Indo-Burma Wetland Outlook 2022

TOWARDS WISE USE OF INDO-BURMA'S WETLANDS

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Foreword

The *Indo-Burma Wetland Outlook 2022* is the first-ever wetlands outlook for the region, and it comes at a crucial moment for wetlands.

The countries of Cambodia, Lao PDR, Myanmar, Thailand, and Viet Nam host a rich diversity of wetlands, from high-altitude wetlands in the headwaters of the Ayeyarwady, extensive floodplain wetlands in the Mekong River systems to coral reefs, mudflats, mangroves, and seagrass beds along the coasts.

The wetlands in the region provide habitat for an extraordinary diversity of plants and animals—many endemic to the region—contributing to the ranking of the region as one of the top 10 Biodiversity Hotspots for irreplaceability.

These diverse wetlands and species act as Nature-based Solutions and provide sustenance, livelihood support, and climate benefits to nearly a quarter of a billion people in the five countries. As an example, the wetlands of the Mekong River support fisheries providing essential protein for more than 60 million people, many of whom have depended on these resources for generations.

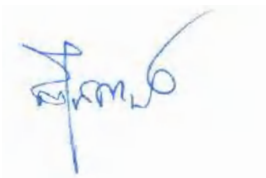
Despite their importance, wetlands in the region are critically threatened by a wide range of pressures, resulting in their degradation and destruction. Critical threats include conversion for agriculture and urbanization, pressure from hydropower development, pollution, and over-extraction of their natural resources, in a context of population expansion and growing economies. Climate change is also increasingly impacting wetlands ecosystems, already affecting the availability and effectiveness of the ecosystem services they provide.

Understanding the current situation of wetlands in the region is key to effectively integrating wetlands within countries' agendas on biodiversity, climate change adaptation and mitigation, and food and water security.

This Outlook, developed by the Indo-Burma Ramsar Regional Initiative, which I have the pleasure to Chair, is the first-ever attempt to gather essential existing information on wetlands in the region. It results from several months of collaborative efforts to document, compile and analyse existing knowledge to provide messages and recommendations for policy makers and address a wide range of the issues and challenges facing the region's wetlands. I want to thank the many contributors to this cooperative document, coming from all sectors and levels of society. We all have a role to play in stemming the loss and degradation of wetlands across the region.

I hope that the publication of the Outlook, coinciding with the Ramsar COP 14, will inspire policy changes and provoke discussions and collaborations on how to strengthen wetlands conservation to reverse the negative trends throughout the region and ensure the ongoing provision of ecosystem services.

Dr. Srey Sunleang



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The Outlook is the result of interviews, literature reviews, and knowledge from governments, Ramsar site managers, universities, civil society organisations and communities working and living in the region. It aims to bring together the latest data to understand the current and future situation of wetlands in the region.

The IBRRI Secretariat would like to thank all of the individuals who took time and effort out of their busy schedules to contribute to the production of the Outlook. In particular, the Secretariat would like to thank Robert McInnes and Nick Davidson for leading the development of the Outlook.
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The ASEAN Centre for Biodiversity (ACB) has kindly supported the printing and publication of the Outlook.

It is our hope that the Indo-Burma Wetland Outlook draws more attention to wetlands in the region, and the essential services that they provide. It is only by working together through collaborative efforts such as this one, that we can ensure the future conservation and wise use of wetlands.

Abbreviations and Acronyms

ACB	ASEAN Centre for Biodiversity
ALAN	Artificial Light At Night
ASEAN	Association of Southeast Asian Nations
CEPA	Communications, Education, Participation and Public Awareness
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CO	Collapsed
COP	Meeting of the Conference of the Parties
CR	Critically Endangered
CSO	Civil Society Organisation
CSR	Conservation Status Review
DD	Data Deficient
EAAFP	Est Asian-Australasian Flyway Partnership
ECSI	Ecological Character Status Index
EN	Endangered
FAO	Food and Agriculture Organization of the United Nations
ha	Hectare
IBRRI	Indo-Burma Ramsar Regional Initiative
IBWO	Indo-Burma Wetland Outlook
IPBES	Intergovernmental Panel on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
km	Kilometre
LC	Least Concern
MRC	Mekong River Commission
MW	Megawatts
NFP	National Focal Point
NGO	Non-governmental organisation
NT	Near Threatened
PDR	People’s Democratic Republic
PM	Particulate Matter
RIS	Ramsar Information Sheet
RLE	Red List of Ecosystems
tCha-1	Tonnes of Carbon per hectare
SDG	Sustainable Development Goals
US$	United States of America Dollars
VU	Vulnerable
WI	Wetlands International
WLI	Wetland Link International

1 Background

1A THE INDO-BURMA RAMSAR REGIONAL INITIATIVE

The Indo-Burma Ramsar Regional Initiative (IBRRI) was jointly developed by the Ramsar National Focal Points (NFPs) of the five countries, namely, Cambodia, Lao People's Democratic Republic (PDR), Myanmar, Thailand and Viet Nam, and IUCN's Asia Regional Office, based on specific needs identified in these countries. It was endorsed by the 52nd meeting of the Ramsar Convention Standing Committee in June 2016. The IBRRI aims to support the coordinated implementation of the objectives of the Strategic Plan of the Ramsar Convention. IUCN acts as the Secretariat for the Initiative under the leadership of the Steering Committee, which includes representatives from the five governments and the Ramsar Convention Secretariat as an observer.

The IBRRI Strategic Plan (2019-2024) was launched in February 2019. It was developed through extensive consultation with Ramsar authorities in the five countries as well as representatives from national and international non-governmental organisations (NGOs) and academics. The Strategic Plan consists of five operational objectives that align with the Ramsar Convention's Fourth Strategic Plan. Broadly, these objectives are to share knowledge, ensure the conservation of key wetland species, help develop and strengthen policy on wetlands, raise awareness and promote education and ensure that the Regional Initiative is sound and sustainable. The plan was approved by the five Ramsar National Authorities and will guide the work of the countries and partners through 2024.

1B THE INDO-BURMA WETLAND OUTLOOK 2022

Operational Objective 1 (Facilitate and promote wetland knowledge and experience sharing) of the IBRRI Strategic Plan calls for the production of an Indo-Burma Regional Wetland Outlook (Activity 1.1.5). The Strategic Plan states that the process of developing the Indo-Burma Ramsar Regional Initiative Wetland Outlook should be underway by the 14th Meeting of the Conference of the Parties (COP14, November 2022), with a final version published in multiple languages by COP15.

The Indo-Burma Wetland Outlook (IBWO) is the first synthesis of the status and trends for wetlands across the five countries of the region and can act as a baseline for future assessments.

The IBRRI covers the territorial areas of the five countries. Consequently, the area addressed by the IBWO is not identical to the Indo-Burma Biodiversity Hotspot. The Indo-Burma Biodiversity Hotspot includes all non-marine parts of Cambodia, Lao PDR, Myanmar, Thailand and Viet Nam, plus parts of southern China, north-eastern India, Bangladesh and Malaysia.

The IBWO is in arranged in three sections:

1. Background: An introduction to the IBRRI and IBWO
2. Key messages and recommendations: A summary for decision-makers
3. Supporting evidence: Evidence-based analysis of 43 indicators

The IBWO is based on a detailed analysis of 43 indicators. The intention is to provide an audit trail which extends from the original data and research synthesised under each of the 43 indicators through to the key messages and recommended responses. The headline key messages and priority recommended responses have been synthesised from the body of key messages and responses presented for the 43 indicators. The indictors are presented in five sections:

- Status and trends of biodiversity
- Status and trends of values and ecosystem services
- Direct drivers, pressures and threats
- Indirect drivers, pressures and threats
- Existing responses

The indicators were selected to address a broad cross-section of the issues and challenges facing the wetlands of the Indo-Burma region. The information on biodiversity and ecosystem services provides critical insights into the overall ecological character of the region's wetlands. The information on drivers (both direct and indirect) assists in understanding the factors that are driving human-induced change in wetlands across the region. Efforts are already in place and on-going to deliver on the wise use of wetlands. These efforts are considered in the review of existing responses.

The supporting evidence used to develop and summarise the indicators is drawn from peer-reviewed literature or verifiable data sources. Wherever possible, the most recent data and information have been used in the analysis to ensure that that all findings are underpinned by a robust but transparent audit trail. A set of key messages and recommendations has been developed for each indicator. Synergies and complementarities among the key messages and recommendations have been assessed to provide a clear summary for policy makers and wetland managers across the region.

1C THE SOCIO-ECONOMIC SITUATION AND TRENDS IN INDO-BURMA COUNTRIES

The Indo-Burma region today is the product of a long pre- and post-colonial history. The region is characterized by vast ethno- and cultural diversity where Indigenous notions of space, territory and identity have been displaced, fragmented and reconfigured over time. Today, the Indo-Burma region is undergoing rapid population growth, effectively doubling over the last 50 years to a figure not far short of a quarter of a billion people in 2020. Human population growth is fastest in the many urban areas across the region, including in the large cities such as Bangkok, Ho Chi Minh City, Hanoi, Yangon and Phnom Penh.

Human population growth has seen a commensurate growth in the national economies (as measured by both gross domestic product (GDP) and GDP per capita) of the five countries. The relative proportions of different sectors of the economy have changed over time, with the contribution of agriculture generally reducing over the last ten years.

2 Headline Key Messages and Recommended Priority Responses

2A INDO-BURMA WETLANDS – AN OVERVIEW

The evaluation of the 43 indicators has been based on the best available information. However, the evaluation process has exposed the fact that ***the wetland knowledge-base across the region is weak and limited***. The IBWO provides an initial baseline of the status and trends of wetlands across the region. It is recommended that any future assessments should be based on improved knowledge and information (Section 2).

Of the 43 indicators evaluated, ***the state of 22 indicators was assessed as being poor***, 17 as fair and only 4 as being indicative of good status. ***16 of the 24 indicators of wetland biodiversity and ecosystem services demonstrate a negative and deteriorating trend***. The only ecosystem services to demonstrate an increasing or improving trend were fish production, rice yield and hydropower generation. All three of these ecosystem services also generate a range of negative trade-offs which are reflected in deterioration of other indicators. The audit trail and evidence-base for all the indicators are provided in Section 3.

THE OVERALL OUTLOOK FOR THE WETLANDS OF THE INDO-BURMA REGION IS NOT GOOD NEWS. WETLANDS AND THEIR DEPENDENT SPECIES ARE EXPERIENCING PRESENT AND INCREASING THREATS RESULTING IN PROGRESSIVE DETERIORATION AND LOSS. URGENT ACTION IS REQUIRED TO STEM THE LOSS AND DEGRADATION OF WETLANDS ACROSS THE REGION.

However, the region remains one of the most highly biodiverse parts of the world, reflecting the geographical, topographical, geological and climatic diversity of the region. ***The region is rated in the top ten global Biodiversity Hotspots for irreplaceability*** and in the top five for threat. More people live in this region than in any other Biodiversity Hotspot.

The region has an estimated wetland area of over 383,000 km². A wide variety of wetland types are present in the region. ***Human-made wetlands form the largest proportion of wetland area in the region*** (particularly rice cultivation areas, but also aquaculture ponds and reservoirs). ***Coastal natural wetlands are extensive*** (particularly shallow marine waters) ***and globally important*** – especially in Myanmar, while ***the remaining areas of inland natural wetlands are now small and progressively decreasing in area***, largely through conversion to human-made wetlands.

Coastal natural wetlands have been undergoing long-term area losses, particularly of tidal flats and mangroves. The ***loss of coastal wetlands across four (of the five) Indo-Burma countries accounts for one fifth of the total global loss of coastal wetlands***. In many areas, ***natural wetlands have been converted to rice paddy and then subsequently to aquaculture ponds***. To continue to meet the demand for rice, further natural wetlands have then been converted to agriculture to replace the areas lost to fish production. This is particularly the case for floodplain wetlands and seasonally flooded grasslands, and swamp forests, especially in the Mekong Delta. In urban and peri-urban areas throughout the region, natural wetlands have been filled-in and "reclaimed" for infrastructure development as urban sprawl continues to swallow up surrounding floodplains. In contrast, ***human-made wetlands*** (rice cultivation, reservoirs and aquaculture ponds) ***have greatly increased in area over time***. Across the region, ***there is increasingly widespread deterioration of the ecological character of all wetlands, including Ramsar Sites.***

The remaining wetland habitats still support a rich diversity of life including reptiles, mammals, fish, birds and corals. ***Inland wetlands support***

at least 2,843 wetland-dependent species, many of which are endemic to the region, with new species still being discovered. However, knowledge of the ecology of wetland-dependent species is still poor. ***12% of over 7,000 wetland-dependent animal species are at risk of extinction***, including four of the five species of marine turtles in the region. The populations of many globally threatened species are in long-term decline. ***Waterbird populations in the region are in trouble: almost half (47%) of populations for which a trend is available are in decline***, with only 18% increasing.

Climate change is a pernicious threat to wetlands and their dependent species across the region. The ***major rivers of the region are experiencing higher flows in the wet season and increased frequency of low flows and drought*** in the dry season. ***Coral reefs are subject to more frequent, widespread and intense bleaching periods***. Incidents of ***water-borne and vectored disease are increasing*** as temperatures warm. The existing ***protected network of designated wetlands may not be adequate*** to protect distributional changes in wetland-dependent species. Across the region, a significant challenge is the difficulties that arise in ***disentangling the impacts on wetlands from climate change from those arising from other human activities***, such as water abstraction or dam construction.

The region's wetlands are not just important for supporting a diverse fauna and flora, but they ***underpin human well-being and the prosperity of almost a quarter of a billion people***. The ***wetlands provide a range of goods and products, not least fish and rice***, which sustain the growing human population and underwrite regional food security. ***Thailand and Viet Nam are the second and third largest exporters of rice in the world***, In Viet Nam, the majority of this rice comes from the Mekong Delta. The ***fishery in the Mekong River Basin alone provides an important protein source for more than 60 million people***.

Wetlands represent Nature-based Solutions for many of the challenges faced by the people of the region. ***Wetlands also regulate flows of energy, water, sediment and air*** maintaining conditions that are conducive to human prosperity and survival. ***Hydropower generation contributes significantly to energy security*** across the region, but it comes at a cost. ***The number of hydropower dams in the region is steadily increasing***. Poorly designed and managed dams can change the hydrologic, geomorphological and ecological dynamics of the river systems, causing wide-reaching environmental and social impacts. However, there is an ***urgent need to depoliticize the debate about hydropower dam construction and to share robust and verifiable data***.

Coastal wetlands, including ***mangroves, seagrass beds and coral reefs, buffer communities from rising sea levels and storms***. Coastal wetlands also reduce erosion risk, with one study concluding that the economic value of erosion regulation was almost 1.4m US$ ha−1 year−1 (at 2018 prices).

Inland wetlands protect settlements and infrastructure from flooding and reduce disaster risk. ***High-altitude wetlands*** in the headwaters of the Ayeyarwady and Mekong River systems ***mitigate flood peaks and desynchronise downstream run-off events***. Wetlands across the region regulate flows of water. However, the ***conversion of wetlands to other land uses can increase flood peaks in the wet season and amplify the impacts of drought in the dry season***.

Urban wetlands moderate air temperatures and provide aesthetic and recreational resources. In Bangkok, ***urban wetlands have been observed to cool air temperatures by up to 5.67°C***. Many wetland systems store and sequester carbon from the atmosphere and contribute to mitigating the impacts of climate change. Inland freshwater wetlands may store13.39 tonnes of Carbon per hectare ($tCha^{-1}$), whereas ***coastal mangroves may store up to 397.65 $tCha^{-1}$***. The restoration of coastal wetlands can play a significant role in further mitigating climate change.

Well-managed ***wetlands can regulate and reduce the transmission of water-vectored human and wildlife diseases***. However, there is a need for more collaborative work between health and biodiversity scientists to enhance the knowledge-base. ***Wetlands also provide homes and refugia for a variety of pollinators*** upon which home gardens and larger agricultural systems depend.

Both natural and human-made wetlands are regulating and improving water quality across the region. ***Wetlands can remove in excess of 99% of potentially harmful bacteria and pathogens***. Changes in catchment land use, and particularly the ***restoration or creation of wetlands and increases in areas of forest, can improve river water quality*** and improve human well-being.

Tourism prospers in many wetlands, bringing essential financial benefits to local communities and national treasuries. However, poorly regulated tourism can be a potential threat to wetlands. Wetlands are currently playing a significant role in school and university education. Opportunities exist to expand the role of wetlands as education centres. Cultural and spiritual values are deeply embedded in wetlands and their relationships with the human population. Some wetland sites are iconic cultural or spiritual destinations, such as the Shwe Myint Zu Pagoda, Indawgyi Lake Wildlife Sanctuary, Myanmar, which regularly attracts in excess of 100,000 visitors each year.

All of ***the benefits that wetlands provide human society depend on supporting services of habitat provision, soil formation, nutrient cycling, water cycling and primary production***. Without these fundamental ecosystem process and functions, society would be greatly impoverished.

However, the wetlands of the Indo-Burma region are under multiple threats. ***Illegal or over-fishing and hunting and poaching are threatening the internationally important designated sites*** across the region. ***Land use changes*** across catchments, including the increase in agricultural land, the loss of forest and the expansion of urban areas are impacting wetlands. ***Hydropower dams, along with smaller irrigation dams, are negatively altering the ecohydrology*** of the river and stream network. ***57% of all invasive plants are aquatic species***. The number of ***invasive fish species is steadily increasing*** across the region.

Nutrient inputs to rivers and watercourses are steadily increasing, impacting water quality. In the Mekong Delta more than ***95% of water samples failed to reach drinking water standards*** as a result of nitrogen pollution. Many ***emerging contaminants, such as pharmaceuticals and personal care products*** pose a risk to aquatic organisms. Impacts in rivers ultimately manifest themselves in the coastal environment. Plastic pollution is a rapidly emerging significant threat to inland, but particularly to coastal wetlands. Annually, the rivers of Viet Nam, Myanmar and Thailand ***discharge more than 9.0×10^4 metric tons of plastic*** into the marine environment. Plastic bags account for almost 70% of all the plastic waste recorded.

THEREFORE, WITHOUT URGENT AND COORDINATED RESPONSES ACROSS THE REGION, THE FATE OF WETLANDS, THEIR DEPENDENT SPECIES, AND THE OVERALL WELL-BEING OF ALMOST 250 MILLION PEOPLE WILL BE FURTHER COMPROMISED.

Indawgyi Ramsar Site, Myanmar © NWCD Myanmar

2B HEADLINE KEY MESSAGES FOR DECISION-MAKERS

Across the Indo-Burma region, to move towards the wise use of wetlands, urgent responses are required.

