Indoburma Wetlands in Danger

Conservation, Threats and Future - A Situation Analysis

ArcCona Ecological Consulting

Manfred-Hermsen-Stiftung for Nature and Environment

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1. Introduction

We are facing global biodiversity, climate and water crises, with all three playing out in the Indo-Burma Region. The changing climate will put additional pressure on all wetlands, habitats and species, compromising ecosystem services and threatening livelihoods. Safeguarding wetlands and fostering institutional wetland policies are crucial tasks in addressing the crisis and preparing for a warming region. A dedicated and coordinated response within the region is required to adapt to the changes that have happened and to mitigate further damage.

The **Indo-Burma Ramsar Regional Initiative** (IBRRI) was developed jointly by the Ramsar focal points for the five Mekong countries, with the support of IUCN Asia Regional Office. The initiative was endorsed by the Ramsar convention in 2016. It aims to promote the 'wise-use principles' of the Ramsar Convention on the management of wetlands through transboundary engagement, cooperation and knowledge-sharing, leading to partnerships and improving wetland management. The IBBRI strategic plan, 2019-2024, promotes sharing of knowledge and experience on wetlands, the integrated management of Ramsar Sites and other wetlands, and inter-agency and international cooperation.

As part of the IBBRI strategy, IUCN initiated the publication of this Wetlands Outlook for the IBRRI Region. This report is similar to the Global Wetlands Outlook, but focuses on the region's key ecosystem services, and on preparedness for the changing world under new climate regimes.

The IBRRI Wetland Outlook takes stock of the current status and trends within these wetlands and more widely in all five countries. It looks at wetland biodiversity as well as the crucial ecosystem services provided by wetlands. It also considers the key drivers of change, policies in place by Governments, and the management responses implemented by communities, governments and NGOs in response to the deteriorating situation of Indo-Burma's wetlands.

By 2021, Cambodia, Laos, Myanmar, Thailand and Vietnam had designated 37 Ramsar sites and listed three additional Flyway Network Sites. These sites are representative of the key wetlands in the region. All five countries share a set of common river basins, the same water, the same fish and the same migratory species. They also share and rely on the ecosystem services from these sites.

For all Ramsar sites, interviews with wetland experts, rangers, NGO representatives and government agencies and others were conducted, mostly through internet meetings. In addition, a number of published and unpublished reports have been used to compile an assessment of the 40 Ramsar sites as well as the overall situation of wetlands in Indo-Burma.

This Wetland Outlook aims to provide some guidance and recommendations to help countries and communities in addressing the increasing numbers of challenges they face, while safeguarding vital ecosystem services and biodiversity and securing livelihoods for millions of people living with and near wetlands.

2. Status and trends

2.1. Ramsar sites and flyway network sites

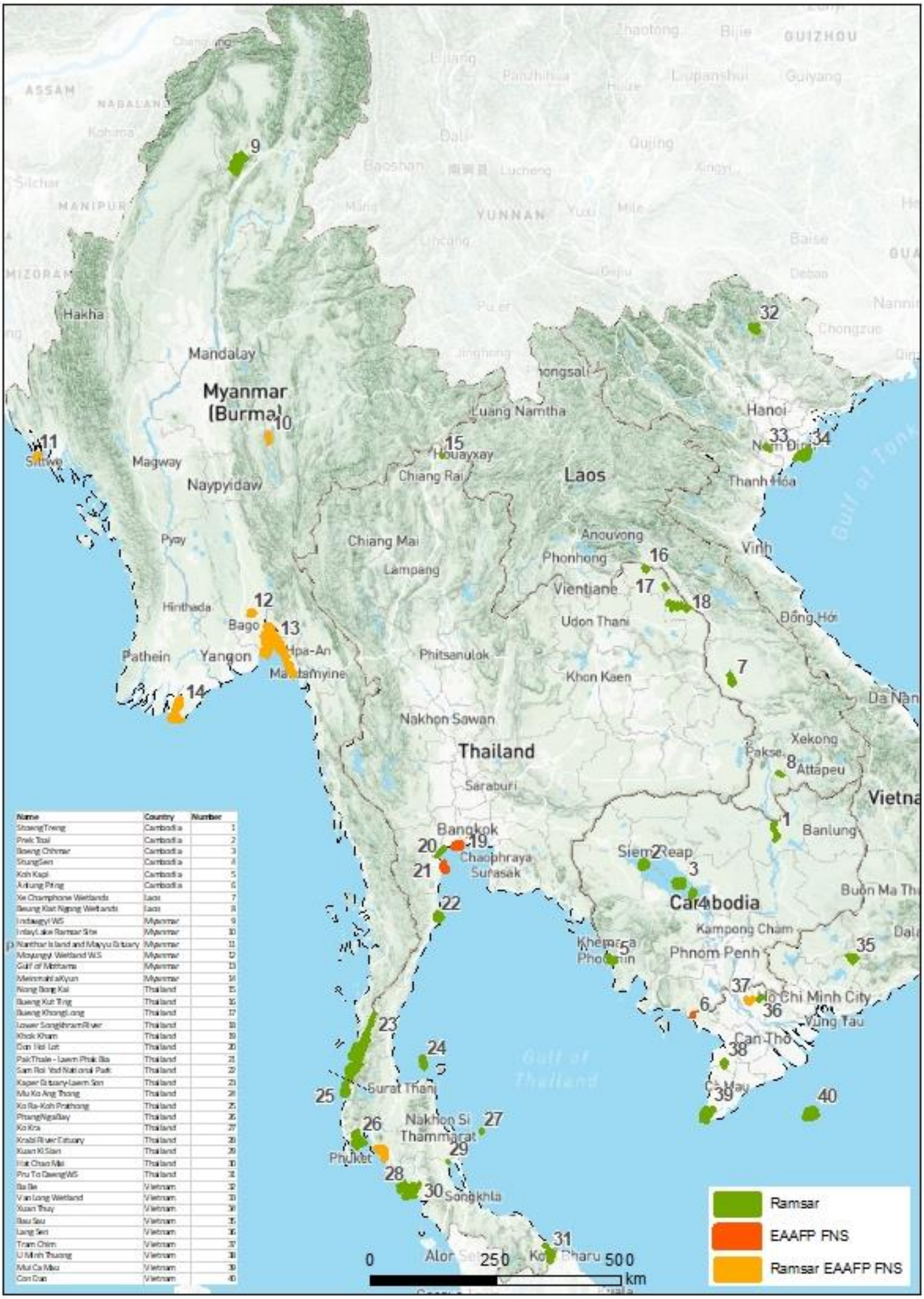
For each Ramsar and Flyway Network Site (FNS) we provide a brief description on biodiversity, key values, ecosystem services, the recent trends and key management interventions. For some sites trends in biodiversity are available for several years and a graph is shown. Otherwise, trend information on biodiversity and ecosystem services is based on interviews. A summary of the trends is provided in two tables at the end of this section.

There are at present (Sep 2021) 37 Ramsar sites and three EAAFP Flyway Network Sites in the region, distributed across the five IBRRI countries as follows in Table 1.

Table 1: Ramsar and Flyway Network Sites by Indoburma countries

Country	Cambodia	Laos	Myanmar	Thailand	Vietnam	Total
Ramsar sites	5	2	6	15	9	37
Flyway network Sites (FNS)	1	-	-	2	-	3
Total	6	2	6	17	9	40

Local people returning from village market along Rakhine beach, Myanmar, Photo: CZ



Name	Country	Number
StoengTreng	Cambodia	1
Prek Toal	Cambodia	2
Boeng Chhmar	Cambodia	3
StungSen	Cambodia	4
Koh Kapi	Cambodia	5
Anlung Pring	Cambodia	6
Xe Champhone Wetlands	Laos	7
Beung Kiat Ngong Wetlands	Laos	8
Indawgyi WS	Myanmar	9
InlayLake Ramsar Site	Myanmar	10
Nanthar Island and Mayyu Estuary	Myanmar	11
Moeyungyi Wetland W.S	Myanmar	12
Gulf of Mottama	Myanmar	13
MeinmahlaKyun	Myanmar	14
Nong Bong Kai	Thailand	15
Bueng Kut Ting	Thailand	16
Bueng KhongLong	Thailand	17
Lower SongkhramRiver	Thailand	18
Khok Kham	Thailand	19
Don Hoi Lot	Thailand	20
PakThale - Laem Phak Bia	Thailand	21
Sam Roi Yod National Park	Thailand	22
Kaper Estuary-Laem Son	Thailand	23
Mu Ko Ang Thong	Thailand	24
Ko Ra-Koh Prathong	Thailand	25
PhangNgaBay	Thailand	26
Ko Kra	Thailand	27
Krabi River Estuary	Thailand	28
Kuan Ki Sian	Thailand	29
Hat Chao Mai	Thailand	30
Pru To DaengWS	Thailand	31
Ba Be	Vietnam	32
Van Long Wetland	Vietnam	33
Xuan Thuy	Vietnam	34
Bau Sau	Vietnam	35
Lang Sen	Vietnam	36
Tram Chim	Vietnam	37
U Minh Thuong	Vietnam	38
Mui Ca Mau	Vietnam	39
Con Dao	Vietnam	40

Fig 1: Locations of Ramsar and FNS sites in Indoburma Region

Table 2: List of all Ramsar and FNS in Indoburma with size, Ramsar ID and date of designation as well as key wetland type

*	Abb	Freshwater	Country	ID	Size ha**	Date	Key wetland type
1	ST	Stoeng Treng	Cambodia	999	14,896	23.06.1999	River
2	PT	Prek Toal	Cambodia	2245	21,348	02.10.2015	Lake Swamp Forest
3	BC	Boeng Chhmar	Cambodia	997	28,648	23.06.1999	Lake Swamp Forest
4	SS	Stung Sen	Cambodia	2365	9,293	02.11.2018	Lake Swamp Forest
6	AP	Anlung Pring	Cambodia	FNS	218	2018	Seasonally flooded grasslands
7	BK	Beung Kiat Ngong Wetlands	Laos	1941	2,251	16.06.2010	Marsh
8	XC	Xe Champhone Wetlands	Laos	1942	12,178	16.06.2010	Swamp Forest + R
9	ID	Indawgyi WSy	Myanmar	2256	47,839	02.02.2016	Lake
10	IN	Inle WS	Myanmar	2356	5,770	10.08.2018	Lake
12	MY	Moeyungyi Wetland WS	Myanmar	1431	10,325	17.11.2004	Marsh & Lake
15	BL	Nong Bong Kai	Thailand	1101	413	05.07.2001	Lake
16	KT	Kut Ting Marshland	Thailand	1926	2,654	19.06.2009	Marsh
17	LSk	Bung Khong Long	Thailand	1098	1,842	05.07.2001	Marsh
18	NB	Lower Songkhram River	Thailand	2420	5,505	15.05.2019	Seasonal Flood Forest + R
29	KK	Kuan Ki Sian of the Thale Noi	Thailand	948	490	13.05.1998	Swamp Forest
31	PS	Princess Sirindhorn WS	Thailand	1102	20,278	05.07.2001	Swamp Forest
32	BB	Ba Be	Vietnam	1938	9,941	02.02.2011	Lake
33	VL	Van Long Wetland	Vietnam	2360	2,730	10.02.2017	Lake
35	BS	Bau Sau Wetlands	Vietnam	1499	13,678	04.08.2005	Swamp Forest
36	LS	Lang Sen	Vietnam	2227	4,783	22.05.2015	Marshes
37	TC	Tram Chim	Vietnam	2000	8,018	02.02.2012	Swamp Forest
38	MT	U Minh Thuong	Vietnam	2228	7,94	30.04.2015	Swamp Forest
				Summary	1,350,917		

*	Abb	Marine & coastal	Country	ID	Size ha**	Date	Key wetland type
5	KO	Koh Kapik	Cambodia	998	13,477	23.06.1999	Mangroves
13	GM	Gulf of Mottama	Myanmar	2299	161,048	10.05.2017	Mudflats
14	MM	Meinmahla Kyun WS	Myanmar	2280	51,087	02.02.2017	Mudflats Mangroves
11	NT	Nanthar Island	Myanmar	2421	3,598	22.05.2020	Mudflats
19	KKh	Khok Kham	Thailand	FNS	12,912	2015	Mudflats Mangroves
20	DH	Don Hoi Lot	Thailand	1099	9,217	05.07.2001	Mudflats Mangroves
21	PL	Pak Thale - Laem Phak Bhia	Thailand	FNS	7,481	2014	Mudflats
22	KS	Khao Sam Roi Yot	Thailand	2238	11,167	08.01.2008	Marsh mangroves
23	KP	Kaper Estuary	Thailand	1183	123,020	14.08.2002	Mudflats Mangroves
24	MK	Mu Koh Ang Thong	Thailand	1184	10,321	14.08.2002	Corals
25	KR	Ko Ra-Ko Phra Thong	Thailand	2153	20,387	12.08.2013	Mangroves Swamp Forest
26	PN	Pang Nga Bay	Thailand	1185	42,284	14.08.2002	Mangroves
27	KA	Ko Kra Archipelago	Thailand	2152	374	12.08.2013	Corals
28	KB	Krabi Estuary	Thailand	1100	30,770	05.07.2001	Mudflats Mangroves
30	HC	Had Chao Mai	Thailand	1182	66,363	14.08.2002	Mudflats Mangroves
34	XT	Xuan Thuy	Vietnam	409	10,917	20.09.1988	Mudflats
39	MC	Mui Ca Mau	Vietnam	2088	38,985	12.12.2013	Mangroves Mudflats
40	CD	Con Dao	Vietnam	2203	42,532	18.06.2013	Corals and seagrass
				Summary	1,029,566		
				Summary in total	2,380,483		

LEGEND		
	*	Number on map, side 1
	**	calculation based on the provided GIS boundaries
	FNS	Flyway Network Site

Detailed Descriptions of all 40 Ramsar and Flyway Network Sites can be found at this link: https://www.m-h-s.org/media/site_descriptions_indo-burma_wetlands.pdf

2.1.1. Wetland area, types and trends

Current area and types

Wetlands cover 280,075 km^2 of Indo-Burma, 14% of the total land area. Myanmar, Thailand and Vietnam contain over 25% each, while Cambodia has 16% and Lao PDR 4%. There are ten main types of wetlands, with marshes and fens making up 59% by area (Table 2.1). In addition to the types listed in the table, the Ramsar convention defines all near-shore habitats where water is six metres deep or less at low tide as wetlands.

Table 3: Area of wetland types across the Indo-Burma Region (km^2)

Wetland type	Cambodia	Laos	Myanmar	Thailand	Vietnam	Indo-Burma
Marsh and fens	31,116	7,741	43,075	48,843	36,502	167,277
Swamp and bog	8,237	1,857	21,786	17,292	25,587	74,760
Lakes and rivers	3,881	805	3,257	3,991	2,481	14,415
Mangrove	588	-	4,255	2,215	1,429	8,486
Intertidal mudflats	102	-	3,087	585	3,021	6,794
Coral reefs	<50	-	1,870	2,130	1,270	5,320
Sea grass beds		-	20	1,110	170	1,300
Wetland in dry areas	88	41	441	465	43	1,078
Saltmarshes	-	-	500	-	-	500
River-/lake-edge	28	25	45	33	12	145
Total wetland (km^2)	**44,040**	**10,469**	**78,336**	**76,664**	**70,514**	**280,075**
Peat forests*	46	191	1,228	638	533	2,636

Source: Murray *et al.* (2019) [mudflats], Soe Htun et al. (2021) [seagrass], Stankovic et al (2021) [seagrass]; Spalding et al (2001) [coral reef]; analysis of mangroves and saltmarsh for this study; ASEAN Peatland forests project (2020) [peat forest]; Gumbricht et al. (2017) [other wetland types].

* peat forests are likely to be a sub-set of some mangrove, swamp, fen and riverine/lake wetlands areas, so are excluded from the total area

Trends in wetland area and status

Since the 1800s, it is estimated that Asia has lost 83% of its wetlands, two-thirds of them since 1945 and one- third since 1970[1].

In addition, an increasing proportion of natural wetlands have been altered for human use, for example for rice paddy or aquaculture. Some artificial wetlands have been created, for example reservoirs and irrigated land. In Myanmar and Vietnam, human-altered and artificial wetlands form between 60% and 70% of all wetlands in the country[2].

Lakes in the region include the largest freshwater body in South-east Asia, Tonle Sap, in Cambodia. Many lakes are being reduced in area due to sedimentation and water abstraction. Indaw Lake (Myanmar) is reported to have lost 10% of its area in the past 15 years, while Yewai and Yit Lakes

[1] Dixon et al. (2016)

[2] Source: National reports to Ramsar COP14, Section 2, Goal 3, Target 8.6. No data is available from Thailand, Cambodia or Lao PDR.

(Myanmar) are reported to dry out completely in the dry season[3]. A survey of 19 lakes in Myanmar found that two lakes had completely dried out and one had hardly any open water left[4].

Indo-Burma has 9,000 km of main **river** channels and over 117,000 km of smaller rivers (see Table 2.2). Even though they make up a small proportion of the total wetland area, they play a critical role because they transport water and nutrients between wetland ecosystems, and provide a route for species to move as part of their life-cycle. The annual pulse of flood water brings fresh sediment which restores soil fertility, and at the same time removes toxins and pollutants. Most rivers are affected by water abstraction, dam building and flood-control works, disrupted in their flow, and causing changes to the annual cycle and the total volume of water and sediment carried. The quality of river water has also changed as a result of pollution from agricultural practices, settlements and industry. Finally, disturbance, over-exploitation of species (e.g. fish) and extraction of mineral resources (e.g. sand and gravel) have all changed the ecology and productivity of rivers. Eight of Indo-Burma's river basins are among 30 identified as high priority for conservation in a global analysis[5].

