Asian Development Bank [ADB], 2013)

River basin	Catchment area (km^2)	Inflow volume (km^3)
Rivers in the Rakhaing State	58,300	139
Rivers in the Tanintharyi Region	40,600	131
Mekong River (in Myanmar)	28,600	18
Bilin River	8,400	31
Bago River	5,300	8

Notes: km^3 = cubic kilometres

Myanmar's inland freshwater resources are comprised of an estimated 8.1 to 8.2 ha of rivers, lakes, and wetlands. Figure 1 depicts the river network in the basin.

There are three large natural lakes that comprise the majority of Myanmar's total freshwater assets (Food and Agriculture Organization and Network of Aquaculture Centres in Asia-Pacific [FAO-NACA], 2003). The lakes and their corresponding size are listed in Table 3.

Table 3 - Three major lakes in Myanmar with location and size (Aung Htay Oo, 2010)

LAKE	STATE/REGION	SIZE (ha^-)
Inle Lake	Shan State	15,500
Indawgyl Lake	Kachin State	12,000
Indaw Lake	Sagaing Region	2,850

Notes: ha = hectare

According to a 2004 wetland inventory, 99 wetland sites are found along the Ayeyarwady and Chindwin Rivers, the Thanlwin and Sittaung Basins, and, to a lesser extent, the Rakhine coastal region (Figure 1).

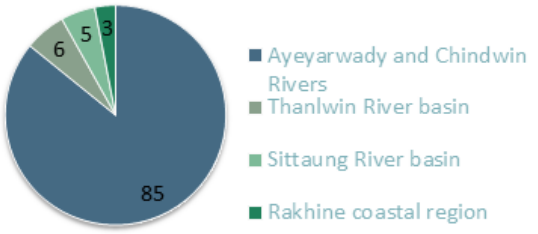

Figure 1 - Number of wetland sites found in the primary basins of Myanmar: (Ministry of Environmental Conservation and Forestry [MECF], 2011)

Figure 2 - River network in the Ayeyarwady Delta and the Central Dry Zone of Myanmar: (map from the Myanmar Information Management Unit, 2016)

In Myanmar, only 1.2 to 1.3 million ha of an estimated 8.1 million ha of freshwater bodies is permanent (Figure 3) (FAO-NACA, 2003; Khin Maung Soe, 2008). Seasonal floodplains comprise the remainder of the freshwater bodies in Myanmar, making the total floodplain coverage comparable to the 7 million ha of the Mekong Basin (FAO-NACA, 2003).

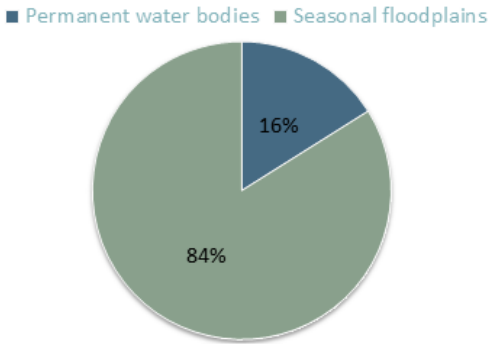

Figure 3 - Contribution of seasonal floodplains and permanent freshwater bodies in Myanmar

1.2 Classification of the Ayeyarwady Basin Wetland Habitats

Wetlands and freshwater habitats in Myanmar were classified broadly according to the Ramsar classification system and Davies et al. (2004; Table 4). Davies used the Ramsar classification system but sub-divided several of the habitat types to account for the broad range of habitats found in Myanmar, particularly wetlands that have undergone anthropogenic modification. Table 4 shows the distribution of all river and wetland habitats in the Ayeyarwady Basin.

Table 4 - Proposed classification for wetlands in the Ayeyarwady Basin

Lacustrine (lakes and ponds)	Permanent
	Seasonal
Riverine (rivers and streams)	Upland high-gradient streams
	Gorges
	Floodplains
	Anastomose channels (braided channels)
	Oxbow lakes
	Deltas
	Man-made canals
Palustrine (marshes and swamps)	Permanent (delta)
	Seasonal
Coastal wetlands	Mangroves
	Mudflats/sand flats

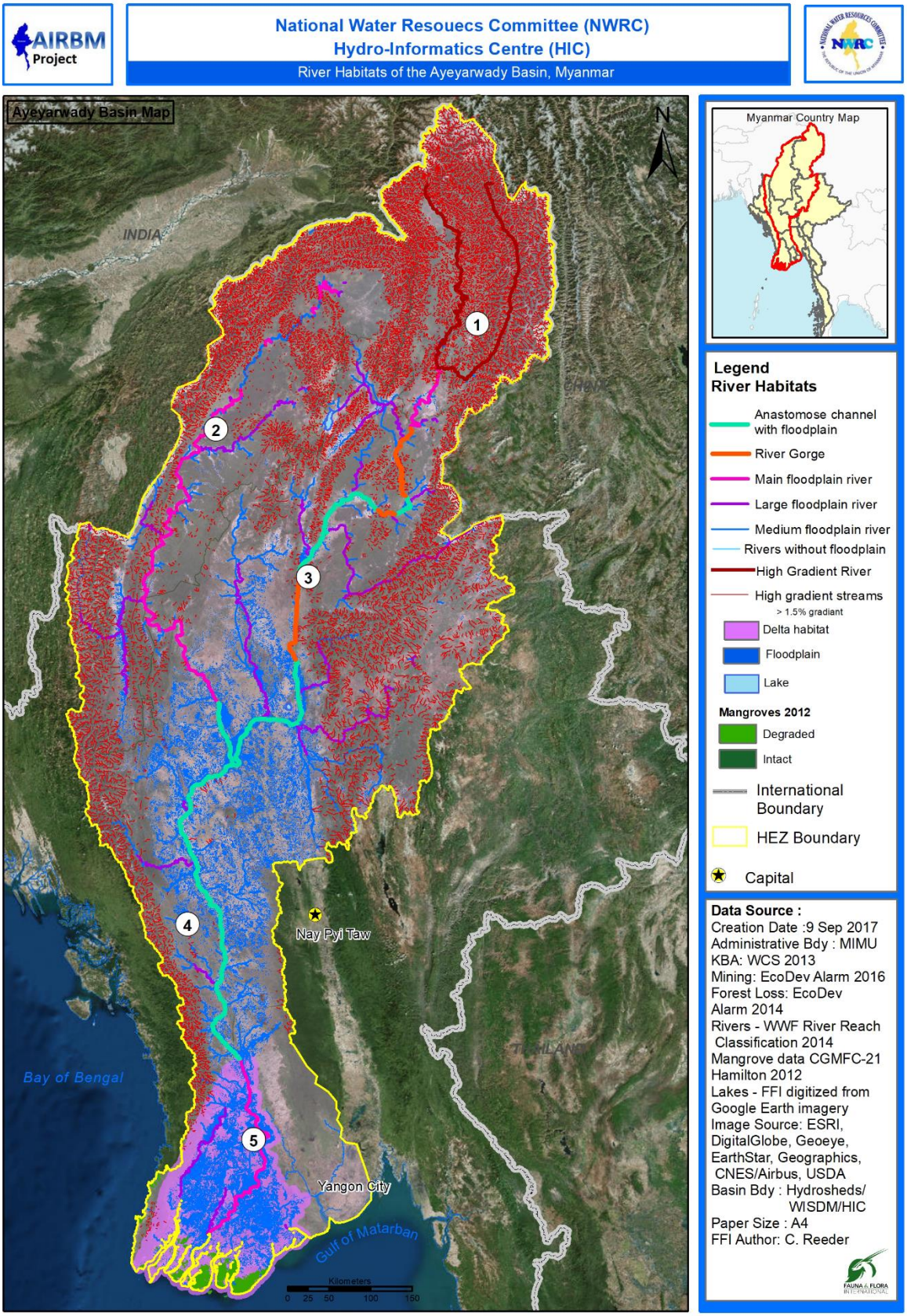

Figure 4 - River and wetland habitats in the Ayeyarwady Basin: Based on Davies et al. (2004), Lehner and Quellet Dallaire (2014), and own observations

Detailed descriptions of each habitat classification are provided below.

2 RIVERINE HABITATS

The riverine wetland classification includes all rivers and streams where water flows in linear channels and includes man-made canals, such as irrigation canals. Riverine wetlands in the Ayeyarwady Basin can be divided into several categories:

2.1 Upland High-Gradient Streams

DESCRIPTION

Upland, high-gradient streams are part of the lotic habitat (rapidly moving water) that dominates the headwaters of the Ayeyarwady and its tributaries, including the Upper Chindwin. These habitats are influenced by many factors, such as rainfall, snow melt, geology, soil characteristics, vegetation, and land use. These factors influence ecological parameters of aquatic ecosystems, such as temperature, dissolved oxygen, pH, conductivity, and turbidity, as well as the composition and distribution of aquatic organisms.

Rainfall and snow melt are the primary drivers controlling flow, water depth, soil erosion, turbidity, and water temperature in these habitats. Rainfall and snowmelt in the upper reaches of the Ayeyarwady and Chindwin Rivers are generally high because of local weather patterns and snowfall and ice accumulating at high elevations. For example, annual mean rainfall within a 10-year period (1999 to 2008) in Putao was approximately 4,697 millimetres (mm). In this location, it rains throughout the year, with approximately 168 days/annum. Most of the mountains and valleys in the upper basin are covered with forest, including some secondary forests, as a result of long-term shifting cultivation by local people.

The upland, high-gradient streams in the Upper Ayeyarwady Basin flow through mountains, folded ranges, and valleys. The prominent physical characteristics of the river in these regions are high velocity flow, steep gradients, shallow depths, and rocky substrates. The habitats range in size from small streams to large tributaries. The river banks are generally steep, with boulders and gravel common throughout the streams, although there are some areas of low flow and sandy substrates. The complex river channel and fast-flowing water help to move plankton downstream through the water column, which provides a food source for aquatic organisms, including benthic macro-invertebrates and fish. Stream temperatures and water velocity are an important factor effecting the composition and distribution of fish species. In these areas, the fast-moving water transports a considerable amount of eroded bedrock material downstream, where the alluvial is deposited onto floodplains.

The chemical and physical parameters of upland, high-gradient streams depend on many factors, including the water source, location, underlying geology, and bank condition. The concentration of the chemical constituents and the physical properties of water depends on stream flows and can vary throughout the year. Water in the Upper Ayeyarwady Basin is generally clear, cold, and free of organic pollution due to low population density and low irrigation intensity.

It is important to distinguish between upland streams, as described above, and upland or high-gradient rivers. Both have in common fast flowing waters and rheophilic (preferring or living in flowing water) species that adapt to these fast-flowing water conditions, such as suckers among the fish. Both the rivers are much larger and have calmer zones that gradually incorporate aquatic habitats for slower moving species. Water from the Mali Hka is generally more turbid than the May Hka and Ayeyarwady Rivers. However, in the regions of May Hka, above Chibwe, the upstream water is very clear compared to the downstream. Some areas in the Upper Basin are high in bromium. The total suspended solids have been measured at 250 milligrams per litre (mg/L) and bromium at 0.565 mg/L (Biodiversity and Nature Conservation Association [BANCA], 2009).

Figure 5 - Small rapids on Mali Hka River (left) and fast run and fish traps on Mula Chaung River (right), both south of Putao (photos credit: M. Kottelat)

Figure 6 - Forest stream in the Indawgyi Wildlife Sanctuary (photo credit: C. Zöckler)

BIODIVERSITY

This habitat type covers a large area (Figure 1) and is rich in species diversity. Most of the areas have not been surveyed and little information is available. During the Environmental Impact Assessment surveys in 2009, some sites in the May Hka and Mali Hka River areas were investigated (BANCA, 2009). Subsequently, fish surveys were conducted in 2016 (Kottelat, 2017), and some information on these species can be drawn from these surveys.

Upland, high-gradient streams support high levels of endemicity due to the uniqueness of the habitat. Smaller species, inhabiting the upper parts of drainages in faster waters, tend to have a small range and are often endemic to a single sub-drainage or a few headwaters (for example, most species of the families *Nemacheilidae (stone loaches)*, *Balitoridae*, and *Sisoridae; catfishes*). As a result, although the number of species in the headwaters of any river is quite low, a significant portion of them are likely to be endemic to that drainage, and the majority of small-range endemics live in headwaters (Tordoff et al., 2012).

Table 5 - Characteristic species of the upland stream, often threatened for this riverine habitat type: (BANCA, 2009; Kottelat, 2017) IUCN threat category shown in brackets. For scientific names see annex of main report, except for amphibians and dragonflies and damselflies

Taxa	Species*	Comments
Mammals	Fishing cat* Small-clawed otter	Only old records, according to skins found in villages. Older records of otters have not been confirmed by camera traps. Otters extremely rare and heavily hunted.
Birds	White-bellied heron*, white-winged duck (EN), ibisbill, wood snipe (VU), Blyth's kingfisher (NT), forktails (including little forktail), plumbeous redstart, and white-capped water redstart	Today, the white-bellied heron appears to be restricted to this habitat type only.
Reptiles	Keeled box turtle (EN), Burmese roofed turtle (EN), giant Asian pond turtle (VU), Indian black turtle (NT), Malayan softshell turtle (LC)	Burmese roofed turtle now possibly extirpated from this habitat after dam construction in small stream in Shan State. Last recorded in 2004
Amphibians	Burmese rock frog, *Rana livida; Bufo macrotis;* and ornate sandfrog, *Microhyla ornate* (LC)	
Fish	Approximately 182 fish species. Members of families Nemacheilidae, Balitoridae, and Psilorhynchidae, Sisoridae. Species of *Tor*, *Oreinus*, *Neolissochilus,* and some species of *Bangana* and *Labeo*.	High proportion of endemic fish species (58%)
Invertebrates	Odonata: *Orthetrum priunosum* and *Neurobasis chinensis* (*Calopterygidae*)	Small selection

Notes:
* For scientific names, see annex of main report, except for amphibians, dragonflies, and damselflies.
EN = endangered VU = vulnerable NT = near threatened LC = least concern

THREATS

Specific threats occurring to this habitat type include deforestation, gold mining and dredging, road construction, overfishing, illegal fishing methods, and the wildlife trade. There is a large amount of gold mining in the Upper Basin, especially between Putao and the Myitsone confluence (local name for the confluence of May Hka and Mali Hka) in the Mali Hka; from the Chibwe to Myitsone confluence in May Hka; and downstream from the Myitsone confluence to Myitkyina (Papworth et al., 2017). The single largest threat for fish specialized for rheophilic habitats are dams, such as the Myitsone Dam that was proposed to be built at the Myitsone confluence (and is currently suspended). Dams completely eliminate rheophilic habitat, both upstream and downstream, and can have devastating effects on the native fish community.