To meet the demands of a growing population and economic development:	Indicators		
► Natural wetlands have been steadily drained, infilled, converted, polluted, altered and lost. The rates of degradation and loss are still increasing.	A3 C2 C5	A4 C3 C6	C1 C4 C7
► The degradation and loss of wetlands has produced considerable negative impacts on human well-being, security, health and prosperity.	B1 B9 B12 B15	B5 B10 B13 B16	B8 B11 B14 B17
► The loss of wetlands has led to impacts on a variety of wetland-dependent species, including many species of conservation concern, and of socio-economic or cultural significance to the people of the region.	A6 B15	A7 B16	A8 B17

To deliver on the water-food-energy security nexus:	Indicators		
► Irrigated agriculture has diverted vast amounts of water away from natural wetlands; irrigation infrastructure has fragmented river systems and impacted fish movement; large reservoir construction behind hydropower dams has increased greenhouse gas emissions and altered the ecohydrological functioning of major river systems.	B2 B8 C6	B3 C2 C7	B6 C4
► Rice production and aquaculture have been critical to food security and economic prosperity, but unsustainable practices have driven the loss of natural wetlands and their dependent species; polluted surface waters; increased water-borne diseases; and altered hydrological cycles.	A3 A8 B9	A6 B2 B11	A7 B3 C7
► Energy generation through hydropower has fueled economic growth, both within the countries of the Indo-Burma region and beyond, but there have been inequitably distributed impacts to people and the environment along the north-south river continuum.	B6 C4 C7	B9 C5	B10 C6

To implement responses that will make a difference needs:	Indicators
► Knowledge, and access to this knowledge, through capacity building, to be improved and depoliticized.	A1 – A8 B1 – B18 C1 – C7 D1 – D3 E1 – E7
► Governmental wetland-related and sectoral policies to become more joined up; fully functioning national wetland committees and national wetland policies to be established; and the multiple values of wetlands to be embedded in wide-ranging decision-making.	B1 E1 E2 E3
► Transboundary cooperation to be enhanced, both through existing bodies such as the MRC and the IBRRI, and through broader initiatives including data acquisition and sharing; knowledge transfer; transboundary policies and regulations; and an understanding of the 'source-to-sea' implications of decisions on the human and natural environments.	E1 E3
► Management effectiveness to be greatly enhanced at the site level through robust management planning and implementation; improved knowledge and capacity; improved education and awareness raising programmes; and engagement with local stakeholders.	E7

2C RECOMMENDED PRIORITY RESPONSES

To move towards improved wise use of wetlands will require a range of responses and the involvement of a variety of actors. The table below synthesises the individual responses identified under each of the 43 indicators. Many of the indicator-specific responses are cross-cutting and address similar issues and themes. The recommended priority responses recognise different roles for the five categories of actors.

These roles are:

■ LEAD RESPONSIBILITY

▣ KEY ACTOR

□ INFORMAL ROLE

Recommended Priority Responses	National Governments	Local Governments / Communities	NGOs / CSOs	Private Sector/ Donors	Knowledge Providers	Indicators
Governance, policy and planning						
► Improve wetland ***governance effectiveness*** in countries across the Indo-Burma region through the establishment and functional operation of national wetland committees and national wetland policies to better support wetland wise use	■	▣	□	□	□	B2 B3 B4 B5 C2 D2
► Ensure that the assessment, ***protection and restoration of wetlands are integrated comprehensively in sectoral policies***, especially regarding energy production, water allocation, land use planning, the agricultural sector, human health and food security and through adequate consideration of wetlands in all Strategic Environmental Assessments (SEAs) and Environmental Impact Assessments (EIAs).	■	▣	□	□	□	B2 B3 B4 B5 B6 B8 B9 C2 C4

► ***Future proof human society from the potential impacts of climate change*** through integrating wetlands fully in mitigation and adaptation policies and decision-making, particularly around the water-food-energy nexus and the application of Nature-based Solutions	B5 B9 B13 B14 C7
► Develop ***wetland-related Nature-based Solutions*** to mitigate flooding, storm damage and erosion, improve water quality and optimise the provision of societal benefits	B10 B13 B14
► Promote the ***health benefits of wetlands***, the wise use of wetland medicinal plants and the control of disease vectors through integration with national and local health professionals as part of "One Health" approaches	B7 B11 B17
► Ensure that the ***cultural, spiritual and religious values of wetland***s are recognized and integrated into cross-sectoral policies, and especially through sustainable tourism initiatives so that their values can be maintained for future generations	B15 B16 B17
► Integrate the ***benefits that wetlands provide*** to human society at all levels of planning and policy implementation to secure local livelihoods, develop circular economies and contribute to sustainable development goals	B2 B3 B4 B5 C7

Effectively managing wetlands						
► Develop robust and comprehensive management plans and planning processes, including stakeholder participation and engagement, for all current and future Ramsar sites and EAAFP Flyway Network Sites	■	▣	▣	▣	▣	B1 B11 E7
► Promote the wise use of wetlands and wetland management practices to enhance the delivery of benefits to society including food production, water quality improvement, climate regulation, tourism and education	■	▣	■	□	□	B1 B2 B3 B4 B5 B8 B9 B14 B15
► Integrate invasive species and unsustainable resource utilisation control measures within wetland management planning	■	▣	■	□	□	C1 C3 C5

Knowledge and capacity development

► Improve the systematic monitoring and reporting on wetland-dependent species to develop a robust baseline and to inform management planning and policy implementation	■	▣	▣	□	■	A1 A4 A6 A7 A8 E1 E3 E6
► Increase the availability of knowledge, and the quality and consistency of information on the distribution and state of different wetland types across the region	■	▣	▣	□	■	A2 A3 A4 E5 B3 E7
► Enhance the understanding and appreciation of the cross-sectoral and multiple values that wetlands provide human society from the local/site level to the national and transboundary levels	■	▣	▣	□	■	B1 B2 B3 B4 B5 B6 B7 B8 B9 B10 B12
► Ensure that best-practices and current data and information are used to evaluate impacts of developments on wetlands in a non-political and objective manner	■	▣	▣	□	■	B9 B10 C1 C2 C3 C4 C5 C6 C7
► Invest in the development of capacity among a diversity of wetland managers and at a range of scales utilising local and Indigenous knowledge, university researchers, NGOs, transboundary forums and international support networks	■	▣	▣	□	▣	B6 B8 B16 C1 C7

Rice farming in Lao PDR © IUCN Lao PDR

3 Supporting Evidence – Indicators

INTRODUCTION

The wise use of wetlands across the region is essential for human well-being and livelihoods. In the past and in the present, there are various policies, regulations, laws and initiatives which have aimed to stem the loss of wetlands and deliver on wise use obligations. Understanding what is happening to the extent and trend in extent of wetlands, the suitability and effectiveness of governance frameworks, the drivers of changes and the appropriateness of response options is essential to ensure that future generations can benefit from wetland values.

The IBWO adopts a robust audit trail in an attempt to distinguish myth from reality and to provide a scientific and evidence-based synthesis of the state of wetlands across the region. The IBWO has synthesised literature, data and information on 43 indicators. The indicators have been selected to represent an overview of the issues and challenges facing the wetlands of the region. As their name suggests, they are indicators, insofar that they provide an indication of an individual issue. Whilst each indicator can tell an individual story, the outlook for wetlands only comes clearly into view when the implications, and the synergies and conflicts among indicators, are integrated and assessed.

The indicators are assembled into five thematic groups:

- A Status and trends of biodiversity
- B Status and trends of values and ecosystem services
- C Direct drivers, pressures and threats
- D Indirect drivers, pressures and threats
- E Existing responses

A summary of the indicators is provided at the beginning of each of the thematic groups. A summary table presents a graphical depiction of the overall state and trend of the indicator. The colour represents the state (green=good; amber=fair; red=poor) and the direction of the arrow represents the trend in the state. Examples are given below. N/A is used where no state or trend data are available or reporting on the state and/or trend is not applicable.

State	Trend	Symbol	Interpretation
Good	Improving (getting better)		The state is good and improving
Fair	Stable (no change)		The state is fair and neither improving or deteriorating
Poor	Deteriorating (getting worse)		The state is poor and deteriorating
Good	No trend information		The state is good but there is no information available on the trend in the state

3A STATUS AND TRENDS OF BIODIVERSITY – SUMMARY

Overview

Eight indicators provide the evidence-base for the status and trends of wetlands and wetland-dependent species in the Indo-Burma region.

The Indo-Burma region is one of the most highly biodiverse parts of the world, and is a wetland-rich area, with an estimated minimum wetland area of over 383,000 km².

Assessment of the status and trends of wetlands and wetland-dependent species indicate that their status is poor, and is further deteriorating, in the Indo-Burma region:

- The areas and status of Indo-Burma natural wetlands, both inland and coastal, are in long-term and continuing decline, largely through their conversion to human-made wetlands and other land-uses such as urban, industrial and infrastructure development.
- In contrast, the area of human-made wetlands (rice cultivation, reservoirs and aquaculture ponds) is in long-term increase, and now forms the largest proportion of wetland area in the Indo-Burma region.
- The status of species depending on wetlands in the Indo-Burma region is poor: many species, including globally threatened species, and their populations are in long-term decline.

Indicator
Wetland habitats
A1 Diversity of wetland habitats
A2 Wetland extent
A3 Wetland area trends
A4 Trends in ecological character of wetlands
Wetland-dependent species
A5 Diversity of wetland-dependent species
A6 Global threat status of wetland-dependent species
A7 Trends in wetland-dependent species in Ramsar and Flyway Network Sites
A8 Trends in waterbird biogeographic populations

Key messages

Indicator		
A1 Diversity of wetland habitats		• The Indo-Burma region is one of the most highly biodiverse parts of the world. • It is rated in the top 10 Biodiversity Hotspots for irreplaceability and in the top five for threat, and with more people living in the region than any other Hotspot. • The Indo-Burma region supports a wide variety of wetland habitats from the mountains to the sea, and has high levels of species' endemism.
A2 Wetland extent		• The Indo-Burma region is a wetland-rich area, with an estimated minimum wetland area of over 383,000 km² and with inland wetlands covering 17% of regional land area • There are gaps in knowledge of wetland extent for some countries and for some wetland classes. • Human-made wetlands (particularly rice growing areas, but also aquaculture ponds and reservoirs) now form the largest proportion of wetland area in the region. • Coastal natural wetlands are extensive (particularly shallow marine waters) and important – especially in Myanmar. • As a consequence of extensive conversion to other land-uses, including to human-made wetlands, the remaining areas of inland natural wetlands are now small.
A3 Wetland area trends		• Inland natural wetlands are progressively decreasing in area, particularly floodplain wetlands and seasonally flooded grasslands, and swamp forests, largely through conversion to human-made wetlands. • Coastal natural wetlands have also been undergoing long-term area losses, particularly of tidal flats and mangroves. • In contrast, human-made wetlands (rice cultivation, reservoirs and aquaculture ponds) have greatly increased in area over time.
A4 Trends in ecological character of wetlands		• There is increasingly widespread deterioration of the ecological character of all wetlands, and of designated Ramsar Sites, in the Indo-Burma region • 44% of wetland ecosystems assessed in Myanmar are at risk of ecosystem collapse. • Red List of Ecosystems assessments have only been made for Myanmar. No assessment has been made for wetland ecosystems in the other Indo-Burma countries.

A5 Diversity of wetland-dependent species		• The Indo-Burma region supports a high diversity of inland wetland-dependent species. • Knowledge and reporting of the diversity and levels of endemism of wetland-dependent species, especially for coastal and nearshore marine species, is poor and needs improving.
A6 Global threat status of wetland-dependent species		• Knowledge of the global threat status of wetland-dependent species is poor, with many being "Data Deficient". • 12% of over 7,000 wetland-dependent animal species assessed in the Indo-Burma region are at risk of extinction (globally threatened). • The most globally threatened animal taxa are marine turtles (80% globally threatened), marine mammals (39%), corals, sea anemones & jellyfish (29%) and freshwater Reptilia (turtles, snakes and crocodiles) (23%). • The populations of many globally threatened species are in long-term decline.
A7 Trends in wetland-dependent species in Ramsar and Flyway Network Sites		• There are widespread declines reported in the populations of wetland-dependent species in Indo-Burma Ramsar and Flyway Network Sites. • Declines are reported as being more widespread in inland than in coastal sites.
A8 Trends in waterbird biogeographic populations		• Waterbird biogeographic populations in the Indo-Burma region are in trouble: almost half (47%) of populations for which a trend is available are in decline, with only 18% increasing. • The populations of almost all globally threatened waterbirds in the Indo-Burma region are in decline. • Over one-third (37.6%) of waterbird populations in the Indo-Burma region of species considered by the IUCN Red List as not being globally threatened are also in decline. • Population sizes and trends of most resident waterbirds in Indo-Burma are very out-of-date and urgently need to be updated.

Recommended responses for decision-makers

Indicator	Recommended response
A1 Diversity of wetland habitats	None
A2 Wetland extent	• Undertake full national wetland inventories in Cambodia, Lao PDR and Thailand. • Undertake assessments of the areas of marshes and swamps and forested wetlands on alluvial soils, coastal lagoons, aquaculture ponds and saltpan areas in all countries in the Indo-Burma region.
A3 Wetland area trends	• Improve Indo-Burma-wide assessment of trends in the areas of floodplain wetlands, seasonally flooded grasslands, swamp forests, peatlands, saltpans and aquaculture ponds.
A4 Trends in ecological character of wetlands	• Address the drivers of wetland deterioration causing the deterioration in the ecological character of all wetlands, and especially of designated Ramsar Sites. • Enact site-level management planning implementation that, wherever possible, addresses the broad drivers of change. • In Myanmar, give priority to Ramsar Site designation (under the “threatened ecological communities” aspect of designation Criterion 2) of areas of wetland ecosystems assessed as globally threatened; • Undertake Red List of Ecosystems (RLE) assessments of wetland ecosystems in Cambodia, Lao PDR, Thailand and Viet Nam.
A5 Diversity of wetland-dependent species	• Improve documentation and reporting on the diversity and distribution of wetland-dependent species in the Indo-Burma region, especially of coastal and nearshore marine species.
A6 Global threat status of wetland-dependent species	• Seek ways of improving the knowledge-base for Red List assessment of Data Deficient species, especially crabs, fish, molluscs and amphibians, in the Indo-Burma region. • Develop national globally threatened species conservation/action plans in the Indo-Burma region, with a priority for Critically Endangered species. • Undertake a Red List Index analysis of trends in globally threatened wetland-dependent species in the Indo-Burma region.
A7 Trends in wetland-dependent species in Ramsar and Flyway Network Sites	• Address the drivers of wetland deterioration causing the deterioration in the ecological character of all wetlands, especially of designated Ramsar Sites. • Implement site-level management planning to improve the status of wetland-dependent species in designated Ramsar and Flyway Network Sites.
A8 Trends in waterbird biogeographic populations	• Identify and implement policy and management interventions to reduce the impacts of the key drivers (habitat loss; illegal hunting) of the deterioration in the status of waterbird populations in the Indo-Burma region. • Establish ways and means to update waterbird population sizes and trends of resident waterbird populations on the East Asia-Australasia Flyway including in the Indo-Burma region.

A1 DIVERSITY OF WETLAND HABITATS

Key messages

- The Indo-Burma region is one of the most highly biodiverse parts of the world. It is rated in the top 10 Biodiversity Hotspots for irreplaceability and in the top five for threat, with only 5% of its natural habitat estimated as remaining and with more people living in the region than any other Hotspot.
- The Indo-Burma region supports a wide variety of wetland habitats from the mountains to the sea, and has high levels of species' endemism.

The Indo-Burma Biodiversity Hotspot

The Indo-Burma region is one of the most highly biodiverse parts of the world. All five Indo-Burma countries (and some adjacent parts of Bangladesh, India, Malaysia and China) lie within the Indo-Burma Biodiversity Hotspot (Figure A1.1), one of only 36 such hotspots recognised globally. The Indo-Burma Hotspot covers a total land area of 2,308,815 km², larger than any other Hotspot (Mittermeier et al. 2004).

The Indo-Burma Hotspot is rated in the top 10 hotspots for irreplaceability and in the top five for threat based on the proportion of original habitat remaining (CI 2011) and with more people living in the region than any other Hotspot (Mittermeier et al. 2004 in CEPF 2020).

Diversity of wetland habitats in the Indo-Burma region

The Indo-Burma region supports a very wide variety of habitats and high overall biodiversity, reflecting high diversity of climatic zones, landforms and geographical diversity. The area has high levels of species' endemism as a consequence of its evolutionary and geological history. Altitudinally, it ranges from montane systems, including Southeast Asia's highest mountain - Hkakaborazi in Myanmar (5,881 metres) - and the Annamite Mountains in Lao PDR and Viet Nam, to the coasts of the Bay of Bengal, Andaman Sea, Gulf of Thailand and South China Sea.

The region has a wide variety of natural wetland ecosystems. These include:

- Caves in extensive limestone karst systems, with high levels of endemism, the largest of which is the Phong Nha-Ke Bang/Hin Nam No landscape shared between Lao PDR and Viet Nam;
- Peatlands (both forested and non-forested);
- Some of the largest river systems in Asia (Mekong, Chao Phraya, Ayeyarwady, Thanlwin (Salween), Chindwin, Sittaung, Red and Pearl (Zhu Jiang)) rivers and their formerly extensive associated floodplain wetlands and seasonally flooded grasslands (now mostly converted to rice production and aquaculture);
- Rivers and streams ranging from fast-flowing rocky mountain streams to wide, slow-flowing lowland rivers braided by large, partly vegetated, sand and rock bars. These occur particularly along the Mekong River and its major tributary complex the Sekong-Sesan-Srepok, and the Ayeyarwady River in Myanmar.
- Glacial lakes in montane areas;
- Lowland lakes including the Great Lake of Tonle Sap (Cambodia), Southeast Asia's largest freshwater lake, and Inlay Lake and Indawgyi Lake in Myanmar; and major coastal deltas.

The region's coasts have large and important areas of mangroves, tidal flats, seagrass beds and shallow marine waters. The largest, most ecologically important intertidal ecosystems are found near large river mouths, notably the Red River and Mekong Deltas in Viet Nam, the Inner Gulf of Thailand, and the Ayeyarwady Delta and Gulf of Mottama in Myanmar.

The region has large areas of human-made wetlands, particularly rice production areas, and also aquaculture ponds and reservoirs.

Box A1.1

What are Biodiversity Hotspots?

To qualify as a Biodiversity Hotspot, an area must meet two criteria:

- Contains at least 1,500 species of vascular plants found nowhere else on Earth (known as "endemic" species); and

- Has lost at least 70% of its primary native vegetation.

Conservation International (CI): https://www.cepf.net/our-work/biodiversity-hotspots/hotspots-defined

Note that Biodiversity Hotspots cover terrestrial (including inland wetland) systems and some coastal systems, but not nearshore marine systems.

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CI (Conservation International) (2011) The world's 10 most threatened Hotspots (in CEPF 2020).

Mittermeier, R.A., Robles Gil, P., Hoffmann, M., Pilgrim, J.D., Brooks, T.M., Mittermeier, C.G. and Fonseca, G.A.B. da. 2004. Hotspots Revisited: Earth's Biologically Richest and Most Endangered Ecoregions. Mexico City: CEMEX.

Figure A1.1

The Indo-Burma Biodiversity Hotspot. Source. Mittermeier et al. (2004) in CEPF (2020).