Table 4 Major Rivers in the Indo-Burma Region and their key hydrological and biodiversity features

River name	Basin Area	Countries	Discharge	Trend in discharge
	km2		cubic metre/ second	
Mekong	811,000	CH, VN, TH, CB, MY LA	16,000	DEC
Ayeyarwady	411,000	MY CH IN	15,112	DEC
Salween	324,000	CH MY TH	6,600	
Hong Ha (Red)	143,700	CH VN	2,640	
Chao Phraya	160,400	TH	718	DEC
Kaladan	40,000	IN MY	3,468	
Ma	36,000	VN		
Sittaung	31,000	MY	1,542	
Ca	28,500	VN		

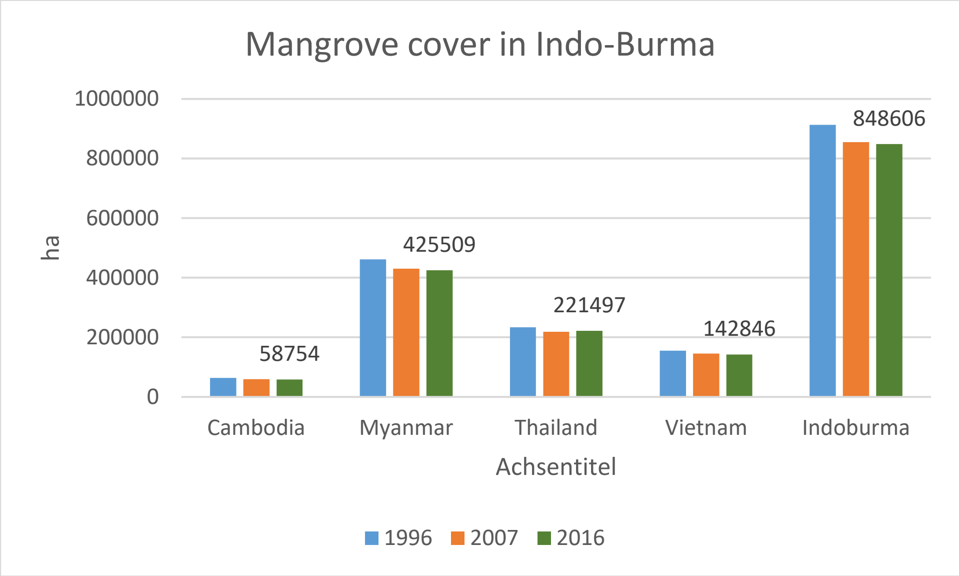
Sources: Allen *et al.* 2012, Kottelat 2017, Groombridge & Jenkins 2002

Peat forms in wetlands when organic matter does not fully decompose because it is saturated, and layers of peat may accumulate to be meters thick. Peatlands may be forested or unforested. They are an important store of carbon and water, and require careful management, as drainage and peat extraction leave them exposed to erosion or fire.

Mangroves occur naturally in most coastal areas in the region. The area of mangroves declined from 9,100 km^2 in 1996 to 8,500 km^2 in 2016 (Fig. 2.1), although restoration efforts in Thailand reversed the decline in that country and contributed to a slowing of the decline across the region. Nevertheless, pressure from expansion of rice growing and aquaculture remains intense, and Myanmar had the highest annual mangrove deforestation rate globally (Fries et al 2019). In addition to the clearance of mangroves, surveys suggest that large areas have been degraded by logging and cutting for fuelwood, meaning that their ecosystem functions, including biodiversity and carbon storage, will be reduced (Zöckler et al, 2021).

[3] Davies et al., (2004)
[4] Aung et al. (2016)
[5] Groombridge & Jenkins (2002)

Fig 2 Mangrove distribution in the Indo-Burma countries in 1996, 2007 and 2016, values in hectare



Source: World Mangrove Watch; Bunting et al. 2018

Intertidal mudflats are widespread along the coast of Indo-Burma. Myanmar ranks 11th globally for the extent of its mudflats (Murray et al 2019). The extent and location of mudflats changes with patterns of coastal and riverine erosion and deposition, and these are in turn affected by changes in land use, dam building, and rainfall intensity in the catchment. Mudflats are a highly productive, dependent on tidal inundation for nutrients and oxygen. They provide feeding and breeding habitat for many species, including fish and water birds. Embankments and 'reclamation' (drying of mudflats) for agriculture, aquaculture and salt pans have reduced intertidal areas.

Salt marshes are rare in the tropics, but have developed in the Gulf of Mottama (Myanmar) because a regular tidal bore prevents the establishment of mangrove trees. They are a key habitat for storing carbon.

Salt marsh with *Ruppia maritima* in the Gulf of Mottama Ramsar site, Photo: CZ

Coral reefs are patchily distributed in shallow seas of Indo-Burma, most often forming fringing reefs around islands and areas with hard substrate. 77% - to 100% of reefs in the region are considered 'at risk' (Spalding et al., 2001) as a result of increased sedimentation and eutrophication from land-based sources, rising sea temperatures and increasing sea water acidity. In combination, these factors cause bleaching and death of the coral. Bleached corals are more easily damaged by wave action during storms, which are becoming more frequent and severe with climate change.

Seagrass beds are important habitat for marine life, including marine turtles and dugongs and many fish species, but also for their ecosystem services, such as nutrient recycling, carbon sequestration and storage (Costanza et al., 2014; Nordlund et al., 2016). Seagrass is declining across the region due to eutrophication, pollution, sedimentation, physical disturbance, trawling and aquaculture (Unsworth et al., 2018; Mishra and Apte, 2021, Stankovic et al 2021). Vietnam lost 50% of its seagrass meadows between 1990 and 2020 as a result of these factors (Luong et al., 2012; Chen et al., 2016; Tinh et al., 2020). Across the region, the current rate of decline (118 km^2/2.82% per year) could lead to loss of all sea grass in Indo-Burma by 2030[6].

2.2. Wetland Biodiversity

An estimated 10,000-15,000 wetland-dependant vertebrates, arthropods and molluscs species live in Indo-Burma's wetlands. They include at least 3400 fish species, and 36 marine mammals including Irrawaddy dolphins (*Orcaella brevirostris*), Indo-Pacific Finless Porpoise (*Neophocaena phocaenoides*), Indo-Pacific Humpback Dolphin (*Sousa chinensis*), and dugong *(Dugong dugon)*.

There is scattered information available of certain vertebrates and little if any for invertebrates available for most of the 40 Ramsar and FNS sites. Table 3 shows the status and trends for most taxonomic groups at each site, divided in freshwater and marine sites.

[6] recalculated from figures in Stankovic et al. 2021

Table 5: Biodiversity at Ramsar Sites

*	Abb	Freshwater	Cou-ntry	Mammals	Marine M	Fish	Birds	Reptiles	Amphibians	Crustaceans	Molluscs	Dragonflies	Corals	Seagrass/ Saltmarsh	Overall Trend
1	ST	Stoeng Treng	Camb	DEC	STA	DEC	DEC	DEC							DEC
2	PT	Prek Toal	Camb	INC		STA	INC	STA							INC
3	BC	Boeng Chhmar	Camb	DEC		DEC	DEC	DEC							DEC
4	SS	Stung Sen	Camb	DEC		DEC	DEC	DEC							DEC
6	AP	Anlung Pring	Camb				DEC								DEC
7	BK	Beung Kiat Ngong Wetlands	Laos				DEC	STA							DEC
8	XC	Xe Champhone Wetlands	Laos	DEC		DEC	DEC	DEC	DEC		STA				DEC
9	ID	Indawgyi WSy	Myan	DEC		DEC	STA				DEC				DEC
10	IN	Inlay Lake	Myan	DEC		DEC	DEC								DEC
12	MY	Moeyungyi Wetland WS	Myan			DEC	DEC	DEC	DEC						DEC
15	BL	Bung Khong Long	Myan	STA		DEC	INC	DEC	DEC	DEC	DEC				DEC
16	KT	Kut Ting Marshland	Myan			DEC	INC	DEC	DEC	DEC	DEC				DEC
17	LSk	Lower Songkhram River	Myan	DEC		STA	STA	DEC	DEC	DEC					STA
18	NB	Nong Bong Kai	Myan			DEC	DEC		DEC	DEC	DEC	DEC			DEC
29	KK	Kuan Ki Sian of the Thale Noi	Myan	DEC	STA	DEC	INC	DEC	DEC	DEC	DEC				DEC
31	PS	Princess Sirindhorn WS	Myan	DEC		DEC	DEC	DEC	STA						DEC
32	BB	Ba Be	Myan	DEC		DEC	DEC	DEC							DEC
33	VL	Van Long Wetland	Myan	INC		STA	STA								STA
35	BS	Bau Sau Wetlands	Myan	STA		STA	STA	INC							STA
36	LS	Lang Sen	Myan	DEC		DEC	DEC	DEC							DEC
37	TC	Tram Chim	Myan	DEC		DEC	DEC	DEC							DEC
38	MT	U Minh Thuong	Myan	DEC		DEC	STA	DEC							DEC

*	Abb	Marine & coastal	Cou-ntry	Mammals	Marine M	Fish	Birds	Reptiles	Amphibians	Crustaceans	Molluscs	Dragonflies	Corals	Seagrass/ Saltmarsh	Overall Trend
5	KO	Koh Kapik	Camb	DEC	DEC	DEC	DEC	DEC						STA	DEC
13	GM	Gulf of Mottama	Myan			DEC	DEC							STA	DEC
14	MM	Meinmahla Kyun WS	Myan	STA		DEC	DEC	STA					DEC		DEC
11	NT	Nanthar Island	Myan			DEC	DEC	DEC		STA	STA				DEC
19	KKh	Khok Kham	Thai	DEC	STA	DEC	STA	STA	DEC	DEC	DEC				DEC
20	DH	Don Hoi Lot	Thai	DEC	INC	DEC	INC/INC	INC	DEC	DEC	INC				INC
21	PL	Pak Thale Laem Bhia	Thai	DEC	STA	DEC	INC/STA	INC	DEC	DEC	DEC				DEC
22	KS	Khao Sam Roi Yot	Thai	INC	STA	STA	STA	DEC		STA	DEC		STA		STA
23	KP	Kaper Estuary	Thai	STA	INC	DEC	INC/INC	STA	STA	DEC	DEC		DEC	STA	STA
24	MK	Mu Koh Ang Thong	Thai	INC	INC	STA	INC	STA	INC	STA	STA		STA	STA	INC
25	KR	Ko Ra-Ko Phra Thong	Thai	DEC	STA	STA	DEC/STA	STA	STA	STA	STA		STA	INC	STA
26	PN	Pang Nga Bay	Thai	STA	STA	DEC	STA	STA	DEC	DEC			STA	STA	DEC
27	KA	Ko Kra Archipelago	Thai	STA	STA	STA	DEC	DEC		STA	STA		STA		STA
28	KB	Krabi Estuary	Thai	STA	INC	DEC	INC/DEC	INC	DEC	DEC	DEC		STA	INC	STA
30	HC	Had Chao Mai	Thai	STA	INC	DEC	STA	DEC	DEC	STA	DEC		STA	STA	DEC
34	XT	Xuan Thuy	Viet				DEC								DEC
39	MC	Mui Ca Mau	Viet	DEC		DEC	DEC	DEC							DEC
40	CD	Con Dao	Viet		DEC	DEC							DEC	STA	DEC

LEGEND	
*	Number on map, side 1
DEC	decrease
STA	stable
INC	increase
	breading birds/wintering guests
	unknown, no appearance

The number of wetland plants is unclear due to the difficulty of separating wetland and non-wetland species, although there are at least 252 higher plants (Landsdown, 2012), and 261 different algae species have been identified from the Myanmar coast (Soe Thun et al, 2021).

Table 6: Species richness of the main river basins in Indo-Burma

River basin name	Countries	Number of fish species	Number of Odonata species
Mekong	CH, VN, TH, CB, MY LA	450	
Ayeyarwady	MY CH IN	388	149
Salween	CH MY TH	151	208
Hong Ha (Red)	CH VN	253	163
Chao Phraya	TH		181
Kaladan	IN MY		
Ma	VN		
Sittaung	MY	200	
Ca	VN		

Sources: Allen et al 2012, Kottelat 2017, Groombridge & Jenkins 2002

Threatened species

Many wetland species are threatened with extinction as a result of the loss and degradation of their habitat, over-exploitation and competition with alien species. Of 7030 animal species which have been assessed in Indo-Burma, 842 (12%) are threatened (Table 7). Over 20% of marine turtles, freshwater reptiles, mammals and corals are assessed as threatened. The assessment of some groups, especially arthropods, molluscs and annelids, is incomplete, meaning that there are likely to be more threatened species in these groups. 119 species (1.7% of all animals assessed) are considered critically endangered.

Plants cannot be easily separated into wetland and non-wetland species, so figures for all plants are reported[7]. Of plant 2979 species assessed in Indo-Burma, 522 (18%) are threatened, including 105 critically endangered, 207 endangered and 210 vulnerable species. Overall, 2.2% of the species assessed are critically threatened, 4.6% endangered, and 6.8% vulnerable.

[7] One study, Landsdown (2012), assessed 252 aquatic plant species in Indo-Burma and found five of them were globally threatened.

Table 7: Numbers of wetland species assessed and Red List Threat Status

Species Group		Number of species assessed	Number of species by red List category				
English name	**Scientific name**		**CR**	**EN**	**VU**	**total red list**	**% of red list species**
Molluscs	Mollusca	695	12	16	37	65	9
Crabs and shrimps	Decapods	324	0	12	20	32	10
Dragonflies	Odonata	534	3	4	12	19	4
Fish	Piscines	3423	39	88	123	250	7
Amphibians	Amphibia	383	4	35	35	74	19
F/w turtles, Snakes & Crocodiles	Reptilia	309	24	22	25	71	23
Marine Turtles	Reptilia	5	1	1	2	4	80
Water birds	Aves	226	9	14	13	36	16
Mammals (Land and Freshwater)	Mammalia	479	21	42	40	103	22
Marine Mammals	Mammalia	36	5	5	4	14	39
Corals, sea anemones, jellyfish	Cnidaria	562	1	10	153	164	29
Star fish and sea urchins	Echinodermata	54	0	5	5	10	19
Total		**7030**	**119**	**254**	**469**	**842**	**12**

Source: IUCN red List, accessed June 2021

CR: Critically endangered; EN: endangered; VU: vulnerable

Marine Mammals

With limited surveys and the difficulty of estimating numbers, knowledge of the distribution and population of marine mammals in the region is incomplete. However, it is clear that many populations and subpopulations are small and threatened. Even though new populations of Irrawaddy dolphins, Indo-Pacific finless porpoises, and Indo-Pacific humpback dolphins were documented in the Gulf of Mottama in 2018, and the presence of Irrawaddy dolphins confirmed in coastal waters off of Ho Chi Minh City, Vietnam in 2020 (Long Vu, personal communication), these species are believed to be declining.

Marine mammals face multiple threats, particularly bycatch (non-target capture) in fishing gear, and habitat degradation. The two separate riverine populations suffer the impacts from hydropower projects, while marine populations are affected by trawling, overfishing and coastal development, especially for dugongs, which depend on seagrass.

Birds

The wetlands of the Indo-Burma region provide a habitat for millions of resident and migratory waterbirds. The region is part of the East-Asian Australasian Flyway (EAAF) many of the wetlands support globally significant numbers of birds. Their numbers are declining is a result of habitat loss, fragmentation and human pressure, and especially because of hunting (Gallo-Cajiao *et al.* 2020, Studds et al. 2018).

At inland sites the situation for migrant birds is stable, but several rare resident species appear to be on the verge of extinction in the region. Black-necked stork (*Ephippiorhynchus asiaticus*) is now found in only a few sites in Cambodia, around Tonle Sap and the Cardamon region, where a stable population remains (PT BC ST).

Coastal sites in the region are important for several 'critically endangered' and 'endangered' species, such as the Spoon-billed sandpiper (*Calidris pygmaea*) (XT, KKh, PL, KS GM, MM, NT and once even in KO) see also Fig 3. The Indo-Burma region, especially the Gulf of Mottama, is by far the most important area for this species, holding more than 40% of the wintering population (Pyae Phyo Aung 2019). The Gulf of Mottama is also one of only a few mega-sites globally that regularly hold more than 100,000 waterbirds (Butler et al. 2001, Zöckler et al. 2014). No other site in the region hosts such large numbers of waterbirds. This and several other sites are also important for the endangered Spotted Greenshank (*Tringa guttifer*) (XT, KKh, KO. PL, KS MM NT, GM, KB, HC).