2.2 Irrawaddy Canyons (Including Gorges)

DESCRIPTION

The Ayeyarwady River has three well-known canyons that are located (in a downstream direction) between Sinbo and Bhamo, immediately downstream of Bhamo and downstream of Katha. The first canyon of the river begins approximately 12 km downstream of Sinbo (N 24° 44.69'; E 97° 03.08') and continues for approximately 45 km. The river narrows from approximately 1 km wide down to only 200 to 300 metres (m) wide at the mouth of the canyon, with depths of 30 to 40 m. Steep banks lead up to heavily forested ridges on either side of the river that rise as high as 900 metres above sea level (masl), although most of the ridges along the river are approximately 500 masl. This canyon has fast moving water with extensive rapids and large eddies that are created by rock outcroppings in the middle of the stream. Mean annual flows through the gorge average approximately 9,500 m^3s^{-1} (Davies et al., 2004).

Figure 7 - The beginning of the first canyon of the Ayeyarwady River, downstream of Sinbo

Approximately 30 km downstream of Bhamo, the river narrows from approximately 1 km wide down to approximately 400 m as it enters the second canyon. This canyon could also be classified as a gorge, because the banks are steep with some vertical limestone cliffs rising up to 100 m above the river. River depths range from 25 to 30 m. The river is confined on both sides by rocky banks, and there is very little floodplain habitat, if any. After approximately 12 km, the gorge opens up into outwash floodplain, just upstream of Shwegu (N 24° 11.12'; E 96° 50.53').

Figure 8 - The beginning of the second gorge of the Ayeyarwady River, downstream of Bhamo photo credit: C. Zöckler, Feb 2017)

Figure 9 - Gorge near Bhamo during the dry season (photo credit: C. Zöckler, Feb 2017)

Figure 10 - The Gorge near Bhamo during the rainy season (photo credit: D. Lee, June 2017)

Approximately 55 km downstream of Tagaung, the river enters the third canyon of the Ayeyarwady River (beginning at N 23° 02'; E 95° 97'). Although less remarkable then the other canyons, the river narrows to approximately 500 m wide and becomes deeper (15 to 20 m) with a faster current speed. The canyon remains straight for approximately 30 km before abruptly turning to the west, for approximately 8 km along another fault line, and then continues southeast for another 20 km toward the Town of Singu at the end of the canyon. Floodplain habitat is limited in the third canyon to flooded margins along the bank of the river.

Figure 11 -The third canyon of the Ayeyarwady River (photo credit: D. Lee, Jul 2017)

BIODIVERSITY

Most of the canyons are defined by narrow river channels, few sand bars, and shores with often still intact forested river banks. Generally, these areas are poor in terrestrial species diversity, but, by analogy with information from the Salween and Mekong, rapids are inhabited by a great number of specialised fishes, often with restricted ranges.

Table 6 - Characteristic species of the canyons and gorges

Taxa	Species
Birds	Pied kingfisher, great cormorant
Reptiles	Not recorded
Amphibians	Nor recorded
Fish	There has never been a specific survey or published information on fishes from the canyons and gorges.

THREATS

These habitats generally face similar threats to other habitats in the Ayeyarwady Basin, although these threats may not be as pronounced due to a relatively small amount of geographical coverage and limited access. However, deforestation, gold mining and dredging, overfishing and illegal fishing methods, and the wildlife trade are all common. This is especially true in the first gorge downstream of Sinbo that is currently controlled by the Kachin Independence Army, which does not enforce government restrictions on illegal fishing methods (i.e., electrofishing and poison), gold mining, and agricultural contaminants.

2.3 Deep Pools

DESCRIPTION

Deep pools can be found throughout the Ayeyarwady Basin, especially in the upper and middle sections of the river as well as the headwaters. This habitat type is defined by relatively deep sections of the river (often >30 m) that provide refuge for a number of aquatic species and may also act as spawning habitats. Deep pools are often found in bedrock or mixed bedrock-alluvial stretches of the river, as this sort of structure is necessary for their formation. Depths and areas of deep pools vary significantly throughout the river; however, deep pools are defined by their depth relative to the surrounding sections of the river and usually feature low current velocities.

Very little information exists on the location of deep pools in the Ayeyarwady Basin. Surveys conducted for the State of the Basin Assessment (SOBA) project revealed a deep pool along the western bank of the river near the Town of Tigyaing, where water depths measured up to 77 m (N 23°45.42'; E 96°09.23). Elsewhere in the basin, deep pools have been located and designated as Fisheries Conservation Zones (FCZs) in an effort to protect these important habitats. In the Upper Mali Hka, Fauna and Flora International (FFI) has identified several deep pools in the Hpongon Razi area (Figure 12).

BIODIVERSITY

Deep pools are known to provide refuge habitat for several fish species, especially in the dry season when water levels recede. However, few surveys have been done in the Ayeyarwady Basin to characterize the species found in these important habitats. Information from the Salween and Mekong Rivers indicates that these areas are inhabited by a great number of fishes that often migrate to other parts of the river at different times of the year. For example, in the Lower Mekong Basin, 75% of the catch landed by the Cambodia *dai* fishery depends on fish populations that utilize deep pools (Halls et al., 2013). Many fish inhabit deep pools throughout the year. Some species spawn in deep pools, such as *Bosemania microlepis* and *Hypsibarbus malcolmi*, which are thought to spawn in deep pools in the Mekong River (Halls et al., 2013).

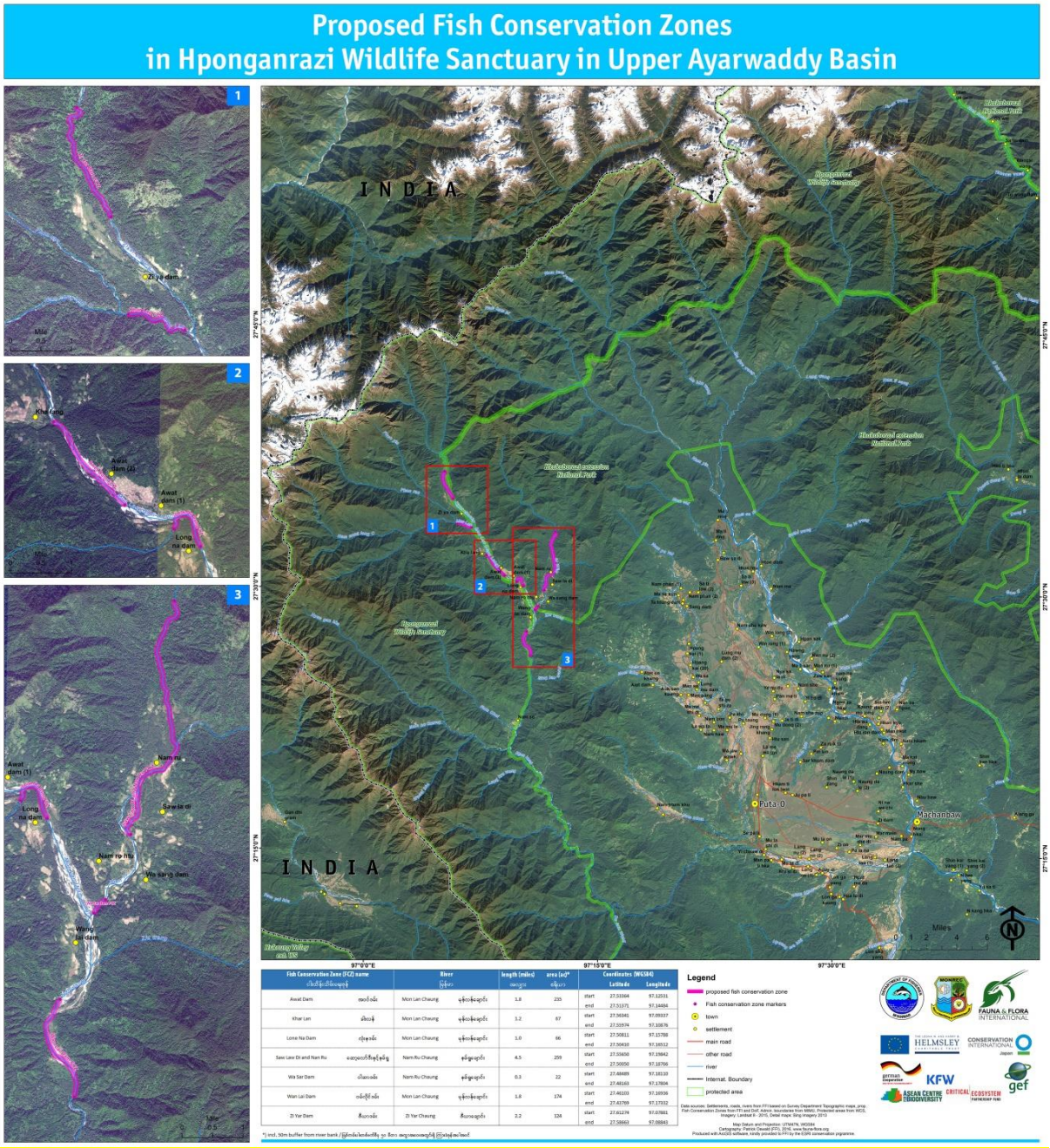

Figure 12 – The location of FCZs around deep pools in the Upper Mali Hka

THREATS

Although these habitats are relatively small in geographical coverage, they play an important role in supporting biodiversity and, thus, may be more susceptible to threats than other habitats in the Ayeyarwady Basin. Overfishing and illegal fishing methods are common in deep pools, especially in the dry season when many fish species take refuge in these habitats. Strict law enforcement is needed to uphold government restrictions on illegal fishing methods (i.e., electrofishing, poison, explosives) as well as agricultural contaminants. Deforestation, gold mining, and dredging are also common practices that may play a role in degrading these habitats.

2.4 Main River Floodplains

DESCRIPTION

Floodplain River channels can be found throughout the length of the river and are especially predominant in the upper section of the river between Myitkyina and the Sinbo. In these reaches, the river has a low gradient, slow flowing water, and extensive sand, silt, and gravel bars. Most notably, the river is heavily meandering, with semi-permanent river banks that regularly overtop during the wet season, leading to extensive wetland creation in the surrounding lowland areas. During high flows, the river channel can change tremendously, as soft sediments on the outside bend of the river become eroded.

The Ayeyarwady is generally quite wide along the floodplain sections of the river (approximately 700 to 800 m), with depths of approximately 12 to 18 m in the wet season. Water levels vary by an estimated 2 to 3 m between the dry season and the wet season. River banks, on the outside bends of the river, are approximately 5 to 7 m high. Temperatures in the main channel of the river average approximately 25°C during the wet season and 15°C during the dry season.

A map of Myanmar's floodplains and wetlands is shown in Figure 15. Myanmar's topography and flood pulse system account for a high volume of water passing through Myanmar. However, significant variance in volume results in highly variable water access, temporally and spatially (Kye Baroang, 2013).

Figure 13 - Vast expanses of sand bars with different layers of sand and pebbles

Figure 14 - Naturally occurring erosion in the floodplain section of the Upper Ayeyarwady River (Jun 2017)

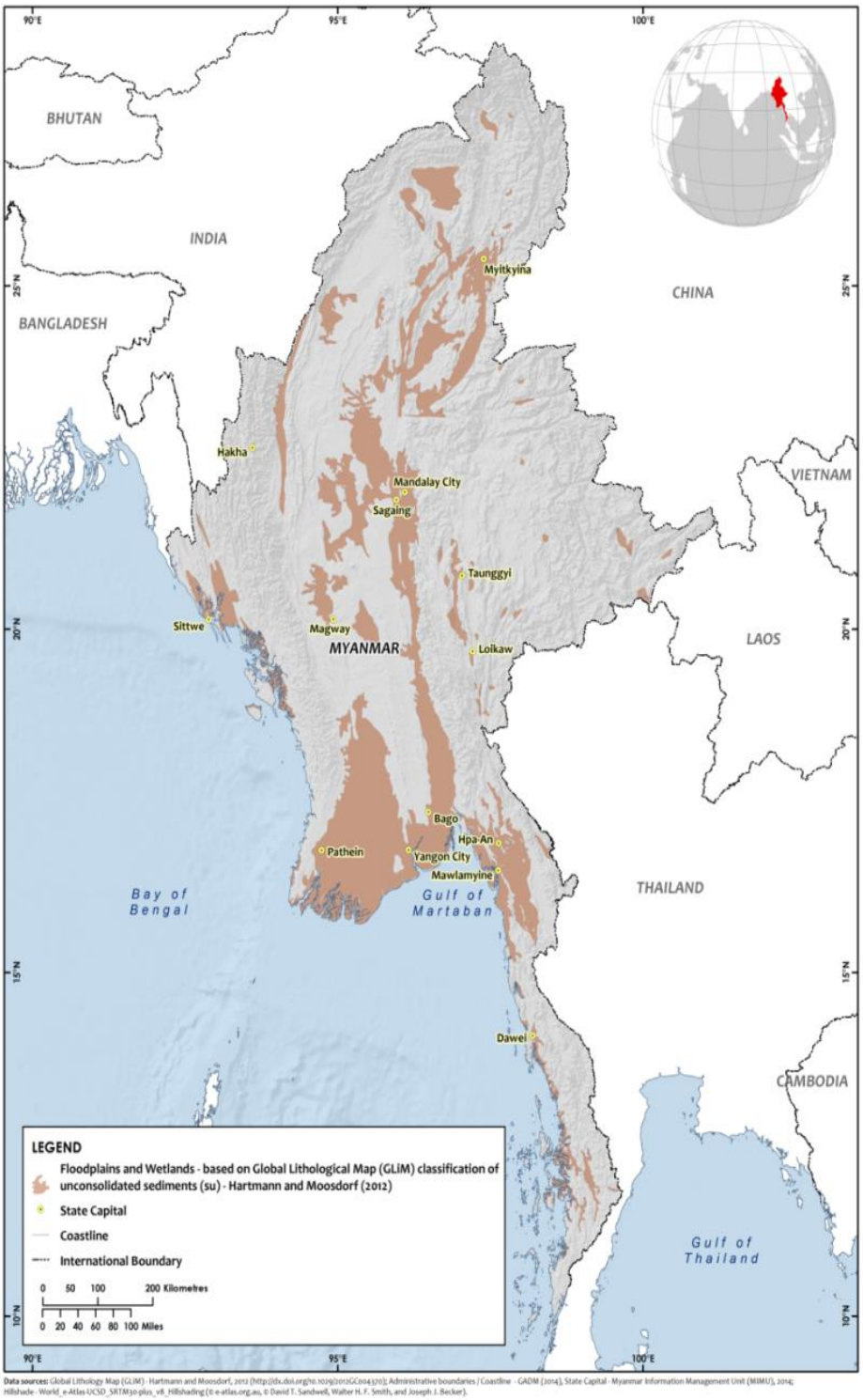

Figure 15 - Map of floodplains and wetlands derived from a geological map of unconsolidated sediments (Courtesy of Jason Benedict, WorldFish. Data: Global lithology map, Institut für Geologie, Hamburg University, Germany)

When this information is related to an administrative map, it highlights the number of townships within the Ayeyarwady Basin that have floodplains (i.e., aquatic habitats). These floodplains get flooded in the wet seasons and constitute important habitats for aquatic fauna.