Lotus grows in Beung Kiat Ngong Ramsar Site, Lao PDR © IUCN Lao PDR

A2 WETLAND EXTENT

Key messages

- The Indo-Burma region is a wetland-rich area, with an estimated minimum wetland area of over 383,000 km²
- There are gaps in knowledge of wetland extent for some countries and for some wetland classes.
- Coastal natural wetlands are extensive (particularly shallow marine waters) and important – especially in Myanmar.
- Human-made wetlands (particularly rice growing areas, but also aquaculture ponds and reservoirs) now form the largest proportion of wetland area in the region.
- As a consequence of extensive conversion to other land-uses, including to human-made wetlands, the remaining areas of inland natural wetlands are now small.

The Ramsar Convention has repeatedly recognised that knowledge of the areas and distribution of wetlands is an essential basis for policy and planning to achieve wetland conservation and wise use.

Here the areas and distribution of different classes of wetlands in the Indo-Burma region are assessed through the compilation of wetland areas from multiple sources for different wetland classes. Areas are available for Indo-Burma for most, but not all, classes of inland natural, coastal natural and human-made wetlands. However, the areas of most of these missing classes[1] are believed to be mostly small in the Indo-Burma region. Wetland classes are those applied by Davidson and Finlayson (2018) and Ramsar Convention (2018).

Although the Ramsar Convention expects each Contracting Party to undertake a comprehensive national wetland inventory, the extent of such inventory is insufficient to provide a source of wetland area and distribution in the Indo-Burma region. Only two Parties (Myanmar and Viet Nam) have such an inventory, with only partial inventory reported by Lao PDR and Thailand.

Details of national and Indo-Burma region wetland areas, and their sources, are provided in Appendix 1. Descriptions of the areas and distributions of each wetland class are provided in Appendix 2.

Wetland extent and distribution in the Indo-Burma region

Total wetland areas:

Indo-Burma is a wetland-rich region. The minimum total wetland area in the Indo-Burma region is estimated as 383,161.06 km² (Appendix 1). This forms approximately 2.4-2.6% of the global wetland area estimated by Davidson & Finlayson (2018, 2019).

The largest total areas of wetlands in Indo-Burma are in Thailand (32% of Indo-Burma total) and Myanmar and Viet Nam (28% each), with smaller areas in Cambodia (9%) and 3% in Lao PDR (Figure A2.1).

[1] Areas are not available for most or all Indo-Burma countries for the following wetland classes. Inland natural wetlands: rivers & streams, marshes & swamps on alluvial soils, forested wetlands on alluvial soil. Coastal/marine natural wetlands: sandy beaches, rocky shores, coastal lagoons. Human-made wetlands: small ponds, wastewater treatment ponds, saltpans, palm oil/pulpwood plantations on peat soils.

Table A2.1

Estimated areas of wetlands in the Indo-Burma region. a. minimum areas (km²) and b. % areas. Source: Multiple sources in Appendix 1.

a. Area km²

Wetland category	Cambodia	Lao PDR	Myanmar	Thailand	Viet Nam	Indo-Burma total
Inland natural	3,372.04	1,250.47	7,563.49	2,823.92	6,563.50	21,573.42
Coastal/ marine natural	2,394.52	0	22,462.55	12,848.68	19,606.95	57,262.70
Human-made	29,446.19	9,613.96	79,639.38	109,928.72	85,871.32	304,324.94
Total	35,212.75	10,864.43	109,665.42	125,601.32	112,041.77	383,161.06

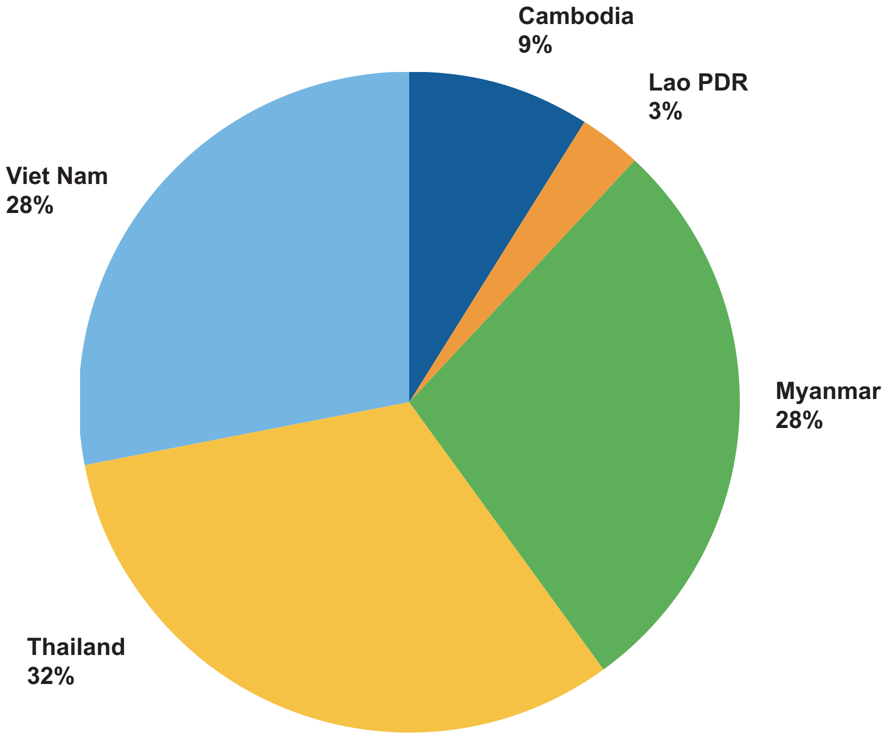
b. Percentage (%) of area

Wetland category	Cambodia	Lao PDR	Myanmar	Thailand	Viet Nam	Indo-Burma total
Inland natural	9.58	11.51	6.90	2.25	5.86	5.63
Coastal/ marine natural	6.80	0.00	20.48	10.23	17.50	14.94
Human-made	83.62	88.49	72.62	87.52	76.64	79.42

Inland natural and human-made wetlands form a substantial component (16.8%) of the land area of the Indo-Burma region. The largest proportions of national land areas formed of wetlands are in Viet Nam (27.9%) and Thailand (22.0%), with smaller proportions in Cambodia (18.3%) and Myanmar (12.9%) and the smallest proportion in Lao PDR (4.6%) (Figure A2.2).

Figure A2.1

The percentage distribution of all wetlands across Indo-Burma countries. Source. Appendix 1.



Areas of inland natural, coastal/marine natural and human-made wetlands

Across the Indo-Burma region, the largest areas of wetlands are now human-made (mostly inland), covering at least 304,324.94 km² (79% of the regional wetland area) and dominated by rice cultivation areas (see Appendix 2).

There are also large coastal/marine natural wetland areas in the Indo-Burma region, covering 57,262.70 km² (15% of the regional total), almost half of which (49.6%) are shallow marine waters <6m depth of permanent inundation (see Appendix 2).

As a consequence of their extensive conversion, particularly for rice cultivation, aquaculture ponds, reservoirs and urbanisation, there is now only a small area (21,573.42 km², 6% of regional wetland area) of natural inland wetlands (mostly lakes) remaining in the region (Figure A2.3).

Human-made wetlands dominate the area of wetlands in all five Indo-Burma countries: Lao PDR 88%, Thailand 88%, Cambodia 84%, Viet Nam 77% and Myanmar 73%. (Figure A2.4). There are very small remaining areas of inland natural wetlands in each of the five Indo-Burma countries: national percentages of between 2.3% in Thailand to 11.5% in Lao PDR (Figure A2.4).

Figure A2.2.

The percentages of Indo-Burma country land areas formed by inland natural and human-made wetlands.

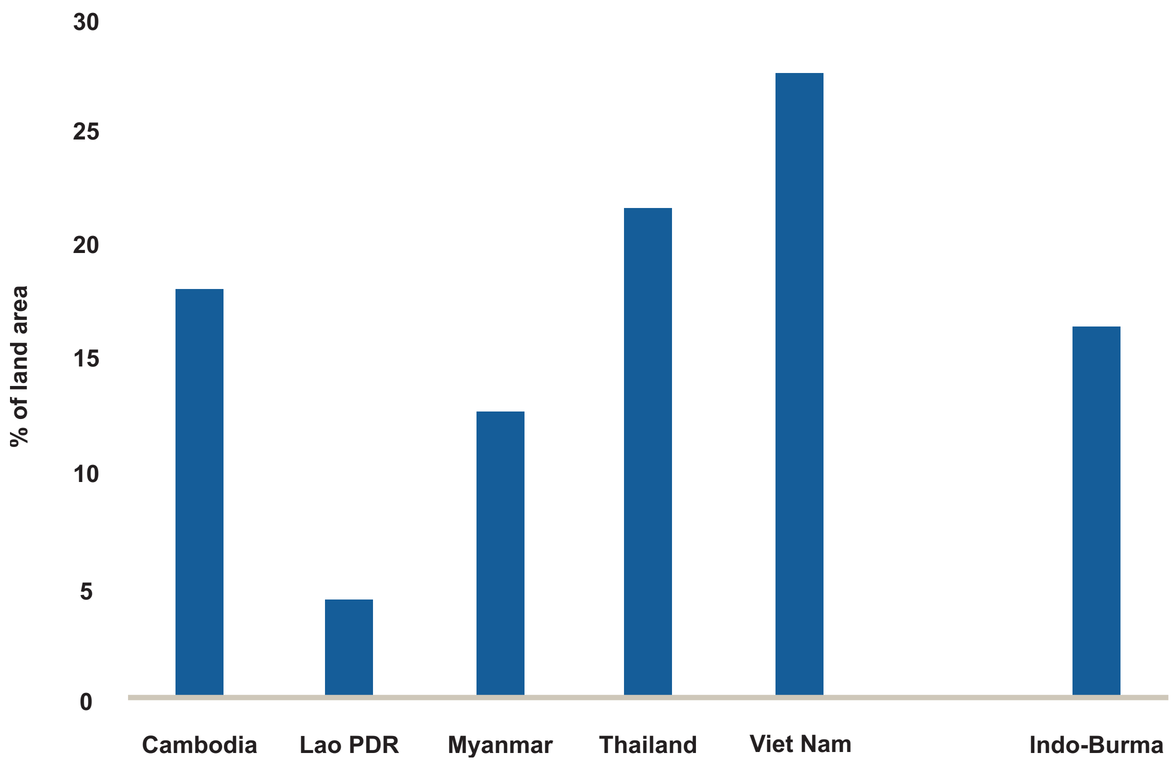


Figure A2.3.

The distribution of total wetland areas of different categories across Indo-Burma countries. Source. Appendix 1.

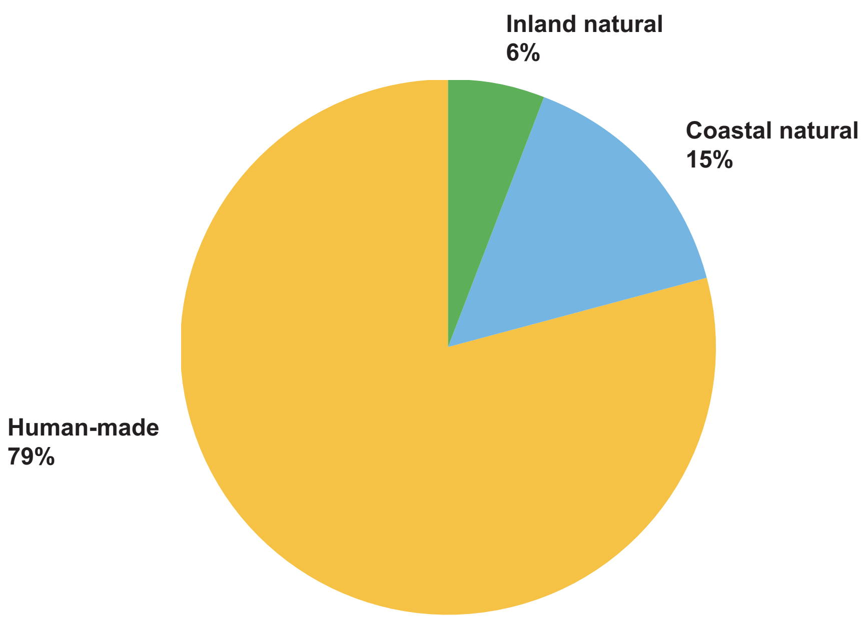
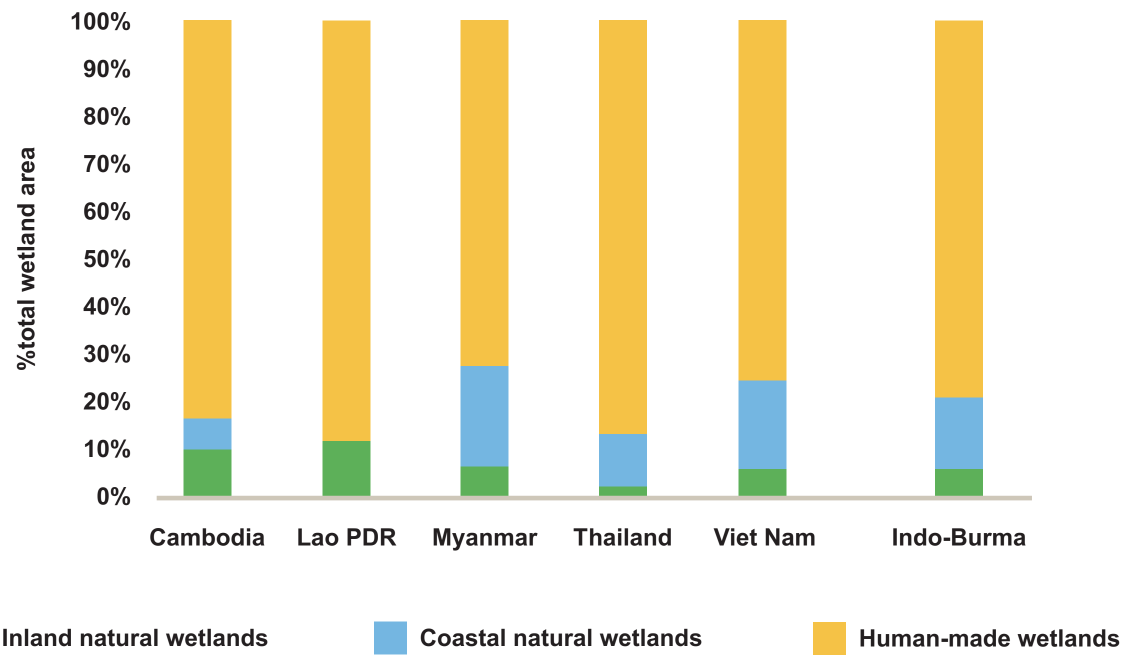


Figure A2.4.

Percentages of different broad wetland categories in Indo-Burma countries. Source. Appendix 1.



Recommendations

- Undertake national wetland inventories for Cambodia, Lao PDR and Thailand.
- Undertake assessments of the areas of marshes and swamps and forested wetlands on alluvial soils, coastal lagoons, aquaculture ponds and saltpan areas in all countries in the Indo-Burma region.

References

Davidson, N.C. and Finlayson, C.M. 2018. Extent, regional distribution and changes in area of different classes of wetlands. Marine & Freshwater Research 69: 1525-1533.

Davidson, N.C. and Finlayson, C.M. 2019. Updating global coastal wetland areas presented in Davidson and Finlayson (2018). Marine & Freshwater Research. doi: 10.1071/MF19010

Ramsar Convention on Wetlands. 2018. Global Wetland Outlook: State of the World's Wetlands and their Services to People. Ramsar Convention Secretariat, Gland, Switzerland.

A3 WETLAND AREA TRENDS

Key messages

- Inland natural wetlands are progressively decreasing in area, particularly floodplain wetlands and seasonally flooded grasslands, and swamp forests, largely through conversion to human-made wetlands.
- Coastal natural wetlands have also been undergoing long-term area losses, particularly of tidal flats and mangroves.
- In contrast, human-made wetlands (rice cultivation, reservoirs and aquaculture ponds) have greatly increased in area over time.

Trends in the area of wetlands in the Indo-Burma region have been assessed at least in part for some, but not all, wetland classes. A qualitative summary of trends from available information (Appendix 3) is provided in Table A3.1.

Over time, areas of natural wetlands, both inland and coastal wetland classes, have been progressively decreasing in the Indo-Burma region. In contrast, there have been progressively increasing areas of human-made wetlands (rice cultivation, reservoirs and aquaculture ponds), often at the expense of natural wetlands (see Appendix 3).

Appendix 3 provides information separately of the area changes of different wetland classes. However, these changes do not happen in isolation from each other: rather they are often inter-related and caused by simultaneous multiple drivers.

A recent global change assessment of losses and gains between 1999 and 2019 in the highly dynamic areas of coastal wetlands (tidal flats, mangroves and tidal marshes) reports more area loss than gain globally (Murray et al. 2022). About three-quarters of the global net area decrease has been in Asia, with 69% of this being in just three countries (Indonesia, China and Myanmar). The coasts of the Indo-Burma region account for 18% of the global net loss of coastal wetlands (see Appendix 3) with the greatest losses being in Myanmar (12% of global net loss) and Viet Nam (5% of global net loss). There have been much smaller losses in Cambodia and Thailand (see Appendix 3). Box A3.1 provides an example of wetland class area change interactions, in the Mekong Delta, Viet Nam.

Table A3.1.

Qualitative summary of reported trends in the area of different wetland classes in the Indo-Burma region, derived from Appendix A.3. Note that the time-period of area trend differs between assessment sources.

▲	Increase	▼	Decrease
▲ ▲	Large increase	▼▼	Large decrease

Wetland Class	Qualitative area trend
Inland natural wetlands	
Lakes	▼
Floodplain wetlands/seasonally flooded grasslands	▼ ▼
Swamp forests	▼ ▼
Peatlands	▼
Coastal natural wetlands	
Mangroves	▼ ▼
Tidal flats	▼
Seagrass beds	▼
Coral reefs	▼
Human-made wetlands	
Rice cultivation	▲ ▲
Reservoirs	▲ ▲
Aquaculture ponds	▲ ▲

Recommendations

- Improve Indo-Burma-wide assessment of trends in the areas of floodplain wetlands, seasonally flooded grasslands, swamp forests, peatlands, saltpans and aquaculture ponds.