Mudskipper *Periophthalmus* in mangroves of Southern Myanmar, Photo: CZ

Broad-billed Sandpiper in Ayeyarwady Delta Ramsar site, 2016, Photo: CZ

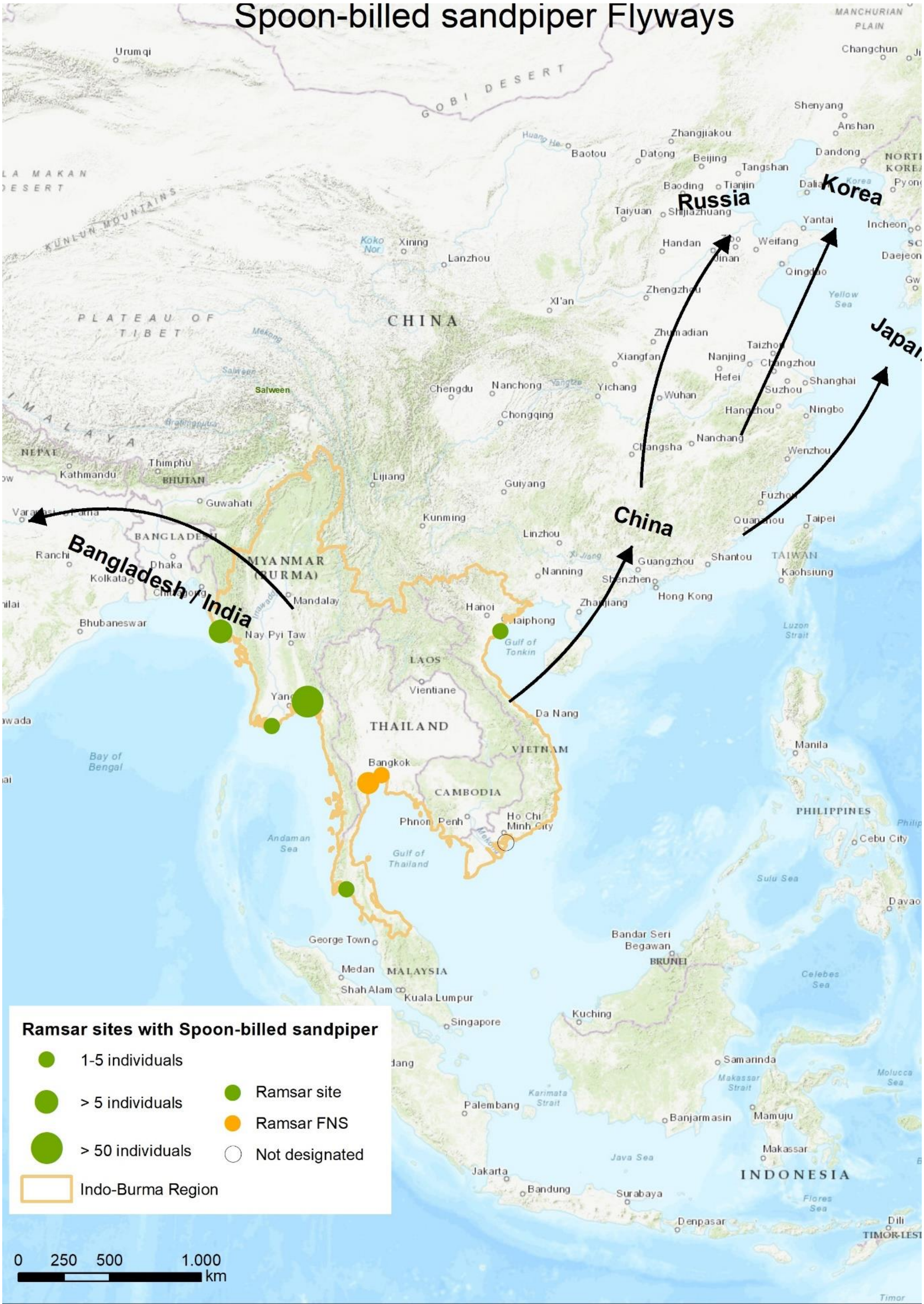


Fig 3: Spoon-billed Sandpiper Flyway paths and use of key Ramsar sites (green) and FNS (yellow)

Disappearing species

The Indo-Burma was the last known habitat for two species now believed to be extinct: the Pink-headed Duck (Tordoff et al 2008) and the White-eyed River Martin (BirdLife International). Several other wetland species, some of them with their main population in Indo-Burma, are on the verge of extinction in the region (Figure 4)

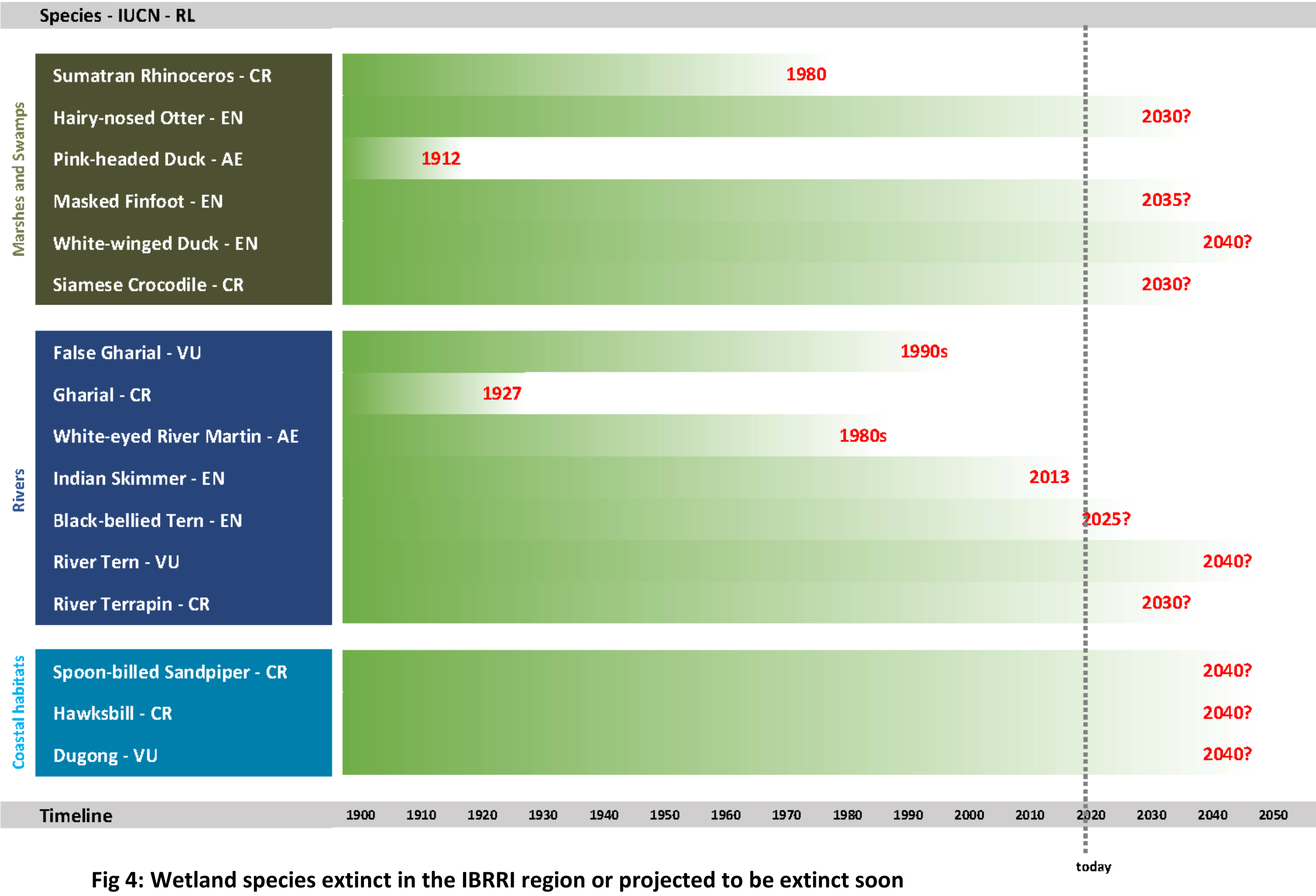


Fig 4: Wetland species extinct in the IBRRI region or projected to be extinct soon

It is likely that less than 100 Masked Finfoot Heliopais personatus (EN) are left in Indo-Burma (Chowdhury et al 2020). The species is now only regularly recorded around Tonle Sap in Cambodia. It was last recorded in Vietnam in 2003 (Eames et al 2003) and Thailand over 20 years ago (Chowdhury et al 2020).

The Indian Skimmer (Rynchops albicollis) (EN) nests almost exclusively in riverine habitats and spends the non-breeding season in estuaries. In 2012, no birds were recorded at the last known regular non-breeding site in the Indo-Burma Region, in the Kaladan estuary (Myanmar) (Zöckler et al 2014). The disappearance of the species is likely linked to habitat loss as a result of the Kaladan Multipurpose Project, which making the river navigable for larger ships, connecting Mizoram in India to the Sittwe Seaport in Rakhine. Only a few scattered single individuals have been recorded since in the entire region.

There are three to seven breeding pairs of Black-bellied Tern (Sterna acuticauda) (EN) left on the Ayeyarwady River (Zöckler et al. 2020). The other population, on the Mekong River, is reported to have gone (Claassen, et al 2017), and the species may soon be extinct in Indo-Burma. The closely related River Tern (Sterna acuticauda) (VU) is also declining sharply, with only 2 pairs left in the Stung Treng Ramsar site in Cambodia (Mittermeier et al 2019) compared to 100 or more only a decade before (Timmins 2008).

Reptiles

The reptile fauna in Indo-Burma is very diverse, but is the most threatened taxa after marine mammals, with 25 (8%) of 314 species critically endangered and a further 23 (7%) endangered (see Table 8). Key threatened species are listed in Table 8). Among the 40 Ramsar and flyway network sites, reptiles are declining at 20 sites, and only a show a stable or increasing trend in 12 sites. Five of the six sites showing an increasing trend are coastal and marine.

The **Siamese Crocodile** (*Crocodylus siamensis*) (CR) is now known from only a handful of sites in Cambodia and Laos, having disappeared from the rest of the region. The crocodile requires a large area of habitat, to allow seasonal migration (Simpson and Bezuijen 2010), and its reproductive output is low (Whittaker, 2007; S. Leslie pers. com). There is a successful re-introduction programme at one site in Cambodia, but other populations here and in Laos are declining because of sand mining, water extraction, agricultural encroachment and expansion of invasive plant species. Without successful intervention, the Siamese Crocodile will suffer the fate of the **Gharial** (*Gavialis gangeticus*) (CR) which was last recorded in 1927 in the Shweli River, Myanmar and **False Gharial** (*Tomistoma schlegelii*) (VU), last recorded in the 1990s in Southern Thailand (PS).

Most **riverine turtles** are threatened by hydrological changes, dredging and sediment shifts, unsustainable fishing practices and development schemes. The Softshell Turtles *Nilssonia formosa*, *Chitra vandyiki* and the two *Batagur spp*. are endemic to Indo-Burma, and all are critically threatened. *Batagur baska* is receiving special protection through a guardian and head-starting programme at a breeding site at the Chindwin River, Myanmar (Platt & Platt 2016) but the other species have not yet received this level of attention. Any further damming or human alteration of the river hydrology is threatening the fragile nesting ecology of these species.

Table 8: Globally threatened wetland dependent reptile species, their RL status, and their occurrence in Ramsar and FNS in the Indoburma Region

	Common name	Scientific name	RL	List of Ramsar sites
1	Burmese Narrow-headed Softshell Turtle	*Chitra vandiyki*	CR	ID Ayeyarwady River
2	River terrapin	*Batagur baska*	CR	PT ST SS
3	Burmese roofed turtle	*Batagur trivittata*	CR	Upper Chindwin
4	Giant Asian pond turtle	*Heosemys grandis*	CR	PT BK SS XC BS
5	Yellow-headed Temple Turtle	*Heosemys annandalii*	CR	PT SS BC BK MT XC BS MC
6	Yellow Pond Turtle	*Mauremys mutica*	CR	VL
7	Wattle-necked Softshell Turtle	*Palea steindachneri*	CR	VL
8	Elongated Tortoise	*Indotestudo elongata*	CR	ID PT MK, KK, BK BL BS
9	Burmese mountain tortoise	*Manouria emys*	CR	ID
10	Burmese peacock softshell turtle	*Nilssonia formosa*	CR	ID Ayeyarwady River
11	Hawksbill turtle	*Eretmochelys imbricata*	CR	MK KP KA KB HC NT KR CD
12	Siamese crocodile	*Crocodylus siamensis*	CR	XC PT BC SS ST
13	Keeled box turtle	*Cuora mouhotii*	EN	BB VL
14	Big-headed turtle	*Platysternon megacephalum*	EN	BB
15	Asian Giant Soft-shell Turtle	*Pelochelys cantorii*	EN	PT SS
16	Green turtle	*Chelonia mydas*	EN	MK HC KP, KA KR KB HC NT MM CD
17	Black-breasted Leaf Turtle	*Geoemyda spengleri*	EN	BB
18	Southeast Asian box turtle	*Cuora amboinensis*	EN	LSk KK HC BK, MK KS SS MT LS BC ST PS BS MC
19	Black marsh turtle	*Siebenrockiella crassicollis*	EN	PT KK KS BK SS PS KR BS MC
20	Asian Leaf turtle	*Cyclemys oldhamii*	EN	BK PS
21	Voris's water snake	*Enhydris vorosei*	EN	Ayeyarwady Delta
22	Asiatic softshell turtle	*Amyda cartilaginea*	VU	ID PT LSk KT BK, KK SS LS BC PT BL ST PS BS MC
23	King cobra	*Ophiophagus hannah*	VU	LSk BT KA KK KB HC KS
24	Olive Ridley turtle	*Lepidochelys olivacea*	VU	KP PN HC NT MM KR CD
25	Leatherback	*Dermochelys coriacea*	VU	KP KR PN KA NT CD
26	Loggerhead turtle	*Caretta caretta*	VU	NT
27	Burmese Python	*Python bivittatus*	VU	BK
28	Chinese Soft-shell Turtle	*Pelodiscus sinensis*	VU	BB VL

Fish

There are at least 1178 fish species in the Chao Phraya, Mekong and Vietnamese rivers (Kottelat et al 2012) plus at least 193 endemic fish species in the Ayeyarwady River system. Many fish species are migratory and rely on free-flowing rivers to move between the places where they spawn and mature. The rivers of the region hold some of the world's largest fish, including the critically endangered Mekong giant catfish *Pangasianodon gigas*, and the endangered giant freshwater whipray *Himanthura polylepis,* the largest fish in the region, with a width of over two metres.

Biological and spiritual value of the Ayeyarwady River

The Ayeyarwady River is the second largest river system in the region after the Mekong in terms of drainage basin and water discharge. It originates from rivers draining the Himalayan glaciers of northern Myanmar and flows south, through a large delta into the Andaman Sea. The Ayeyarwady, Thanlwin and smaller Sittaung rivers all discharge into the Gulf of Mottama, creating one of the largest and most productive intertidal mudflat areas in South-east Asia (Glover et al 2021).

In 2020, the annual discharge at Pyay, close to the head of the delta is 379 ± 9 Mt of water and 326 ± 91 Mt of sediment (Baronas et al., 2020). Agricultural irrigation and tributary damming have decreased the total discharge of the river since the first gauging in 1869–1879, when the average annual river discharged 422 ± 41 Mt of water and 364 ± 60 Mt of sediment (Furuichi et al., 2009; Robinson et al., 2007). However, Ayeyarwady River discharge has decreased significantly less than that of other large river systems. The combined Ayeyarwady and Thanlwin Rivers currently carry the third largest sediment load globally, whereas the system was the seventh largest prior to modern damming of other major rivers (Chen et al., 2020; Milliman & Farnsworth, 2011).

Damming has disrupted the natural flow of almost every river in South-east Asia, dramatically decreasing sediment delivery to the coast. This, combined with sea level rise, deforestation, sub-surface water extraction, dredging, and levee construction (Syvitski et al., 2009) has led to increasingly severe flooding across the economically important deltas of the region. The Ayeyarwady and Thanlwin Rivers are the only large Asian rivers with no dams on the main channel (Grill et al., 2019). The Ayeyarwady system is also comparatively unaltered by levee construction, water removal, and other human modification. The river is still flowing freely, transporting water, nutrients, sediments and providing a habitat for animals, such as fish and dolphins, along its course. The conservation and careful management of this unique and largely unaltered river system is of utmost priority.

Biodiversity in the river

The Biodiversity of the Ayeyarwady river is very diverse, with several rare and globally endangered species. Kottelat (2017) identified 388 fish species in the river basin, of which 193 species are endemic. Assessment of fish diversity is limited, and the number of species might be as high as 550, with many of them potentially threatened.

Flock of Small Pratincoles on Ayeyarwady River near Singhu, Photo: S. Pfützke

Less than 100 Irrawaddy Dolphin (Orcaella brevirostris) are thought to survive in a few sections of the river. This isolated freshwater sub-population of the species is classified as critically endangered by IUCN. A special Irrawaddy River Dolphin Protection Zone with restrictions on fishing has been implemented in some stretches in the central reaches (WCS 2008).

Waterbirds include characteristic species that nest on the pebble and sand banks in the river, including river lapwing (Vanellus duvaucelii), small pratincole (Glareola lactea), river terns (Sterna aurantia) and the globally endangered black-bellied tern (Sterna acuticauda). The Ayeyarwady River is the last stronghold for the black-bellied tern in Indo-Burma. River lapwings were once widespread, but have declined severely across the region (Goes 2014, Mittermeier et al. 2019, Xayyasith pers. comm, Zöckler et al., 2020).

Riverine Turtles are the most threatened reptile group. The Burmese peacock softshell turtle (Nillsonia Formosa) (CR) is endemic to the Ayeyarwady and Sittaung basin, while the Burmese narrow-headed softshell turtle (Chitra vandijki) (CR) is endemic to these two rivers and the Thanlwin. There are few recent observations of either species, and populations are believed to be declining due to over-harvesting for food and medicine markets in southern China (Platt et al. 2014, Platt & Platt 2016).

Biodiversity in the delta

The Ayeyarwady delta includes the MM Ramsar site, and the river is a vital source of the sediments which form the inter-tidal mudflats of the GM Ramsar site. The Gulf of Mottama is the most important wintering site for the critically endangered Spoon-billed Sandpiper (Calidris pygmea) (Zöckler et al. 2014) and a highly productive site supporting the livelihoods of more than 150 fishing communities.

Spiritual values

The famous and venerated former monk Shin U Pagoke (265 or 182 BCE) is worshipped by villagers and fishermen along the river every year in early February, with specially built shrines floated down the river in his honour. He is believed to protect worshippers from danger. He is also venerated in Northern Thailand and Laos. Some Burmese believe that Shin U Pagoke is still living, in a floating brass palace in the southern ocean, and that he can be invoked through a special Pali incantation, and that his mere invisible presence will prevent storms and floods.

Floating shrine in honour of Shin U Pagoke, Singhu, Feb 2017, Photo: CZ

2.3. Wetland ecosystem services

Wetlands in Indo-Burma provide provisioning, supporting and regulating ecosystem services which are essential for the functioning of the economy of the five countries (MEA 2005). In addition, wetlands provide important cultural and spiritual services.

Climate change impacts on the ability of wetlands to deliver these services, and at the same time, wetlands have an important role to play in mitigating and adapting to climate change.

2.3.1. Regulating Services: Climate regulation

Healthy wetlands are a vital component of the fight against climate change. They absorb carbon dioxide, buffer the impacts of extreme weather, and cool the areas around them. Maintaining wetlands thus is a key nature-based solution for climate change.

Mangroves, seagrass beds, salt marsh and peat swamp forests playing an especially important role in **sequestering and storing carbon**. In Indo-Burma, mangrove and peat swamps hold by far the largest carbon stocks (Table 9).