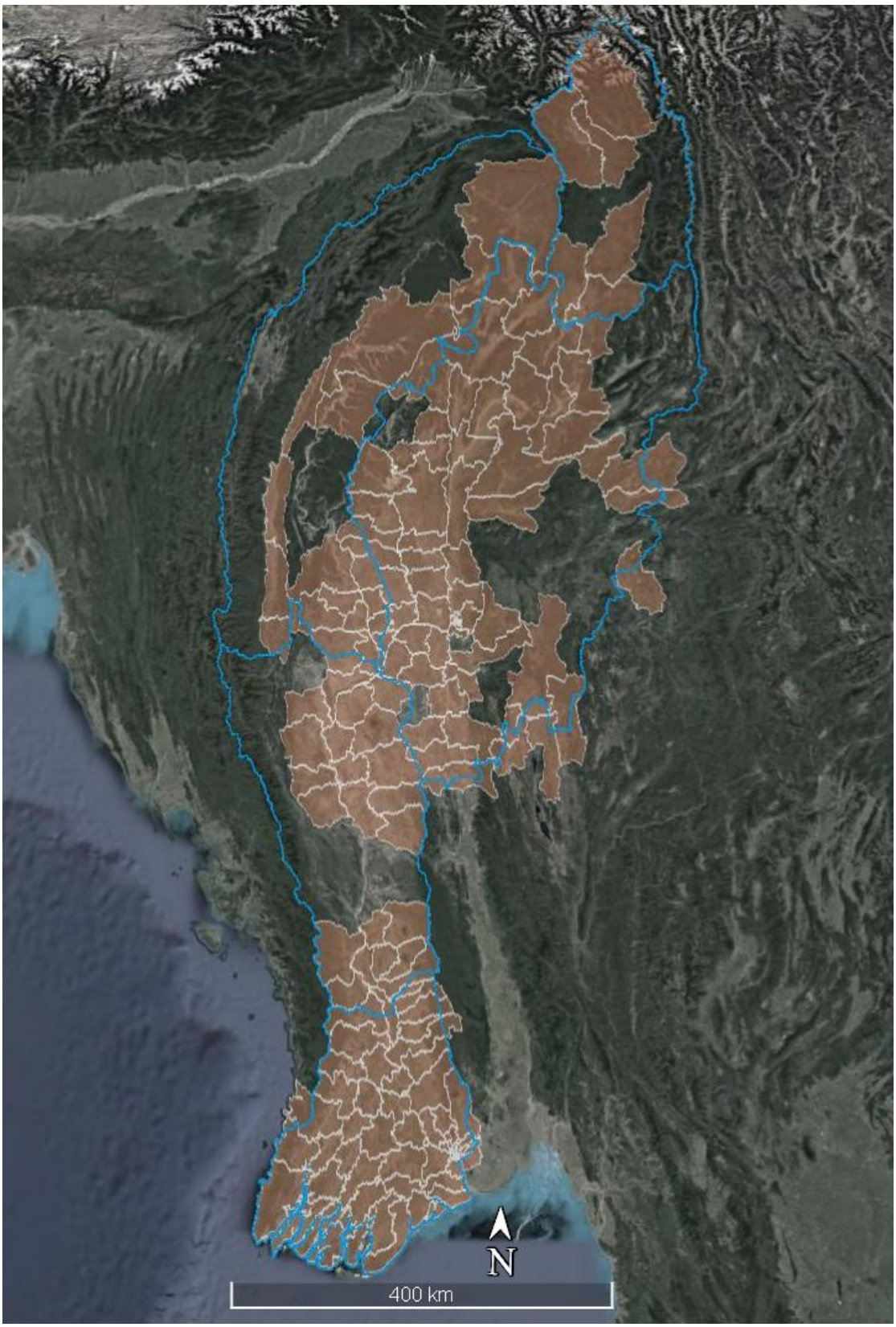

Figure 16 - Map of townships, floodplains, and wetlands in the Ayeyarwady Basin Source: derived from the above map

There are numerous sand and silt bars in the floodplain sections of the river; however, at high water during the rainy season, these features are under water. Large amounts of loose sediment and a dynamic river channel result in numerous flow patterns, including slack water, turbulent flows, and eddies in the dry

season. Erosion is evident at nearly all exposed outside banks that do not have rocky outcrops. Loose sediments, deposited along the river during high flows, are often rich in nutrients and can become covered by grasses, shrubs and trees, which may become flooded at high flows. This habitat heterogeneity is displayed by a wide range of different sediments, ranging from fine sand to large pebbles, and rich bank vegetation that creates many places for fish to spawn within the main river channel.

There are many river-associated wetlands in this section, such as seasonal marshes and low-lying lakes. These are created when the river overtops the banks during high flows. Additionally, the continuous erosion and meander of the river channel results in the creation of numerous cut-off channels and oxbow lakes, which are created when portions of the old river channel become cut off from the river.

BIODIVERSITY

The wide array of microhabitats within this type of floodplain river habitat hosts a large number of species. It is different types of sediments and the structures on the bank as well as under water that creates the large range of habitats. Table 7 lists a few selected characteristic species from different taxa.

Table 7 - Characteristic species for the large floodplain river habitat type

Taxa	Species	Comments
Mammals	Small-clawed otter (VU)	Not suitable for many mammals due to disturbance and persecution. The otter species has been reported in former times but not in recent records.
Birds	Ruddy shelduck, bar-headed goose, small pratincole, great cormorant, gadwall, river lapwing (NT), river tern (NT), and oriental darter (NT)	Trend data available for some species (see figures and table below).
Reptiles	Burmese roofed turtle (EN) and Asian softshell turtle	Currently, only found in the Chindwin Basin.
Amphibians	Not recorded	
Fish	Some representatives are *Pethia padamya*, *Syncrossus berdmorei*, *Rita sacerdotum*, *Laubuka fulvescens*, *Channa marulius*, and *Salmostoma sladeni*.	For more details see Kottelat (2017)
Invertebrates	Not recorded	

Trends in Biodiversity

In recent years, there has been a decrease in floodplains that is attributed to dam and infrastructure development (Khin Maung Aye et al., 2006). Trends in biodiversity of floodplain-associated taxa are reviewed in Table 8.

Table 8 - Trends in Waterbirds at the Myitkyina - Sinbo River stretch from 2000 to 2017 (van der Ven, 2000; AWC, Wetlands International, 2017; Thet Zaw Naing, 2006; AWC, Zöckler and Lay Win, 2016; Zöckler and Thant Zin, 2017)

Species	Scientific name	2000	2001	2002	2003	2004	2006	2007	2016	2017	Trend
Cormorant	*Phalacrocorax carbo*		600	405	974		211	597		316	DEC
Little cormorant	*Phalacrocorax niger*		22	12	34		35	20		0	DEC
Darter	*Anhinga melanogaster*		51	104	65		47	35		18	DEC
Bar-headed goose	*Anser indicus*	4070	3085	946	3443		1381	708	670	106	DEC
Ruddy shelduck	*Tadorna ferruginea*		2170	2548	3626	3884	3000	2097		1285	DEC
Gadwall	*Anas strepera*	2367		1348	1728		1690	1384	365	325	DEC
Spot-billed duck	*Anas poecilorhynchus*	939	162	145	266			172		272	INC?
Ferruginous pochard	*Aythya nyroca*		26	2	26		389	1500		1	DEC
Tufted duck	*Aythya fuligula*		50	55	176		460	130		0	DEC
Red-crested pochard	*Netta rufina*	18		6	14			16	5	0	DEC
Goosander	*Mergus merganser*		108	50	82		59	115		9	DEC
Goldeneye	*Clangula bucephala*	4	29	1	4		18	28	1	5	DEC
Small pratincole	*Glareola lactea*		2540	1155	7785		2954	2792		3160	DEC
Eurasian crane	*Grus grus*	2419	1457	757	1503		846	165		28	DEC
Black stork	*Ciconia nigra*		80	233	163		26	27		43	DEC
Great crested grebe	*Podiceps cristatus*				20		30	36		10	DEC
Grey heron	*Ardea cinerea*		75		44			20		40	STA
Little egret	*Egretta egretta*		50	58	50			105		73	STA
Great egret	*Egretta alba*		7	9	7			9		44	INC
Mallard	*Anas platyrhynchos*	546	36	29	47		48	106		400	INC
Pintail	*Anas acuta*		38		5			6		20	STA
Teal	*Anas crecca*		20	4	16					50	?
Wigeon	*Anas penelope*		5	10	22		10	8			?
Greylag goose	*Anser anser*		379	121	31			1958		84	DEC
Pallas' gull	*Larus ichthyaetus*		130	98	160		95	157		44	DEC
Temminck stint	*Cakidris temminckii*		38	32	31					103	STA?
Little ringed plover	*Charadrius hiaticula*		4	19	14		32	6		57	INC
River lapwing	*Vanellus tectus*		8		8		5			8	STA
Greenshank	*Tringa nebularia*		40	29	6			36		26	STA
River tern	*Sterna aurantia*		65	38	69			1		0	DEC
Wooly necked stork	*Ciconia episcopus*		1	2	2			2		0	DEC
Lesser adjutant	*Leptoptilos javanicus*			10	14			1			DEC
White-tailed eagle	*Halieatus albicollis*			5	1			3		0	DEC
Spot billed pelican	*Pelecanus philippensis*	222			12	59		70			?

Notes:
DEC = declining INC = increasing STA = stable

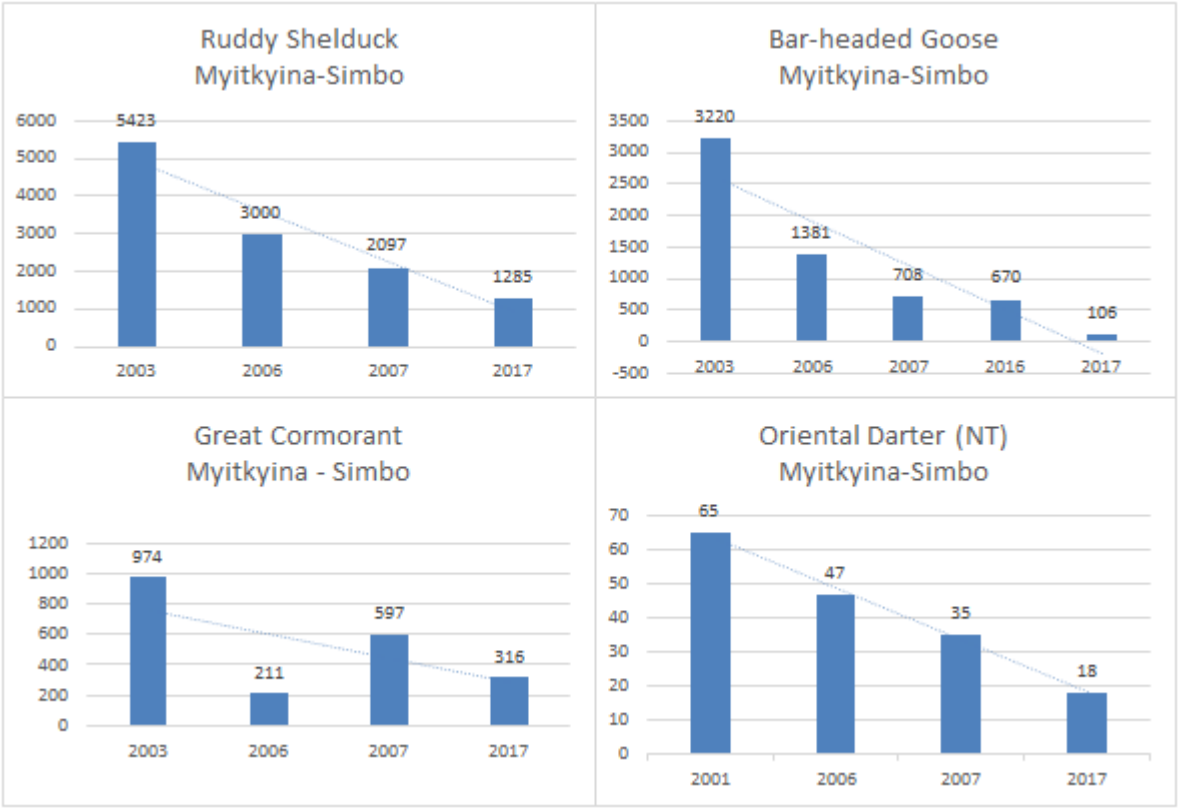

Figure 17 - Trends in wintering populations of several migratory waterbirds and one resident bird (oriental darter); (a) ruddy Shelduck *Tadorna ferruginea*; (b) bar-headed goose, *Anser indicus*; (c) great cormorant, *Phalacrocorax carbo;* and (d) oriental darter, *Anhinga melanogaster* in the Ayeyarwady River between Myitkyina and Simbo (Davies et al., 2004; Thet and Lwin, 2006; van der Ven and Thet, 2008)

Trends in the actual riverine habitats are difficult to measure. However, trends in biodiversity indicate the state of the habitat. The deteriorating situation along this river stretch is well illustrated by the decline of several key characteristic waterbird species that indicate the degrading environmental conditions. Considering the decline is wide-spread across all taxa and across the different flyways of the migratory and resident birds (i.e., oriental darter and small pratincole), the root causes for the decline are largely due to local issues.