References

Dang, A.N.T., Kumar, L., Reid, M. and Nguyen, H. 2021. Remote Sensing Approach for Monitoring Coastal Wetland in the Mekong Delta, Viet Nam: Change Trends and Their Driving Forces. Remote Sensing 13: 3359. https://doi.org/10.3390/rs13173359

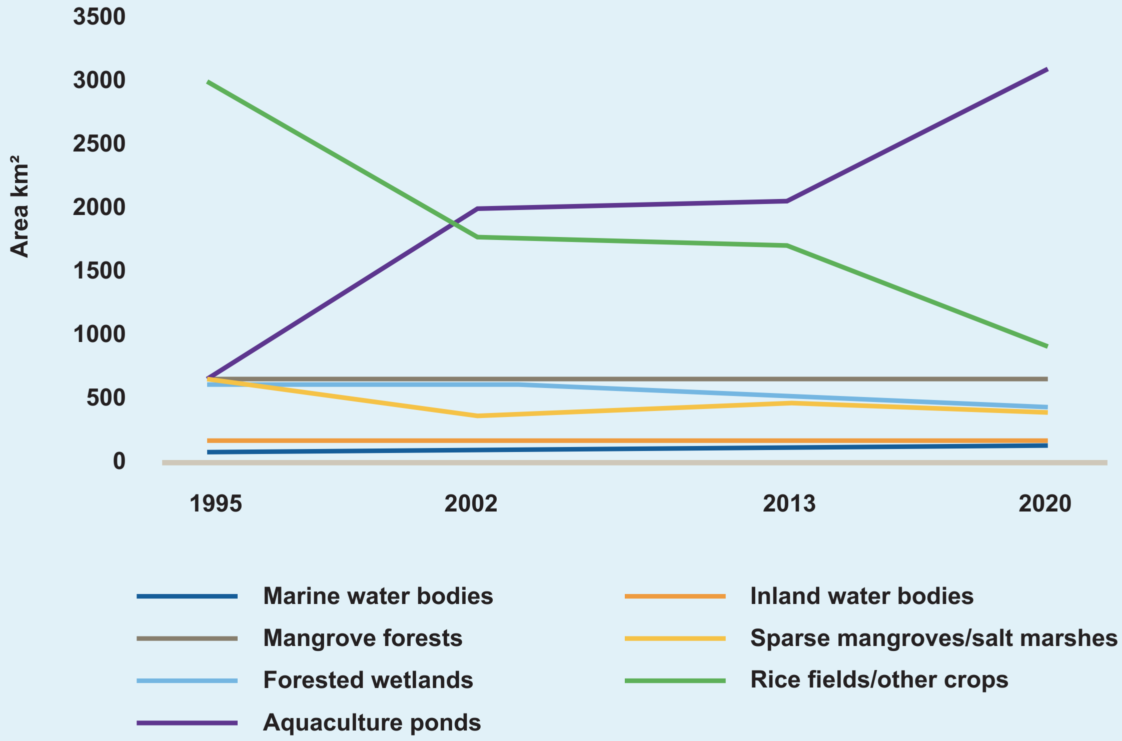
Murray, N.J., Worthington, T.A., Bunting, P., Duce, S., Hagger, V., Lovelock, C.E., Lucas, R., Saunders, M.I., Sheaves, M., Spalding, M., Waltham, N.J. and Lyons, M.B. 2022. High-resolution mapping of losses and gains of Earth's tidal wetlands. Science 376: 744–749.

Box A3.1

Inter-related changes in the areas of different classes of wetlands in the Mekong Delta, Viet Nam

Changes in the area of individual classes of wetlands often do not occur in isolation, but are inter-related, and caused by simultaneous multiple drivers. A 25-year (1995-2020) remote-sensing assessment of changes in the areas of multiple wetland types in part of the Viet Nam Mekong Delta illustrates major changes in the areal composition of wetlands.

The most dramatic change has been a shift from rice production and other agriculture areas being the largest (51% of total area) wetland type in 1995, to an increasing dominance of aquaculture ponds (56% of total area) in 2020. Over the 25-year period aquaculture pond area increased by over 370%, and rice production area decreased by over 70%. Most of the aquaculture pond area increase was through conversion from rice production areas, but some was the conversion of mangroves, which decreased in area by 5% and forested wetlands, which decreased in area by 32%. The area of forested wetlands has also decreased because of fires.



Changes in the areas of different classes of wetlands in the Mekong Delta (Viet Nam) from 1995-2020. Source. Redrawn from data in Wang et al. (2021).

Rising sea-level was identified as a main underlying driver of some of these changes, including through coastal erosion leading to mangrove loss, and increasing inland salinization of soils. But most of these rapid area changes are recognised as being directly driven by policies on land-use for economic development in the region.

Source. Dang et al. (2021).

A4 TRENDS IN THE ECOLOGICAL CHARACTER OF WETLANDS

Key messages

- There is increasingly widespread deterioration of the ecological character of all wetlands, and of designated Ramsar Sites, in the Indo-Burma region
- 44% of wetland ecosystems assessed in Myanmar are at risk of ecosystem collapse.
- Red List of Ecosystems assessments have only been made for Myanmar. No assessments have been made for wetland ecosystems in the other Indo-Burma countries.

The area of natural wetlands throughout the IBRRI region is reported as decreasing, and the area of human-made wetlands increasing (see Indicator A3). Assessments of the status and trends of the ecological character of remaining wetlands in the Indo-Burma region are limited, but since 2012 Ramsar Contracting Parties have reported, in their triennial National Reports, a qualitative assessment, at the national scale, of trends in the ecological character of their wetlands generally and of their Ramsar Sites in particular.

Since 2012, Ramsar Parties in the Indo-Burma region have reported increasingly widespread deterioration of the ecological character of their wetlands generally and of their designated Ramsar Sites (Figure A.4.1).

Although deterioration of the ecological character of Ramsar Sites has been consistently reported as being less widespread than that of wetlands generally (Figure A.4.1), it is of considerable concern that the deterioration of Ramsar sites is also reported by governments as becoming increasingly widespread in the Indo-Burma region (Figure A.4.1). This is a similar trend of increasingly widespread wetland ecological character deterioration as that reported by Parties for the larger Asia Ramsar region, and globally (Davidson et al. 2020).

Box A4.1

The ecological character of wetlands

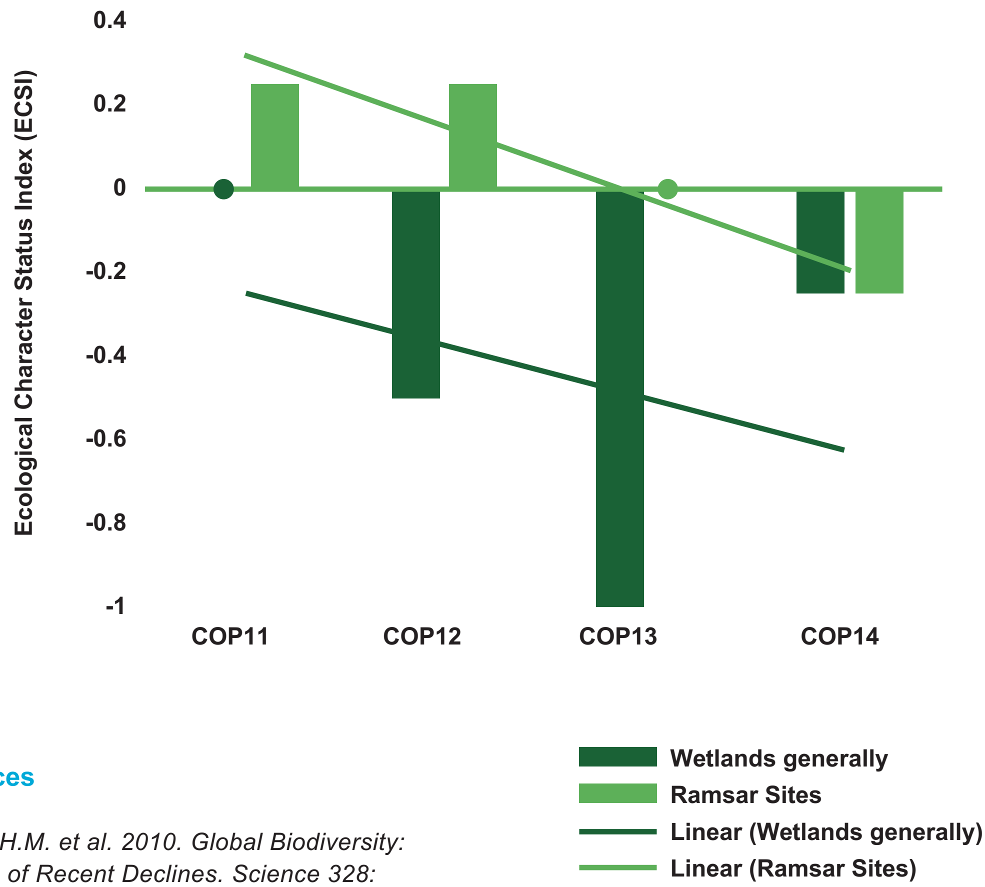
The Ramsar Convention defines the ecological character of wetlands as “the combination of the ecosystem components, processes, benefits and services that characterise the wetland at a given point in time”. (Ramsar Convention 2005, Resolution IX. 1 Annex A).

Recommendations

- Address the drivers of wetland deterioration causing the deterioration in the ecological character of all wetlands, and especially of designated Ramsar Sites.
- Enact site-level management planning implementation that wherever possible addresses the broad drivers of change.
- In Myanmar, give priority to Ramsar Site designation (under the “threatened ecological communities” aspect of designation Criterion 2) of areas of wetland ecosystems assessed as globally threatened;
- Undertake Red List of Ecosystems (RLE) assessments of wetland ecosystems in Cambodia, Lao PDR, Thailand and Viet Nam.

Figure A4.1.

National trends in the ecological character of wetlands generally, and of designated Ramsar Sites, in IBRRI countries as reported by these Contracting Parties in their Ramsar National Reports since Ramsar COP11 (2012).



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Ramsar Convention. (2005). Resolution IX. 1 Annex A. A Conceptual Framework for the wise use of wetlands and the maintenance of their ecological character. Available at: https://www.ramsar.org/sites/default/files/documents/pdf/res/key_res_ix_01_annexa_e.pdf

Data sources

Ramsar National Reports. https://www.ramsar.org/documents?field_quick_search=2964

Data analyses

The Ecological Character Status Index (ECSI) calculates a simple, comparable, metric of status and trends of wetlands and wetland-dependent species (see e.g. Butchart et al. 2010; Davidson et al. 2020). The ECSI takes into account considers the number of stable records as well as the numbers of decreasing (NDEC) and increasing (NINC) records. The ECSI is calculated as:

$$ECSI = \frac{N_{INC} - N_{DEC}}{N_{TOTAL}}$$

The ECSI ranges from +1 (all increasing) to -1 (all decreasing).

Box A4.2

Status of Red List wetland ecosystems: Myanmar

The IUCN Red List of Ecosystems (RLE) (https://iucnrle.org) assesses the risk of ecosystem collapse, under categories similar to those applied under the IUCN Red List of Threatened Species. The eight RLE categories of ecosystem risk are: Collapsed (CO), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC), Data Deficient (DD), and Not Evaluated (NE). RLE assessments have now been undertaken in over 100 countries around the world.

In the Indo-Burma region, Red List of Ecosystems assessments have been undertaken only in Myanmar (Murray et al. 2020). The Myanmar RLE assessment includes 16 wetland ecosystems (six for inland natural wetlands and 10 for coastal natural wetlands).

A number of Myanmar wetland ecosystems are at risk of collapse (Figure below): seven (43.8%) of Myanmar wetland ecosystems are assessed as globally threatened (CR, EN, VU), with five (31.3%) being Critically Endangered. Three inland systems and four coastal systems are globally threatened. One ecosystem is assessed as Near Threatened (NT) and five (31.3%) as of Least Concern (LC), with three being Data Deficient (DD).

The seven RLE-identified globally threatened Myanmar wetland ecosystems are:

Inland wetlands:

Central dry evergreen riparian forest (CR)
Central Ayeyarwady floodplain grasslands (CR)
Ayeyarwady floodplain wetlands (EN)

Coastal wetlands:

Ayeyarwady kanazo swamp forest (CR)
Dwarf mangrove (shrubland) on shingle (CR)
Rakhine mangrove forest on mud (CR)
Ayeyarwady delta mangrove forest (EN)

Under the Red List of Ecosystems criteria, the main reason why Myanmar wetland ecosystems are assessed as globally threatened and under risk of collapse is the long-term and continuing area loss and conversion to other land-uses (Appendix 5).

Reference

Murray, N.J., Keith, D.A., Tizard, R., Duncan, A., Htut, W.T., Hlaing, N., Oo, A.H., Ya, K.Z., Grantham, H. (2020) Threatened Ecosystems of Myanmar. An IUCN Red List of Ecosystems Assessment. Version 1.0. Wildlife Conservation Society. ISBN: 978-0-9903852-5-7

Data source

IUCN Red List of Ecosystems – Myanmar. https://www.myanmar-ecosystems.org/myanmar-ecosystems

Status of Red List wetland ecosystems: Myanmar

A5 DIVERSITY OF WETLAND-DEPENDENT SPECIES

Key messages

- The Indo-Burma region supports a high diversity of inland wetland-dependent species.
- Knowledge and reporting of the diversity and levels of endemism of wetland-dependent species, especially for coastal and nearshore marine species, is poor and needs improving.

The Indo-Burma region supports a high diversity of inland wetland-dependent species: there are at least 2,843 such species (of plants, molluscs, odonates, turtles, amphibians, fish, waterbirds and mammals only) known from the region (Allen et al. 2012) (Table A5.1). The Indo-Burma region supports significant proportions of the global diversity of these taxa, ranging from 5.5% of global amphibian species to 16.4% of freshwater turtles (Table A5.1). The diversity of freshwater turtles (42 species) in the Indo-Burma region is reported the greatest of any part of the world (CEPF 2020).

These numbers are recognised as minima of the diversity of the whole Indo-Burma region, for several reasons:

- Allen et al.'s (2012) assessment did not cover the central and western Myanmar parts of the Indo-Burma region;
- The assessment is for inland wetland-dependent species only, and does not cover coastal and nearshore marine species;
- Overall, knowledge of freshwater biodiversity in the region is still at the exploratory stage, with numerous taxonomic uncertainties, large areas un-surveyed, and many species known only from a single locality (CEPF 2020); and
- Many new species are being discovered in the region every year (WWF 2021): over 3,000 new species since 1997, and most recently 224 species in 2020. Not all of these species are inland wetland-dependent, but the 2020 discoveries include 16 new species of fish and 17 species of amphibians.

The richness of inland wetland-dependent species varies across the region (Figure A5.1). The highest species richness (416 to 526 species present per sub-catchment) is in lowland areas along the lower and middle Chao Phraya River (Thailand), and the main stem of the Mekong River as it flows along the Lao PDR-Thailand border into northern Cambodia (Khorat Plateau and Kratie-Stung Treng ecoregions). There are lower levels of species richness in mountainous areas such as in the Salween catchment, the Tenasserim mountain range and the eastern Gulf of Thailand. Although this lower recorded numbers of species associated with highland areas might be because of their lower diversity of habitats, it may also reflect less survey and research having been undertaken in these areas (Allen et al. 2012).

There is a high, but still poorly known, diversity of fish species, and high levels of endemism, in the rivers and lakes of the Indo-Burma Region. The Lower Mekong Basin supports at least 850 freshwater fish species, with a total estimate of 1,100 species if possible coastal or marine visitors are included and may be exceeded in species richness globally only by fish diversity in the Amazon and Congo Basins. The Ayeyarwady River basin supports at least 388 fish species (and possibly up to 550 species), of which 193 species (50%) are endemic to the basin.

River rapids are particularly important for high species richness, endemism and periodic congregations of fish, as are some headwaters areas (e.g. more than a quarter of fishes recorded from the Dakchung Plateau in Lao PDR are apparently endemic). Inle Lake in Myanmar has been isolated for significant periods of geological history, resulting in the evolution of many endemic taxa: of 49 fish species recorded there 17 species (35%) are considered as endemic (Kano et al. 2016).

The Indo-Burma region supports a number of giant freshwater fish species, all of which are at risk of extinction due to overharvesting, habitat conversion and loss and pollution. These include Mekong giant catfish *(Pangasianodon gigas)*, Mekong freshwater stingray *(Dasyatis laosensis)*, several *Himantura* stingrays, giant carp *(Catlocarpio siamensis)* and Jullien's golden carp *(Probarbus jullieni)*. Most of these large species are migratory, and require the maintenance of little-changed, large-scale aquatic systems. These long-distance migrations are also made by many smaller species; and many such species are endemic to a single catchment.

Of 309 inland wetland-dependent species of turtles, snakes and crocodiles in the region almost one-quarter (23%) are globally threatened, with 24 species assessed as Critically Endangered (see Indicator A6).

Other freshwater taxa are much less studied in the region. One exception is the Pomatiopsidae, a family of aquatic gastropods (snails), for which the Mekong Basin represents a remarkable centre of radiation, with at least 121 species occurring (CEPF 2020).

At least 394 species of inland and coastal waterbirds use the East Asia-Australasia Flyway, within which the Indo-Burma region lies. Of these, at least 200 waterbird species occur in the Indo-Burma region. The diversity of shorebirds (Charadriiformes) on this Flyway (79 biogeographic populations of 67 species) is the highest of any flyway globally (Stroud et al. 2006).

The diversity and distribution of coastal and nearshore marine species in the Indo-Burma region is poorly documented. But at least five species of marine turtles, five species of marine mammals, 562 species of Cnidaria (corals, sea anemones, jellyfish) and 54 species of Echinoderms (starfish and sea urchins) are known from the region, many of which are globally threatened (CEPF 2020).

Recommendations

- Improve documentation and reporting on the diversity and distribution of wetland-dependent species in the Indo-Burma region, especially of coastal and nearshore marine species.

Table A5.1.

Minimum numbers of inland wetland-dependent species of different taxa in the Indo-Burma region. Note that this assessment does not include central and western Myanmar. Source. Allen et al. (2012).