Table 9: Estimates of carbon stock per hectare and in total in Indo-Burma[8]

Ecosystem	Estimate tonnes carbon/ hectare	Estimate of total carbon stored (million tonnes C)					
		Cambodia	Lao PDR	Myanmar	Thailand	Vietnam	Indo-Burma
mangrove	1023	60		435	227	146	868
seagrass	122	0	0	0.2	14	2	16
salt marsh	250	0	0	13	0	0	13
peat swamp	2009	9	247	38	128	107	530
Total		**69**	**247**	**554**	**380**	**273**	**1,523**

Source of carbon stock/hectare estimates:
mangrove: Donato et al (2011)
seagrass: Stankovic et al (2021)
Salt-marsh: Ruiz-Fernández (2018)

The ability of wetlands to absorb and store carbon is reduced when there is less water available, for example because of an upstream dam, or because of drainage and construction of levees. When wetlands dry, they are vulnerable to erosion and fire, which releases the carbon they store. Carbon may be also be lost through cutting of mangrove or swamp forest trees. Soil erosion from intense

[8] There are several sources of uncertainty in the figures in table **, including:

- the volume of carbon stored in mangrove varies depending on the depth and organic matter content of the soil, by natural differences in growth, and by any cutting or other disturbance.
- the volume of carbon stored in salt-marsh in the region has not been measured. Ruiz-Fernández et al (2018) measured carbon in tropical salt-marsh in other areas, and found a wide variation between sites, from 30 – 465 tonnes C/ha. The mean is used here.
- the volume of carbon stored in peatland depends on the depth and type of peat. A global average figure for tropical peatland is used here (Page et al (2011) quoted in Warren et al (2012)). Sites in South-east Asia shows a range of 330 – 3130 tonnes C per hectare.

rainfall increases water turbidity and limits the ability of sea grass to absorb carbon. Conversely, reduced natural sediment deposition, for example as a result of up-stream dams, may lead to the loss of mangrove and mudflats. Sea level rise combined with more frequent storm events may erode coastal salt-marshes, mudflats and mangroves.

In addition to absorbing and storing carbon, **wetlands can be a source of greenhouse gases** including carbon dioxide and methane. Irrigated rice is estimated to contribute about 30% of all the methane and 11% of all the nitrous oxide released by the agriculture sector globally (IPCC, 2007). Greenhouse gas emissions have increased with the rising yield per unit area of rice in the region, a result of irrigation and intensive use of fertilisers and pesticides. Sustainable rice cultivation (See section 4.2.1.2) reduces these emissions.

Wetlands contribute to **local climate cooling** (Costanza et al 1997), reducing temperatures by 1 – 3℃ (Zhang et al. 2021, Wenguang et al 2020). Changes in water levels and eutrophication can reduce the cooling effect.

2.3.2. Regulating Services: water regulation

The different habitat types and soils in freshwater wetlands, such as reeds, sedges and swamps, act as sponges that absorb water in wet periods and gradually release it back into river, also re-charging ground-water aquifers. In doing so they smooth the seasonal peaks of water availability, reducing the risk of severe floods and intense drought. The bigger and more intact the wetland, the greater its capacity to store and supply water.

In low-lying coastal regions, especially the large deltas of Indo-Burma, coastal wetlands play a vital role in preventing the intrusion of sea water into the ground- and surface waters that are used for domestic supplies and agriculture.

Across the Indo-Burma region, the ability of almost all wetlands to provide this regulating function has reduced by drainage, conversion of flood-plains and wet season inundation zones into agricultural land, and impounding rivers through construction of levees. Interviews for this study reported a decline in the quality of water regulation services at 50% of freshwater sites and 40% of coastal sites.

The function of wetlands is vital for adaption to climate change. Extreme weather events are expected to increase in frequency and intensity in future (IPCC 2021), and these increase the risks of both floods and droughts. Rising sea levels also increase the risk of salt-water intrusion and coastal flooding. Both impacts mean that the need for the services provided by wetlands is even greater. Maintaining and restoring fully-functioning ‘wetland sponges’ requires the management of wetlands to retain their ecological functions, an effective nature-based solution which protects people, property and agricultural land around the wetlands and downstream as well as biodiversity.

2.3.3. Regulating Services: natural hazards

In addition to water regulation, wetlands, especially mangroves, mudflats and saltmarsh, provide a natural barrier to high tides, winds and waves caused by tropical cyclones, as well as unpredictable events such as tsunamis. In doing so they protect coastal settlements, infrastructure and agricultural land from the worst impacts of these events.

The ability of coastal wetlands to provide these services has declined with their degradation and conversion. Interviews for this study reported a decline in the capacity of coastal wetlands to mitigate storm damage at 40% of coastal sites, and a reduction in erosion control at 75% of coastal sites.

Table 10: Ecosystem Services in all Ramsar Sites in the Indoburma Region

				Provisional Services						Regulatory Services			Cultural Services	
*	Abb	**Freshwater**	Country	CO2 storage	Rice	Fisheries	Reeds& Grasses	Timber NTFPs	Water provision	Erosion regulation	Flood&drought regulation, water retention	Water purification & waste treatment	Tourism	Sacred sites
1	ST	Stoeng Treng	Camb	DEC	DEC	DEC			DEC		DEC	DEC	x	
2	PT	Prek Toal	Camb	DEC		INC	*		DEC	DEC	DEC	DEC	x	
3	BC	Boeng Chhmar	Camb	DEC		DEC			DEC		DEC	DEC	(x) potential	
4	SS	Stung Sen	Camb	DEC	DEC	STA		DEC	DEC		DEC	DEC	(x) potential	
6	AP	Anlung Pring	Camb	DEC	DEC	DEC			DEC		DEC	DEC		
7	BK	Beung Kiat Ngong Wetlands	Laos	DEC ***	DEC		STA	DEC	DEC **	DEC	DEC ***	STA ***	x	
8	XC	Xe Champhone Wetlands	Laos	DEC ***	DEC	DEC					DEC			x
9	ID	Indawgyi WSy	Myan	DEC	STA	DEC			STA	DEC	STA	DEC	x	x
10	IN	Inlay Lake	Myan	DEC	DEC	DEC	DEC		DEC	DEC	DEC	DEC	x	x
12	MY	Moeyungyi Wetland WS	Myan		STA	DEC			DEC		STA	DEC	x	
15	BL	Bung Khong Long	Myan		STA	STA	DEC	STA**	STA		STA	STA	x	
16	KT	Kut Ting Marshland	Myan		STA	STA	DEC	STA**	STA		STA	DEC	x	
17	LSk	Lower Songkhram River	Myan		STA	STA	DEC	STA**	INC ***		INC ***		x	
18	NB	Nong Bong Kai	Myan		STA	DEC	DEC	DEC	STA		STA	DEC	x	x
29	KK	Kuan Ki Sian of the Thale Noi	Myan	STA ***		STA	STA	STA *	INC		INC		x	
31	PS	Princess Sirindhorn WS	Myan	STA***		STA	STA	DEC	INC		STA		x	
32	BB	Ba Be	Myan	DEC				DEC	STA	STA	STA	STA	x	
33	VL	Van Long Wetland	Myan	STA	STA	STA			STA		STA	DEC	x	
35	BS	Bau Sau Wetlands	Myan	STA		STA			STA		STA	STA	x	
36	LS	Lang Sen	Myan	DEC	DEC	DEC			DEC		DEC	DEC		
37	TC	Tram Chim	Myan	DEC	DEC	DEC	DEC	DEC	DEC		DEC	DEC	x	
38	MT	U Minh Thuong	Myan	DEC ***	DEC	DEC	DEC		DEC		DEC	DEC	x	
*	Abb	**Marine & coastal**	Country	CO2 storage	Rice	Fisheries	Reeds& Grasses	Timber NTFPs	Water provision	Erosion regulation	Flood&drought regulation, water retention	Water purification & waste treatment	Tourism	Sacred sites
5	KO	Koh Kapik	Camb	DEC		DEC			DEC	DEC	DEC			
13	GM	Gulf of Mottama	Myan	INC		DEC				STA	STA			
14	MM	Meinmahla Kyun WS	Myan	DEC		DEC		DEC		STA	DEC		x	x
11	NT	Nanthar Island	Myan	DEC		DEC				STA	DEC		x	
19	KKh	Khok Kham	Thai	INC***		STA		STA		DEC	STA		x	
20	DH	Don Hoi Lot	Thai	INC***		INC		INC		DEC	STA		x	
21	PL	Pak Thale Laem Bhia	Thai	INC***		STA		STA		DEC	DEC		x	
22	KS	Khao Sam Roi Yot	Thai	STA *		INC	STA	DEC *	STA	DEC	STA		x	x
23	KP	Kaper Estuary	Thai	INC ***		INC		DEC *		DEC	INC		x	
24	MK	Mu Koh Ang Thong	Thai	STA*		STA		STA	INC	DEC	STA	INC	x	
25	KR	Ko Ra-Ko Phra Thong	Thai	STA***		STA	STA	DEC		DEC	STA		x	
26	PN	Pang Nga Bay	Thai	STA***		INC	INC	DEC		DEC	STA		x	
27	KA	Ko Kra Archipelago	Thai			STA					STA		x	
28	KB	Krabi Estuary	Thai	INC***		STA	INC	INC		DEC	INC		x	
30	HC	Had Chao Mai	Thai	INC***		STA	INC	DEC		DEC	STA	DEC	x	
34	XT	Xuan Thuy	Viet	DEC		DEC					DEC			
39	MC	Mui Ca Mau	Viet	INC***		DEC			DEC	DEC	DEC	DEC	x	
40	CD	Con Dao	Viet	STA		DEC	STA			DEC	DEC			

LEGEND

*	Number on map, side 1
DEC	decrease
STA	stable
INC	increase
	unknown, no appearance

Climate change is causing an increase in the frequency and intensity of tropical storms in the region. Extreme events like destructive cyclones now make landfall on Indo-Burma's coastline annually, compared to once every three years in the 20th century (NAPA2012). Cyclones Mala (2006), Nargis (2008) and Giri (2010) were the most severe and damaging cyclones Myanmar has experienced. (Myanmar Climate Strategy 2019). Conservation and restoration of healthy mangrove forests is a cost-effective approach to reducing the social and economic damage of these events. Understanding of how and where to re-plant and restore mangroves is becoming increasingly sophisticated (see section 4: mangrove restoration).

2.3.4. Provisioning service: freshwater supplies

Water is an essential service for daily life, agriculture and economic activity. As a key component of the water cycle, rivers and underground aquifers play a critical role moving water from areas of high rainfall to areas of high demand for water. They also regulate water quality, because they retain water and have alternating dry and wet conditions with steep bio-geochemical gradients, acting as a filter of poor quality water that flows into them (UNEP 2016).

Wetlands absorb large volumes of excess nutrients from agricultural land and settlements, and significantly reduce the threat from toxic pollutants. These services depend on the levels of pollution being within the capacity of the wetland to process them, and the maintenance of annual flood cycles which flush out accumulated toxins.

There are multiple sources of water pollution and different land use and land management patterns create different pollution patterns.

Most water pollution in the region is from agriculture, with chemicals, organic matter, and discarded veterinary drugs being released from farms and paddy fields into water bodies. Levels of fertiliser pollution vary sharply: while Myanmar only applies on average 7.5 kg /ha of Nitrogen fertiliser, Thailand and Vietnam apply over 70 kg/ha (Raitzer et al. 2015).

Pollution from heavy industry or chemical factories is still relatively rare in the Indo-Burma countries, although the lower Chao Phraya basin in Thailand is already heavily polluted (see box below). Industrialisation is starting to cause problems in other areas. Pollutant levels in wastewater in the Hlaing Tharyar and Shwe Pyi Thar industrial zones, Myanmar, are reported to have increased (Green Motherland Development Association/K.Win Phuy Phuy, 2016). Industrial water pollution is also caused by mining and oil and gas extraction. Chemicals such as arsenic, sulfuric acid and mercury used in mining are significant water pollutants (Kaza et al 2018).

Interviews for this study reported a declining capacity to provide water in 55% of freshwater sites, with an improvement at 15% and no change at 30%.

2.3.5. Provisioning service: irrigated agriculture

Indo-Burma is the global centre of rice cultivation, exporting the commodity all over the world, and rice is by far the most important crop in terms of value. In many areas intensive, irrigated cultivation produces two or three harvests per year. Between 1997 and 2017, the area of rice production in Indo-Burma increased by 15%, from 255,270 km^2 to 293,660 km^2 (Table 11). The largest percentage increase was in Lao PDR (73%), but the greatest increase in area was in Cambodia, where 10,857 km^2 were brought into rice cultivation. Nevertheless, Thailand has the largest area of rice cultivation in the region.

Table 11: Area of rice cultivation

	Cambodia	Lao PDR	Myanmar	Thailand	Vietnam	Indo-Burma
Area, 1997 (km^2)	19,500	5,540	60,700	99,320	70,210	255,270
Area, 2017 (km^2)	30,357	9,563	69,459	107,196	77,085	293,660
Increase (km^2)	10,857	4,023	8,759	7,876	6,875	38,390
% increase	56	73	14	8	10	15

Source: FAO Stat (accessed Aug 2021)

Table 12 shows the area of irrigated land in the countries of the region. The total irrigated area is almost 140,000 km^2, over 7% of the entire land area of the region.

Table 12: Area of irrigated land

Type of irrigation	Cam	Laos	Myn	Thai	Viet	Total
using surface water (km^2)	5,067	2,717	20,108	59,338	41,270	128,500
using groundwater (km^2)		2	1,000	4,810	4,585	10,397
Total	5,067	2,720	21,108	64,149	45,855	138,899

Source: FAOSTAT accessed Aug 2021

The development of irrigated agriculture has led to the conversion of many natural wetlands, as well as the conversion of dryland ecosystems. The artificial wetlands created for rice cultivation rely on rivers (sometimes dammed) and lakes for their water, and they now make up around 70% of all water consumption in the region.

The ability of natural wetlands to support irrigation is linked to their role in water regulation, and their size and ecological intactness. Interviews for this study reported declining ability of wetlands to support irrigation at almost 50% of freshwater sites, with the remainder reporting no change.

Climate change will impact on the ability of wetlands to sustain large areas of irrigated agriculture. Irrigated areas are often vulnerable to severe flooding, which damages crops and infrastructure, as well as to water shortages. Where too much of the natural wetland water regulating function has been replaced by irrigated rice, the wetlands' ability to moderate the impacts of climate change will be impaired, and this will cause food insecurity and economic harm. A balance needs to be found between using land and water for food production, including rice, and ensuring that wetlands retain the ability to buffer climate extremes and continue to provide others vital services.

2.3.6. Provisioning service: fisheries and other wild products

Wetlands support diverse fisheries in habitats from shallow nearshore waters (including coral reef, seagrass, mangrove, and mudflat habitats) to inland waters (including rivers, lakes, swamps, and flooded forests). Many fish use different types of wetlands at different stages in their life-cycles – mangroves and sea-grass beds are nurseries for many fish species which are found as adults on coral reefs and coastal seas, for example. Some fish undertake migrations between wetlands to breed. These species are referred to regionally as "white fish", that undertake migrations from main river channels to tributaries and floodplains, while "black fish" undertake more limited migrations from rivers to floodplains.

Maintaining healthy fish populations, therefore, does not only require conservation of the wetlands where the adults are caught, but also healthy, inter-connected wetlands of all type.

Fisheries provide a primary source of protein for populations in Southeast Asia, with small-scale fisheries being particularly important to local communities (Pomeroy et al. 2016, Muthmainnah et al. 2015). It is likely that the value of inland fisheries is underreported and underestimated (Bartley et al. 2015), meaning that their importance as a source of subsistence and supplementary livelihood is probably greater than their assessed market value would suggest. Properly assessing the value of wetland fisheries resources is hampered by the widespread lack of monitoring data, particularly catch per unit effort (CPUE) estimates (Bartley et al. 2015), especially for inland fisheries.

Generally, fisheries appear to be declining substantially throughout the region's freshwater and coastal fisheries, a trend echoed by data from specific sites with fish catch monitoring (see Table 10 and Ramsar site section), where 52% of freshwater sites and 41% of coastal sites reporting a decline in fisheries. These declines were reported to be a result of over-fishing, competition with invasive species, loss of wetlands, pollution and disruption to the lifecycles of migratory fish species. In Cambodia, low water levels (largely caused by hydrological alterations through damming, water use for agriculture, and diversion of water flow) in the Tonle Sap Lake have negatively affected fish populations in the lake as well as those which migrate into rivers in the Mekong Delta. In Vietnam's Mekong Delta area, this reduction of water flow and water level is also driving declines in fish stock.

Climate change will impact fisheries directly (e.g. through changes in habitats which may make them unsuitable for target fish species, spread of diseases and parasites) and indirectly, through changes in rainfall and the hydrological cycle.

2.3.7. Cultural and spiritual services

Many wetlands and rivers serve important spiritual, cultural and recreational functions. Several sites are worshipped or have mythological associations. An annual festival at **Lake Indawgyi** (ID) in Myanmar attracts millions of visitors. In the Ayeyarwady Delta, the **Meinmahla Kyun** Wildlife Sanctuary (MM) is a place of myth and pilgrimage. The Lao wetland Xe Champone (XC) is famous for its Siamese crocodiles (CR) and its many different sacred natural sites, which range in area from a few square metres around a tree to sites of more than 30 hectares. At Pyu Lake (Myanmar), local tradition forbids the use of boats, helping to maintain sustainable fisheries (T. Aung per. Comm.)

Studies have shown that many sacred sites in Asia show high levels of biodiversity (Dudley et al. 2010). However, in some sites local people are worried about their ability to maintain local beliefs and practices, because of increasing influence from the outside world, linked to improved road access, and a lack of spirit masters taking up responsibilities (Glemet et al. 2016).

Meinmahla Kyun Ramsar site, Photo: CZ

Fisherman on floating car tyre at Pyu Lake Mandalay Region Myanmar, Photo: Kyaw Myo Naing

3. Key issues and drivers of change to wetlands and their ecosystem services

The multiple pressures on wetlands are complex, interacting and demand integrated solutions. This section focuses on a set of the most widespread and important drivers of change. Section 4 reviews the solutions that have been tried or proposed.