The patterns described in the present report show 22 declining waterbird species and only four increasing. Even the spot-billed duck's population (see Figure 18) might also have decreased if count data from 2000 are included in the analysis (van der Veen, 2000). The decline of waterbird species is most pronounced in the main river floodplains compared to others, pointing to the potential impact of gold dredging on the river that has increased considerably over the past 15 years (Davies et al., 2004; Zöckler and Thant Zin, 2017).

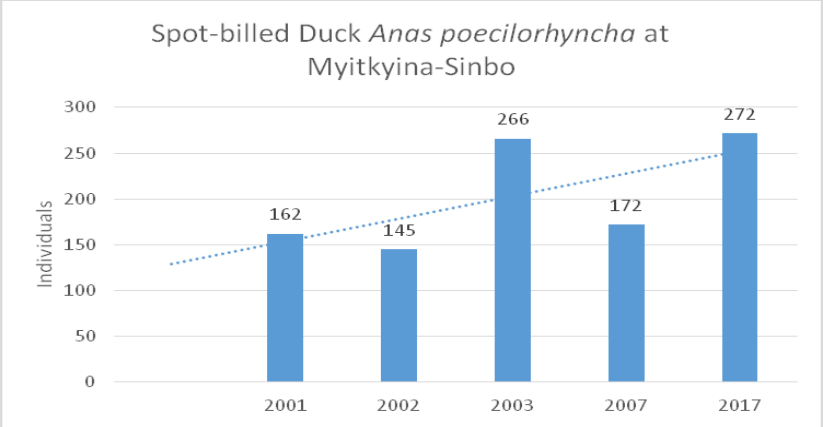

Figure 18 - Trend in spot-billed ducks, *Anas poecilorhyncha*, at the river stretch between Myitkyina and Sinbo

THREATS

The main floodplain river habitat type faces a number of threats, including illegal fishing methods (i.e., electrofishing and poison), deforestation, environmental degradation, poaching and bird trapping, agricultural contaminants, introduced species, and weak law enforcement. Gold dredging is prevailing and has been increasing to a level that has had an impact on biodiversity, which can be seen in birds (Table 5) and possibly fish (that have not been monitored).

The natural movement of the river in this section results in heavy erosion on the outside bends of the river. The Town of Ta Law Gyi is located in an oxbow cut-off, and there is concern that the town may be cut off from the river entirely if sediment keeps filling in the entrance to the oxbow.

Rapid forest loss was reported in this section of the river near Sinbo. Villagers noted that Chinese businessmen were buying land concessions in the area and clearing the forests for tissue banana plantations. Heavy logging pressure for firewood was also reported.

2.5 Anastomosing Channels (Braided Channels)

DESCRIPTION

An anastomosing channel is characterized by multiple channels that divide and reconnect and are separated by semi-permanent banks that often enclose floodplains. Included in this definition are braided channels, however, anastomosing rivers are separated from braided channels in that they consist of low-gradient, deeper channels, with more stable banks. Braided river channels generally form in steeper gradients and exhibit much less bank stability.

The majority of the Ayeyarwady River is characterized by long stretches of braided channels and a landscape dominated by sand features (i.e., bars, islands, and banks). This braided, or anastomosis, channel is more distinct than the meandering river pattern that is found in other large Indo-Burma rivers, such as the Mekong (Lehner and Quellet Dallaire, 2014). The Ayeyarwady River consists almost entirely of anastomosing channels from the end of the first gorge near Bhamo to the delta. Anastomosing channels comprise more than 75% of the Middle Ayeyarwady, stretching nearly 1,000 km in total.

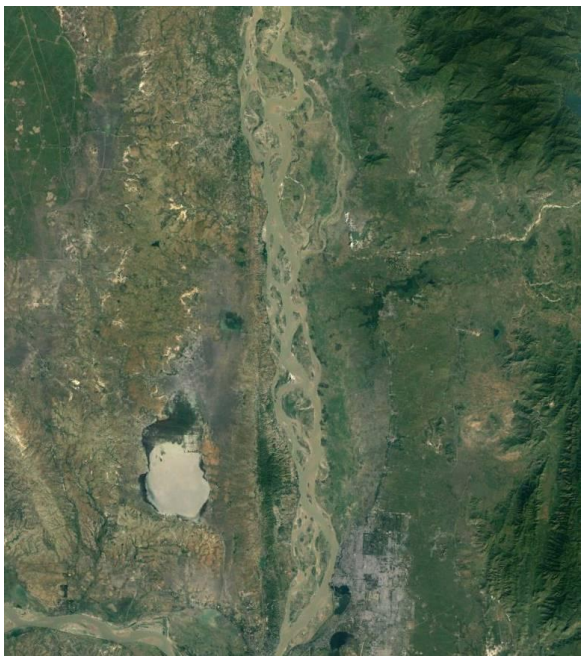

Figure 19 - Anastomosing river channel in the vicinity of Mandalay

Anastomosing sections of the Ayeyarwady River are defined by wide areas of interconnecting river channels. In the rainy season, high water floods most of the braided channel, leaving only some of the higher elevation islands exposed in the middle of the river. High water floods shallow depressions in the islands, creating extensive seasonal wetlands within the river channel. These areas are used for extensive agriculture in the dry season.

Easily eroded banks and a dynamic river channel can result in the formation of numerous sand and silt bars in the anastomosing sections of the river, although at high water during the rainy season, these features are under water. These habitat conditions also result in numerous and diverse flow patterns, including slack water, turbulent flows, and eddies in the dry season. Erosion is evident in many locations. Loose sediments, deposited along the river during high flows, are often rich in nutrients and can become covered by grasses, shrubs, and trees, which may become flooded at high flows.

Figure 20 - Multiple layers of sediment demonstrate the huge dynamic between the seasons in Bhamo, Feb 2017). (Photo credit: C. Zöckler)

Figure 20 - Anastomose river channel downstream of Shwegu during the rainy season (Photo credit: D. Lee)

The chemical and physical parameters of the anastomose wetland habitat depends on many factors, including the location, underlying geology, and bank condition. The concentration of the chemical constituents and the physical properties of water depend on stream flows and can vary throughout the year. Chemical constituents of anastomose habitats in the Ayeyarwady Basin vary greatly because of the area and diversity of this habitat throughout the basin.

BIODIVERSITY

This habitat type is prevailing (75%) in the Middle Ayeyarwady and dominated by wide river banks and large sediment deposits.

Table 9 - Characteristic species for the anastomosing river channel habitat type

Taxa	Species	Comments
Mammals	Irrawaddy dolphin (CR) Smooth-coated otter, *Lutrogale perspicillata* (VU)	The river population of the Irrawaddy dolphin has been classified by IUCN as CR. It is exclusively distributed in this river habitat type. The otter species has been reported in former times but not in recent records.
Birds	Ruddy shelduck, small pratincole, black-bellied tern (EN), river tern (NT), river lapwing (NT), great cormorant, gadwall, pintail duck, great thick-knee (NT), little ringed plover, and Temminck's stint.	Rich in waterbirds. Overall, still more than 30,000 birds. Only remaining river habitat left for the black-bellied tern (EN).
Reptiles	Burmese roofed turtle (EN), Burmese peacock softshell turtle (EN), and giant Asian softshell turtle (VU).	No recent records for Burmese roofed turtle
Amphibians	Not recorded.	
Fish	There are no characteristic fish species for this habitat type. The fish community is comprised of species that can be found throughout the river, including the anastomosis and gorge habitat types. In total, 177 species were recorded. Some representatives are: *Hyporhamphus limbatus*; *Rhinomugil corsula*; *Tenualosa ilisha* (ilisha); *Cephalocassis jatius*; *Glossogobius giuris;* and the freshwater mudskipper, *Periophthalmodon septemradiatus*.	For details on fish diversity see Kottelat (2017)

TRENDS IN BIODIVERSITY

Trends are available for selected species and selected river stretches only. Due to active conservation measures and awareness raising, the population of the Irrawaddy dolphin is stable at a low level. Most remarkable is the decline, or disappearance, of the river tern from most of the Ayeyarwady River. While Thet Zaw Naing and Ngwe Lwin (2006) still recorded 81 river terns between Bhamo and Mandalay in 2006, there were only 2 in 2017. For other species, the trends are less clear, as the example of the ruddy shelduck demonstrates in Figure 22.

There is less information available for previous counts from 2001 to 2003 for this section downstream, but it looks like a similar decline occurred for many species. Ruddy shelduck seems to have increased in some stretches near Katha and Mandalay, but nowhere near compensating for the loss of more than 75% of the species further upstream or the numbers that had been counted in the same area in 1993 (see Figure 21).

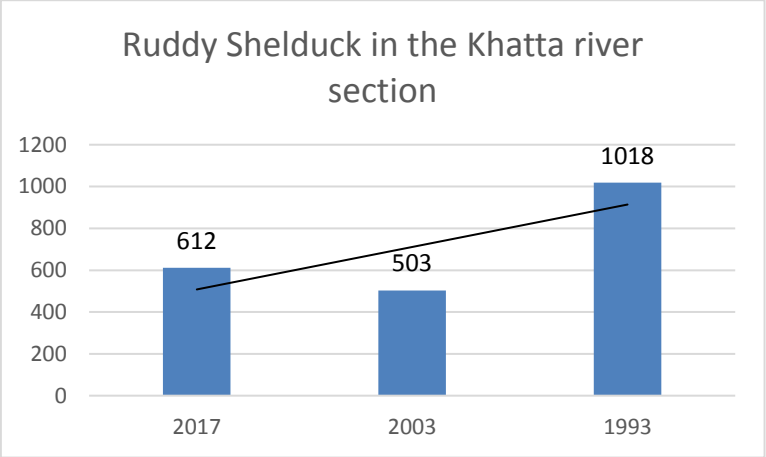

Figure 21 - Number of ruddy shelducks, *Tadorna ferruginea*, in the river section from Katha to Tagaung at three points in time for approximately a 25-year period (Davies et al., 2004; AWC, Wetlands International, 2017; Zöckler and Thant Zin, 2017)

The spot-billed duck only declined marginally from 590 to 480. Several duck species, like the northern shoveler, teal, and widgeon, registered in small numbers in 2003 and were not observed in 2017. The number of cranes has increased from 18 to 56, which could be part of a more wide-spread overall increase that has been noticed or a redistribution of the birds from other areas upstream. Trend data are also available for grey heron, which was abundant by 46 individuals but declined to only 28. The number of cormorants is about stable. The number of darter might have slightly increased from 4 to 6, but it could also be redistributed between different subsections. Interestingly, the number of waders and, in particular, the lesser sand plover and the little ringed plover, was high in 2003. More than 180 lesser sand plovers were noted in 2003, while in 2017, no more than 20 birds were spotted, including the stretch between Katha and Tagaung. However, a large number of 108 Kentish plovers were noted in 2003, and it is assumed that the species could have been misidentified. In total, the number of small plovers declined from 195 to 154. It would be important to define, more clearly, the boundaries for comparisons of future data with this and previous waterbird counts.

THREATS

The anastomosis habitat type faces a number of threats, including fishery declines due to illegal fishing methods (i.e., electrofishing, poison, small net mesh sizes), deforestation, agricultural contaminants, introduced species, wildlife hunting and poaching, and weak law enforcement. Gold dredging and sand mining are prevailing and have been increasing to a level that has had an impact on biodiversity, which can be seen in birds (Table 5) and possibly fish (that have not been monitored).

Fishing activity was commonly observed during surveys despite the ban on fishing during the closed season. Weirs and fish traps were observed near the mouths of several tributaries.

Rapid forest loss is apparent in this section of the river, especially in the Central Dry Zone. Land clearing for agriculture was common in this area, and heavy logging pressure for firewood was also prevalent. In addition, agriculture encroachment into floodplain areas is common near the river, and several tributaries appeared to be diverted for irrigation

2.6 Man-Made Canals

DESCRIPTION

Man-made canals are an important wetland type in Myanmar and can be found throughout the Ayeyarwady Basin. Canals dug for irrigation and domestic water supply purposes have been in existence for hundreds of years, especially in and around the Central Dry Zone. Although man-made canals can occur in a variety of forms, many of the old canals have a flora and fauna similar to natural flowing waters. However, the fish community in many of these habitats is likely depauperate and will be more similar to the fish communities found in swamps. The size, depths, and diversity of these habitats are highly variable and dependent on the intended use. Generally, these habitats are relatively shallow, with slow flowing water and relatively little complexity compared to a natural river channel. Flow regimes vary throughout the year but are intended to ensure year-round flows for irrigation or drinking water supply. The chemical and physical parameters of man-made canals depend on many factors, including the level of connectivity with the river, age, location, underlying geology, and substrate. There are large areas of irrigated land in the Central Dry Zone, where the chemical constituents of the water are driven by the high alkalinity of the soil.

Because of the frequency and old age of this wetland type in many cases, adequate records and maps do not exist to characterize spatial coverage.

BIODIVERSITY

No characteristic biodiversity has been found to typically be attributed to this man-made habitat type.

THREATS

Many of the old canals that have a fauna similar to that of natural flowing waters face the same threats, especially agricultural contaminants, introduced species, and heavy fishing pressure.