Taxon	No. species in Indo-Burma region	% species in Indo-Burma of global no. of species
Plants	252	n/a
Molluscs	430	8.6
Odonates	473	8.3
Turtles	42	16.4
Amphibians	234	5.5
Fish	1,178	7.9
Waterbirds	220	10
Mammals	14	9.7
Total	**2,843**	

References

Allen, D.J., Smith, K.G., and Darwall, W.R.T. (Compilers). 2012. The Status and Distribution of Freshwater Biodiversity in Indo-Burma. Cambridge, UK and Gland, Switzerland: IUCN

CEPF. 2020. Indo-Burma biodiversity hotspot. Ecosystem profile, 2020 update. Critical Ecosystem Partnership Fund, Conservation International, Arlington, USA. https://www.cepf.net/sites/default/files/ep_indoburma_2020_update_final-sm_0.pdf

Kano, Y. et al. 2016. A dataset of fishes in and around Inle Lake, an ancient lake of Myanmar, with DNA barcoding, photo images and CT/3D models. Biodiversity Data Journal 4(4):e10539

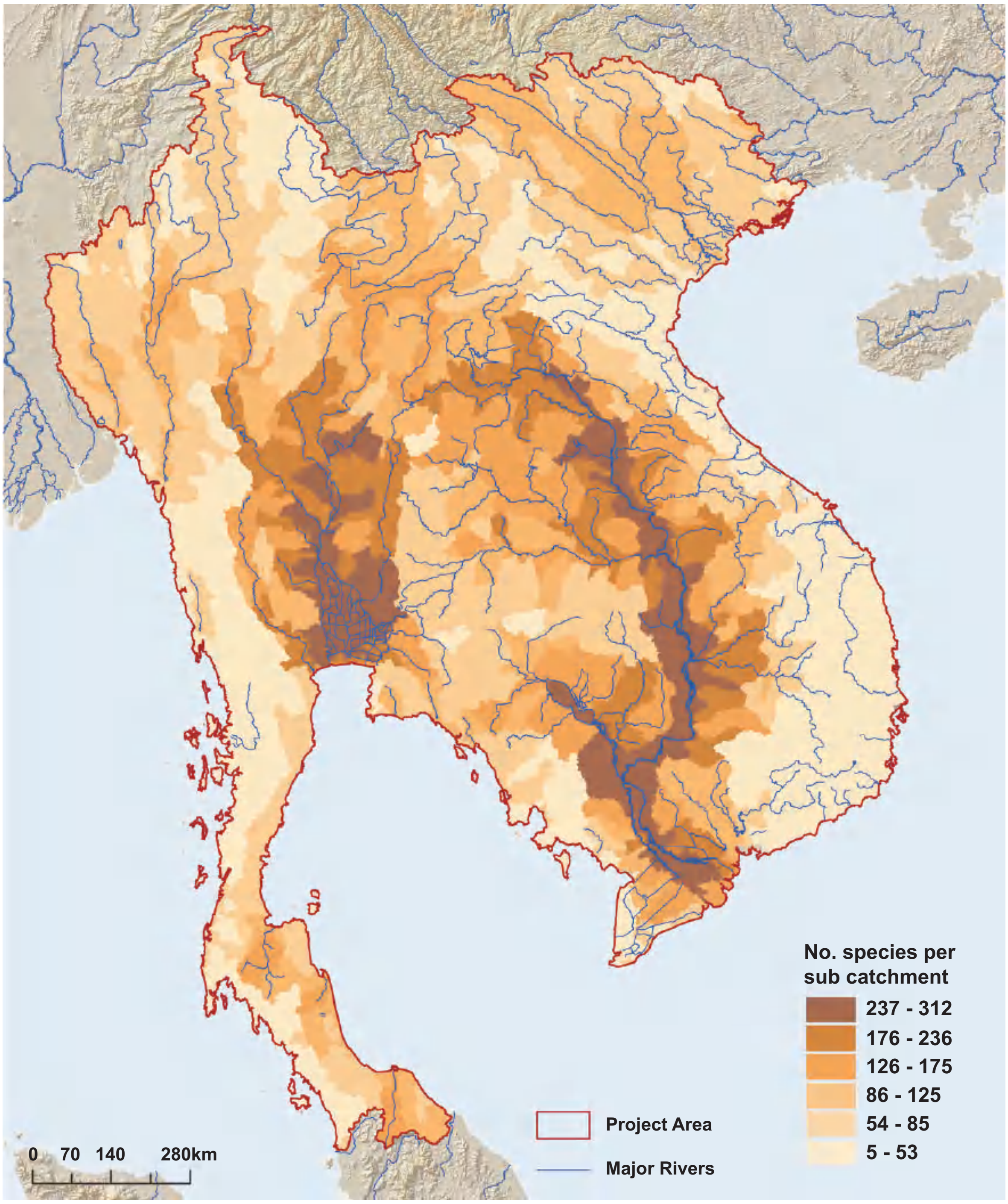
Stroud, D.A., Baker, A., Blanco, D.E., Davidson, N.C., Delany, S., Ganter, B., Gill, R., Gonzales, P., Haanstra, L., Morrison, R.I.G., Piersma, T., Scott, D.A., Thorup, O., West, R., Wilson, J. & Zockler, C. 2006. The conservation and population status of the world's waders at the turn of the millennium. Pp 643-648 in Waterbirds around the world (Eds. G.C. Boere, C.A. Galbraith & D.A. Stroud.) The Stationery Office, Edinburgh, U.K.

WWF Greater Mekong. 2021. New species discoveries in the Greater Mekong 2020. World Wide Fund for Nature, Gland, Switzerland

Spot-billed Pelican (Pelecanus philippensis) in Stung Sen Ramsar Site, Cambodia © Vong Vutthy

Figure A5.1.

Species richness of inland wetland-dependent species (fish, molluscs, odonates and crabs only) in Indo-Burma sub-catchments. Source. Allen et al. (2012). © IUCN.



Coordinate system: World Cylindrical Equal Area
Source: IUCN Indo-Burma Freshwater Biodiversity Assessment
The boundaries and names shown and the designations used on this map do not imply any official endorsement, acceptance or opinion by IUCN

A6 GLOBAL THREAT STATUS OF WETLAND-DEPENDENT SPECIES

Key messages

- Knowledge of the global threat status of wetland-dependent species is poor, with many being "Data Deficient".
- 12% of over 7,000 wetland-dependent animal species assessed in the Indo-Burma region are at risk of extinction (globally threatened).
- The most globally threatened animal taxa are marine turtles (80% globally threatened), marine mammals (39%), corals, sea anemones & jellyfish (29%) and freshwater Reptilia (turtles, snakes and crocodiles) (23%).
- The populations of many globally threatened species are in long-term decline.

Since 1964 the IUCN Red List of Threatened Species has assessed the risk of extinction of species of animals, plants, corals and fungi. Red List species categories are: Critically Endangered (CR), Endangered (EN), Vulnerable (VU) – together these three categories are considered globally threatened with extinction – Near Threatened (NT), Least Concern (LC), Data Deficient (DD), Extinct (EX) and Extinct in the Wild (EXW).

To date, globally over 142,500 species have been assessed, with more than 40,000 (28%) of these species considered to be threatened with extinction (CR, EN, VU). This includes 41% of amphibians, 37% of sharks and rays, 33% of reef building corals, 26% of mammals and 13% of birds.

Global threat status of wetland-dependent species in the Indo-Burma region

There is insufficient knowledge of many wetland-dependent species in the Indo-Burma region for their global threat status to be assessed. For example, Allen et al. (2012) reported that for some inland wetland-dependent taxa (Fish, Odonata, Molluscs, Plants, Crabs, Amphibians, Birds and Mammals only) over one-third (34%) were "Data Deficient". The poorest extent of knowledge was for crabs (56% species Data Deficient), fish (44%), molluscs (33%) and amphibians (32%).

Of the 7,030 species in the Indo-Burma region which have a Red List global threat status assessed, 842 (12%) are globally threatened (CR, EN, VU) (Table A6.1). Of these, 119 species (1.7%) are Critically Endangered, 254 (3.6%) are Endangered and 469 (6.7%) are Vulnerable.

Overall, the global threat status of animal species in the Indo-Burma region is relatively low (12% globally threatened) compared with the global average (28%). However, there are major differences in the global threat status of different animal taxa in the region (Table A6.1; Figure A6.1). Of these, 113 species (1.7%) are Critically Endangered, 252 (3.6%) are Endangered and 464 (6.7%) are Vulnerable.

The highest global threat levels are for marine turtles (80% globally threatened), marine mammals (39%), corals, sea anemones & jellyfish (29%) and freshwater Reptilia (turtles, snakes and crocodiles) (23%). The lowest global threat levels in the Indo-Burma region are for dragonflies (4%), fish (7%), molluscs (9%), crabs and shrimps (10%) and waterbirds (10%).

However, these species-level assessments may underestimate the level of extinction threat at the finer-scale biogeographic population level. For example, although at the species level, only 10% of waterbirds are considered globally threatened in Indo-Burma (Table A6.1), the biogeographic populations of almost half (47%) of all species of waterbirds in the region (regardless of threat status) are in decline (see Indicator A8).

For plants, the global threat status of species depending on wetlands has not been separately assessed for the Indo-Burma region, as it is difficult to identify which plant species are and are not wetland-dependent. Of 2,979 plant species assessed in Indo-Burma, 522 (18%) are globally threatened. Of 252 aquatic plant species assessed in Indo-Burma only five (2%) were globally threatened (Landsdown 2012).

Extinctions

The Indo-Burma region is the last known area for two wetland-dependent bird species now considered likely to be extinct: The Critically Endangered (CR) Pink-headed Duck *Rhodonessa caryophyllacea* has not been confirmed in the wild since 1949 (Tordoff et al. 2008); and possibly also the Critically Endangered (CR) White-eyed River Martin *Eurochelidon sirintarae*. The Gharial *Gavialis*

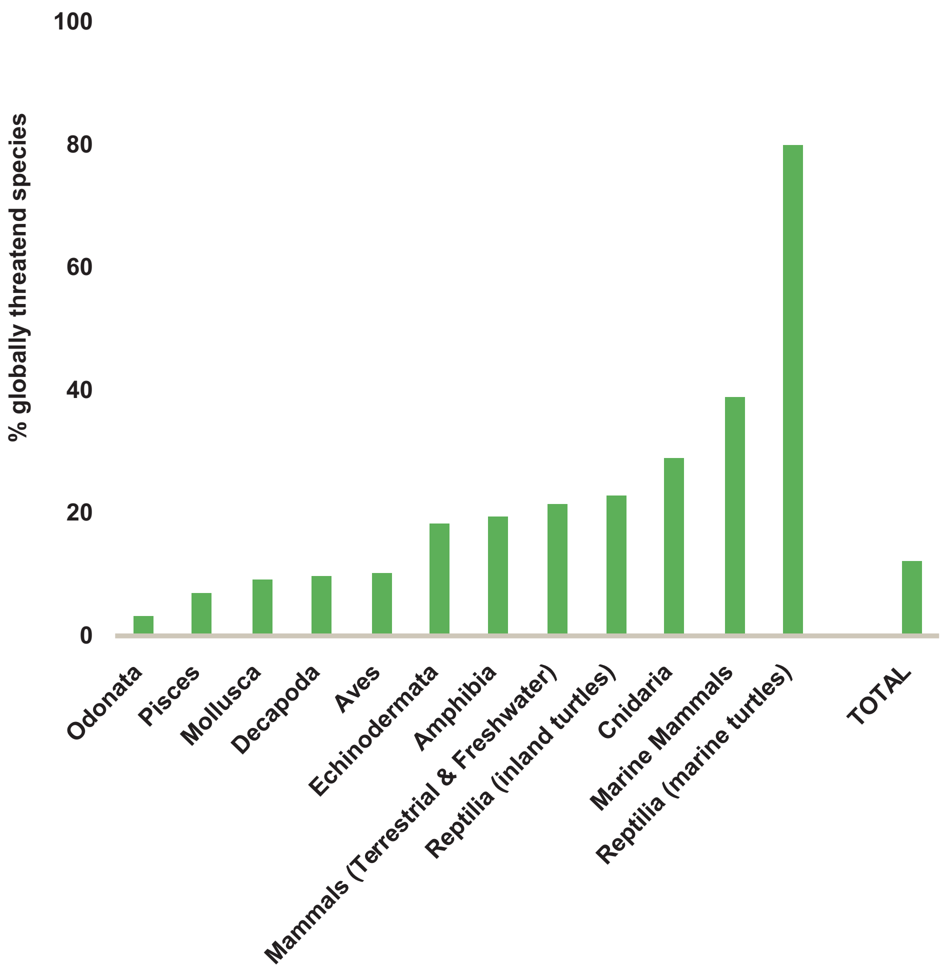
Table A6.1

Numbers and percentages of globally threatened species (CR, EN, VU) of different animal taxa in the Indo-Burma region.

Taxon		No. of species					
English name	**Scientific name**	**No. species Red List assessed**	**Critically Endangered (CR)**	**Endangered (EN)**	**Vulnerable (VU)**	**Total globally threatened**	**% globally threatened**
Molluscs	Mollusca	695	12	16	37	65	9.4
Crabs and shrimps	Decapoda	324	0	12	20	32	9.9
Dragonflies	Odonata	534	3	4	12	19	3.6
Fish	Pisces	3423	39	88	123	250	7.3
Amphibians	Amphibia	383	4	35	35	74	19.3
Inland Turtles, Snakes & Crocodiles	Reptilia	309	24	22	25	71	23
Marine Turtles	Reptilia	5	1	1	2	4	80
Waterbirds	Aves	226	3	12	8	23	10.2
Mammals (Terrestrial & Freshwater)	Mammalia	479	21	42	40	103	21.5
Marine Mammals	Mammalia	36	5	5	4	14	38.9
Corals, sea anemones, jellyfish	Cnidaria	562	1	10	153	164	29.2
Star fish and sea urchins	Echinodermata	54	0	5	5	10	18.5
Total		**7,030**	**113**	**252**	**464**	**829**	**11.9**

Figure A6.1

Numbers and percentages of globally threatened species (CR, EN, VU) of different animal taxa in the Indo-Burma region.



gangeticus (CR) is now considered extinct in the Indo-Burma region: it was last recorded in 1927 in the Shweli River, Myanmar. The False Gharial *Tomistoma schlegelii* (VU), may also be extinct in the Indo-Burma region: it was last recorded in the region in the 1990s in Southern Thailand.

Trends in the status of globally threatened species in Indo-Burma

The Red List Index (RLI) calculates trends over time in the global threat status of species. An RLI has not yet been calculated specifically for wetland-dependent species in the Indo-Burma region. However, there are indications from other RLI analyses that these species are likely to be at a progressively increasing risk of extinction in the Indo-Burma region. The RLI global threat status of wetland species in the broader Asia-Pacific region has progressively deteriorated since 1995, as has the status of all species in each of the five Indo-Burma countries.

Concerning waterbirds, the population sizes of most of the 23 biogeographic populations of globally threatened waterbird species in the Indo-Burma region for which a trend is available are decreasing: 82.6% are decreasing (or probably decreasing), 13.0% are stable (or probably stable) and only one (Oriental White Stork *Ciconia boyciana*) is probably increasing (see also Indicator A8).

Further information on the status of selected globally threatened wetland-dependant species in the Indo-Burma region is provided in Appendix 4.

Recommendations

- Seek ways of improving the knowledge-base for Red List assessment of Data Deficient species, especially crabs, fish, molluscs and amphibians, in the Indo-Burma region.

- Develop national globally threatened species conservation/action plans in the Indo-Burma region, with a priority for Critically Endangered species.

- Undertake a Red List Index analysis of trends in globally threatened wetland-dependent species in the Indo-Burma region.

References

Allen, D.J., Smith, K.G., and Darwall, W.R.T. (Compilers). 2012. The Status and Distribution of Freshwater Biodiversity in Indo-Burma. Cambridge, UK and Gland, Switzerland: IUCN

Lansdown, R. 2012. The conservation of aquatic and wetland plants in the Indo-Burma Region. In D. J. Allen, K.G. Smith and W.R.T. Darwall (Comp.). The status and distribution of freshwater biodiversity in Indo-Burma. Cambridge U.K. and Gland Switzerland. IUCN. p114-123.

Tordoff, W.W., Appleton, T., Eames, J.C., Eberhardt, K., Hla, H., Ma, K.M., Zaw, S.M., Moses, S. & Aung, S.M. 2008. The historical and current status of Pink-headed Duck Rhodonessa caryophyllacea in Myanmar. Bird Conservation International 18: 38–52.

Data sources

IUCN Red List of Threatened Species. https://www.iucnredlist.org/search (accessed June 2021)

IUCN Red List Index (RLI). https://www.iucnredlist.org/assessment/red-list-index (accessed 24 January 2022).

A7 TRENDS IN WETLAND-DEPENDENT SPECIES IN RAMSAR AND EAAFP FLYWAY NETWORK SITES

Key messages

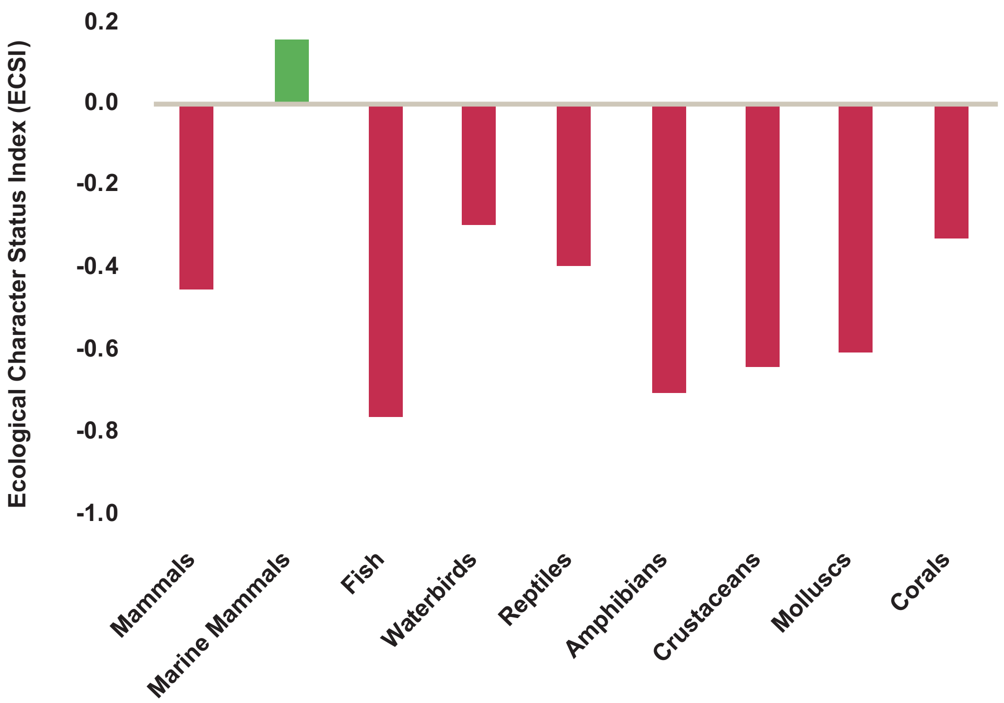
- There are widespread declines reported in the populations of wetland-dependent species in Indo-Burma Ramsar and Flyway Network Sites.
- Declines are reported as being more widespread in inland than in coastal sites.

A qualitative, expert opinion, assessment of the population size trends of a range of wetland-dependent animal taxa is provided by Zöckler, et al. (2021b) for the 40 designated Ramsar/EAAFP Flyway Network (FNS) Sites in the Indo-Burma region.

Almost all wetland-dependent animal taxa (mammals, fish, waterbirds, reptiles, amphibians, crustaceans, molluscs, corals) are assessed as declining in more Ramsar/FNS Sites than increasing, with most widespread declines being for fish, amphibians, crustaceans and molluscs (Figure A7.1). Only marine mammals were assessed as having an overall positive trend. The trend reported for waterbirds is consistent with the overall trends in the biogeographic populations of waterbirds depending on the Indo-Burma region (see Indicator A8).

Figure A7.1

Trends in the status of wetland-dependent animal taxa in Indo-Burma Ramsar/FNS Sites. Source. Data from Zöckler, et al. (2021b).



Widespread declines in wetland-dependent species of different taxa are reported for both inland and coastal Ramsar/FNS Sites, but declines reported across almost all taxa are more widespread for inland than for coastal Ramsar/FNS Sites (Figure A7.2).

Recommendations

- Address the drivers of wetland deterioration causing the deterioration in the ecological character of all wetlands, especially of designated Ramsar Sites.
- Implement site-level management planning to improve the status of wetland-dependent species in designated Ramsar and Flyway Network Sites.

References

Zöckler, C. et al. 2021b. Indo-Burma Ramsar and Flyway Network Site Descriptions. Unpublished report to IUCN, Bangkok, Thailand.