3.1. Climate Change

The future climate is partly determined by the magnitude of future emissions of greenhouse gases (primarily carbon dioxide, methane and nitrous oxide), aerosols, and other natural and man-made factors. The International Panel on Climate Change (IPCC 2021) states the continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system including the increasing likelihood of severe, pervasive, and irreversible impacts for people and ecosystems. The main climate-related drivers of impacts on wetlands in Southeast Asia include: warming and drying trends, extreme temperatures, extreme precipitation, damaging cyclones, sea level rise, oceanic oxygen depletion and ocean acidification. These drivers will affect wetlands, agricultural productivity and are likely to lead to water shortages, salinity intrusion, more riverine, coastal and urban flooding and an increase in climate-induced public health issues. As a consequence, they will also exacerbate poverty and inequality in the region (Hijiokaet al. 2014).

3.1.1. The present situation

The IPCC (2021) report that human-induced climate change is partly responsible for an increase in the frequency and intensity of heavy precipitation events since the 1950s, and the later onset and earlier withdrawal of the southwest monsoon, which means that its average duration has decreased from 144 days (1961-1990) to 121 days (1981-2010). There are complex and locally specific patterns of change, however. In Indo-Burma, rainfall has risen overall across the region, but has decreased in Tonkin (northern Vietnam) and on the Tenessarim Peninsula. The mean temperature is reported to have risen by around 1.8°C (Government of Myanmar, 2019), and sea levels rose by an average of 3.4 (±0.7) mm/year from 1993 – 2014 on the coast of the Mekong Delta.

3.1.2. Climate Change Projections

The IPCC presents its climate change projections in terms of low, medium and high and very high emissions scenarios. The intermediate scenario predicts a **temperature** increase of 0.8-2.6˚C by 2100 across Indo-Burma (IPCC 2014). Higher monsoon rainfall is also predicted, with an increase of 412 mm (21%) in annual average **rainfall** predicted for the central Mekong basin (Trần Thục 2016), but there are variations across the region. Rainfall models suggest an increase in rainfall intensity, rather than more rainy days (ICEM, 2013). In addition, the proportion of **cyclones** which are 'intense' (categories 4-5) is predicted to increase, with peak wind speeds in these storms also increasing. (IPCC 2021).

Projections of **sea level rise** for Myanmar's coast range from 0.37 to 0.83 cm meters by the 2080s, and possibly as high as 1.22 meters (Horton et al. 2016). A sea level rise of 0.5 metres would move shoreline of the Ayeyarwady Delta inland by 10 kilometres, with significant impact on local communities and livelihoods. A sea level rise of 1 metre by the 2100 (high emissions scenario) would inundate 39 % of the Mekong Delta.

3.1.3. Impacts of climate change

Climate change poses large risks to human health, biodiversity, global and regional water and food security. The combination of high temperature and humidity compromise normal human activities, including growing food or working outdoors in some areas for parts of the year (IPCC, 2014). Inland areas are vulnerable to increased flooding and drought, while coastal areas are vulnerable to sea-level rise and cyclones.

Some 85% of the rural population in Indo-Burma rely on climate-sensitive sectors for their livelihoods, with 70% dependent on rain-fed agriculture, livestock and fishery and forest resources. The livelihoods and wellbeing of a large part of the population are highly sensitive and vulnerable to climate change. Vulnerability Assessments to Climate Change conducted in townships such as Pakokku (Central Myanmar) demonstrate that failing to address the consequences of climate change on agriculture will drastically reduce the ability of people to live from agriculture by 2050 (Fee et al., 2016).

Changes in water supply quality and availability will impact the agriculture, energy, and tourism sectors, with downstream impacts on the economy. The countries of Indo-Burma are particularly vulnerable to economic impacts of climate change because of their rural and agrarian populations. The predicted cost of climate change may be as high as 6.7 percent of the Gross Domestic Product (GDP) per year in Thailand and Vietnam. (NBSAP Vietnam 2011)

The degradation of wetlands caused by climate change will have severe impacts on the unique and threatened ecosystems of the Indo-Burma region, and on the species that depend on them. Further reductions in species populations, and even extinctions, can be expected.

3.2. Hydropower development and the impacts on wetlands

Development of large-scale hydropower is proceeding rapidly in the large river basins of the Indo-Burma region, in particular in the Mekong, Thanlwin and Ayeyarwaddy river basins.

The World Commission on Dams (WCD, 2000) concluded that hydropower development has had extensive impacts on rivers and aquatic ecosystems, altering ecosystems and the species they support, and leading to disappearance of some species. Specific impacts are:

- loss of aquatic and riparian habitat upstream of dams, due to flooding of valleys and river channels;
- reduced river flow downstream, creating drought-like conditions which cause water-stress for riverine plants, and can lead to intrusion of saltwater into coastal freshwater systems;
- discharges from dams are often different in timing and volume from natural seasonal flow regimes, causing problems for species which have adapted to synchronise breeding or other stages of their life cycle with the annual changes of water volume. Alteration of the natural flood cycle has a serious impact on riparian vegetation and aquatic plants;
- dams impede the migration of fish upstream to spawning grounds, and the downstream journeys of larvae and juvenile fish are disrupted because they are unable to find their way through the reservoir or experience physical damage when passing through turbines;
- water held behind dams deposits some of the sediment and nutrients it has carried from upstream. When water is released to flow downstream, it no longer re-charges the productivity of floodplain soils as it would have done with natural flooding. This reduces biological productivity and impacts agriculture, fisheries and biodiversity. The reduced flow of sediment to the delta means that replenishment and accretion of mud and silt in coastal wetlands slows down, leaving these wetlands more vulnerable to erosion.

3.2.1. Current status of hydropower in Indo-Burma

All the countries in the region are promoting increased hydropower as a way to expand electrification while reducing carbon emissions, and they rely heavily on assumed expansion of hydropower to meet their emissions reduction commitments under the Paris agreement. However, these plans generally ignore emissions from hydropower projects, caused by upstream deforestation, disruption of natural flood cycles and use of large volumes of concrete. Some of these effects could be mitigated by careful planning of hydropower projects, taking a river-basin-wide approach, maintaining key natural river flow features, and optimising water availability for all uses.

Cambodia already has relatively high rates of electrification, but nevertheless plans to expand its hydropower production and reduce dependence on fuel oil for power generation. The country has 1.3 GW of installed hydropower capacity (2020). In 2018 the 400 MW Lower Sesan II project was commissioned on a tributary of the Mekong, a result of collaboration between Chinese, Cambodian and Vietnamese companies. Other proposed projects include the Sesor Dam, on the main channel of the Mekong. Cambodia's NDC sets a target of 25% renewables by 2030, including hydropower, but otherwise makes no reference to this source of energy.

Hilly terrain and high rainfall mean that **Lao PDR** has high technical potential for hydropower. The country currently (2020) has installed capacity of 7.3 GW, and a target of 20 GW by 2030 (Lao NDC, updated 2021), with over 50 sites are expected to be operational by 2025. With 90% of Laos already electrified, most of this power is for export. Hydropower development is central to the country's emissions reduction targets. The 2015 'Policy on Sustainable Hydropower Development in Lao PDR' states that 'Hydropower Development Plans shall be undertaken in collaboration with relevant stakeholders in the management, utilization of water and water resources for the optimal benefits.', and requires comprehensive social and environmental impact assessments, conservation of natural habitats, and compensation or restoration where such losses are unavoidable. The Lao PDR NBSAP is the only policy to refer to the potential emissions from hydropower, recognising the risk of deforestation at the 31 potential hydropower sites in forested areas.

Myanmar has a substantial need for power, with the lowest grid connected electrification rate in Southeast Asia, with only 40% of the population supplied. It is estimated that at least 500 MW of additional generation capacity is required every year up to 2030 to meet domestic demand. The country is said to have the potential for 100 GW of hydropower, with only 3.3 GW developed to date (2020). A further 1.5 GW are under construction, and 69 projects totalling 43.8 GW are proposed. The National Electrification Plan (2014) aimed to deliver electricity to the whole country by 2030, with much of this provided by a tripling of hydropower capacity by 2030.

Thailand's currently (2020) has 4.5 GW of hydropower capacity, with more expected to be commissioned shortly. Thailand is also pioneering solar-hydro plants, fitting floating solar hydropower lakes. However, the country does not see a significant role for these sources in its energy mix, with the Climate Change Master Plan 2015-2050, and the Power Development Plan 2010-2030, proposing to replace natural gas with coal and imported electricity (including from Lao PDR). The expected growth in hydropower and renewables is limited.

As well as the Mekong, the many rivers flowing from the **Vietnamese** highlands to the sea mean that the country has large potential for hydropower. At 17.1 GW (2020), Vietnam has the highest installed capacity of any of the Mekong countries (see figure 5). After initial rapid growth, environmental and social concerns led to a review of the national hydropower strategy and suspension of several hundred planned projects. Vietnam's NDC refers to a plan to 'maximise hydro-power' along with other renewable sources, although elsewhere there is reference to ‘striking a balance’ between the various sources. no specific targets are set for its development.

3.2.2. Hydropower in the Mekong river basin

There are numerous dams on the tributaries of the Mekong, and further dams are planned. Two main-channel dams have already been constructed in the lower Mekong basin, at Xayabouri and Hou Sahong in Lao PDR. Up to 11 large-scale dams could be operating on the lower Mekong mainstream by 2040 (MRC 2017; International Rivers 2019).

Existing and planned hydropower developments on the Mekong River and its tributaries are predicted to lead to up to 96% reductions in the amount of sediment carried by the river, as well a significant reduction in transport of nutrients such as phosphorus and nitrogen, which would lead to a 12-27 % reduction in the primary productivity of the aquatic systems in the delta area (Piman and Shrestha 2017).

The existing dams have already altered the unique reverse flow hydrology of the Mekong River and southeast Asia’s largest lake, Tonle Sap. In the flood season water flows from the Mekong into the lake, flooding large areas and replenishing soil nutrients. In the dry season the flow is reversed as water moves from the lake into the Mekong. This cycle is crucial for the lake’s exceptional productivity, which supports a major fishing industry and dry season agriculture (IGES 2020). Delays in wet season floods, reduced height and extent of the floods, and higher water levels in the dry season (Hecht et al. 2019) have changed the flood cycle. The impacts include drier conditions in the swamp forests of the region, making them more vulnerable to fire.

Dams block the journeys of fish migrating to their spawning grounds. While fish passages have been successfully trialled in the Mekong basin for low dams (e.g. small weirs, flood control devices) (Hortle & Nam 2017), the large numbers, diversity of species, and different timing of migration journeys means they may not be a viable solution for the high hydropower dams (Silva et al., 2018). Nevertheless, fish passages continue to be proposed as a solution.

Highly threatened species potentially affected by dams in the lower Mekong basin are Mekong Giant Catfish (*Pangasianodon gigas*), Mekong Giant Salmon Carp (*Aaptosyax grypus*), Giant Carp (*Catlocarpio siamensis*) , Siamese tiger perch (*Datnioides pulcher*), Mekong Freshwater Stingray (*Hemitrygon laosensis*), Flying minnow (*Laubuka caeruleostigmata*), Mekong Herring (*Tenualosa thibaudeaui*), and especially long-distance migrants, such as Krempf’s Catfish (*Pangasius krempfi*) (CEPF 2020) and river turtles and waterbirds.

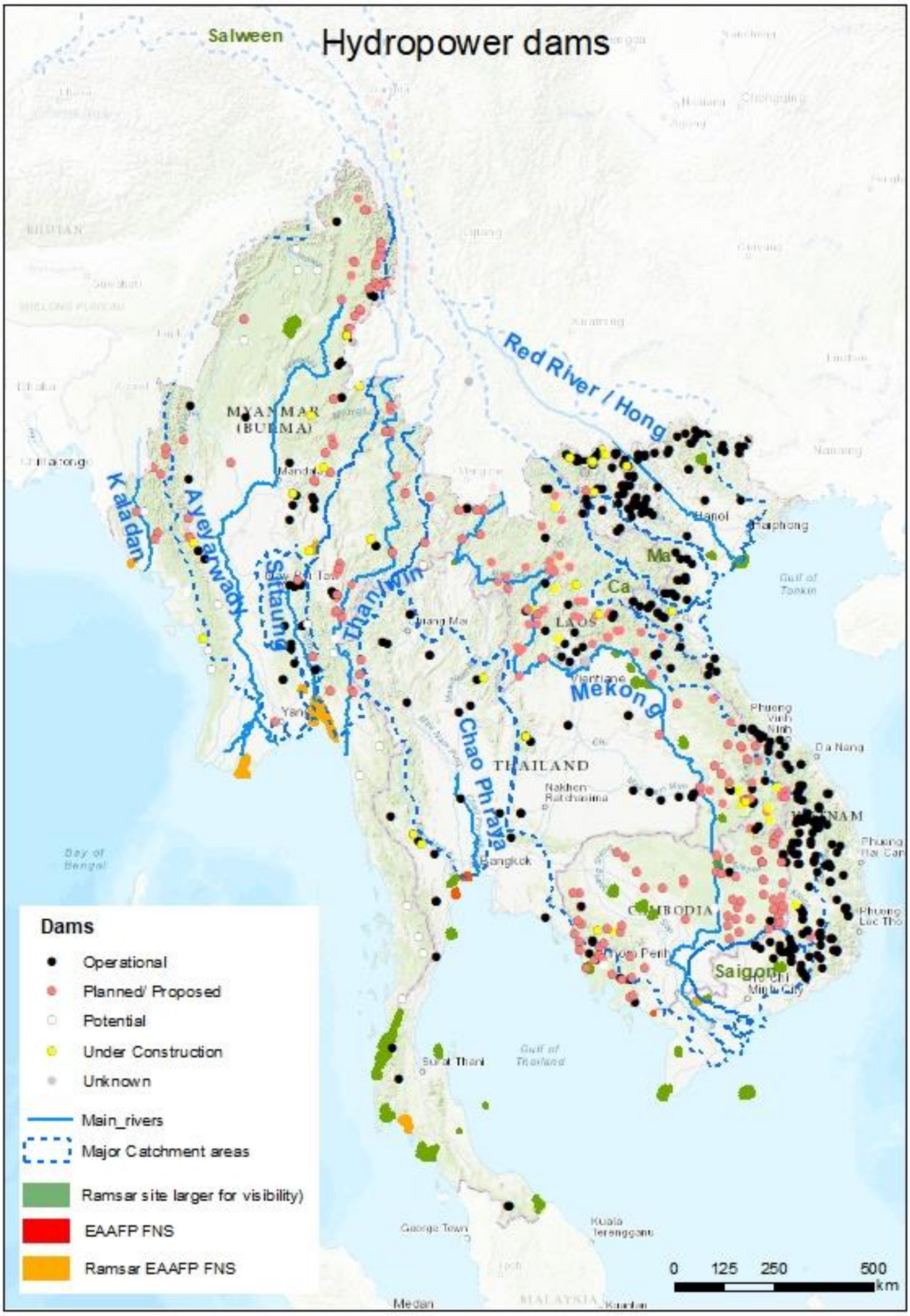


Fig. 5: Major River Basins and distribution of operational, planned and dams in construction in Indoburma

3.2.3. Hydropower in Myanmar

The hydropower sector is in the early stages of development in Myanmar, and the country has Indo-Burma's largest rivers without any mainstream dams, the Ayeyarwady (1500 km), its major tributary the Chindwin (900 km), and the Thanlwin (1200 km) and Sittaung (300 km). All of these rivers have globally important wetlands and biodiversity, and while hydropower can contribute to meeting Myanmar's need for electricity and foster economic development, there is still an opportunity to balance electricity generation with environmental and social values.

Seven sections of the Ayeyarwady have global biodiversity values that would qualify them as Ramsar sites[9], but none have legal protection. Poorly planned hydropower schemes, especially the development of large mainstream dams, would damage on system connectivity, basin processes, ecosystem services and biodiversity. Integrated basin planning would allow the cumulative impact of multiple projects to be considered, and can significantly reduce impacts (WWF 2016).

Plans for large-scale hydropower are already a focus for civil society and community networks, such as the Burma Rivers Network. In 2016, 422 organizations, representing the country's diverse ethnic communities as well as national and international non-government organizations, issued a statement urging the government to abandon plans for coal and large hydropower projects in Myanmar. Already, the Myitsone (Ayeyarwady), Tamanthi (Chindwin) and Tanintharyi hydropower projects, totalling 7,800 MW capacity, have been suspended as a result of concerns about their environmental and social impact and potential to generate conflict (IFC 2018).

A strategic environmental assessment of the Myanmar Hydropower Sector (IFC, 2018) was carried out with Myanmar Ministry of Electricity and Energy, and Ministry of Natural Resources and Environmental Conservation. The SEA concluded that if the planned 69 projects (52 GW) across the country were built, major damage would be caused to Myanmar's rivers, with altered seasonal and daily river flows, fragmented river systems, decline in water quality, reduced downstream sediment load, erosion and loss of biodiversity and habitats. The proposed dams would require large-scale resettlement, and cause loss of river-dependent livelihoods. The SEA proposes hydropower development in river basins with lower environmental values, and recommends:

- basin-level planning of hydropower development, including sub-basins, taking into account the cumulative impact of existing and planned developments
- offsetting the impact of hydropower on affected river basins by retaining the full functions and values of intact rivers and basins
- hydropower development should be within the capacity of the natural system, and should not degrade natural values or have significant impacts on communities

3.3. Agriculture and other land use change

As noted in section 2.3.5, **rice** is the dominant crop in Indo-Burma, and its cultivation has dramatically altered wetlands in Indo-Burma's major delta regions, seasonally flooded lake basins and coastal mangroves. In Myanmar, 64% of mangroves in the Ayeyarwady Delta were lost between 1978 and 2011, with 81% of this loss due to conversion to rice paddy (Webb et. al 2014). As a result, the protection that mangrove forests provide from storms has been reduced. Gradual and continuing encroachment is occurring in many inland wetlands, including ID in Northern Myanmar, XC in Central Laos and NB and BL in northern Thailand (see also text Box Indaw Chaung in section 4).

[9] Zöckler & Kottelat (2017) Ayeyarwady State of the Basin Assessment

Expansion and intensification of rice farming is also threatening Tonle Sap Lake in Cambodia and its associated wetlands. About one-third of the seasonally flooded grassland and scrubland was converted to paddy fields between 2003 and 2018. Some of the conversion is in response to lower wet season flood levels, caused by upstream land use change and dams (Learn 2020). Seasonally flooded grasslands are also being converted in the lake plains of Myanmar, such as at IN and ID, despite law enforcement efforts at some sites (FFI 2020, see figure in box).