3 LACUSTRINE HABITATS

3.1 Lakes (Including Seasonal)

DESCRIPTION

Lacustrine wetland habitat exists in many forms in the Ayeyarwady Basin, including permanent and seasonal, natural and artificial, and fresh and saline water bodies. Lacustrine wetlands can first be divided based upon whether or not water is present all year round. Lakes and ponds that normally have water all year are considered permanent, while lakes or ponds that dry out regularly during the dry season are considered seasonal. Lakes and ponds in the basin can then be divided based upon whether or not they are natural or man-made (artificial). Artificial lakes are those that have been dammed by a large structure to create a new wetland. Included in artificial lakes are also areas in which a stream or natural body of water has been modified to hold water for all or part of the dry season. For example, year-round ponds and storage tanks in the Central Dry Zone are often created by enlarging natural water bodies.

Lacustrine wetland habitats can also be divided according to the salinity of the water. The water in freshwater lakes is fresh all year round, while the water in saline lakes has a year-round conductivity (which is related to salinity) of greater than 1,000 µS/cm. Water in variably saline lakes is fresh during the wet season, but it gets progressively more saline during the dry season due to intense evaporation. Most of the lacustrine wetlands in the Ayeyarwady Basin are freshwater, but there are several small permanently saline lakes and many seasonally saline wetlands in the Central Dry Zone.

Figure 22 - Fish traps in a permanent lake near Katha in the Ayeyarwady Basin

Lacustrine habitats in the Ayeyarwady Basin are enormously varied in terms of size, depth, diversity, flow-regimes, and other physical parameters. Lacustrine wetlands in the basin range from large, biologically rich to seasonal, shallow depression lakes and small ponds. Indawgyi Lake is one of the largest natural lakes in Myanmar. It is an ecologically important area that is both a Ramsar Site and a wildlife sanctuary and is known to support high levels of biodiversity and endemism. Despite an extensive littoral zone, the lake reaches depths of approximately 22 m near its western side. Small seasonal lakes are present throughout the length of the Ayeyarwady River and are seasonally flooded by high flows from the river. Many of these areas dry up into small ponds in the dry season and provide valuable fishing habitat that is utilized heavily be local fishermen.

Figure 23 – Shallow, seasonally flooded wetland adjacent to the Ayeyarwady River

Chemical constituents of lacustrine habitats in the Ayeyarwady Basin vary greatly. Turbidity levels in lacustrine wetland habitats depend on location and time of year. Large wetlands, like Indawgyi Lake, have good water clarity in the dry season (3.45 m Secchi depth), while shallow, seasonal lakes adjacent to the Ayeyarwady River show relatively low water clarity during the wet season (<0.5 m Secchi depth). Saline lakes can show even lower water clarity due to extensive phytoplankton populations that reduce transparency. Conductivities vary depending on the season and the degree of water flow through the wetland habitats. During the wet season, the water may be fresh but then become progressively more saline during the dry season. While most lakes and ponds have conductivity values ranging from 50 to 150 µS/cm, several of the habitats that evaporate during the dry season have conductivities above 1,000 µS/cm, being above the limit for the definition of freshwater (assuming this high conductivity is due only to salt, not other ions). The conductivity of the water in these wetlands may vary substantially throughout the year.

Figure 24 - Lake Indawgyi (photo credit: C. Zöckler, Dec 2014)

Biodiversity

Lakes and ponds are mostly distributed in the Central Dry Zone and in the Kachin State. The largest, Lake Indawgyi, is relatively well studied, while others have hardly any information available. Table 10 lists a few selected characteristic species from different taxa for permanent lakes, such as Indawgyi, Indaw, or Khule Inn.

Table 10 - Characteristic species for the lake habitat type

Taxa	Species	Comments
Mammals	Small-clawed otter	Found in some of the more remote oxbow lakes.
Birds	Purple swamphen, pheasant-tailed and bronze-winged jacana, cotton pygmy goose, ferruginous duck (NT), Baer's pochard (CR), tufted duck, moorhen, ruddy-breasted crake, wood sandpiper, Temminck's stint, openbill stork, greenshank, greater spotted eagle (VU), lesser adjutant (VU), citrine wagtail, dabbling ducks, and coot.	Composition of birds varies during the seasons, with jacanas staying for breeding, while most of the waders and ducks are winter migrants.
Reptiles	Not recorded.	
Amphibians	Nor recorded.	
Fish	78 species of fish recorded in the lake. Only one is endemic: *Mastacembelus pantherinus.*	
Invertebrates	Not recorded.	
Macrophytes	*Salvinia. Eichhornia (invasive), Polygonum* and *Vallisneria, Ceratophyllum, Trapa* and *Ludwigia adscendens.*	Richest in macrophytes.

Figure 25 - Woman harvesting submerged macrophytes on Indaw Lake (photo credit: C. Zöckler, Dec 2016)

TRENDS IN BIODIVERSITY

Lakes, especially in the Central Dry Zone, are exposed to increasing demands from irrigation and other human uses that have caused their levels to decrease. Water levels have also fallen in response to deforestation, as in the example of Indaw Lake (Sagaing, Middle Ayeyarwady). Several lakes have diminished in size. Indaw Lake, for example, lost approximately 10% of its coverage in the past 10 to 15 years according to local people. Aung et al. (2016) revisited 19 lakes in the basin, which Davies et al. (2004) had surveyed for waterbirds, and found two completely dried out lakes and one at low level with hardly any open water left.

TRENDS AT LAKE INDAWGYI

Extensive data from Lake Indawgyi allows for an examination of trends in biodiversity from 2000 to 2017. Figure 26 and Figure 27 show two examples: one declining species, the gadwall (*Anas strepera*), and a species increasing in abundance, the glossy ibis (*Plegadis falcinellus*).

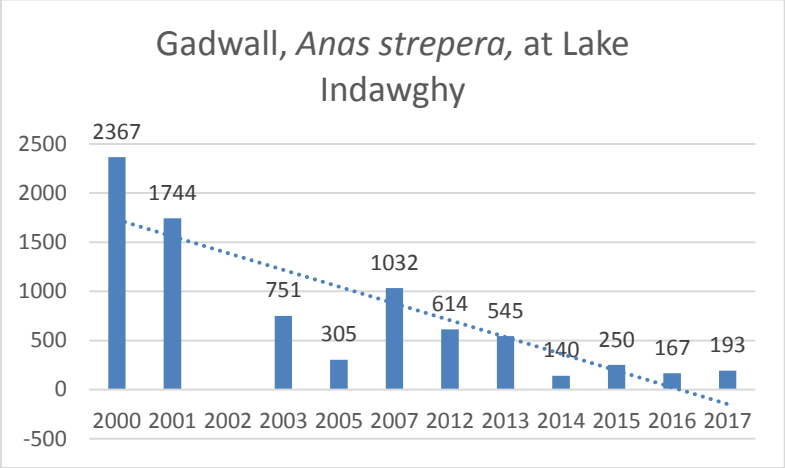

Figure 26 - Trend of wintering gadwall at Lake Indawgyi

One of 11 species declining over the past 17 years. (van der Veen, 2000; AWC, Wetlands International, 2017; Davies et al., 2004; Thet Zaw Naing, 2006; Indawghy Wildlife Sanctuary Forest Rangers; Ngwe Lwin pers. comm.; Zöckler, 2015; Zöckler and Lay Win, 2016)

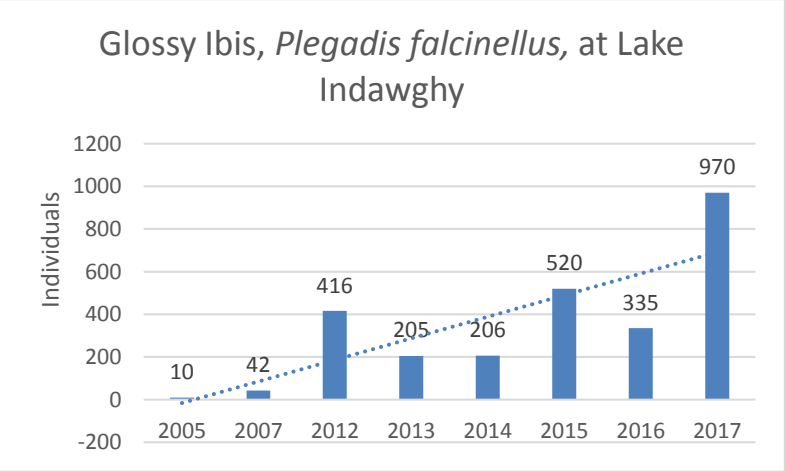

Figure 27 - Glossy ibis, *Plegadis falcinellus*: One of nine species increasing over the past 17 years

TRENDS AT LAKE INDAW

While in 1993, 2,121 pintail ducks were counted on the lake. By 2017, none of these were present anymore. In 1994, the AWC counted 336 bronze-winged jacanas, *Metopiduis indicus* – a wading bird that favours floating vegetation. By 2017, only 8 birds were observed. The spot-billed duck is still present, but it has also declined steadily (see Figure 28).

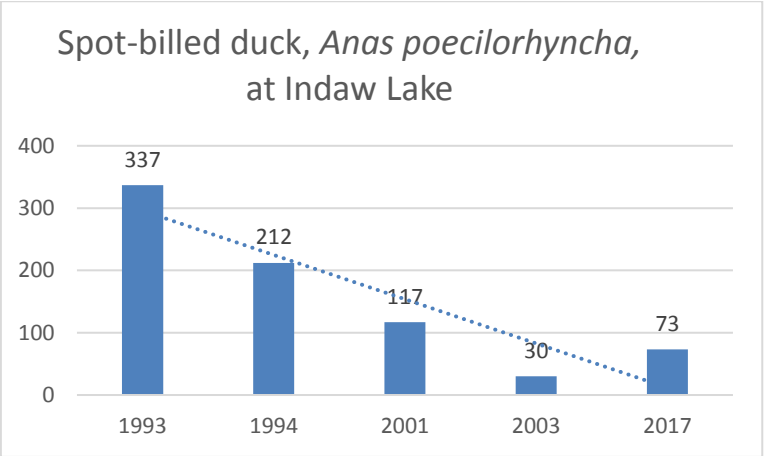

Figure 28 - Trend in spot-billed ducks, *Anas poecilorhyncha*, at Indaw Lake

THREATS

Many of the lakes, especially in the Central Dry Zone, are diminishing in size or drying out completely. Aung et al. (2016) found only 17 of the 19 lakes that were surveyed in 2003 (Davies et al., 2004), and one had hardly any open water in 2016. Demand for irrigation for agricultural purposes is increasing and taking a toll on the remaining wetlands. Agriculture is also draining lakeside swamps and encroaching on lakeside forests. Lake Indaw, for example, lost much of its lakeside swamp area in the southwest corner in 2005 and 2006, when according to local farmers, the area was drained and turned into rice paddies.

Further threats include poaching, over-fishing, and disturbance by boat traffic. Lake Indawgyi is also polluted in places with mercury from gold mining, but no data are available to determine the level of threat to fish, biodiversity, and people.

Interestingly, Pyu Lake in the Mandalay Region is spiritually protected. The local people do not use boats on this lake, because they fear it will disturb the lake spirits. The effect is good for conservation. As a result, there is more fish abundance and also many waterbirds still on the lake, including Baer's pochard (CR).

3.2 Oxbow Lakes

DESCRIPTION

Oxbow lakes are formed when a river meander is cut off from the main river, resulting in a free-standing body of water. The resulting wetland has a distinctive curved 'U' shape. This habitat type includes river cut-offs, which are meanders that still have connectivity to the river on at least one side but do not have current flowing through them. Floodplain sections of rivers that exhibit high sinuosity and have easily eroded river banks (e.g., sand, silt) are likely to form oxbow lakes and cut-offs.

In floodplain sections of the river with numerous meanders, deposition of sediments occurs on the inside bank, while erosion and undercutting occur on the outside bank. Continuous deposition and erosion cause the formation of a pronounced meander, with a narrow neck of land between the two outside banks. When this narrow neck is finally cut through, often during high flows, a new straighter river channel is formed and an abandoned meander loop, called a cut-off, is formed. Eventually, deposition of sediments will seal off the cut-off from the river channel, forming an oxbow lake. This process can occur over a time scale from a few years to several decades and, sometimes, becomes essentially static, resulting in a permanent cut-off channel.

Oxbow lakes and cut-offs have little to no flow and relatively shallow depths due to sediment accretion. Oxbows on the Ayeyarwady floodplain rarely exceed 4 m in depth. Vegetation, such as *Homonoia* and *Polygonum sp*., are common around oxbow lakes, where they stabilise soft sediments, slow the passage of

water and contribute organic matter to the sediment. These are significant components in the process of succession occurring in oxbow lakes, whereby standing open water in more recent oxbows becomes vegetated and marshy in oxbows that are slowly filling with sediment.

The chemical and physical parameters of oxbow lakes and cut-offs depends on many factors, including the level of connectivity with the river, age, location, underlying geology, and bank condition. The concentration of the chemical constituents and the physical properties of water can vary throughout the year, as the habitat can receive an influx of water during the wet season. Conductivity and dissolved oxygen can become high in these wetlands but change seasonally due to evaporation (which concentrates salt content) and annual overturn of the water (which brings oxygen deficient water to the surface (Davies et al., 2004).

Examples of this habitat type in the Ayeyarwady River can be found in the floodplain area of the river downstream of Myitkina near the village of Talawgyi, which is located on a river cut-off. This type of wetland is also common near the downstream end of large tributaries, such as the Moguang Chaung, before the confluence with the Ayeyarwady.

Figure 29 - Oxbow Lake near Talawgyi in the dry season (photo credit: C. Zöckler)

Figure 29 - Oxbow lake habitat near Ta Law Gyi in the rainy season (photo credit: C. Zöckler, June 2017)

Figure 30 - Oxbow habitat in the Ayeyarwady River and Moguang Chaung near Tar Law Gyi

BIODIVERSITY

This habitat can be found widely in the Middle Ayeyarwady and the Chindwin Basin and changes species composition with the seasonal changes. Table 11 lists a few selected characteristic species from different taxa.

Table 11 - Characteristic species for the oxbow lake habitat type

Taxa	Species	Comments
Mammals	Small-clawed otter	Found in some more remote oxbow lakes.
Birds	Pheasant-tailed and bronze-winged jacana, cotton pygmy goose, ferruginous duck (NT), tufted duck, moorhen, ruddy-breasted crake, wood sandpiper, green sandpiper, greenshank, Pacific golden plover, and dunlin.	Composition of birds varies during the seasons, with jacanas staying for breeding while most of the waders are winter migrants.
Reptiles	Not recorded.	
Amphibians	Not recorded.	