Data analyses

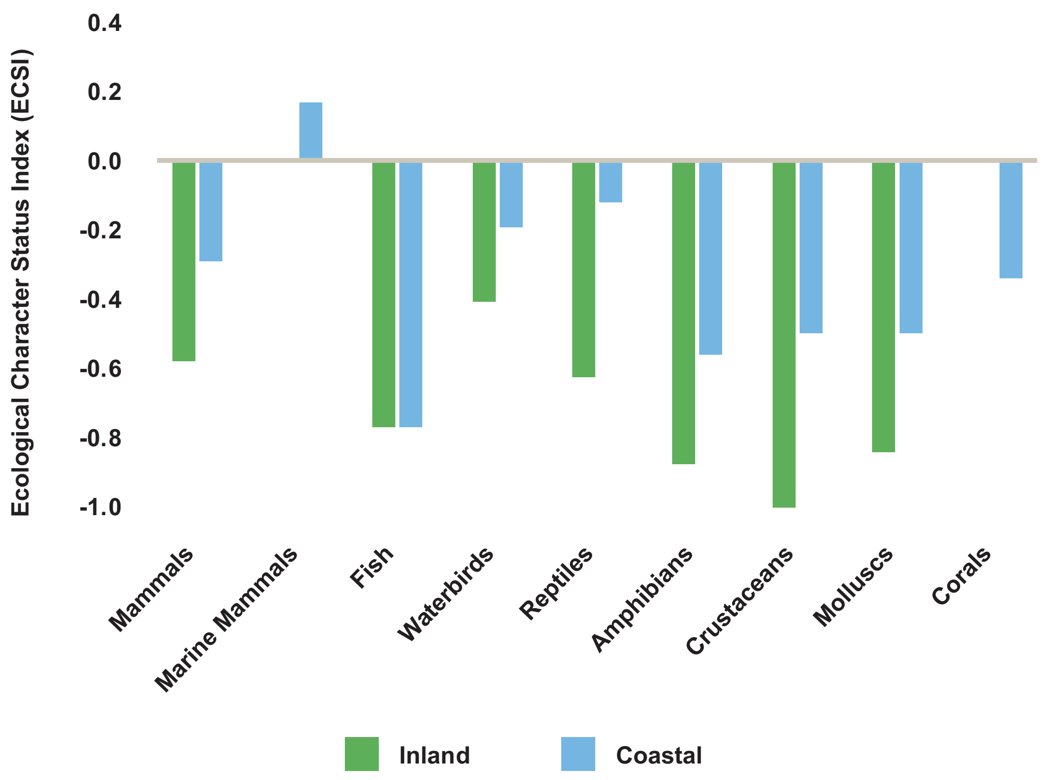
The Ecological Character Status Index (ECSI) calculates a simple, comparable, metric of status and trends of wetlands and wetland-dependent species (see e.g. Butchart et al. 2010; Davidson et al. 2020). The ECSI considers the number of stable records as well as the numbers of decreasing (NDEC) and increasing (NINC) records. The ECSI is calculated as:

$$ECSI = \frac{N_{INC} - N_{DEC}}{N_{TOTAL}}$$

The ECSI ranges from +1 (all increasing) to -1 (all decreasing).

Figure A7.2

Trends in the status of wetland-dependent animal taxa in inland and coastal Indo-Burma Ramsar/FNS Sites (data from Zöckler, et al. 2021b).



A8 TRENDS IN WATERBIRD BIOGEOGRAPHIC POPULATIONS

Key messages

- Waterbird biogeographic populations in the Indo-Burma region are in trouble: almost half (47%) of populations for which a trend is available are in decline, with only 18% increasing.
- The populations of almost all globally threatened waterbirds in the Indo-Burma region are in decline.
- Over one-third (37.6%) of waterbird populations in the Indo-Burma region of species considered by the IUCN Red List as not being globally threatened are also in decline.
- Population sizes and trends of most resident waterbirds in Indo-Burma are very out-of-date and urgently need to be updated.

At least 180 biogeographic populations of waterbird species occur in the Indo-Burma region. Of these, most (137 populations; 76.1%) are migratory, with 43 populations (23.9%) being resident (i.e. non-migratory).

The status of these populations, as of all those using the East Asian-Australasian Flyway (EAAF), is poorly known. Assessments of trends in the population sizes of populations occurring in the Indo-Burma region are available for only 111 (61.6%) of these populations: 90 migratory populations and 21 resident populations.

Overall trends of waterbird biogeographic populations in the Indo-Burma region

Many of the waterbird biogeographic populations in the Indo-Burma region for which a trend is available are decreasing, with more populations decreasing than increasing (Table A8.1; Figure A8.1). Overall, 46.8% of populations are decreasing, with 35.2% stable and only 18.0% increasing (Ecological Character Status Index (ECSI) -0.288).

The status of almost all categories of waterbird populations is declining (negative ECSIs) (Table A8.2; Figure A8.2). The worst status is for all resident populations (ECSI -0.857), populations of globally threatened species (ECSI -0.720) especially their resident populations (ECSI -0.923), and resident populations of Near Threatened (NT) and Least Concern (LC) species (each ECSI -1.000). For migratory populations, 37.8% are in decline, with 40.0% stable and 22.2% increasing (ECSI -0.156) (Table A8.2; Figure A8.2).

The only categories of waterbird populations with a slightly positive ECSI status are migratory Anatidae (ducks and geese) (ECSI +0.083) and migratory populations of NT species (ECSI +0.071).

There are considerable differences in the population trends of migratory waterbirds of different families. For example, half (50%) of migratory shorebird populations (Charadriidae, Haematopodidae, Recurvirostridae, Scolopacidae) are decreasing (ECSI -0.444), but only 20.8% of migratory ducks, geese and swans (Anatidae) (ECSI +0.083) and 33.3% of migratory herons and egrets (Ardeidae) (ECSI -0.444) (Table A8.2).

Table A8.1

Biogeographic population trends of migratory and resident waterbirds in the Indo-Burma region.

	Number of biogeographic populations		
	Decreasing	Stable	Increasing
Migratory	34	36	20
Resident	18	3	0
Total	**52**	**39**	**20**

Figure A8.1

Trends in the status of waterbird biogeographic populations in the Indo-Burma region.

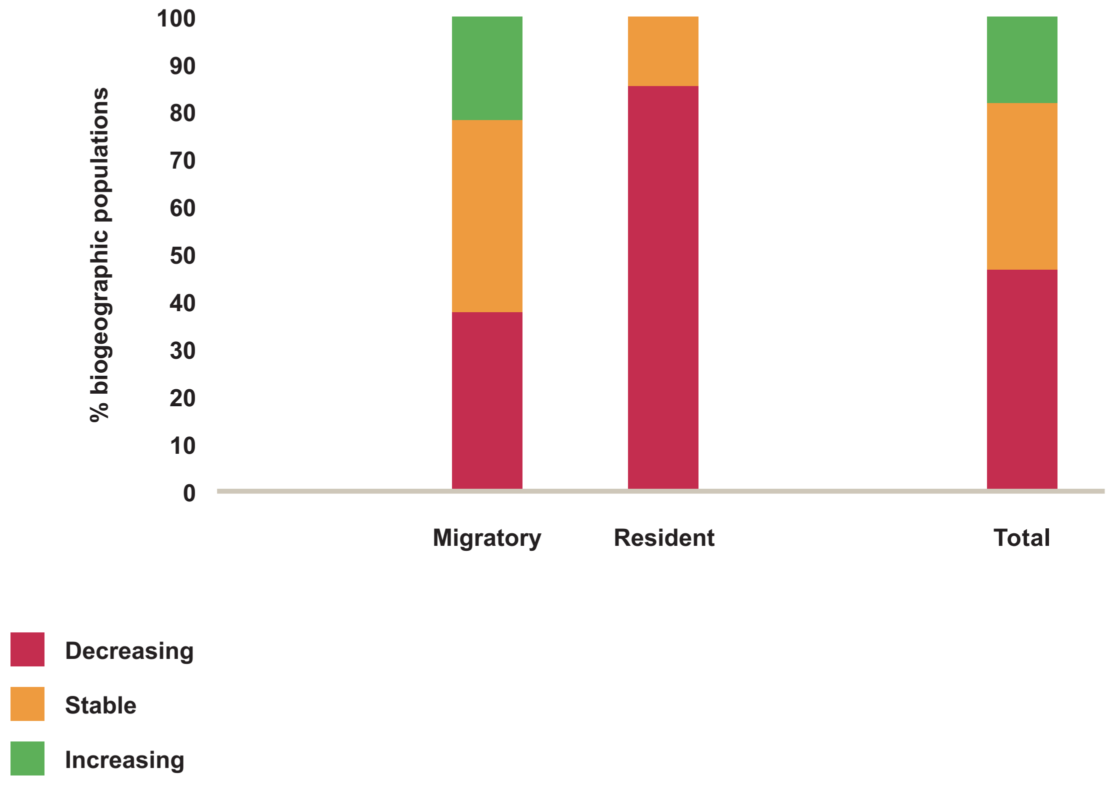


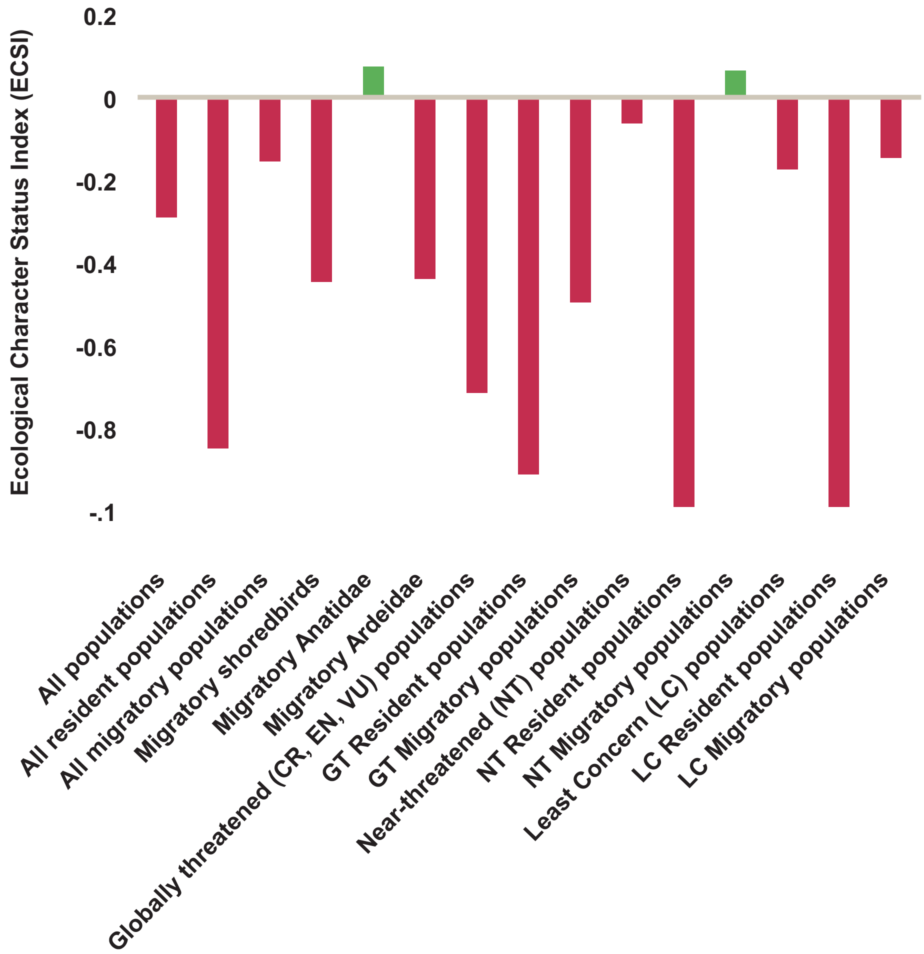
Table A8.2

Ecological Character Status Indices (ECSI)s of different categories of waterbird biogeographic populations in the Indo-Burma region. The ECSI ranges from +1 (all populations increasing) to -1 (all populations decreasing).

Waterbird biogeographic population category	No. of populations with trend assessment	Ecological Character Status Index (ECSI)
All populations	**111**	**– 0.288**
All resident populations	21	– 0.857
All migratory populations	90	– 0.156
Migratory shorebirds	36	– 0.444
Migratory Anatidae	24	+ 0.083
Migratory Ardeidae	9	– 0.444
Globally threatened (CR, EN, VU) populations	**25**	**– 0.720**
Resident populations	13	– 0.923
Migratory populations	12	– 0.500
Near-threatened (NT) populations	**16**	**– 0.063**
Resident populations	2	– 1.000
Migratory populations	14	+ 0.071
Least Concern (LC) populations	**69**	**– 0.174**
Resident populations	5	– 1.000
Migratory populations	64	– 0.141

Figure A8.2

Ecological Character Status Indices (ECSI) of different categories of waterbird biogeographic populations in the Indo-Burma region. The ECSI ranges from +1 (all populations increasing) to -1 (all populations decreasing).



These findings of declining waterbird populations in Indo-Burma are consistent with published findings from other parts of the East Asia-Australasia Flyway, with rapid declines in migratory populations reported from several countries. For example, Amano et al. (2010) reported that, for shorebirds migrating through Japan, 12 species out of 41 (29.3%), and 16 out of 42 (38.1%) populations have declined significantly during spring and autumn migration, respectively. Similarly, declines in many shorebird populations have been reported from Australia (Clemens et al. 2016), the Yellow Sea (Studds et al. 2017) and East & Southeast Asia (McInnon et al. 2012). Trends in population sizes of other waterbird taxa in the region have been less reported.

Trends of biogeographic populations of IUCN Red List species in the Indo-Burma region

Twenty-three of the 24 biogeographic populations of globally threatened waterbird species (IUCN Red List categories Vulnerable (VU); Endangered (EN); and Critically Endangered (CR)) in the Indo-Burma region have population trends available (Appendix 6). Most (82.6%) of these populations are decreasing (or probably decreasing), with 13.0% stable (or probably stable) (ECSI -0.720) (Table A8.2). The population of only one globally threatened waterbird (Oriental White Stork *Ciconia boyciana*; EN) is probably increasing.

The populations of all four CR species are declining, as are nine populations of EN species. Eight of the 12 migratory populations of globally threatened species are declining (or probably declining). All 12 populations of resident globally threatened species are declining. At least 11 populations of globally threatened species appear to be in long-term decline.

A population trend assessment is available for 15 of the 21 populations of Near Threatened (NT) waterbird species. More Near Threatened populations are decreasing than are increasing: 31.3% of these populations are decreasing, 43.7% are stable and 25.0% are increasing (ECSI -0.630).

Most waterbird species (132; 73.3%) occurring in the Indo-Burma region are assessed by the IUCN Red List as being of Least Concern (LC). Their population status is poorly known, with population trend assessments available for only 68 (51.5%) of these populations. Knowledge is particularly poor for resident populations of LC species, with trend assessments available for only five (18%) of 28 populations.

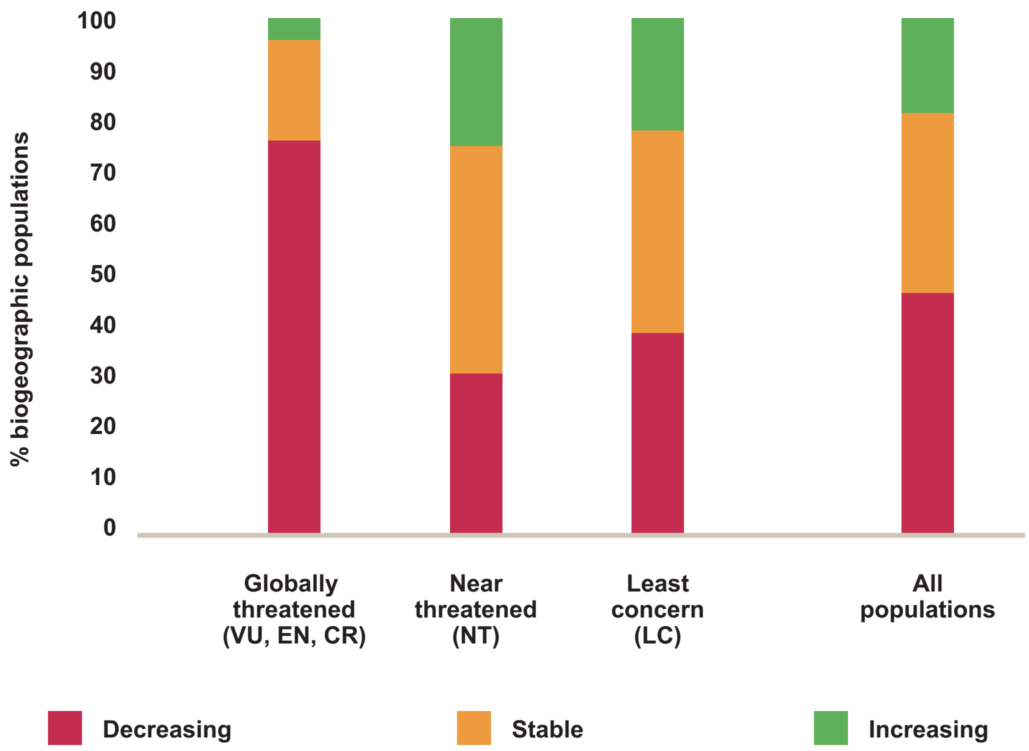
For LC populations with a trend assessment, over one-third (39.1%) are decreasing with 39.1% stable and 21.8% increasing (ECSI -0.174). 37.5% of assessed migratory populations are decreasing (ECSI -0.141), as are 60.0% of assessed resident populations (ECSI -1.000).

At the species level, the global threat status of waterbirds in the Indo-Burma region (10% of species globally threatened) is low, compared with that of many other taxa in the region (Indicator A6). However, waterbird population trends at the biogeographic population level show a different, and considerably worse, story for the Indo-Burma region (Figure A8.3).

Although it is not surprising that almost all (76.0%) of Indo-Burma populations of globally threatened species are decreasing, it is of concern that 31.3% of Indo-Burma populations assessed by the IUCN Red List as Near Threatened (NT) are decreasing (ECSI -0.063). Furthermore, 39.1% of Indo-Burma populations of species assessed by the Red List as of Least Concern (LC) are also decreasing (ECSI -0.174) (Figure A8.3).

Figure A8.3

Trends in the status of waterbird biogeographic populations of different IUCN Red List species categories in the Indo-Burma region.



Overall, over one-third (37.6%) of waterbird biogeographic populations in the Indo-Burma region of species currently assessed by the IUCN Red List as not being globally threatened are decreasing (ECSI -0.153). These populations are at increasing risk of extinction.

Drivers of waterbird population declines in the Indo-Burma region

It is widely reported that the major driver of waterbird population declines on the East Asia-Australasia Flyway is the continuing drainage and conversion of both inland and coastal wetlands to other land-uses such as agriculture, dams and reservoirs and urban and industrial development. This is well documented particularly for the coasts of the Yellow Sea (e.g. Murray et al. 2012) and inland China and East and Southeast Asia intertidal habitats (Mackinnon et al. 2012). Long-term and continuing inland and coastal wetland conversion and loss is widely reported for Indo-Burma countries (e.g. UNEP 2004) but is less well documented.