Vietnam's previous 'rice first' policy led to expansion and intensification of rice cultivation in the Mekong delta and the loss of most natural wetlands, including peat swamp forests, freshwater swamp forest and seasonally flooded grassland. In addition, half of the mangrove forests were converted to shrimp farms. However, the Mekong development plan now acknowledges that rising sea levels, up-stream dams and changes in the annual seasonal flooding pattern mean that a third of the delta may have to switch to brackish water land-use. The plan calls for restoring mangrove barriers and redesigning aquaculture (Hoang et al. 2016).

The IBRRI countries produce a surplus of rice, meaning that there are opportunities to shift to sustainable production systems which would allow re-generation of wetland ecosystem services without threatening food security.

In addition to rice cultivation, **aquaculture** is a key driver of degradation and loss of coastal wetlands throughout south-east Asia (Richards & Fries 2015), responsible for an estimated 20% to 50% of mangrove loss in Thailand (Enright and Quarto, 2015), and 30% of mangrove loss in South Vietnam (Binh et al., 2005).

In southern Thailand the expansion of **oil palm** is also an important factor driving loss of mangrove forest, and the same process may be underway in Thaninthary Region in southern Myanmar (Richards & Fries 2015, De Alban et al. 2019).

Lastly, the **charcoal** production and trade with Thailand has been a major driver for the precipitous degradation of mangroves in southern Thaninthary, Myanmar (Graham 2017, Zöckler et al 2018, De Alban 2019).

3.4. Over-fishing, hunting and poaching

Supplies of animal protein in the form of fish and other animals are a key provisioning service provided by wetlands which sustains the livelihoods of millions of people in Indo-Burma (section 2.3). However, in many cases growing demand and adoption of new harvest methods has led to unsustainable exploitation which leads to species extinctions, the loss of the resources on which people depend and can contribute to degradation of ecosystem functions.

Over-fishing

For inland and marine wetland fisheries, overexploitation and illegal fishing are the major threat, as well as infrastructure development projects. For inland wetland fisheries, habitat degradation is the primary threat, primarily through hydropower development, wetland conversion, pollution, and diversion of water resources for other uses, including agriculture. Other threats include invasive species, with sources including aquaculture, and diseases carried by these species to native fishes.

Fisheries data is inconsistent and often does not capture the full value of the industry. However, evidence from individual sites demonstrates that over-exploitation (combined with habitat degradation and hydrological change) is reducing the productivity of the region's fisheries. Indawgyi Lake (ID) in Myanmar has shown continuous declines in fish landing over the three years since 2018 (Zau Lunn, personal communication 2021). This is at least partially attributed to an increase in illegal fishing pressure with the provision of electrofishing equipment by fish buyers working to supply demand from China.

Fishing methods such as the use of bombs and poisons to capture shallow coastal water can have devastating impacts on coral reefs and seagrass beds. Fishing indirectly contributes to the killing of the region's threatened freshwater dolphin species, and to marine mammals (whales and dolphins), which drown when they become entangled in abandoned nets or fishing gear.

Bird hunting

Bird hunting for as trade, local consumption, and as a traditional practice is reducing bird populations in virtually all wetlands in Indo-Burma, including officially protected sites. Waterbirds are hunted indiscriminately, in contrast to other parts of Asia where species such as cranes are regarded as non-huntable species. The best protected sites are those which have been protected by community-based management (GM, NT) or where strict guardian programmes have been established (PT).

Reptile hunting

Eggs and adult freshwater and marine turtles are hunted for food, trade and medicinal purposes. While this was a traditional activity, increasing demand and improved transport links have resulted in commercialization of the trade. Marine turtles are officially protected but law enforcement is poor. There are signs that protection efforts by Myanmar Department of Fishery are slowing the decline of Olive Ridley Turtles in MM.

Villagers transporting a freshly killed softshell turtle, *Amyda cartilaginea (VU),* in southern Myanmar – a species that is projected to become critically endangered in the coming decade, Photo: CZ

3.5. Synergistic effect of multiple drivers

At present, hydropower development has the greatest short-term impact on wetlands, causing significant changes to flow and sedimentation, especially in the Mekong basin and delta. Agriculture has significant impacts in the specific areas where expansion is taking place. Climate change is a more gradual, long-term impact, but is expected to become more significant with time. However, all three drivers of change interact with each other, and potentially magnify the damage to wetlands.

As an example, reduced wet season river flows from dams will be compounded by higher temperatures and reduced rainfall as a result of climate change, forcing farmers to abstract more water to maintain irrigated agriculture, putting further pressure on already stressed water supplies from natural wetlands. In coastal areas, loss of mangrove driven by agriculture exposes the coastline to erosion from wave action, which is becoming more intense as a result of increased storm events through climate change. At the same time, the amount of sediment reaching the delta to replenish the coastal mudflats and mangroves is declining, a result of upstream dams, and contributes to coastal erosion.

These kinds of effects are already being felt in the region. At Labutta, in the Ayeyarwady Delta, Myanmar, the degradation of mangroves exposes people to storm-surges and erosion caused by of sea-level rise. MM still holds some swathes of mangroves but they are largely degraded, diminishing the storm protection of the hinterland. However, moderate sea level rise in the Ayeyarwady Delta can still be offset by the huge volume of sediment delivered by the largely un-dammed river system. In contrast, in the Mekong delta sea level rise has a greater impact, due to the higher levels of disruption to the natural flow of the river (Ogston et al. 2017, Glover et al. 2021).

Higher temperature and lower rainfall will increase water stress in Central Myanmar and Northern Thailand. Several key wetlands have already been lost altogether (Aung et al. 2016) and many others experience water stress, periods of drying out such as IN, IL, but also in Northern Thailand NB, KT and several others. Upstream river flow disruption by hydropower dams (see section 3.2.) is exacerbating the water stress for these sites. Their vital role in providing key ecosystems services for fisheries, water provision and biodiversity is jeopardised and compromised.

Crab fishing in mangroves near Gwa in southern Rakhine, Myanmar, Photo: CZ

4. Management responses

4.1. Policy framework on wetlands management

Wise use is fundamental to achieving the Ramsar convention objective of maintaining the **ecological character of wetlands**. Promoting wise use requires action at the level of policies and institutions, data and knowledge creation, as well as site-specific actions such as conservation, management and restoration. It may involve establishing shared targets, inventory and monitoring, clarifying roles and responsibilities for wetlands management, and mechanisms for coordination.

The **Integrated Water Resource Management** (IWRM) approach is a key to delivering wise use at river basin level, and to sustaining water supplies for agriculture, energy, industry and domestic use. IWRM is a multi-stakeholder approach, with river basin committees playing a key role in making decisions on how to maintain the ecological balance between land use, water input, water storage and water use (See also section 4.2.3).

This section summarises the status of policies, and the institutions that implement them, across the IBBRI countries, while section 4.2 provides examples of site-level actions taken to implement wise-use principles.

4.1.1. International and regional agreements

Many wetlands, their ecological services and the issues which threaten them, operate across international boundaries, and involve the IBBRI members, China and other countries. A series of international agreements provide a platform for dialogue and collaboration on water and wetlands management.

The globally important role of wetlands in sustainable human development is recognised in the **UN Sustainable Development Goals**, with targets specifically related to wetlands under SDG 14 ('Life below Water'), SDG 15 ('Life in Land'). In addition, wetland services and products contribute directly to the achievement of the SDGs concerned with poverty, hunger, water, energy and climate. All the strategic goals of the **Aichi Targets**, agreed by the signatories to the **Convention on Biological Diversity,** are also relevant to wetlands. It is expected that '**Post-2020 Global Biodiversity Framework'**, which replaces the Aichi targets[10], will re-iterate their importance. Plans to deliver the CBD and Aichi Targets at country level are contained in five-yearly National Biodiversity Strategy and Action Plans (NBSAPs). The NBSAPs of the IBBRI countries are described briefly under the national policy section, below.

The **East Asian – Australasian Flyway Partnership** (EAAFP) is an international agreement, outside the UN system but recognised by Ramsar and the CMS. It aims to protect migratory waterbirds, habitats and human livelihoods across the flyway, which covers 22 countries. Cambodia, Myanmar, Thailand and Vietnam are partners, and have endorsed the EAAFP Strategic Plan 2019–2028. All four countries have identified Flyway Network Sites (FNS) under the partnerships' initiative.

[10] The post-2020 framework is expected to be adopted at the second phase of the UN Biodiversity Conference in May 2022, in Kunming, China

Mangroves for the Future (MFF) is a partnership which provides a platform for collaboration on the conservation of coastal ecosystems throughout South-east Asia, including in the four coastal IBRRI countries. It focuses on capacity, livelihoods and governance to achieve its aim.

The **Paris Agreement** is an international treaty adopted in 2015 under the **UN Framework Convention on Climate Change** (UNFCCC). The treaty operates in five-year commitment periods, with increasingly ambitious goals for reduction of greenhouse gas emissions. During the first commitment period, ending in 2020, member nations submitted their Nationally Determined Contributions (NDCs), containing analyses of greenhouse gas emissions, mitigation and adaptation strategies, and commitments for action to reduce emissions. Given the prominence of the climate change agenda internationally, it is important that the role of wetland ecosystem services in mitigating climate change (See section 2) and the threat posed to wetlands by climate change (Section 3) are recognised and promoted in the NDCs. It is also important that the wider impacts of renewable energy solutions on wetlands and their ecosystem services– especially hydropower – are fully considered. The integration of wetlands into the NDCs of the IBBRI countries is briefly summarised in the national policy section, below.

Cambodia, Lao PDR, Thailand and Vietnam are signatories of the 1995 **Mekong Agreement**, and members of the **Mekong River Commission.** China and Myanmar are dialogue partners of the commission, which aims to facilitate dialogue and cooperation in the Lower Mekong River Basin. The MRC has attempted to facilitate a balanced discussion of the benefits and costs of hydropower, including establishing a mechanism which allows countries planning projects to inform other affected Mekong country partners.

In 2016, China and the five IBBRI countries signed the **Lancang-Mekong Cooperation Agreement** (LMC). The agreement has a number of cooperation mechanisms, including meetings of leaders, foreign ministers and senior officials. Working groups address cooperation on economic development and poverty reduction, but there is little reference to principles of sustainability.

4.1.2. National policies

4.1.2.1. Wetland inventories

Inventories are a key decision-making tool for policies and plans for the wise use of wetlands. All of the IBBRI countries have completed wetlands inventories, although those for Cambodia and Lao PDR are over 20 years old. A preliminary inventory of wetlands in **Cambodia** was developed in the 1990's. The country's national report to the Ramsar COP 14 (2021) states that an update to the inventory is 'in progress'. In its submission to the Ramsar COP in 2018, **Lao PDR** reports that the most recent inventory was carried out in 1996, although there were plans for a revision in 2012. **Myanmar** has updated its first inventory, prepared in 2004, with the revised documents published in 2019 (Vol. 1, Technical Documents) and 2020 (Vol. 2, Comprehensive Inventory). The country's National Wetlands Policy (see below) mandates updating the inventory to include information on ecosystem health, setting standards for water and wetland quality, and monitoring. **Thailand's** first national wetlands inventory was completed in 2002, and is available on-line. A study to review and update the inventory was completed in 2020, and in 2021 was under consideration of the relevant committees. The update process is mandated in the Integrated Biodiversity Management Master Plan B.E. 2558-2564 (2015-2021) and the Biodiversity Management Action Plan B.E. 2560 – 2564 (2017-2021). **Vietnam's** inventory and assessment was updated in 2016, and in 2021 was being updated again as part of the National Land Inventory Program. The inventory is mandated in a Decree (2019) on conservation and sustainable use of wetlands, and implemented as part of the Land Inventory in line with a 2020 MONRE Directive.

4.1.2.2. Wetland policies in the IBBRI countries

Some IBBRI countries have chosen to develop a specific National Wetland Policy, while others address wise use of wetlands through related policies, for example through biodiversity or land use. The purpose of a National Wetlands Policy is not to replace all other policies and regulations affecting wetlands, but *to create a framework for coordination and cooperation between the different sectors and stakeholders*.

Cambodia does not have a national wetlands policy, although its National Water Law (2007) calls for the development of a policy to promote sustainable and effective use of water resources. The management of wetlands is influenced by a large number of regulations and institutions (see below), and a proposed Natural Resource and Environment Code has been discussed for several years but is not yet enacted. **Lao PDR** also lacks a stand-alone wetlands policy, but water is recognised as critical for both hydropower and irrigation, and the 2017 Law on Water and Water Resources includes provisions on wetlands and water resources protection, and river-basin management.

Myanmar has a National Wetland Policy and Strategic Actions (2019) which provides an over-arching framework for wetland conservation and management, summarising wetland values and the threats to them, and identifying strategic actions. These include local stakeholder management committees, restoration and enhancement of wetlands and promotion of wise-use. **Thailand** does not have a separate national wetlands policy, but has integrated wetlands management into its NBSAP (see below). **Vietnam's** National Action Plan on the Conservation and Sustainable use of Wetlands for 2020 – 2030 (2019) prescribes specific policies on wetland management, wetland protected areas, Ramsar sites, priority actions and resources needed. The circular guiding implementation of the action plan is reported to be in the process of approval.

4.1.2.3. Integration of wetlands into other sectoral policies

Sections 2.3 and 3 describe how wetlands affect and are affected by many critical sectors of the economy and society, including food production, economic development, employment, health, transport, energy, water, and even transboundary security. As a result, the wise use of wetlands needs to be integrated into the policies and programs of other key sectors. Such integration is a key aim of the IWRM approach (section 4). Across the IBBRI countries, there are many examples of wetland wise use being integrated into the policies of closely related sectors - such as forestry, biodiversity and climate. Progress with integration of wetlands wise use into other sectors, including agriculture, energy and water, is more variable.

Cambodia has a suite of laws which indirectly address wetland management, including Laws on Fisheries (2006), Water Resource Management (2007), Protected Areas (2008). The Law on Water Resource Management specifies that IWRM should be used to deliver sustainable water management, and mandates MOWRAM to develop a policy on water resources management, conservation and development. Integration of the many laws affecting environmental management in Cambodia has been proposed in a Natural Resource and Environment Code. A final draft of the code has been available since 2017, but in August 2020 the code had not been enacted into Law.

Policy in **Lao PDR** is guided by five-year economic and social development plans. The 8th NESDP (2015-2020) includes an outcome on 'Natural resources and environment are effectively protected and utilized according to green and sustainable direction'. Targets include promotion of IWRM in 7 priority basins. The draft of the 9th NSEDP (2021 – 2025) continues this shift towards 'green and environmentally friendly development', further defined as economic growth which is climate resilient, resource-efficient, socially inclusive and eco-friendly. However, the 2018 report to the Ramsar COP notes that 'The status of wetlands generally has deteriorated because regulations governing their conservation are limited'. The Environment Law (2012) briefly mentions aquatic ecosystems, and calls for setting maximum levels for pollutants, and publication of a three-yearly state of the environment report. The country's report to Ramsar COP 13 notes that wetlands have been integrated into policies on poverty, urban development, infrastructure and wastewater management, with partial integration into agriculture, tourism and industry policies. In **Myanmar**, a multi-agency committee (see below) works through the National Water Framework Directive (2014), to coordinate implementation of an integrated river basin management approach to water resources. The Directive adopts the IWRM approach as the basis of water management in the country. Other regulations cover aspects of wetlands conservation such as invasive species, participation of local communities, and strategic environmental assessment. The country's report to COP14 noted that wetlands conservation was integrated into policies on biodiversity, forests and coastal zone planning, and 'partially' integrated into policies on poverty eradication, water, agriculture, tourism, aquaculture and fisheries, and wastewater management and water quality. The level of integration into some critical areas – such as mining and energy, and pollution – is unknown.

Thailand reports the highest levels of integration of wetlands conservation into national policy of any of the IBRRI countries, with full integration reported for policies on poverty eradication, water, coastal management, forests, agriculture, tourism, aquaculture and fisheries, pollution and wastewater management and water quality. Partial integration is reported for industry, infrastructure, urban development and energy and mining. Key policies include the National Water Resources Act B.E. 2561 (2018), the Master Plan for Water Resource Management B.E. 2561-2580 (2018-2037), the Enhancement and Conservation of National Environmental Quality Act (No.2) B.E. 2561 (2018), the National Forest Policy B.E. 2562 (2019) and the Act on the promotion of Marine and Coastal Resources Management, B.E. 2558 (2015). The latter includes provisions on integrated coastal zone management. **Vietnam's** overarching policy framework for resource management is the current five-year Economic and Social Development plan (2021 – 2025), which while continuing an emphasis on export-led growth and economic growth, seeks to shift towards higher value, more environmentally sustainable economy. A large number of laws potentially affect wetlands, including the revised Environmental Protection Law (2020), which promotes sustainable management of wetlands for tourism and aquaculture, and mandates EIA for developments in important wetlands.

4.1.3. Institutions for the implementation of wise use policies

Given the multiple sectors and stakeholders involved in wetlands management, effective policy development and implementation requires (a) a lead agency with a clear mandate for the conservation of wetlands, and (b) a mechanism for policy-level coordination across key sectors. There is considerable variation in the institutional arrangements across the IBRRI countries.

In **Cambodia**, the Ministry of Environment, the Ministry of Agriculture, Forestry and Fisheries and the Ministry of Water Resources and Meteorology playing a lead role among nine Ministries involved in wetlands management. High-level coordination takes place through the Council of Ministers, the National Climate Change Committee and the Cambodian National Mekong Committee.

Management of natural resources in **Lao PDR** is the responsibility of the Ministry of Natural Resources and Environment (MONRE) and the Ministry of Agriculture and Forestry (MAF). There is no agency for overall coordination on wetlands issues.

In **Myanmar**, wetlands conservation is led by the Ministry of Natural resources and Environmental Conservation (MONREC), with some 17 other Ministries involved. Policy coordination is promoted through the National Water Resources Committee and the National Wetland Committee.