THREATS

In general, oxbow lakes face declining fish populations due to overfishing, illegal fishing methods (i.e., electrofishing, poison, and explosives), small net mesh sizes, introduced species, and weak law enforcement. Many oxbow lakes are part of the fisheries lease system, which was recently changed so that the duration of each lease was reduced from 3 years to 1 year. This has resulted in less incentive for conservation and increased the exploitation of the fisheries.

Oxbow lakes also face threats from agricultural contaminants, erosion, and deforestation. The Town of Ta Law Gyi is located in an oxbow cut-off, and there is concern that the town may be cut off from the river entirely if sediment keeps filling in the entrance to the oxbow.

4 AQUATIC HABITATS IN THE DELTA

The Ayeyarwady Delta spans approximately 22,000 km² (3.2% of the country) and is characterized by brackish river water in the dry season. Water salinity and distance to the sea comprises three primary ecological zones that are listed and briefly characterized in Table 12. Figure 31 and Figure 32 show the three zones on a map.

Table 12 - Description of the three primary ecological zones of the Ayeyarwady Delta

Zone	Description
Floodplain zone	low salinity (freshwater); freshwater fish species; and large-scale fencing for fishing
Estuarine zone	temporary brackish water; multiple waterways; patchwork of rice fields, trees, and villages; and degraded mangroves along waterways
Coastal front zone	flat land; semi-permanent brackish water; salty soils; little vegetation; and costal/marine fishing focus

Figure 31 - Topographic map of the three ecological zones in the Ayeyarwady Delta (Adapted from Johnstone et al., 2012)

Figure 32 - View of the three ecological zones in the Ayeyarwady Delta (based on Google Earth images)

Figure 33 depicts the upstream limit of saline intrusion during the dry season (March spring tide). The area depicted below includes the cities of Pathein, Bogale, Pyapon, and Dedaye. The average situation over the 5 years is indicated by the orange line on the map. Measurement is reported as one part per thousand (ppt) isohaline 1 m below surface level.

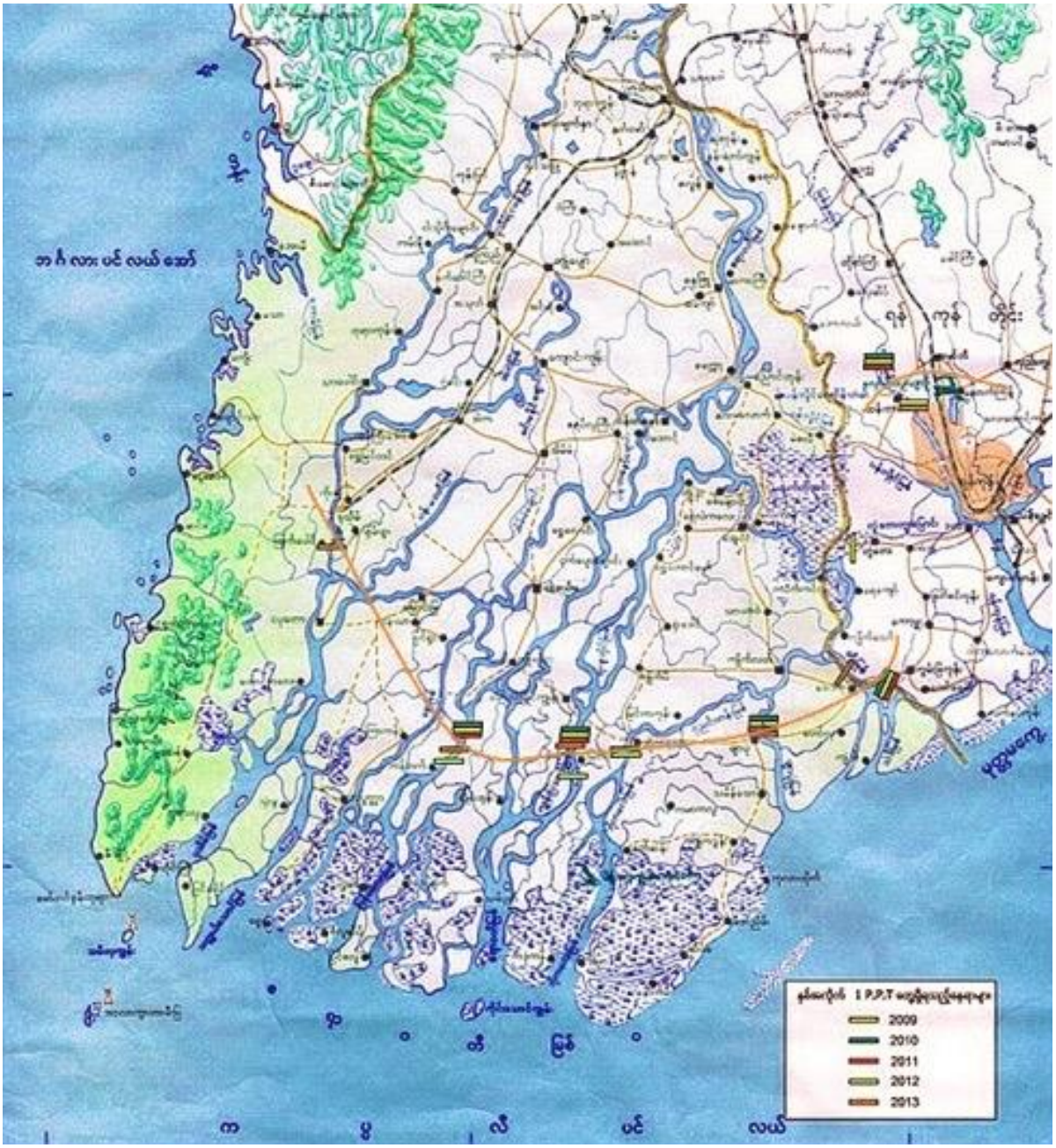

Figure 33 - The upstream limit of saline intrusion (one gram/litre isohaline) during the dry season: Measured in March over 5 years (Dr. Aung Than Oo, Irrigation Department, Ministry of Agriculture and Irrigation)

More recently, the *Atlas of the Ayeyarwady Delta* by the Integrated Ayeyarwady Delta Strategy provided an update of this map, in agreement with the previous one:

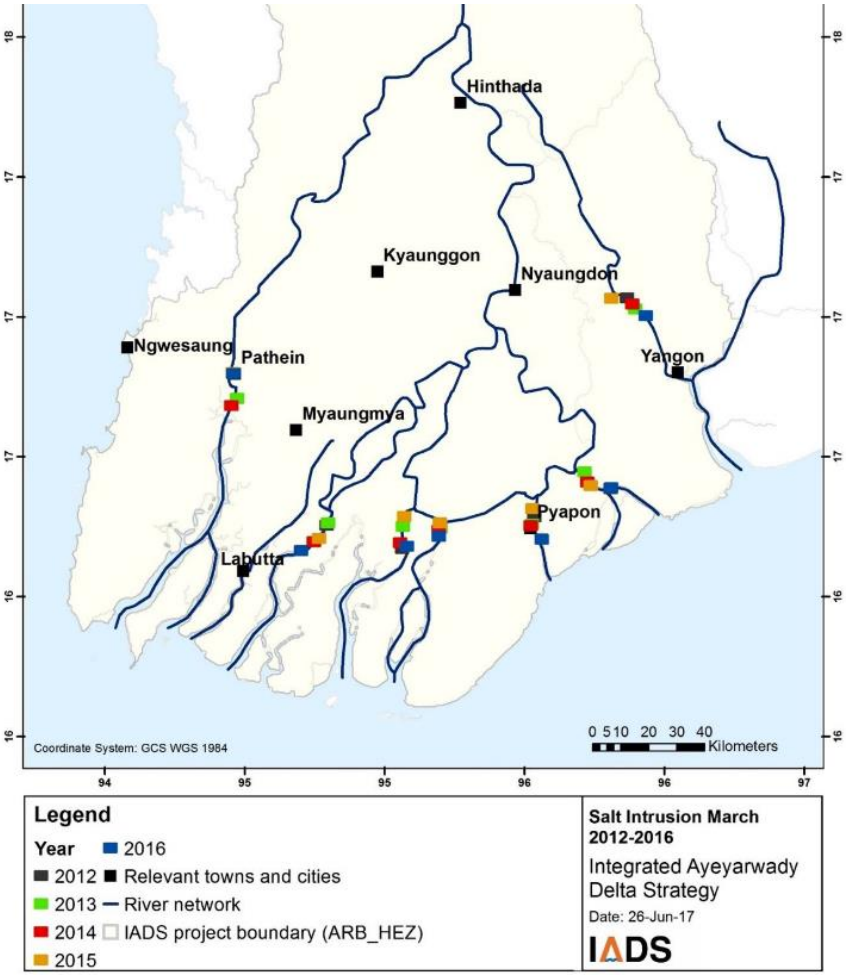

Figure 34 - The upstream limit of saline intrusion during the dry season (source: draft version of the IADS Atlas of the Ayeyarwady Delta, in prep.)

The Pathein River and Ayeyarwady River (6.14 m and 5.24 m deep, respectively) are the two deep rivers that make up the Ayeyarwady Delta. There are shallow rivers surrounding these two deeper rivers, and they are depicted in Figure 35 and Figure 36.

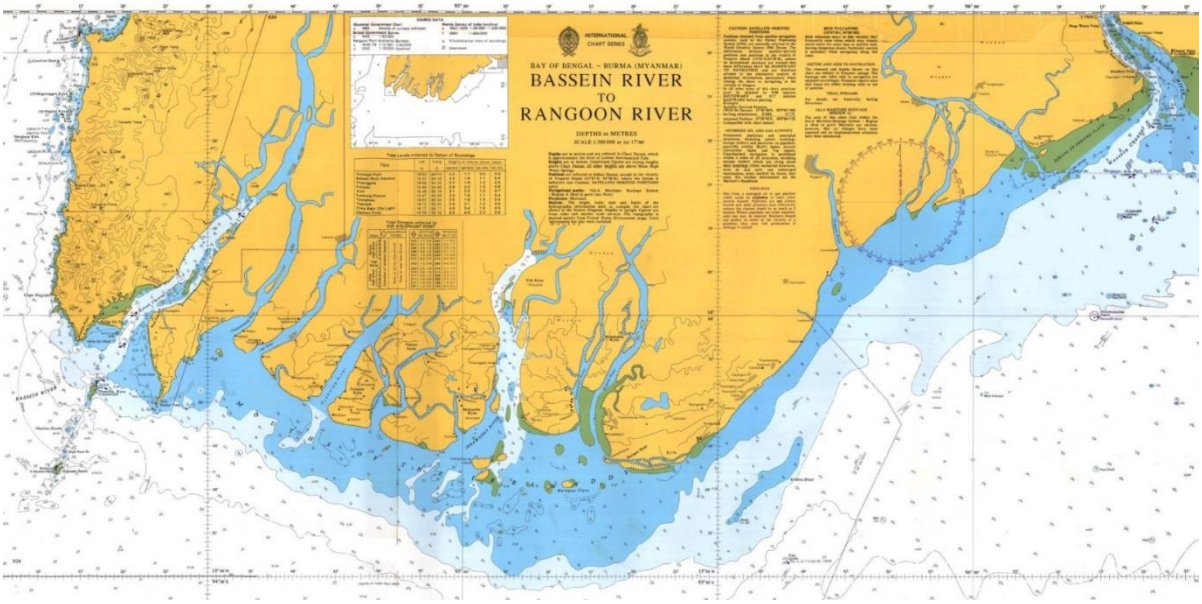

Figure 35 - Water depth in the Ayeyarwady River (Excerpt from an International Chart Series navigation map)

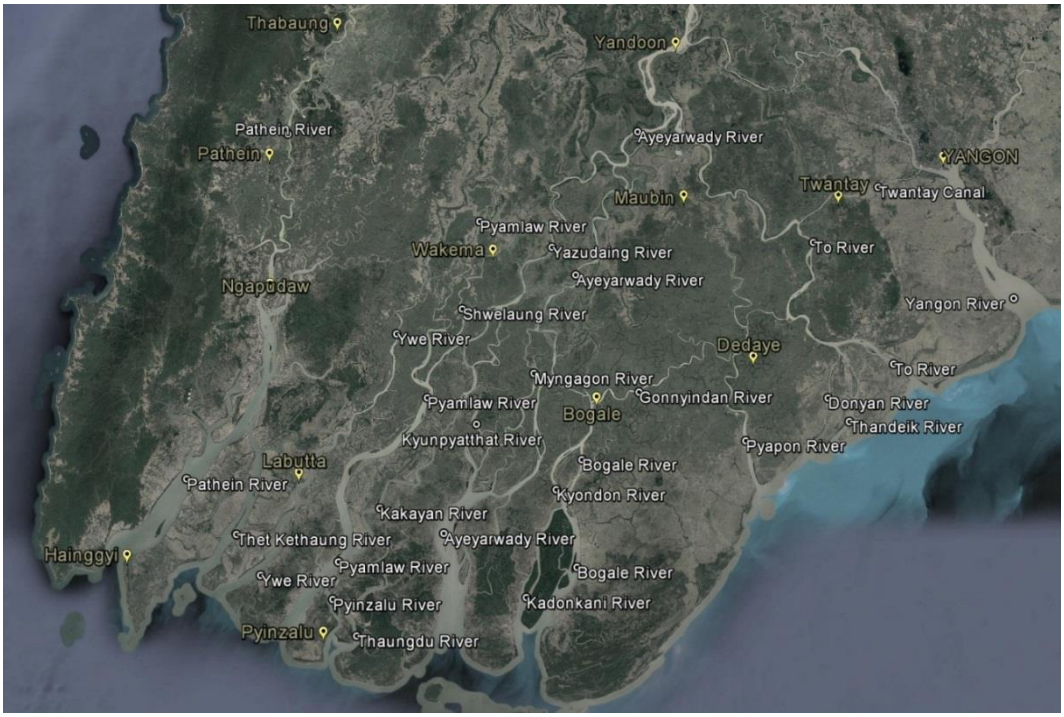

Figure 36 - Major rivers and cities in the Ayeyarwady Delta (Google Earth and local topographic maps)

4.1 Marshes and Swamps

DESCRIPTION

These areas consist largely of marshes dominated by grasses, reeds, and small water channels; small pockets of bushes and thickets; and, in some rare cases, forests that are inundated for periods during the wet season and are found near rivers and lakes and in other low-lying areas. These are relatively open, with trees of small stature. It is worth noting that this forest type makes up a discrete WWF ecoregion (IM0116), which is considered to be Critical/Endangered. Many of the swampy and marshy areas in the delta region have been drained for agricultural purposes. Often, a mosaic of marshes interspersed with paddy fields is left. The combination of these can be very healthy, but it is difficult to maintain the right balance, and the expanding demand for agricultural land is diminishing the swamps and marshes and their habitats as breeding grounds for fish, birds, amphibians, and dragonflies.