Long-term, widespread and largely illegal hunting of waterbirds in the EAAF region, including Indo-Burma, is increasingly recognised as an additive driver to habitat loss driven declines in waterbird populations (Gallo-Cajiao et al. 2020), but is not yet well documented. However, for example, in the Indo-Burma region Zockler et al. (2010) considered hunting in Myanmar as the main driver of the continuing decline of the population of the Critically Endangered Spoon-billed Sandpiper.

Recommendations

- Identify and implement policy and management interventions to reduce the impacts of the key drivers (habitat loss; illegal hunting) of the deterioration in the status of waterbird populations in the Indo-Burma region.

- Establish ways and means to update waterbird population sizes and trends of resident waterbird populations on the East Asia-Australasia Flyway including in the Indo-Burma region.

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Data analysis

In its Waterbird Population Estimates, Wetlands International (WI) codes waterbird biogeographic population trends as either Decreasing (DEC), stable (STA), Increasing (INC) or unclear/unknown (UNC). For populations with a trend assessment of more than one of these trend categories (e.g. DEC/STA) for analyses the trend has been allocated to each of these categories for that population.

The Ecological Character Status Index (ECSI) calculates a simple, comparable, metric of status and trends of wetlands and wetland-dependent species (see e.g. Butchart et al. 2010; Davidson et al. 2020). The ECSI considers the number of stable records as well as the numbers of decreasing and increasing records. The ECSI is calculated as:

$$ECSI = \frac{N_{INC} - N_{DEC}}{N_{TOTAL}}$$

The ECSI ranges from +1 (all increasing) to -1 (all decreasing).

Data limitations

A population trend is available for only 111 (58.9%) of these biogeographic populations occurring in the Indo-Burma region, i.e. there is no trend available for assessment for over 40% of these populations. The situation for resident populations is worse than for migratory populations: no trend assessment for 53.5% of resident populations compared with no trends for 37.2% of migratory populations.

Whilst the EAAFP 1st Conservation Status Review (CSR1) has now recently provided up-to-date trend assessments for migratory populations, there have been no such recent updates for most resident populations: almost all of these date from the early–mid 2000s at the latest and so are now considerably out-of-date. There is an urgent need to update population sizes and trends for these resident populations on the EAAF and the Indo-Burma region.

3B STATUS AND TRENDS OF VALUES AND SERVICES – SUMMARY

Key messages

- Eighteen indicators form the basis of the status and trends of wetland ecosystem services and the values that they provide to the human societies across the Indo-Burma region.

3.B Status and Trends of values and services	
B1 Wetland values	↓
B2 Provisioning service – rice production	↑
B3 Provisioning service – fisheries and aquaculture	↑
B4 Provisioning service – other food production	→
B5 Provisioning service – water use	↓
B6 Provisioning service – energy generation	↑
B7 Provisioning service – other (timber, medicines, ornamentals, etc.)	○
B8 Regulating service – climate regulation	↓
B9 Regulating service – water regulation	↓
B10 Regulating service – hazard regulation	↓
B11 Regulating service – disease and pest regulation	↓
B12 Regulating service – pollination	↓
B13 Regulating service – erosion regulation	↓
B14 Regulating service – water purification	→
B15 Cultural service – recreation and tourism	→
B16 Cultural service – education	↓
B17 Cultural service – religious and spiritual	↓
B18 Supporting services	↓

Key messages

Indicator	Status & Trend	Key Messages
B1 Wetland values	↓	• Wetlands are essential to the well-being of human society across the Indo-Burma region. The degradation of wetlands erodes the contributions that nature makes to people and comprises the health and well-being of society. • Numerous studies have been conducted across the region, from the site to sub-regional level, to evaluate and understand the values of wetland ecosystems. Often these studies have focused on a subset of values and used economic valuation techniques to demonstrate value. • Further work is required to ensure that the plurality of values and multiple world views regarding human-wetland interactions are captured and integrated into decision-making, planning and policies across the region. • Often ecosystem services, such as rice production or aquaculture, are prioritized to the detriment of other ecosystem services. Robust efforts are required to ensure that negative and positive trade-offs among ecosystem services are understood and that win-win scenarios are delivered. • Reporting on the ecosystem services of Ramsar Sites, as captured in the RIS, requires improvement to ensure that their multiple values area captured and clearly identified as elements of their ecological character.
B2 Provisioning service – rice production	↑	• The production of rice is an essential source of nutrition and income for the people of the Indo-Burma region, and a major export commodity, with Myanmar, Thailand and Viet Nam amongst the world's largest rice exporters. • The total area of land under rice production peaked in 2010 and then has remained relatively static since 2010, while at the same time, average rice yields/hectare increased. • The actual location of land under rice cultivation area has also shifted somewhat as rice fields in some areas are converted to other uses (urban sprawl, aquaculture ponds, expansion of rubber growing, etc.) and other land, including natural wetlands, is brought under rice production in other areas.
B3 Provisioning service – fisheries and aquaculture	↑	• Capture fisheries and increasingly aquaculture play a vital role in the provision of protein, livelihoods and economic resources to a significant percentage of the population of the region. • The Mekong River basin supports one of the largest inland transboundary fisheries in the world and is a significant component of food security in the region. Climate change, dam construction and operation and hydro-geomorphological changes all represent challenges to the long-term sustainability of inland capture fisheries.

		• A lack of accurate or consistent approaches to data collection and the involvement of local ecological knowledge undermines the evaluation of importance and functioning of fisheries across the region.
B4 Provisioning service – other food production	→	• Wetlands in the Indo-Burma region provide human society with a great variety of food resources. Without the provision of these resources, the health and well-being of society would be severely compromised. • In addition to rice, many other plants and animals are harvested from wetlands and provide essential components of the human dietary needs. • Whilst wetland provisioning services undoubtedly contribute greatly to human well-being across the region, unsustainable exploitation has resulted in some negative impacts. Concerns have been raised regarding intensive duck rearing, the proliferation of invasive species and pollution of the aquatic environment through intensification of food production.
B5 Provisioning service – water use	↓	• Agriculture is the single highest user of water withdrawn from wetlands. Despite a relative abundance of water resources, seasonal differences, driven by the prevailing climate, influence the availability of water in many parts of the region. • The area of land equipped for irrigated agriculture appears to be stable, however accurate data are limited for the last ten years. • Whilst wetland provisioning services undoubtedly contribute greatly to human well-being across the region, unsustainable exploitation has resulted in some negative impacts. Concerns have been raised regarding the challenges around competing water resource demands and the sustainability of the current trajectory of water uses.
B6 Provisioning service – energy generation	↑	• Electricity generation through hydropower makes a substantial contribution to energy resources across the region. Electricity generation from hydropower will have an impact on the future development trajectory of the countries • Hydropower development can generate impacts on the physical, ecological and human elements of river ecosystems. Any future hydropower projects need to consider these issues fully and objectively, including cumulative impacts of multiple projects within the same river system, and transboundary impacts in shared river systems.
B7 Provisioning service – other (timber, medicines, ornamentals, etc.)	○	• Many wetlands across the region provide a variety of other materials and products which are utilized by local communities and are fundamental to their quality of life. • The integration of multiple wetland products, such as medicinal plants, fuelwood and timber into wetland agricultural systems can deliver multiple benefits. • The traditional knowledge of the medicinal uses of wetland plants is at risk from being lost and needs to be captured and maintained.

B8 Regulating service – climate regulation	• Wetlands in the Indo-Burma region store and sequester vast amounts of carbon, which mitigate the impact of climate change. • Land use changes and wetland degradation and loss are undermining this store and contributing to climate change. • The loss of carbon stocks from inland wetlands is considered to be a great risk due to the challenges of restoring the net climate cooling effect of these systems. • The restoration of coastal wetlands can deliver a net climate cooling effect in a relatively short time-term (less than 10 years), whereas the restoration of inland, freshwater wetlands will only achieve a net cooling effect across a decadal time-frame (potentially over 260 years). • At the local scale, wetlands can mitigate increasing air temperatures, whilst their wise use, restoration and creation can contribute to reduce human mortality rates and improve the quality of life for local communities.
B9 Regulating service – water regulation	• Many wetlands play a critical role in recharging groundwater across the Indo-Burma region. This is particular the case for floodplain wetlands in the great river systems of the region. • The sustainable management of wetlands to facilitate groundwater recharge should be considered in the context of wider, linked socio-hydrological systems to understand the systemic interactions and to avoid undesired consequences. • The role that different wetland types play in recharging groundwater and regulating surface water flows remains relatively poorly understood and generalizations can be inappropriate. • There is good evidence that well managed wetlands can regulate surface water flows, reducing the impacts of flooding and droughts downstream. • Climate change and other anthropogenic pressures are altering patterns and rates of groundwater recharge from wetlands and the role in wetlands in regulating surface water flow. However, the implications of these remain unclear and require greater investigation.
B10 Regulating service – hazard regulation	• Wetlands from the high-altitude headwaters, through the vast floodplains to the coastal systems all have the potential to mitigate flooding downstream through storing water, reducing the magnitude of floods and desynchronizing flood peaks. • The drainage and conversion of wetlands across the various river basins of the Indo-Burma region will have increased flood risk and make human communities more vulnerable to flooding under a changing climate. • In the coastal zone, mangrove forests have the ability to mitigate the impacts of storm surges and provide physical refugia during time of storms.

		• Other coastal wetland systems, including seagrass beds and coral reefs attenuate the power of waves reaching the shoreline and offer some protection against storm surges. • Low-lying deltaic areas are increasingly at risk of storm surge as a result of reductions in their sediment supply reducing accretion rates, rising sea levels and increased frequency of tropical cyclones associated with climate change. The presence of intact coastal wetland systems can provide a nature-based option for the protection of vulnerable communities. • Increases in inland and coastal wetland loss and degradation will reduce the effectiveness of wetlands to mitigate hazards and potentially result in significant socio-economic impacts across the region. The protection and restoration of wetlands from the headwaters to the sea can provide cost-effective solutions to disaster risk management.
B11 Regulating service – disease and pest regulation	↓	• Wetland-dependent species, such as mosquitoes, snails and flukes, can be vectors for a range of human diseases. Well-managed wetlands can help to attenuate the threats posed from these species to humans. • Wetland degradation, pollution and inappropriate management can increase the incidence of disease and impact widely on human health. • The specific role of wetland biodiversity in moderating health risks remains poorly understood and requires significant attention from both the environmental and health sectors.
B12 Regulating service – pollination	↓	• Wetlands support abundant pollinators, such as hoverflies, bees, butterflies, birds and mammals that support plant fertilization and reproduction both within and beyond wetland ecosystems. • Agriculture, and particularly rice and cash-crop production, depend on many wetland-dependent species for pollination. • Robust scientific knowledge and local understanding of the roles and importance of pollinators is limited across the region.
B13 Regulating service – erosion regulation	↓	• Coastal wetlands, including mangroves, seagrass beds and coral reefs, can all help to prevent coastal erosion across the region. • The role of wetlands in regulating coastal erosion, particularly in the Mekong Delta region, is being undermined by wider anthropogenic and hydrogeomorphological changes in the river systems of the region. • Erosion is a natural process across the river systems of the region. Human activities are accelerating and altering fluvial erosion rates across the region. • The role of riparian or floodplain wetlands in regulating erosions is poorly understood and reported from the region.

B14 Regulating service – water purification	• Wetland are currently playing a critical role in improving water quality, whilst reducing waterborne disease and providing additional benefits in urban and rural settings across the region. • To ensure that wetlands sustainably remove pollutants requires appropriate design and management. • There is a direct link between the wise use of wetlands and human health benefits through the ability of wetlands to remove pathogens and other contaminants.
B15 Cultural service – recreation and tourism	• Before the COVID-19 pandemic, both international and domestic tourism were increasing in the region, and are starting to return again, as the pandemic wanes. Wetlands provide important destinations for this burgeoning population of tourists. • Without appropriate environmental protection, infrastructure investment, regulation and enforcement and local capacity-building, wetland tourism can quickly become unsustainable and transition from an opportunity to a threat. • The development of strategic approaches to wetland tourism needs to be cross-sectoral and ensure a balance between economic investment, social cohesion and environmental protection.
B16 Cultural service – education	• Wetland visitor and education centres across the region are providing informal learning opportunities for local, national and international people, raising awareness of wetland issues and enriching people's knowledge of environmental issues. • Informal learning is also taking place at a community scale at numerous wetlands resulting in enhanced understanding and delivery of wise use of wetlands. • Wetlands play a critical role in formal education at all levels from schools to universities.
B17 Cultural service – religious and spiritual	• Across the region, wetlands play an integral role in the religious and spiritual belief systems of millions of people. • Many spiritual and religious values are poorly recognized in government policies. Understanding and integrating spiritual beliefs into wetland policies and management planning is critical to maintaining their important cultural and relational values. • Spiritual, cultural and religious wetland-related festivals are of vast importance across the region. The sustainable management of these festivals, through the application of wise use principles, is critical if undesirable and negative unintended consequences are not to occur.
B18 Supporting services	• Supporting services are poorly recognized and evaluated in the majority of studies conducted on wetland ecosystem services in the region. Where assessed, the emphasis is characteristically on the provision of habitat, soil formation and nutrient cycling.

• Supporting services are critical to maintain the functioning of wetlands and the delivery of provisioning, regulating and cultural services and need to be better considered in decision-making.

Recommended responses for decision-makers

Indicator	Recommended responses
B1 Wetland values	• In line with the IBRRI Strategic Plan Target 2.4, document best practices in wetland management from the Indo-Burma Region, particularly those that robustly integrate multiple values and approaches to managing trade-offs, and share the knowledge widely across the region. • Ensure that consistent and robust approaches are used to understand the ecosystem services and multiple values of the Ramsar sites so that best practices in wetland management can those target the multiple values. • Create more awareness of little-known/little-understood and therefore under-appreciated values of wetlands through CEPA efforts.
B2 Provisioning service – rice production	• In line with the IBRRI Strategic Plan Target 1.2, using existing data held by government agencies, conduct targeted research on the impacts of intensive and extensive rice production methods and the possible co-benefits of different farming approaches, including enhancing biodiversity. • In line with the IBRRI Strategic Plan Target 3.2, ensure that the contribution of wetlands to wider policy frameworks, such as food security, poverty reduction and human health is fully integrated through dissemination of best-practice examples. • Through CEPA programmes, highlight both the implications of maximizing rice production at the expense of other wetland ecosystem services and the negative impacts of intensification of rice production on natural wetlands.
B3 Provisioning service – fisheries and aquaculture	• There is limited information available on the spatial distribution and area of aquaculture ponds across the region, therefore efforts are needed to address this data gap, particularly with regards to shifts from rice farming to aquaculture. • Develop guidance and recommendations on integrated fish-rice systems and ecosystem-based approaches to sustainable fish production. • In line with the IBRRI Strategic Plan Target 3.2, ensure that the contribution of wetlands to wider policy frameworks, such as food security, poverty reduction and human health is fully integrated through dissemination of best-practice examples. • Enhance transboundary fisheries management measures, including the effectiveness of seasonal closures and fish conservation areas; the protection of migratory fish pathways and spawning grounds; and improving fisheries governance at local, national, and transboundary scales based on robust knowledge.

B4 Provisioning service – other food production	• Ensure that the breadth of food substances harvested from wetlands is fully understood and the potential impacts of their provision are evaluated. • In line with the IBRRI Strategic Plan Target 3.2, ensure that the contribution of wetlands to wider policy frameworks, such as food security, poverty reduction and human health is fully integrated through dissemination of best-practice examples.
B5 Provisioning service – water use	• Improve the availability and quality of data on water usage especially by agriculture. Use the improved data to assess likely impacts of water abstraction on wetland systems. • Pursue effective and sustainable water agricultural demand management programs, particularly with regards to rice production, that reduce abstraction rates and minimize the impacts on other wetland systems. • Promote transition away from rice-growing towards less water-intensive and more profitable forms of agriculture • In line with the IBRRI Strategic Plan Target 3.2, ensure that the contribution of wetlands to wider policy frameworks, such as food security and water resource management is fully integrated through dissemination of best-practice examples
B6 Provisioning service – energy generation	• In line with the IBRRI Strategic Plan Target 1.1, conduct specific research into the provision of energy through hydropower and the associated environmental and social impact of further development of this ecosystem service, including cumulative impacts of multiple hydropower schemes in the same river system, and transboundary impacts in shared river systems. • Energy generation through hydropower needs to be set within a wider renewable energy generation strategy for the region and capitalizing on other forms of renewable energy production including solar and wind, as well as improvements in energy efficiency and conservation; and regional power trading supported by interconnectivity of the power grids of the Indo-Burma countries, in order to meet sustainable development targets and to address challenges around the water-energy-food nexus.
B7 Provisioning service – other (timber, medicines, ornamentals, etc.)	• Promote the wise use of native medicinal plants and ensure cultural and knowledge links are protected and maintained.
B8 Regulating service – climate regulation	• Protect existing wetlands to ensure that carbon stocks are retained and not released into the atmosphere. Develop programmes of wetland restoration that form part of climate change mitigation strategies. • Ensure that improved estimates of existing carbon stocks in different wetland types are generated from studies across the region. • Evaluate the success of carbon accumulation and net climate cooling of wetland restoration projects in both coastal and inland areas. • Ensure that wetlands are considered as mitigation for increasing local air temperatures and are effectively integrated into human health strategies and policies in both rural and urban environments.

B9 Regulating service – water regulation	• Avoid making generalizations about the role of wetlands in moderating groundwater recharge and influencing surface water flow. Different wetlands, in different locations, may function very differently and empirical evidence should be used to demonstrate this. • Improve knowledge on the hydrological functioning of different wetlands and their linkages with wider socio-ecological systems. • Future proof human society from the potential impacts of climate change across the region through integrating the hydrological functioning of wetlands in cross-sectoral policies and decision-making, particularly around the water-food-energy nexus.
B10 Regulating service – hazard regulation	• Improve understanding of the role of different wetland types across fluvial catchments in the mitigation of flooding. • Improve the understanding of how coastal wetlands can mitigate storm surges around the different coastal areas and ensure that appropriate wetland management interventions are targeted where maximum benefits will accrue. • Continue to protect and restore wetlands from the headwaters to the coast as vital nature-based solutions within integrated disaster risk reduction strategies.
B11 Regulating service – disease and pest regulation	• Wetland management planning should consider potential risks to human health and integrated appropriate management control or mitigation strategies. • The health benefits of wetlands need to be better understood and integrated into cross-sectoral policies that embrace the optimization of ecosystem services including the management and mitigation of impacts on human health. • Specific information on individual vectors, their environmental requirements and species-specific wetland management strategies need to be developed and integrated into comprehensive cross-sectoral practices.
B12 Regulating service – pollination	• The importance of wetland dependent species to agricultural production needs to be better understood and communicated to wetland managers. • The creation of botanical diverse margins to wetland agricultural system, such as around the margins of rice paddy systems or irrigation channels, should be strongly encouraged to increase the diversity and abundance of pollinators. • The use of pesticides and the control of invasive species is essential to protect populations of pollinators.
B13 Regulating service – erosion regulation	• Protect, maintain and increase the areas of coastal wetlands, particularly mangroves and seagrass beds, to regulate accelerating rates of coastal erosion, particularly around the Mekong Delta. • Develop nature-based solutions, including floodplain reconnections, to mitigate fluvial erosion impacts and to provide additional societal benefits.
B14 Regulating service – water purification	• Wetlands can play a strategic role in the management of urban and agricultural wastewaters and should be better integrated into water management planning processes across the region. • Opportunities should be sought to create multi-benefit wetlands in urban and peri-urban environments to sustainably manage domestic, industrial and other wastewater streams.