In **Thailand,** wetlands conservation is overseen by the Office of Natural Resources and Environmental Policy and Planning. A sub-committee on wetlands management involves the Ministry of Natural Resources and Environment, and experts from government and NGOs. The Office of the National Water Resources promotes and evaluates the management of water resources.

In **Vietnam**, wetland management is the responsibility of the Ministry of Natural Resources and Environment (MONRE) and the Ministry of Agriculture and Rural Development (MARD), with provincial and district governments. No specific coordination mechanism for wetlands exists.

4.2. Management solutions

This section describes the experiences and lessons in Indo-Burma with:

- addressing the drivers of wetlands degradation and loss, such as hydropower, agriculture, pollution, over-fishing and hunting (4.2.1)

- restoring resilient wetlands using nature-based solutions, which provide enhanced ecosystem services and are more able to withstand climate change (4.2.2)

- taking an Integrated Water Resource Management (IWRM) approach that considers multiple stakeholders and issues across a single basin (4.2.3)

4.2.1. Addressing the drivers of wetlands degradation and loss

4.2.1.1. Hydropower and dams

Management of dams

Some of the problems caused by dams, especially unseasonal flooding and low water flows in the wet season, could be addressed through improved coordination between the dam managers and downstream users. This has proved complex in Indo-Burma, however, especially because most rivers cross international boundaries. The Mekong River Commission (See section 4.1.2) has had some success in facilitating data sharing between countries, but overall coordination across international boundaries and between sectors remains a challenge.

Mitigating the impact of dams on fish migration has also proved difficult (section 3.2.2). One response to the impact of dams on local fisheries has been to establish reservoir fisheries. However, this rarely benefits the downstream communities affected by loss of flow, and often involves stocking with non-native fish species. Productivity tends to decline after an initial boost, though there are proposals to manage these reservoirs to be more like native wetland habitat, with deep pools to ensure fish stock survival through water level changes.

Dam removal
Dam removal started in the US in the 1990s after realising the dangers and implications for wetlands and water resources. By 2021 a total of 1700 dams have already been removed, employing 126,000 people in a US$25 billion business (American River 2021). In Europe, some large dams have already been removed in France and Spain, and in Germany and Sweden dam removals are in the pipeline. Dam removal and 're-wilding' of river flow is supported as part of the EU 'Green Deal' (Riverwatch & Manfred-Hermsen Foundation 2017). The approach has yet to be tried in the Indo-Burma region.

Removing of dams is not only crucial for allowing fish species to migrate along all river stretches and support local community livelihoods, but is also considered as an essential component in preparing for the impacts of future climate change.

Advantages of dam removal:

- Rivers return to their natural water flow and water level fluctuation, benefitting wetlands and wetland productivity downstream.
- Fish and other animals will be able to migrate freely again (Riverwatch & Manfred-Hermsen Foundation 2017).
- Natural transport of sediments, debris and nutrients will be restored.
- Water quality will improve and the natural water temperature will be readjusted (American Rivers)
- In some cases, the removal of old dams is a better economic option than renovation, maintenance and the retrofitting with fish ladders (Born et al 1998, International Rivers 1999). There are also positive economic impacts for local fisheries, tourism and employment (Jewell 2016)
- The risk of dam collapse/failure is removed
- Free-flowing rivers will be more resistant to climate change than impounded rivers. (Riverwatch & Manfred-Hermsen Foundation 2017)

Using natural wetlands for treatment of wastes
Floodplains, riparian zones, and wetlands play a key role in the integrity and functioning of aquatic ecosystems. Because they retain water and have alternating dry and wet conditions with steep bio-geochemical gradients, they act as filters of poor-quality water that flows into them. Hence, their protection and restoration is an important element of water quality management at regional or catchment scales (UNEP 2016).

4.2.1.2. Agriculture

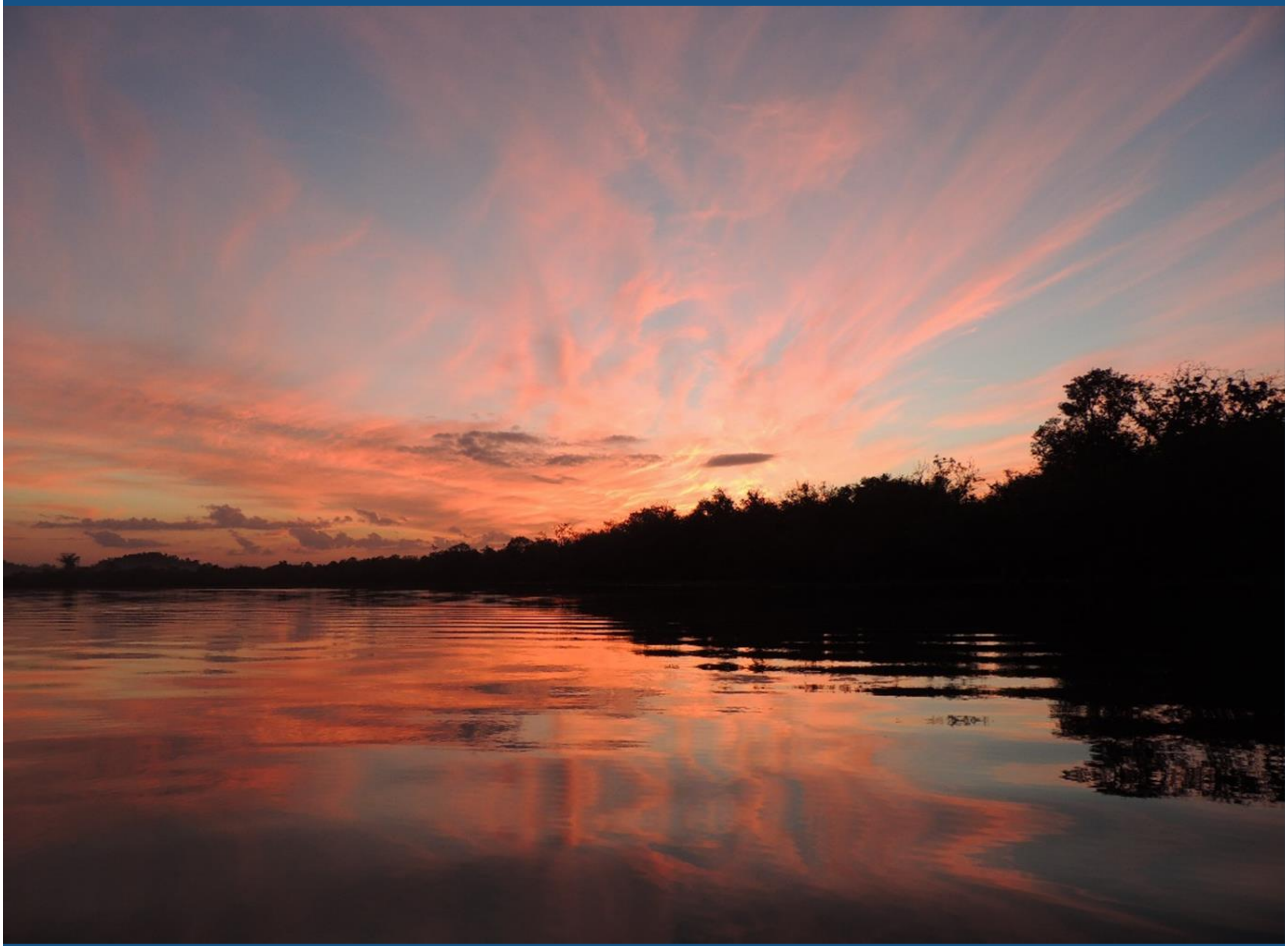
Agriculture, especially rice farming, has caused the conversion of large areas of wetland, as well as requiring large volumes of water for irrigation and creating significant nutrient and chemical pollution. Several approaches have been tested in the Indo-Burma region to introduce more sustainable rice farming to reduce environmental impacts and contribute to the wise use of wetlands as well as preparing for changes in climate and hydrology.

Sustainable Rice production in Indaw Chaung region of lake Indawagyi

The Sustainable Rice Platform (SRP), promotes efficient production of rice using less water, less inputs, and reducing methane emissions, minimizing environmental impacts, while enhancing smallholder incomes and food security. SRP has gained traction in Vietnam, Cambodia, Thailand and more recently in Myanmar. Olam international has been one of the founding members and corporate partners to adopt SRP standards. (Olam 2020)

Integrated systems with rice and fish in combination with integrated pest management strategies have been proven to provide economically, ecologically and socially sustainable alternatives to rice monoculture. These systems require less pesticides and fertilisers, provide a diversified income from both fish and rice, and have less negative impacts on the environment and people's health (Hu et al. 2016).

In Myanmar FFI introduced organic, wildlife-friendly rice farming at ID. By 2020 more than 200 farmers have been certified through the Myanmar Participatory Guarantee System (PGS) for organic farming, which benefits globally 'vulnerable' Sarus Cranes Antigone antigone, who are feeding in the rice fields. PGS provides an alternative for organic certification based on trust, social interaction and peer-reviews (IFOAM 2008).



Lake Indawgyi, Photo: CZ

A similar approach has been initiated with the IBIS rice initiative in Cambodia. IBIS rice was launched in 2009 combining organic farming certification with habitat conservation for the Giant Ibis Thaumatibis gigantea and other globally threatened species. The IBIS Rice project currently has around 1,500 smallholder farmers growing organic rice using wildlife-friendly methods. (Phnom Penh Post 15th June 2021; Birdlife 2018).

Changes in agriculture in wetlands are also being made in response to climate change. As the Mekong delta in Vietnam sinks relative to sea level, greater flooding is expected. In response, there is a shift away from preventing all floods, which requires high dikes, to controlled flooding. This new approach seeks to safely contain floodwaters within the system by increasing floodplain water retention capacity, reducing downstream flood risk. Agriculture also has to adapt, with triple-harvest rice monoculture replaced by double-harvest rice production and flood-resilient crops during the flood season. Examples of the latter are lotus (*Nelumbo nucifera*) and indigenous floating rice (*Oryza prosative).* (Tran et al. 2019; Smajgl et al. 2015). Lotus cultivation can be combined with additional services, such as aquaculture, water retention, and tourism, and requires less fertilizers and pesticides and suits the land and water conditions in the upper VMD very well. Allowing floodwaters to enter lotus fields enriches soils and creates habitats for fish and other aquatic species. Lotus cultivation can also be part of a system of floodwater storage for dry season usage. (Tran et al. 2019; Tran et al. 2018; Andrew Wyatt pers. com. 2021). A study exchange from BK in Lao PDR to Champhone District, Savannakhet province, incorporated lessons on flood tolerant rice varieties and planting techniques in high flood areas. Rice seed was distributed and brought back for BK cultivation pilots (IUCN 2019).

4.2.1.3. Pollution, water flow and water quality

The challenges of water pollution in the 160,400 km^2 Chao Phraya basin in Thailand are serious. To address these issues, Thailand has developed master plans of water quality management for major river basins including the Chao Phraya. Construction of wastewater treatment facilities in municipalities is prioritised, as well as a control of wastewater from industrial and agricultural sources. Charging fees for waste discharges is also being studied and will be applied to many sites in the near future. Four municipalities apply the Polluter-Pays Principle for wastewater treatment plants and more are working towards this policy. Water quality models and geographic information system (GIS) have also been developed and used as tools to help decision-makers in water quality management (Pattanee, 2005). The government has “mobile land doctor units” helping farmers to diagnose and remedy land degradation problems.

In addition to improving water quality, studies are underway to plan how the available water can be better managed. The Chao Phraya River Basin regularly experiences major flooding in the upper and lower reaches as well as El Niño-related droughts. Water resources are heavily allocated across economic sectors, eliminating any possibility of new large-scale reservoirs. However, an analysis of the flow records shows that, on average, 28% of the wet-season flows that discharge into the Gulf of Thailand could be harvested without significantly impacting the water use from existing large to medium storages, nor the riverine or coastal ecosystem. For the ‘**Underground taming of floods for irrigation (UTFI) concept**’ field trials with specifically constructed recharge basins have shown that that floodwater can be captured, re-directed and used to recharge the vast, shallow alluvial aquifers in the central plains, situated upstream of the major flood-prone areas. Capturing peak flows would take place largely in the wetter years, reducing damaging flooding and offsetting the decline in groundwater levels in the agricultural plains due to year-round pumping to irrigate high-water crops. The scheme could generate around US$200 million of agricultural income per year to boost the livelihoods of thousands of farming households, as a result of additional water made available in drier periods (Pavelic et al., 2012). To capture and re-direct the flood water, around 200 km^2 of land need to be managed for groundwater recharge – the equivalent of about 0.1% of the basin area. Farmers would need to be encouraged to utilize their land for recharge and thereby become 'stewards' who manage infrastructure for the benefit of downstream communities. Water resource managers and flood protection authorities would need to provide overall coordination, capacity building and incentives for effective adoption by farmers.

Bringing this study to reality in the Chao Phraya would require detailed investigations to determine the areas where environmental conditions are suitable for aquifer recharge, as well as analyses to identify workable institutional arrangements (Pavelic et al., 2012). There is also an opportunity for ecological co-benefits. The current proposal for re-charge ponds involves concrete ponds around pipes connected to the aquifer. Changing the design to allow for more natural wetlands could fulfil the purpose of groundwater recharging but at the same time add additional services such as water and ground water purification, flood reduction and augment wetland biodiversity in the River basin.

4.2.1.4. Over-fishing

Community Fisheries (CF), including Fisheries Conservation Zones (FCZs), are a widespread approach to inland fisheries management in the region, by which communities are granted the right to manage and monitor their own fisheries areas – including developing management plans. Though there is no widespread monitoring of the function and success of FCZs, it is generally assumed that where CFs have the means to monitor their fisheries, there have been locally positive impacts on fisheries resources. Governments generally encourage the designation of CFs, though follow-up on whether these CFs are actively implemented is limited. CFs are also a potential means for long-term, locally-led monitoring of fisheries, where technical training is provided and resources for monitoring are available.

In Myanmar, fisheries management, particularly for inland fisheries, was decentralized in the mid-2010s, with authority devolved to the state and regional level, at which some states and regions incorporated CFs into their policy. This includes Ayeyarwady Region and Mon State (partially covering the Gulf of Mottama). In Indawgyi, FCZs have been established and recognized by the Kachin State Department of Fisheries, though there is no government support for patrolling.

In the Gulf of Mottama, an increase in catch of Croaker (*Johnius belangerii*) as well as mango fish (*Polynemus paradiseus*), River Hilsa (*Tenualosa ilisha*), and mixed mullet was reported in late 2019 through 2020 by fish buyers, according to data collected by the Gulf of Mottama Project. This was attributed to collaborative patrolling teams monitoring for illegal fishing (fine-mesh stake nets). However, this monitoring has been on hold due to the military coup in Myanmar, and anecdotal reports suggest that illegal fishing has resumed.

Experience has shown the potential but also the obstacles faced by CFs. Major areas of concern include continued dependence on external funding, insufficient capacity, and inadequate authority to enforce fishing regulations without collaboration with government departments or police. In Lao PDR, communities do have the authority to enforce regulations in FCZs, but have expressed a need for more resources and training to do so. In Cambodia, there has been an increase in financial support from the

Fisheries Administration to communities for FCZ management – an encouraging trend that shows much potential for meaningful empowerment of communities. In general, the establishment and maintenance of FCZs relies heavily on involvement and support (technical and financial) from international and local NGOs.

There is a need to integrate FCZ into networks to support connectivity for migratory fish stocks. Scoping led by WWF along a ~200km stretch in the Xe Bang Hien River, near XC, has delineated a possible network of 16 FCZs.

In the coastal realm, Myanmar designated its first Locally Managed Marine Areas (LMMAs) in 2017 in the Myeik Archipelago. Communities designate conservation zones and develop and enforce regulations in the LMMA, in partnership with the Department of Fisheries. In Thailand, crab banks for blue swimming crab are implemented by coastal communities, with technical support from the Department of Marine and Coastal Resources and NGOs.

One effort to adapt to decreased water availability due to competition with agriculture is the pumping of water into the Tram Chim (TC) and U Min Thuong (MT) Ramsar sites to maintain fish habitats. However, this is costly and requires extensive monitoring to ensure appropriate water levels. This is not seen as a large-scale solution, but rather an emergency measure for special wetlands with particular biodiversity value.

Properly assessing the value of wetland fisheries resources is hampered by the widespread lack of monitoring data, particularly catch per unit effort (CPUE) estimates (Bartley et al. 2015). There have been efforts to address this, by the Mekong River Commission, and through compilation of local ecological knowledge interviews with fishers. Participatory fisheries monitoring is being carried out, for example by Conservation International with communities in Cambodia. To improve their effectiveness, these efforts need to be integrated into national or region-wide planning and policy development.

Value chain approaches are another avenue for facilitating more sustainable fishing activities, through product value improvement, organizing of fisher associations to push for fairer prices, and development of alternative products. In Myanmar's LMMAs, FFI supports communities in finding new market opportunities for products from the village, including fisheries and small-scale agricultural products. In the Gulf of Mottama, the GoMP has worked to provide communities with iceboxes for prolonging the quality of fresh fish.

The ecosystem services that these fisheries provide for Indo-Burma countries in terms of subsidised nutrition is often not included in computations of the economic value of these fisheries, and as such, government investment in these fisheries tends to be relatively low. This is particularly challenging for fisheries management considering that these governments also are driven to boost their economic development, including focusing on development and agriculture. However, there are examples of meaningful government commitment to sustainable management of wetland fisheries. For example, in Vietnam, the government has provided funding for monitoring and fisheries management in TC, demonstrating an awareness and commitment to sustaining the importance of fisheries for communities and local economy. Additionally, across the region, there are examples of governments supporting the development of community-led Fisheries Conservation Zones (or analogous institutions).

Coordination across organizations working in fisheries management is another response to the need for more strategic, collaborative efforts. The Myanmar Fisheries Partnership is a platform for NGOs, agencies, stakeholder groups, and other institutions for coordination and communication. The Myanmar Fisheries Federation is a network of private sector entities working in fisheries, and has been involved in various fisheries management efforts.