Figure 37 - Delta marshes with flying sarus crane, *Antigone Antigone* (photo credit: C. Zöckler, June 2017)

Figure 40 - Delta marshes interspersed with rice paddies (photo credit: C. Zöckler , June 2017)

BIODIVERSITY

Delta marshes comprise a vast area in the Ayeyarwady Delta. Due to mixing with agricultural land, its total acreage cannot be easily quantified .

Table 13 - Characteristic species for the delta marsh habitat type

Taxa	Species	Comments
Mammals	Smooth-coated otter (VU), muntjac	Some of the otter species might be present in the delta area.
Birds	Purple swamphen, water cock, openbill stork, painted stork (NT), sarus crane (VU), black and yellow bittern, Jerdon's babbler (VU), oriental pratincole, Asian golden weaver (NT), yellow-bellied and plain prinia, common snipe, painted snipe, and ruddy-breasted crake.	Stronghold for breeding Sarus Crane in Southeast Asia; the areas is also a place where Jerdon's Babbler was rediscovered
Reptiles	Not recorded.	
Amphibians	Nor recorded.	
Fish	Swamp eel (*Monopterus cuchia*) and probably *Pillaiabrachia siniae* – a dwarf fish from swamps (Britz, 2017).	Many fish species use the floodplain as a nursery area. Some species can survive dry periods in wet soil.
Invertebrates	Odonata: *Orthetrum sabina,* *Crocothemis servilia* (Libellulidae)	Incomplete selection of dragonflies observed in June.

TRENDS

It appears that the marshes are declining in extent due to agricultural expansion, but no real data are available. Aquaculture and fish ponds have been gradually increasing into the marshes. Figure 41 shows the latest distribution of fish ponds in the delta area. How much of the marshes have been lost in recent years is not known though.

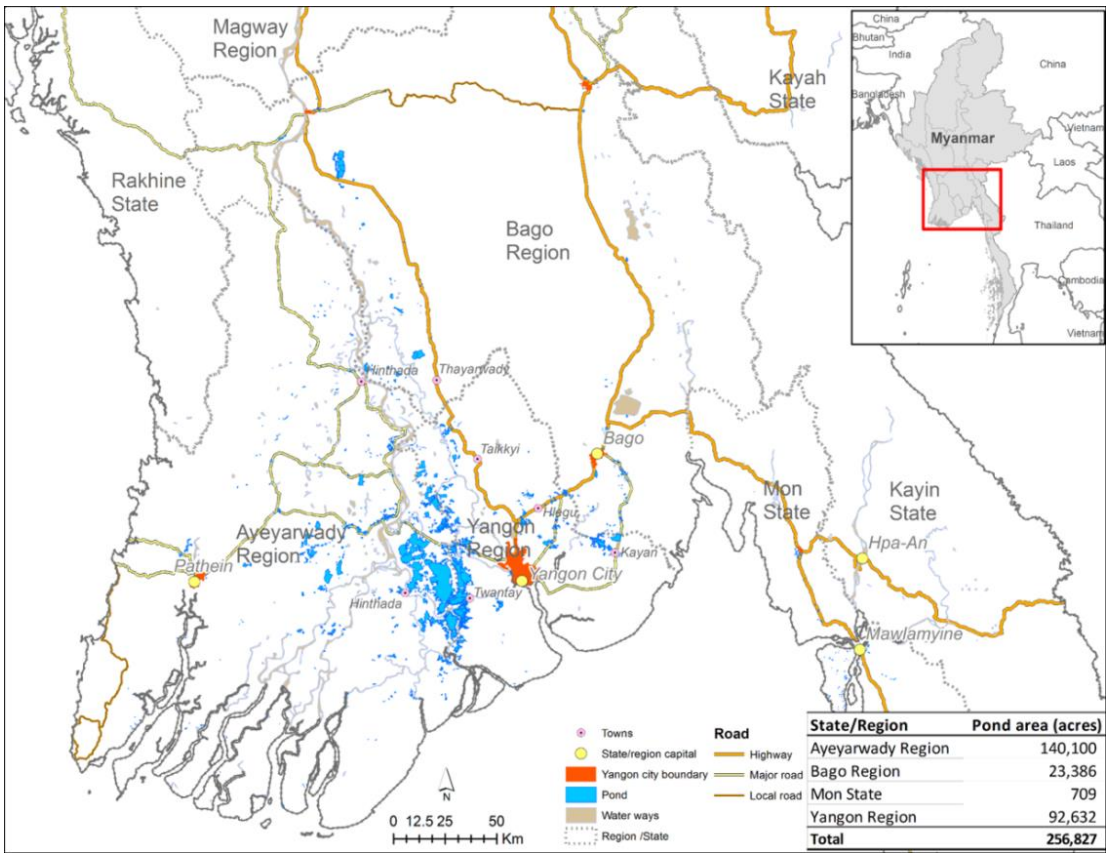

Figure 38 - Extent of fish ponds in the delta region Based on satellite imagery prepared by Ben Belton in 2017 (pers. com.)

THREATS

The expansion of agriculture into the fertile delta marshes is an ongoing process and is likely to continue. Mostly, the area expansion is on behalf of rice paddies, but increasingly, fishponds for aquaculture are encroaching on the marshy grasslands (see Figure 38).

4.2 Mangrove Forest

DESCRIPTION

Historically, mangroves covered the majority of the delta area of the Ayeyarwady Basin. Today, mangroves are only growing in the intertidal coastal area of the river estuary. The forest grows under the influence of saltwater and the intertidal dynamic, which can reach as far as 60 km inland. The composition of mangrove tree species varies by depth, distant, and salinity as well as other biotic and abiotic factors. In the front of a mangrove forest are often the *Avicenna* trees followed by *Rhizophora* spp and *Sonneratia* spp. Some species, like *Sonneratia griffithii,* are globally classified as Critically Endangered.

Figure 39 - Pioneering *Avicennia* mangroves expanding in the Ayeyarwady Delta (photo credit: C. Zöckler, Dec. 2013)

Mangroves trees serve the function of further accreting sediments and gradually raising the soil, allowing more trees of other species to grow. In addition, a huge number of invertebrates and vertebrate animals live in these mangroves, making them one of the most productive ecosystems on the planet. The range of ecosystem services is enormous compared to many other ecosystems. Figure 43 illustrates the wide range of services provided by healthy mangrove ecosystems.

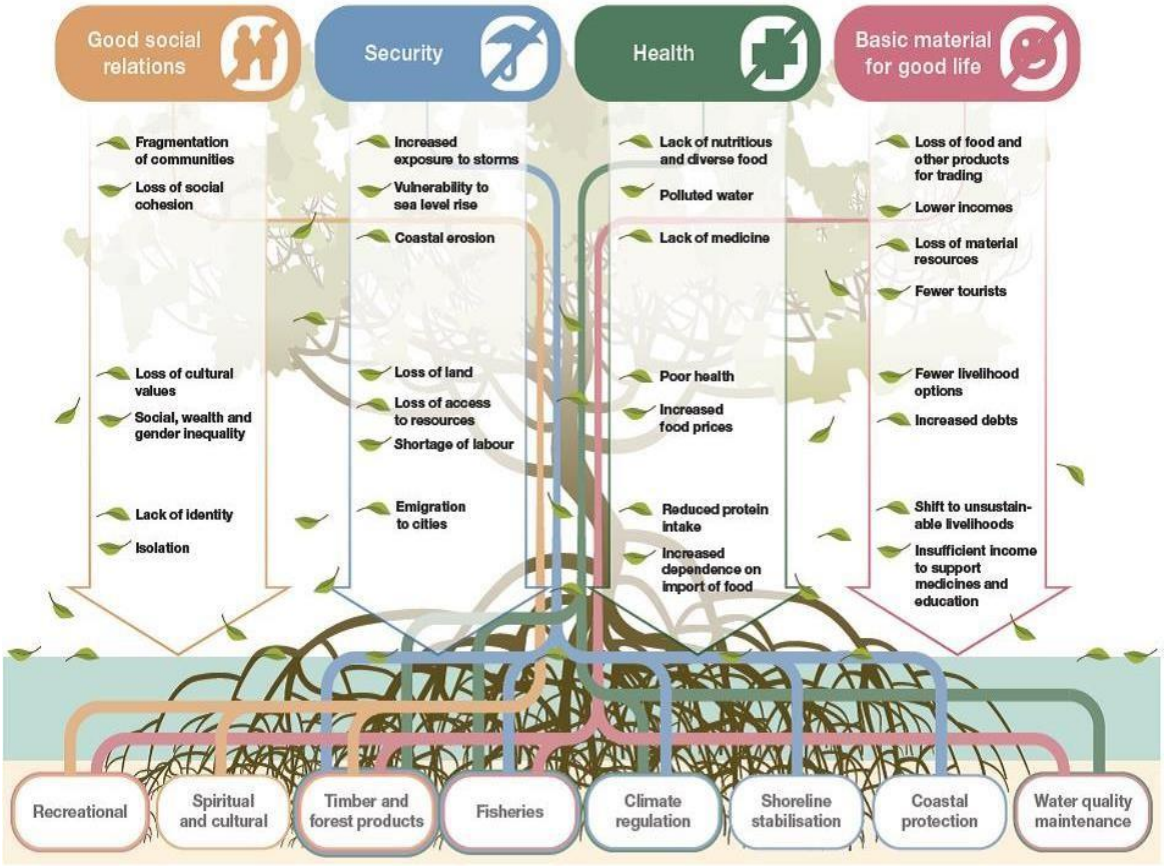

Figure 40 - Range of ecosystem services provided by mangroves (van Bochove et al., 2014)

CURRENT DISTRIBUTION

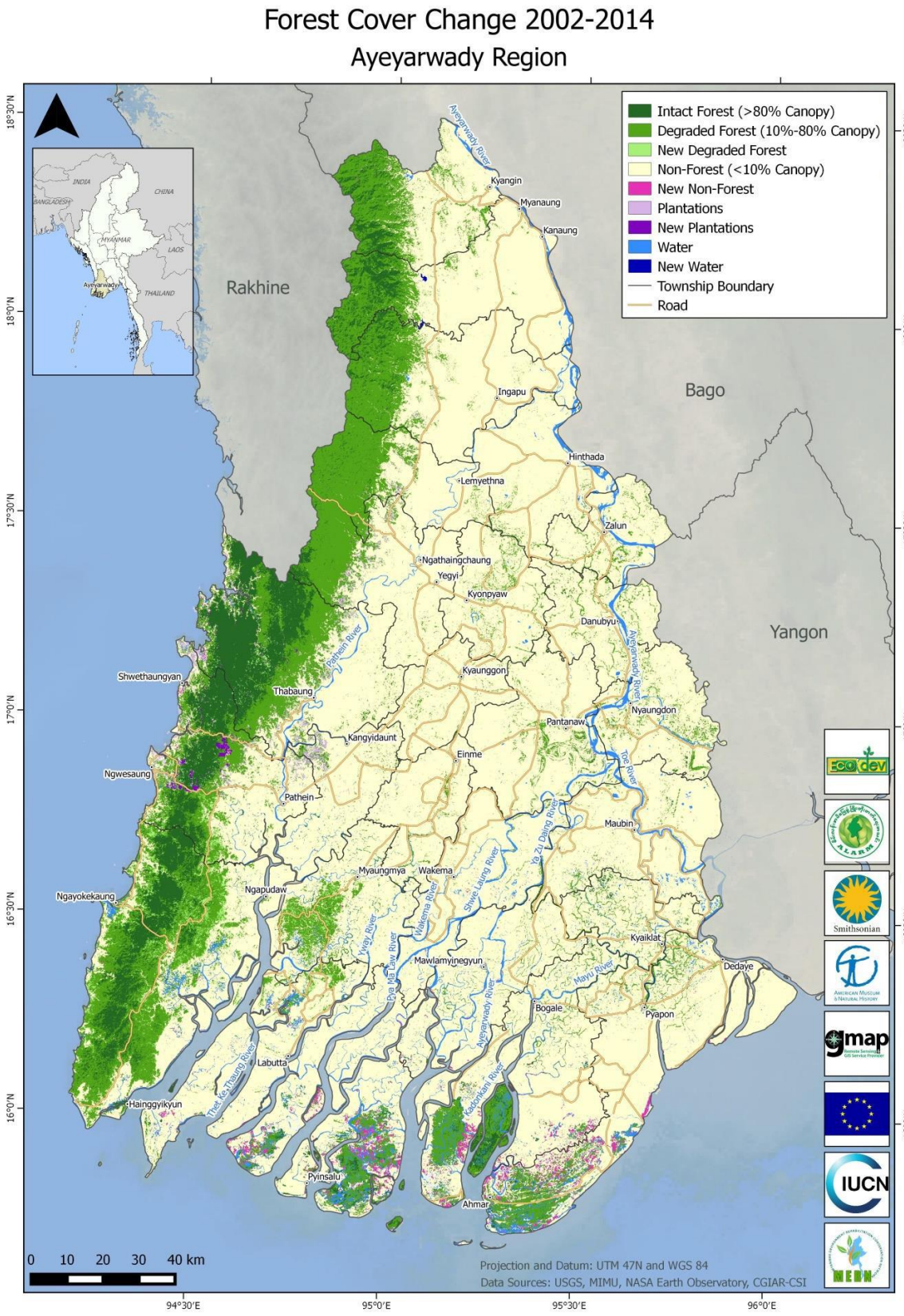

Figure 41 - Current distribution of mangrove and other forest types in the delta region, including new plantations(Bhagwat et al., 2017)

BIODIVERSITY

The mangrove area in the delta region is largely reduced to some small pockets. A list of characteristic species occurring in the Meinmahla Kyun Wildlife Sanctuary (designated as a Ramsar Site in 2017) is shown in Table 14. Also, the Khaing Thaung Island holds a healthy area of mangroves in the centre of the island

The mangrove areas in the delta, especially the Meinmahla Kyun Wildlife Sanctuary, are the last remaining refuge for the fishing cat in the delta, the Ayeyarwady Basin, and possibly in all of Myanmar. It also regularly hosts approximately 20 Irrawaddy dolphins and a good number of hog deer (forest rangers pers. comm.). It is also home to the last remaining wild saltwater crocodile population (Thorbjarnarson et al., 2000) and a successful re-introduction and head-starting programme has been implemented by the Forest Department.