In line with the growing use of CFs and FCZs, community empowerment is generally seen as a critically important management approach. Several projects run by international and local NGOs work to support community capacity for advocacy of their rights, for example, when lobbying against hydropower projects – this includes raising awareness within communities about likely impacts, building capacity for community-led research and monitoring of the current status of local ecosystems so that they can better understand and demonstrate the importance of ecosystem services to authorities, and support for community advocates.

4.2.2. Nature-based solutions to restore and enhance wetlands and ecosystem services

In addition to addressing the drivers of wetland degradation (section 4.1.1), there are opportunities to restore degraded wetlands and thus enhance the multiple ecosystems services they provide – including water regulation, flood mitigation, reducing coastal erosion and storm surges, and absorbing and storing carbon from the atmosphere. By restoring wetlands, their ability to withstand the stresses of climate change in future are also enhanced. These are referred to as nature-based solutions because they involve restoring natural ecosystem processes.

The total estimated stored carbon of mangroves, seagrass, saltmarshes and peatlands is over 1.5 Gt of carbon (see section 2.3). Wet grasslands, marshes and *Melaleuca* forests add substantial additional amounts. The amount of carbon stored in wetlands could be significantly increased by conservation measures aimed at extending and restoring the existing mangroves, seagrass beds and conserving peatland areas by rewetting and stopping extraction (e.g. in MT, TC, LS, BS SS, PT, BC, LSr BK XC IN ID). This would help the IBBRI countries achieve the targets established in their NDCs.

Mangrove restoration

Section 2.3 described the multiple ecosystem services provided by mangroves. There is potential to restore mangroves ecosystems, increasing protection for coastal lands and communities, and increasing the volume of carbon stored. Modelling of the potential for mangrove restoration in Indo-Burma (Worthington and Spalding, 2018) found that 840 km^2 of mangrove which has been lost could potentially be restored, an increase of 10% of the current area, which would store around 27.8 million tonnes of carbon when mature (Table 13). In addition, much of the existing mangrove is degraded. Protecting this mangrove, halting degradation and allowing recovery, would retain existing carbon stocks and sequester further carbon.

Table 13: Potential for mangrove restoration and enhanced carbon storage in Indo-Burma

	Cam	Myn	Thai	Viet	Indo-Burma
Current mangrove area (km^2)	588	4255	2215	1,429.00	8,486.00
Restorable mangrove area (km^2)	55	436	175	174	840
Potential additional carbon storage (million tonnes C)	1.9	13.8	6.6	5.5	27.8

Source: Bunting et al 2018 [mangrove area], Worthington and Spalding (2018) [restoration area and carbon storage]. Figures for carbon storage in Cambodia are calculated from the average storage/km2 given for the other 3 countries

Mangrove restoration has picked up momentum in recent years. This is partly due to the raised awareness about its importance for global climate and several ecosystem services (Richard & Fries 2016), but also due to the collapse of aquaculture, mostly in Thailand and Vietnam (Enright and Quarto (2015), offering large-scale opportunities for coastal restoration. The potential for mangrove restoration is thus in two areas: (1) land that has been completed converted, e.g. to aquaculture or rice paddies, and (2) areas of existing but degraded mangroves.

Re-foresting of cleared mangrove has been practiced for many years in Thailand, mostly on abandoned aquaculture areas. Key lessons for successful restoration (Enright & Wodehouse, 2019) are (a) clarify ownership and social issues, engage the community; (b) select species and design planting with reference to the natural conditions of the area; (c) monitor and share lessons.

Restoring degraded mangrove requires tackling on-going over-harvesting and disturbance. In southern Thaninthary, Myanmar, seven forest user groups (FUGs) have been established to maintain and manage community mangrove forests (Wode 2016). Exploitation of the mangrove is reduced, nurseries established and planting carried out. Remaining challenges are lack of monitoring of management impacts and biodiversity. Sustainable timber extraction difficult due to the small scale of the community forests (Wode 2016).

Seagrass restoration in Thailand

In Thailand, monitoring between 2013 and 2017 found some seagrass beds in good or moderate condition, but deterioration in many areas (Department of Marine and Coastal Resources 2019). In 2019, the Marine, Coastal and Mangrove Resources Research and Development Institute (NIDA) undertook experimental seagrass rehabilitation in 4 areas, totalling 9.6 ha. The experiment compared re-planting of clumps collected from the wild with cultivation of seagrass from seed. Results showed that seagrass restoration works with both cultivation techniques, but suggested that wild-collected plants planted clumps had a greater long-term survival. It also showed the importance of protecting the restoration area from on-going threats, and resulted in a proposal for zoning seagrass beds into strict preservation, low-intensity use and sustainable use zones.

4.2.3. Addressing the drivers through integrated water resource and coastal zone management

Section 3 noted that wetlands are subject to a complex set of factors, including changes to seasonal hydrology and sediment flow as a result of dams, nutrient and chemical pollution from agriculture, domestic and industrial use, and conversion to artificial wetlands or drainage. Climate change interacts with these pressures, making the situation even more complex.

In the face of these complex and growing pressures, achieving sustainable economic development while maintaining wetland ecosystem services and adapting to climate change requires integrated planning at the level of river basins and sub-basins. The **Integrated Water Resource Management** (IWRM) approach aims to incorporate all stakeholders with an interest in the wetland area and across the entire river basin (Section 4). At the heart of the IWRM is the need to ensure that the ecological balance between land use, water input, water storage and water use is maintained. Finding this balance is crucial to sustaining the ecosystem services of the wetlands including water supplies for agriculture, energy, industry and domestic use. Each floodplain or river basin is different, depending on climate, topography, geology and soils, as well as socio-economic factors including land-use. There are signs that the balance has been overstepped, for example in both Lao wetland sites (XC BT), where encroachment of agricultural land (rice paddies) into the wetland has led to an increase in flood events (IUCN 2019). In Myanmar, conversion of wetland at Indaw Chaung in ID to rice has resulted in increased water pollution from agrochemicals, and eutrophication caused by nutrient run-off. The deterioration in water quality impacts domestic water users and fishermen. Similar issues can be found in Thailand (NB, KT and LSk) and Vietnam (LS, TC). In each case, and in each case it is important to seek the right balance between the various ecosystem services, ensuring that stakeholders well represented in the process (Parr et al. 2011).

While IWRM has been adopted in the policies of Cambodia, Lao PDR, Myanmar and Thailand, there are as yet few examples of its implementation. One of the most advanced integrated approaches to coastal zone management is in GM. A management plan, developed for the Ramsar site in 2016 is now being implemented. Key actions include livelihood support, community empowerment, patrols and guardian systems, community-based resource management committee, capacity Building and training.

While not officially labelled as IWRM, the basin-wide 'Water Master Plan' to tackling the water quality and flood/re-charge issues in the Chao Phraya Basin in Thailand involves application of many of the same principles and approaches.

Local people harvesting lampshells (Brachiopoda) at Nanthar Island and Mayyu Estuary in Rakhine, Myanmar. Photo: CZ

5. Recommendations

Healthy wetlands play a key role in tackling the biodiversity, climate and water crises which the world, including the IBBRI countries, are facing. Placing environmental and societal sustainability at forefront of policy making and practice will help to achieve a more balanced approach to economic development. Combining climate change adaptation and mitigation, through water and wetlands, is a triple-win proposal, improving the provision of water supply and sanitation services, biodiversity and combating both the causes and impacts of climate change, including disaster risk reduction. We propose a number of actions in seven key areas that require urgent activities. Several of the proposed actions will address multiple issues and create synergies and double or triple benefits. All five IBRRI governments have made proposal for the expansion of the Ramsar network and these are included here and extended with additional recommendations that are derived from the data compiled for this report.

5.1. Climate Change mitigation and adaptation

Climate change poses a severe threat to the people and economies of all the IBBRI countries. Wetland ecosystem services have a key role to play in adaptation to climate change, in particular through maintaining water supplies and protection from coastal erosion. Conservation and restoration of wetlands is crucial to help people prepare for the increasing impact of climate change in future.

All five IBBRI countries signed up to the UNFCCC and are committed to reducing GHG emissions. While most industrial countries will focus on reducing emissions from burning fossil fuels, the Indo-Burma Region is rich in natural resources and can mitigate GHG emissions also by increasing its natural capital.

For the coastal countries the focus can be on the expansion and restoration of existing mangrove forests. The potential gain in saving GHG emissions is about 0.5 – 1 Gt of carbon, depending on the restoration efforts and the reversing of degradation of existing mangrove forests. Both activities will have multiple benefits for biodiversity and also enhance the rate of sedimentation, heling to counter the impact of sea level rise as well as reducing the severity of storm surges on the coast.

REC 1: Expand and enhance the mangrove restoration efforts

REC 2: Reverse the trend of degrading existing mangroves

In addition, sea grass beds and several freshwater habitats store significant amounts of carbon. It is difficult to assess the actual carbon that is stored in these diverse habitats, but those with organic peat soils of several metres depth are particularly important. Peatland areas in Indo-Burma cover over 2,600 km^2. They vary significantly in their capacity of storing carbon and the large majority is disturbed in one way or the other. Restoration has immediate benefits for saving GHGs, but also great benefits for biodiversity and several ecosystem services such as water provision and water purification among others.

REC 3: Prioritize restoration of peatland-based wetlands

5.2. Agriculture and Land management

Sustainable land use, such as organic rice farming and reduced grazing by animals have multiple benefits for biodiversity, reduction in GHGs and increasing the water retention capacity of the wetlands, hence reducing flood and drought events and their impacts. Restoring wetlands back from formerly converted areas that are now used as rice paddies or aquaculture also has multiple benefits for biodiversity, but more importantly increases the 'sponge' function of wetlands in preventing floods and droughts or reducing their impacts, securing water provision in dry periods for domestic and agriculture use and increases the water quality. Each river basin has a threshold beyond which wetland degradation will have severe consequences in terms of flooding, droughts, water quality and others. Proactive restoration efforts will address these issues early with multiple benefits for biodiversity and others.

The decision of the Laos government not to develop an iron ore mine in or near BT Ramsar site is an important example of applying the wide use principles through wetland policy making in the region.

REC 4: Reduce and ban agrochemicals from most wetland areas and reduce GHGs

REC 5: Reduce density or ban grazing animals from wetlands and reduce GHGs

REC 6: Change arable land to wet grassland and swamp forests to store carbon

REC 7: Increase and restore wetlands areas on currently agricultural land

REC 8: Encourage new land use forms that are water based: Living with the water, swimming aquaculture for e.g. Lotus and other crops

5.3. Hydropower development and River Restoration

Almost all policy instruments and documents related to wetland conservation did not fully regard the implications of Hydropower development, though the ramifications for several wetlands are dramatic. In total eight sites are affected indirectly by dams constructed in the Mekong River Basin (KT, BL LSr BK ST TC LS MT MC). The effects are considered at present much worse than those from climate change. Similar adverse effects of dams should be prevented and no further dams constructed in major river channels and major tributaries. Hydropower is still been labelled as 'green' energy, which largely ignores the massive implications on most of these wetlands in losing the ability to water and food provision loss in biodiversity (ST) and loss of other ecosystem services. The Impacts of small to medium scale hydropower on tributaries is overlooked. Many fish in Indo-Burma are endemic to single tributaries. EIAs often lack fish taxonomic knowledge or are not conducted for small hydropower schemes, although they can lead to extinction of endemics. Dam removal has shown multiple advantages and started in the US and Europe and could set an example for a new strategy in Indo-Burma too.

Cambodia's moratorium on dams is another good example on 'wise use' which could be a model for other countries.

REC 9: No further dam construction in main channels, especially not in the yet undammed Ayeyawady River and its tributaries such as the Chindwin, Shweli, Thanlwin River and others

REC 10: Where possible, decommission existing dams to revitalise the flow of the river and its ecosystem services and ecological communities

REC 11: Restore and upgrade existing dams where possible to allow fish migration and the flow of water, sediments and vital nutrients

REC 12: Restore and protect key river sections for biodiversity and basic ecosystem services

5.4. Save Indo-Burma's precious and unique biodiversity

At least 119 wetland species in Indo-Burma are critically endangered, and a further 254 endangered. Some are close to extirpation and urgent action is required. Hunting of waterbirds, marine and freshwater turtles and mammals is still widespread. Although mostly but not everywhere illegal, there is little law enforcement and little local awareness.

REC 13: Prioritise globally threatened CR wetland species and develop species action plans

REC 14: Enhance the protection of key habitats for endangered species

REC 15: Establish special coastal and river community-based protection areas (CPA) for dolphins, turtles, waterbirds and fish species

REC 16: Establish, promote and maintain head-starting programmes for globally threatened river dolphins, turtles and crocodiles

REC 17: Stop waterbird and turtle hunting in all Ramsar sites and beyond

REC 18: Strengthen law enforcement and stop water bird hunting in all Ramsar sites

REC 19: Establish local Community Conservation Groups (LCGs) and strengthen capacity in conservation and expand awareness programmes

REC 20: Sustainable financing for LCGs and alternative livelihoods for ex-poachers

5.5. Improve inland and coastal fisheries

Fisheries need enhancement at national, site and local community levels. Monitoring is the basis for understanding the impacts of threats as well as the effects of management measures, and for establishing the value of ecosystem services from which communities´ benefit. Existing efforts to empower communities to conduct their own research, organize, and advocate for their rights and resources should be expanded and continued; this includes the empowerment of women, youths, and ethnic groups. The designation and management of community fishing (CF) and fishing conservation zones (FCZ) inland and Locally Managed Marine Areas (LMMAs) at coastal zones should be expanded, supported by the capacity, resources, and authority needed by communities optimally manage these resources.

REC 21: Enhance the CF and FCZ on all riverine wetlands in Indo-Burma

REC 22: Promote and enhance LMMAs for improving coastal fisheries and wetland ecosystems (sea grass, mangrove)

REC 23: Improve the monitoring of fisheries by government agencies and local communities, supported by capacity to analyse and use the data

REC 24: Explore and apply where suitable the eDNA monitoring schemes for fish and other aquatic biodiversity

5.6. Proposing and developing an Indo-Burma Water Framework Directive, based on WFD Myanmar

The Integrated Water Resource Management (IWRM) approach is based on the principle that multiple stakeholders within a River basin are using the water resources and need to agree on the water use and consumption through a committee based on all stakeholders. This will prevent one stakeholder (e.g. agriculture) from dominating the water use, and also includes measures in the upper basin affecting stakeholders downstream. Myanmar has embraced the concept by adopting two policies, the National Water Framework Directive (NWFD) and the National Water Policy (NWP). The NWFD resembles the EU WFD, including the seven principles similar to the principles of the EU WFD, among these, river basin management approach, coordination, and the aim of good ecological status.

REC 25: Implement a region-wide Water Framework Directive

5.7 Expand the Ramsar network

The Ramsar network comprises of 37 sites with a total of 12400 km2. At present these cover coastal sites and inland wetlands reasonably well, but coverage of riverine wetlands and karst wetlands is poor. In addition, three EAA Flyway Network sites have been proposed and included in this report. These sites qualify for inclusion into the Ramsar network, but all five IBRRI countries are committed to enhance the Ramsar network and proposed additional sites to expand the site network by 2025.

List of proposed Ramsar sites:

Site name	key species	type of wetlands	estimated area
CAMBODIA			
Ang Trapeang Thmor Protected Landscape	Sarus Crane, Greater Adjutant, Lesser Adjutant, Spot Billed Pelican, Black Necked Stock, Painted Stork, Milky Stork, Greater Spotted Eagle	Inland wetland and Manmade Wetland	126 km^2
Northen Tonle Sap Flood Plain	Sarus Crane, Greater Adjutant, Lesser Adjutant, Spot Billed Pelican, Black Necked Stock, Painted Stork, Milky Stork, Greater Spotted Eagle	Inland wetland and Seasonal Flooded Grassland	312 km^2
Boueng Prek Lapov Protected Landscape	Sarus Crane, Greater Adjutant, Spot Billed Pelican, Painted Stork	Inundated Inland Wetland	83 km^2
Anlung Pring Protected Landscape	Sarus Crane, Black Tailed Godwit, Garganey	Inundated Inland Wetland	2.2 km^2
Boueng Snae	Lesser Adjutant, Spot Billed Pelican, Painted Stork	Inland Wetland	23 km^2
LAOS			
Beung Sa Ngan	Birds, fishes	swamp	0.3 km^2
Namsuang Reservior	Birds, fishes	reservior	17 km^2
MYANMAR			
Lampi Marine National Park	Sea-turtle, Coral reefs	Coastal	204 km^2
Thameehla Island Wildlife Sanctuary	Sea-turtle	Coastal	0.9 km^2
Ayeyarwaddy Central River Cluster	Black-bellied Tern, Irrawaddy Dolphin	Riverine ecosystem, flooded grassland	400 km^2
Taninthary Mangrove Matrix	Spoon-billed Sandpiper, Nordmann's Greenshank, Great Knot	Mangrove and mudflats	1,500 km^2
Ye Win cave	Bats, Karst Invertebrates	Cave ecosystem	8 km^2
Upper Chindwin	Masked Finfoot, Black-necked Stork, River Tern, River Turtles	Swamp forest Riverine wetlands	>200 km^2
Pho Htaung Gyaing	9 spp. Seagrass, benthos, waterbirds	Mangroves, sea grass beds, coral reefs	40 km^2
THAILAND			
Bang PU	Black-tailed godwit/ great knot	coastal wetland	
Bang Pakong river	irrawaddy dolphins, Giant freshwater prawn	riverline, freshwater, salt water and brackrich	120 km from upsteam to the estuary
Ing watershed	to be surveyed	watershed	
Talay Ban, Satun (PA)	to be surveyed	Lake	
Urban wetland in/near bangkok (Bang Krachao)	to be surveyed	riverline, freshwater and brackish water	Environmental protection area in 2021
Nong Prak Phaya, Satun (PA)	to be surveyed	swamp	
VIETNAM			
Can Gio Biospere Reserve	*Rhyzophora* mangroves, Migratory Water birds, bat	mangrove and mudflats	Coastal wetlands
Phu My habitat and specise conservation	Sarus Crane	grassland and Melaeuca	Freshwater and Melaleuca forest
Dong Rui - Tien Yen		mangrove	

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