The wildlife sanctuary is also one of the last remaining breeding sites for the lesser adjutant stork, more than 100 calling mangrove pittas, and mangrove whistlers. The brown fishing owl has been breeding here successfully since 2015, as well as a few near-threatened brown-winged kingfishers. Table 10 and Figure 34 highlight some of the important and red-listed species. In total, more than 100 bird species have been recorded in the mangroves of the delta region (Zöckler, 2016).

Table 14 - Characteristic species for the mangrove habitat type

Taxa	Species	Comments
Mammals	Fishing cat (VU) Smooth-coated otter (VU), hog deer (VU), Irrawaddy dolphin (VU)	Fishing cat still present in fair numbers. Irrawaddy dolphin coastal population considered VU by IUCN.
Birds	Lesser adjutant stork (VU), mangrove pitta (NT), black-capped kingfisher, brown-winged kingfisher (NT), common kingfisher, green-billed malkoha, whimbrel, and redshank (in winter)	
Reptiles	Saltwater crocodile, *Crocodylus porosus,* (LC) and mangrove terrapin (CR)	Crocodile population boosted by head-starting project. Mangrove terrapin is now considered locally extinct.
Amphibians	Not recorded.	
Fish	Hilsa shad, *Tenualosa ilisha;* toli shad, *Tenualosa toli;* catfish, *Pangasius* spp.; and sea bass, *Lates calcarifer.*	Mangroves are particularly important as nurseries for brackish and marine fish species.
Invertebrates	Numerous crabs (i.e., fiddler crabs) and crustaceans	Particularly diverse in crab species (estimated more than 100 species).

TRENDS

Coastal mangrove forests have been on a steady decline from a mixture of deforestation and agricultural expansion. A 2014 satellite study demonstrated a significant decline in mangrove cover between 2000 and 2013 (Weber, 2014). Figure 33 shows the relative extent of mangrove forests in the Ayeyarwady Delta over 40 years, beginning in 1978, with each decade experiencing a decrease in mangrove cover. The extensive clearing of mangroves for expanding agricultural land has been considered a significant factor behind the loss of life resulting from cyclones Nargis (2008) and Giri (2011). Today, only small pockets of mangroves are left. The Meinmahla Kyun Wildlife Sanctuary is the only officially Protected Area conserving mangroves of the Ayeyarwady Basin. The area is now, together with the adjacent mudflats, designated as a Ramsar Site and a Key Biodiversity Area. Even these areas, however, are still degraded by constant infiltration and pressure by local communities, cutting down mangrove trees for timber and charcoal, in particular.

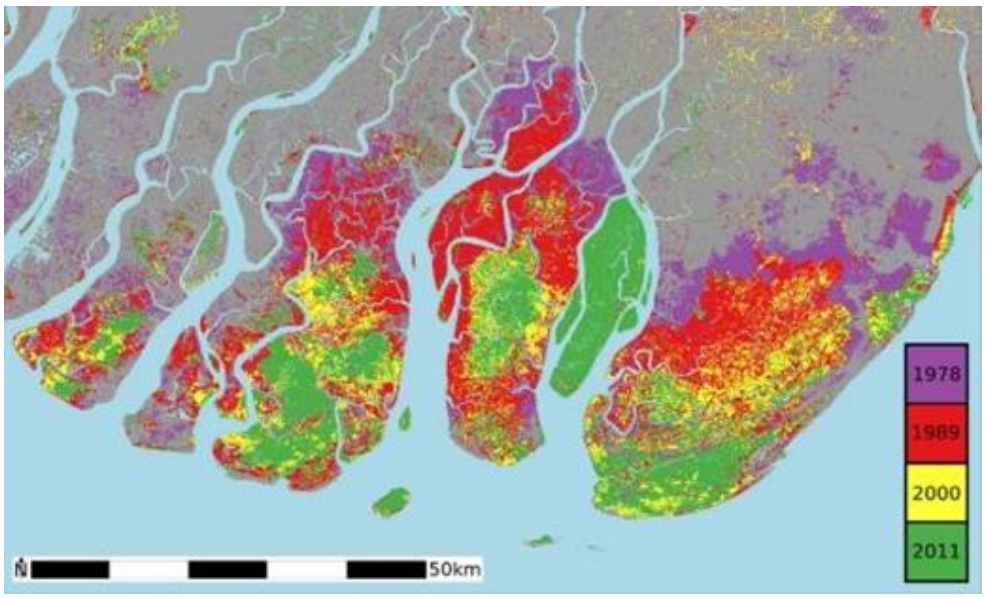

Figure 42 - Loss of mangroves in the Ayeyarwady Delta from 1978 to 2011 (Webb et al., 2014)

There are small pockets of mangroves in other areas that are worth mentioning. The Khaing Thaung Island harbours a huge and largely impac- free area of healthy mangroves in its centre. These are, according to local people, protected by the local communities themselves, who have a keen interest to preserve the fragile ecosystem and their livelihoods in the community. Khaing Thaung is hosting a night roost of more than 370 of the globally near-threatened black-headed ibis and other trigger species, such as the great knot. It is also listed as Key Biodiversity Area and is potentially another Ramsar Site. Other nearby areas include the Pindaye and Kadon Peninsula that host some mangroves but that have been much degraded (see Figure 42).

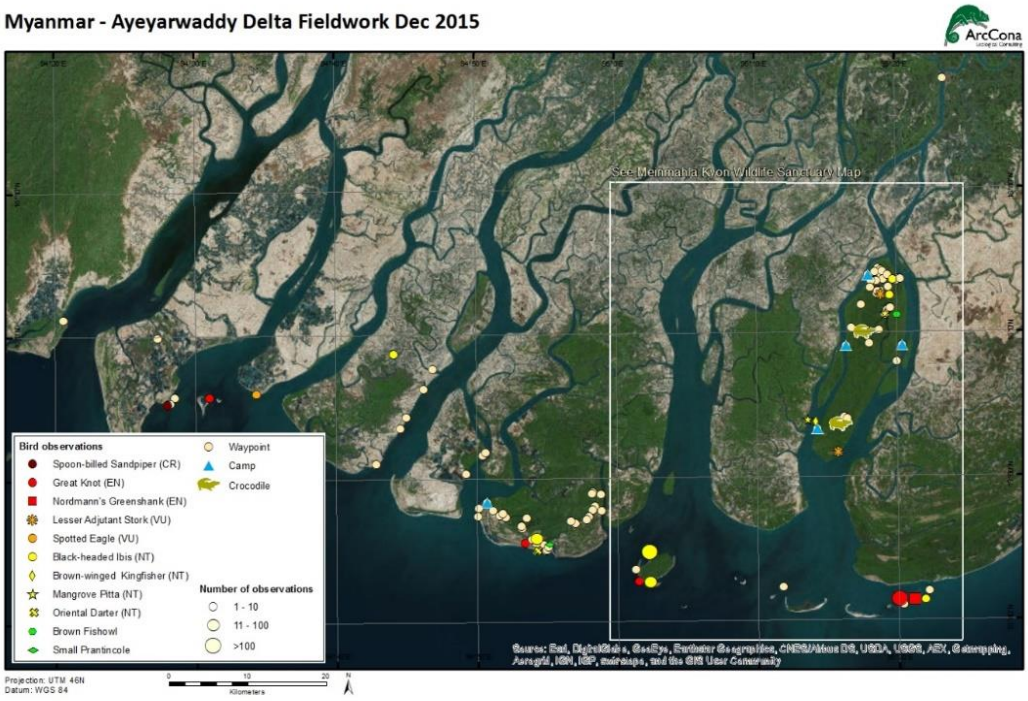

Figure 43 - Distribution of selected key bird and crocodile species in the Meinmahla Kyun Reserve and adjacent areas, including Khaing Thaung Island (Saw Moses and Zöckler, 2016)

THREATS

Mangroves are under enormous pressure from human interference. Agriculture and aquaculture expansion is the main driver of mangrove loss (Webb et al., 2014). The cyclones, Nagis and Giri, destroyed large swaths of forest that have never really recovered. Even in the Meinmahla Kyun Protected Area, logging and timber extraction continues without law enforcement. Some mangrove restoration programmes have been initiated, and some of them show the first sign of success, but many seem to fail due to a range of factors.

4.3 Intertidal Mudflats

DESCRIPTION

In the outer delta areas, in the shadow of the islands, soft and sandy sediments create a dynamic system of intertidal mud and sand flats. These areas are constantly changing, driven by the vast flow of sediments from the river estuary and the tidal dynamic, storms, and surges. Islands, sand, and mudflats are shifting and changing their sediment structure, offering a huge variety of invertebrate life in the form of benthic worms, crustaceans, shellfish, sea stars, and many other benthic life forms. These, in turn, will be the food basis for fish (at high tide) and birds (at low tide), when the area after each tide will be freshly enriched with benthos and food for many different waterbird species.

Figure 44 - Curlew sandpiper, *Calidris ferruginea*, feeding in mudflats at Nga Man Thaung, Outer Delta Islands (photo credit: C. Zöckler, Dec 2014)

Figure 43 shows the key areas of intertidal mudflats in the delta region. These are home to globally endangered bird species, such as the great knot, Nordmann's greenshank, and the even the critically endangered spoon-billed sandpiper, which regularly winters in low numbers in the Meinmahla Kyun Ramsar Site, the Outer Islands, and the Western Delta at Phone Taw Paey Beach near Saka Khaing Island (Zöckler et al. 2014)

BIODIVERSITY

Table 15 - Characteristic species for the intertidal mudflat habitat type

Taxa	Species	Comments
Mammals	Irrawaddy dolphin (VU)	Coastal population of the usually riverine Irrawaddy dolphin
Birds	Black-headed ibis, several shorebirds including spoon-billed sandpiper (CR) and Nordmann's greenshank (EN), great knot (EN) and six shorebird species considered NT, such as curlew sandpiper (NT), caspian tern, little tern, and whiskered tern.	
Reptiles	Olive Ridley turtle (VU), green turtle (EN), leatherback (VU), loggerhead (VU), and hawskbill (CR).	Number of nesting turtles at the islands has declined dramatically and the latter three species might no longer be present in the delta.
Amphibians	Not recorded.	
Fish	mudskipper; eel-gobies; hilsa shad *(Tenualosa ilisha)*; toli shad *(Tenualosa toli)*; and catfish *(Pangasius* spp.).	Economically important species for the fishing communities.

TRENDS

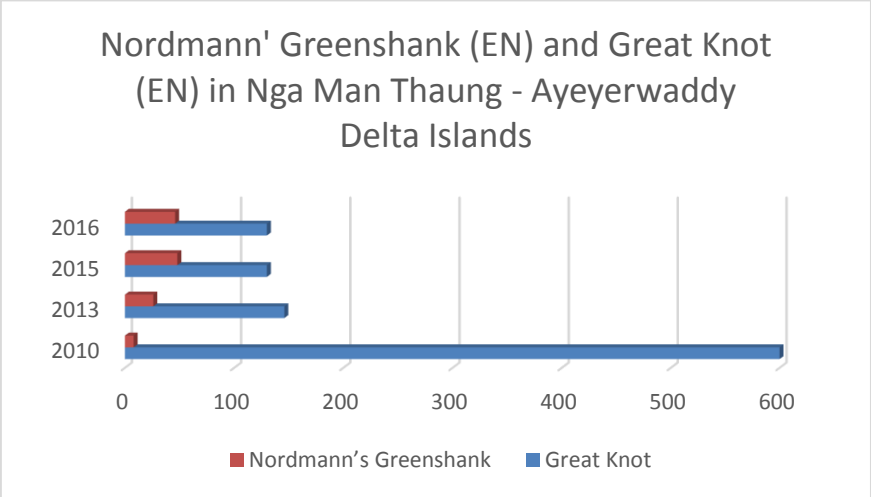

Figure 45 - Trend of two globally endangered wader species (Nordmann's greenshank and the great knot) at Nga man Thaung in the Outer Delta Islands

The trends shown in Figure 45 are stark for the great knot that has been declining sharply all over its range and, hence, was uplisted recently to EN (BirdLife International, 2017). However, the increase in Nordmann's greenshank might not necessarily reflect an increase in population, which is still believed to be approximately 1,000 birds (Zöckler et al., in prep). With the designation of the area as a Ramsar Site in 2017, the area is officially protected.

THREATS

Overfishing and bottom dredging seem to be major problems putting a huge strain on the marine ecosystem of the area. Marine turtles get caught in fishing and ghost nets and drown. Egg collection and turtle harvesting has been declining due to the turtle guarding programmes run by the Department of Fisheries (DoF). Bird hunting is still common on the mudflats at new moons. It has partly been addressed by DoF, instructing their turtle guards to also monitor the main shorebird high tide roosting sites.

5 CONCLUSIONS

This report illustrates the wide range of riverine and wetland habitats in the Ayeyarwady Basin. Almost all are under extreme pressures from human activities, ranging from deforestation, mining, and over-exploitation of natural resources. The level of pressure varies, but it is clear that the current form of protection is inadequate to address the major challenges of all wetland and riverine habitats. The protection of these habitats and its biodiversity would only be possible in close collaboration with the local communities and by providing them with an alternative vision for their future. The development of a large World Heritage Site might provide the necessary background for sustainable development in the region, from the mountain's rivers in the Eastern Himalayas to the Outer Delta Islands.

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