	• Rural land use planning should consider the protection and/or restoration/ creation of areas of wetland (or integrated forest-wetland ecosystems) for the removal of sediments, nutrients and other contaminants to protect in-stream water quality and aquatic ecology.
B15 Cultural service – recreation and tourism	• Share experiences and best practice from across the region to develop site-level sustainable tourism and recreation plans and practices. • Ensure local communities and civil society organizations are involved in the planning of tourism and recreational activities and that they benefit equitably from income and investment. • Develop sustainable finance models that ensure money generated from tourism activities is invested in wetland management, monitoring and restoration.
B16 Cultural service – education	• The development of appropriate wetland education and visitor centres is to be encouraged across the region. The development of any such centre should adhere to published best-practice guidance. • Existing wetland education and visitor centres are encouraged to become part of the Wetland Link International (WLI) network and to share experiences and materials for mutual benefit. • The integration of informal education programmes with tourism activities is to be encouraged to raise awareness of wetland wise use issues. • The creation and implementation of formal wetland education programmes with local schools, colleges and universities is to be strongly recommended as way to develop future generations of wetland managers as well as to more widely raise awareness of wetlands. • Existing collaborative links among universities should be maintained and strengthen to provide benefits to students, researchers and policy-makers in order to enhance the knowledge of wetland science and wise use.
B17 Cultural service – religious and spiritual	• National and local government policies must integrate local wetland spiritual and religious values and ensure their protection. • Better attempts are needed to recognize and capture religious, spiritual and relational values, many of which are challenging to traditional resource economic approaches, so that their values can be maintained for future generations. • Tourism development that targets wetland-related spiritual and religious communities, festivals, sites or events must ensure that wise use principles are strongly applied and that negative impacts on communities, Indigenous People and wetland ecosystems are avoided.
B18 Supporting services	• Ensure that supporting services, and their linkages to other wetland ecosystem services are better understood and more robustly integrated into future assessments.

Women sell wetland fish at a fresh market in the Mekong Delta, Viet Nam © Kathryn Bimson, IUCN

B1 STATUS OF WETLAND VALUES

Key messages

- Wetlands are essential to the well-being of human society across the Indo-Burma region. The degradation of wetlands erodes the contributions that nature makes to people and comprises the health and well-being of society.
- Numerous studies have been conducted across the region, from the site to sub-regional level, to evaluate and understand the values of wetland ecosystems. Often these studies have focused on a subset of values and used economic valuation techniques to demonstrate value.
- Further work is required to ensure that the plurality of values and multiple world views regarding human-wetland interactions are captured and integrated into decision-making, planning and policies across the region.
- Often ecosystem services, such as rice production or aquaculture, are prioritized to the detriment of other ecosystem services. Robust efforts are required to ensure that negative and positive trade-offs among ecosystem services are understood and that win-win scenarios are delivered.
- Reporting on the ecosystem services of Ramsar Sites, as captured in the RIS, requires improvement to ensure that their multiple values area captured and clearly identified as elements of their ecological character.

Status of wetland values in the Indo-Burma region

Ecosystem services are the benefits people obtain from ecosystems (Millennium Ecosystem Assessment, 2005). Wetland ecosystems deliver a range of benefits across the region (see below). Even human-made wetland systems, such as rice paddies or aquaculture ponds, will still deliver ecosystem services. However, often the maximisation of one service (such as intensive rice production through multiple cropping, water abstraction and application of pesticides, herbicides and fertilisers) will be detrimental to the delivery of other more diverse ecosystem services (Everard et al., 2022). A key challenge to the wise use of wetlands is the management of trade-offs among services and the delivery of win-win scenarios (Howe et al., 2014).

Understanding wetland ecosystem services and values

Across the Indo-Burma region, people value nature for its important contribution to their cultural, spiritual, psychological, physical and economic well-being (Brander et al., 2012; Loc et al., 2020; Dang et al., 2021). Human interactions with nature are shaped by the diversity of people's values and value systems, resulting in significant variation in the way economic and non-monetary values are attached to the contributions that wetlands make to human societies in the region (IPBES, 2018). Whilst many of the categories considered under IPBES assessments map closely onto the ecosystem services framework (Millennium Ecosystem Assessment, 2005), this conceptual approach broadens the scope beyond the widely-adopted ecosystem services framework by embracing different knowledge systems, including Indigenous knowledge, and multiple world views regarding human-nature interactions (Kumar et al. 2020). Consequently, assessments of ecosystem services undertaken across the Indo-Burma region may often only report on a subset of the benefits provided by wetlands and do not always reflect the different value systems that human societies consider (McInnes et al., 2017). Similarly, the uptake of ecosystem service concepts or the integration of broader value systems into wetland environmental policies and planning is uneven across the region (Loc et al. 2020). There remains a tendency to attempt to monetize ecosystem services using flawed economic valuation techniques, and often those that are relatively simple to relate to commodity markets, rather than to consider different value systems or link benefits to beneficiaries (Loc et al., 2020).

For instance, a study on the impacts of climate change in the Lower Mekong Basin principally used economic values for water yield and rice production to understand water-related impacts on the ecosystem services (Trisurat et al., 2018). Similarly, a study conducted on Inle Lake Ramsar Site in Myanmar focussed primarily on a comprehensive list of provisioning services and excluded cultural and supporting services (Karki et al., 2018). In Thailand, the multiple values of wetland ecosystems are widely acknowledged, but they still remain understudied and undervalued. Characteristically, there is a failure to comprehensively understand the human-ecosystem functional linkages and to integrate the benefits provided to human society by wetlands into a robust protected area network (Singh et al., 2021). A study of urban wetlands in Cambodia explicitly monetized a subset of the ecosystem services, whilst simultaneously concluding that the total economic value of the ecosystem services was represented by the analysis of this subset of values when it is clearly not the case due to the presence of non-market-based values (Ro et al., 2020).

Undoubtedly, understanding wetland values across the region is critical for the delivery of wise use. However, the emphasis in the published literature is to focus on assigning economic or monetized values to a limited subset of ecosystem services. Whilst there are excellent intentions underpinning efforts to describe the total ecosystem value (TEV) (Intralawan and Rueangkitwat, 2016) or the estimated annual benefits (Aung et al., 2021) of wetlands in the region, such studies fail to capture the full set of values or demonstrate the systemic linkages among the different services, the functioning of the ecosystem and beneficiaries of nature's contributions. Similarly, numerous studies utilise the mapping of wetland ecosystems through the use of earth observation and geographic information systems (GIS) and the subsequent extrapolation of monetary values based on economic valuation techniques (e.g. Karki et al., 2018; Loc et al., 2021). Again, such approaches are helpful but often fail to address multiple value systems and the complex nature of human-nature interactions and the need to manage trade-offs. However, there are numerous studies from the region that use a range of participatory and stakeholder engagement approaches, evaluations of stakeholder perception, linked sociological-ecological and non-monetised assessments (e.g. Berg et al., 2017; Quyen et al., 2017; Flower et al., 2018) that more robustly capture and demonstrate both multiple values and the important systemic linkages which are critical for delivering wise use.

Wetland values and Ramsar sites

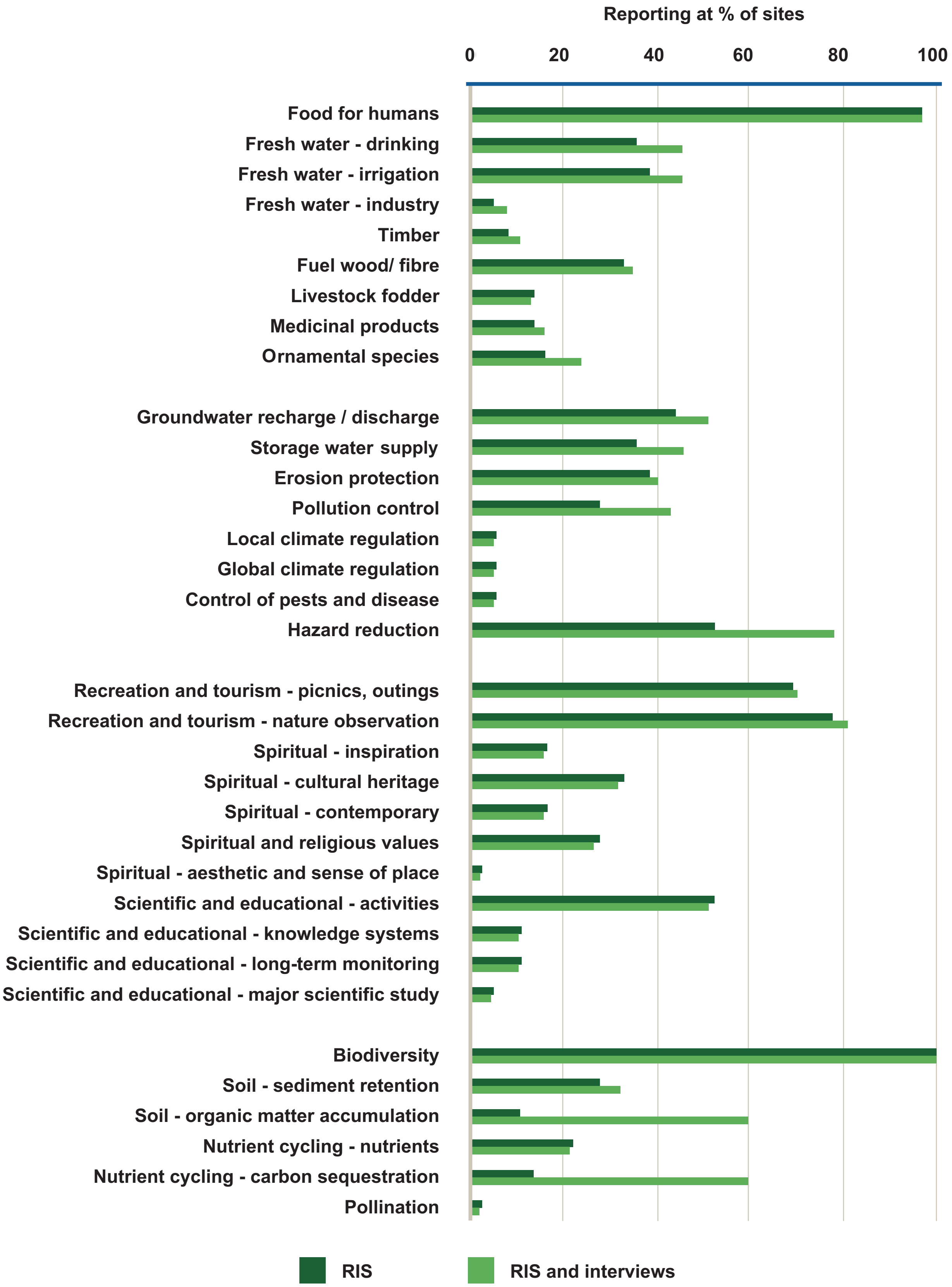
The Ramsar Information Sheets (RIS) for the 37 Ramsar Sites across the region provide information on the ecosystem services and values of the various wetlands. In 2021, interviews were also conducted with site managers and international and national civil society organisations working at site-level to gather additional information on the values of the sites. The information held within the RIS and reported from the site interviews has been analysed to evaluate the frequency of reporting of different ecosystem services (Figure B1.1).

Overall, the information collated from the RIS is broadly verified by the information reported through interviews with personnel familiar with the Ramsar Sites. The most frequently reported ecosystem services are the provision of food (reported from 100% of sites) and the supporting service of providing biodiversity (reported from over 97% of all sites on the RIS or through interviews). The least reported services are the regulating services of local and global climate regulation, the control of pests and disease and the service of pollination. The representation of services reported in the RIS differs somewhat from the information captured in peer-reviewed literature from the region. Climate regulation is represented in some 38% of the published literature on ecosystem service assessments in the region, whereas pest regulation and pollination were only reported from 10% of the published studies in the region (Dang et al. 2021). Whether the differences in reporting reflect a lack of occurrence of a service or a lack of understanding or articulation is not, however, clear.

The largest difference in the reporting on individual services from the two information sources are observed for organic matter accumulation and carbon sequestration. For both these services, the information derived from interviews suggests that these two services are far more prevalent at Ramsar Sites than the reporting in the RIS indicates. It would be expected that the greater awareness on the prevalence of organic matter accumulation and carbon sequestration and global climate regulation would also be reflected in the reporting on global climate regulation, given the critical role of carbon in this service. However, there was no difference in the reporting on the frequency of global climate regulation observed in the two information sources. To a lesser degree, there was a similar anomaly in the reporting on five regulating services: groundwater recharge-discharge, storage water supply, erosion protection, pollution control and hazard reduction. All these services were more frequently reported through the interview process than in the RIS content.

Figure B1.1

Ecosystem services reported on the RIS and through interviews.



Recommendations

- In line with the IBRRI Strategic Plan Target 2.4, document best practices in wetland management from the Indo-Burma Region, particularly those that robustly integrate multiple values and approaches to managing trade-offs, and share the knowledge widely across the region.

- Ensure that consistent and robust approaches are used to understand the ecosystem services and multiple values of the Ramsar sites so that best practices in wetland management can those target the multiple values.

- Create more awareness of little-known/ little-understood and therefore under-appreciated values of wetlands through CEPA efforts.

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B2 PROVISIONING SERVICE – RICE PRODUCTION

Key messages

- The production of rice is an essential source of nutrition and income for the people of the Indo-Burma region, and a major export commodity, with Myanmar, Thailand and Viet Nam amongst the world's largest rice exporters.
- The total area of land under rice production peaked in 2010 and then has remained relatively static since 2010, while at the same time, average rice yields/hectare increased.
- The actual location of land under rice cultivation area has also shifted somewhat as rice fields in some areas are converted to other uses (urban sprawl, aquaculture ponds, expansion of rubber growing, etc.) and other land, including natural wetlands, is brought under rice production in other areas.

Rice production

Rice paddy is classed as a human-made wetland system. Across the Indo-Burma region, rice production is critical both for food security and also for export and economic sustainability. In some areas, three crops of rice are produced in one year. Rice production is, therefore, a provisioning service that provides sustenance for millions of people across the region. Different types of rice systems will generate different benefits to human society. The ambition for rice agriculture should be to combine traditional knowledge and experiences with current and emerging concepts on biological diversity to optimise ecosystem services to support food security. Such a wise use approach should also deliver a range of other benefits to human societies and minimize negative or unwanted consequences (Settele et al., 2018).

In low-lying floodplain and deltaic areas, rice production is the dominant form of agriculture. For instance, in the Mekong Delta area rice cultivation accounts for some 84% of the total agricultural land area (Tong 2017). The rice production in the Mekong Delta contributes to Viet Nam being the third largest exporter of rice in the world (Clauss et al. 2018). Thailand supports the largest area of rice farming in the Indo-Burma region with over 104,000 km², whilst Lao PDR supports the smallest area under rice cultivation. The area of rice production increased steadily across the region from the 1960s until approximately 2010, peaking at just over 310,000 km². However, since 2010, the area of land under rice cultivation has largely remained static or has slightly decreased to approximately 28,000,000 ha in 2020 (Figure B2.1). There is evidence from the Mekong Delta that between 2013 and 2020 some 800 km² of land that was previously under rice cultivation has been converted to aquaculture ponds (Dang et al. 2021). Analysis of other indicators in the IBWO also highlight the transition from rice paddy to aquaculture and the conversion of natural wetlands to rice paddy.

Whilst the total area of land under rice production has broadly remained static over recent years, the yield of rice has slowly increased (Figure B2.2). This potentially reflects efficiencies in the farming and cultivation techniques, the increased likelihood of multiple crops being produced over the course of a year, selection of resilient, high-yielding varieties of rice and increases in use of fungicides, herbicides, fertilizers and pesticides. The increase in yield (in hectogram) per hectare in 2020 is almost three times the value observed in 1961 (Figure B2.2). In addition to increases in rice yield per hectare, the development of the co-culture of rice and aquatic animals, primarily fish but including crabs, prawns, shrimps and duck, is becoming widely practiced across the region and has been considered to represent a competitive alternative to intensive rice monocultures which also provides additional environment and societal benefits (Berg et al. 2017).

Figure B2.1

Trends in area of rice cultivation 1961-2020 (data from FAOSTAT).

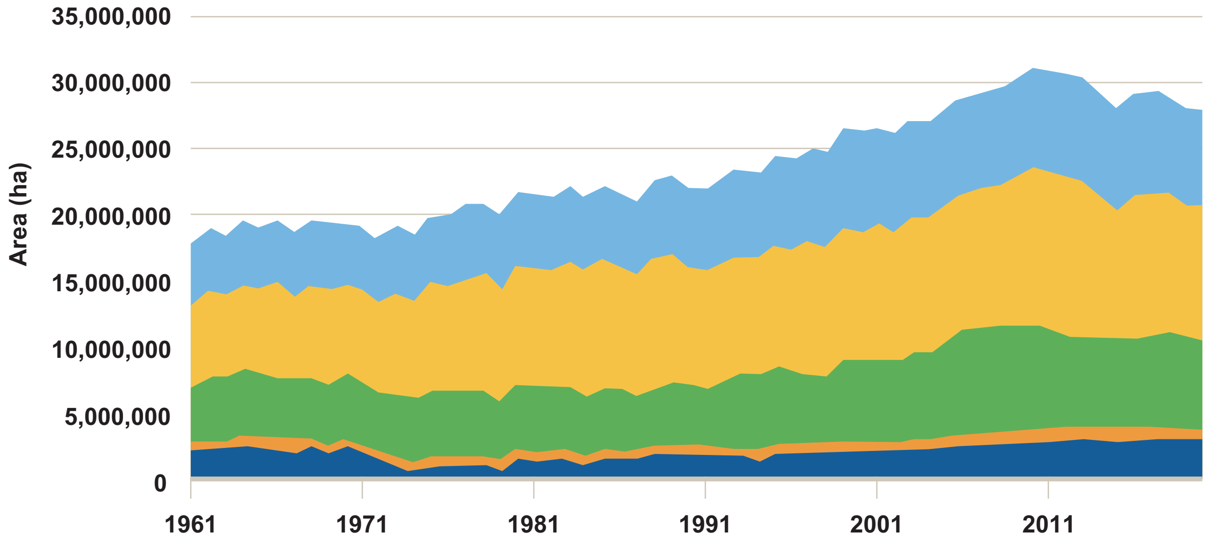
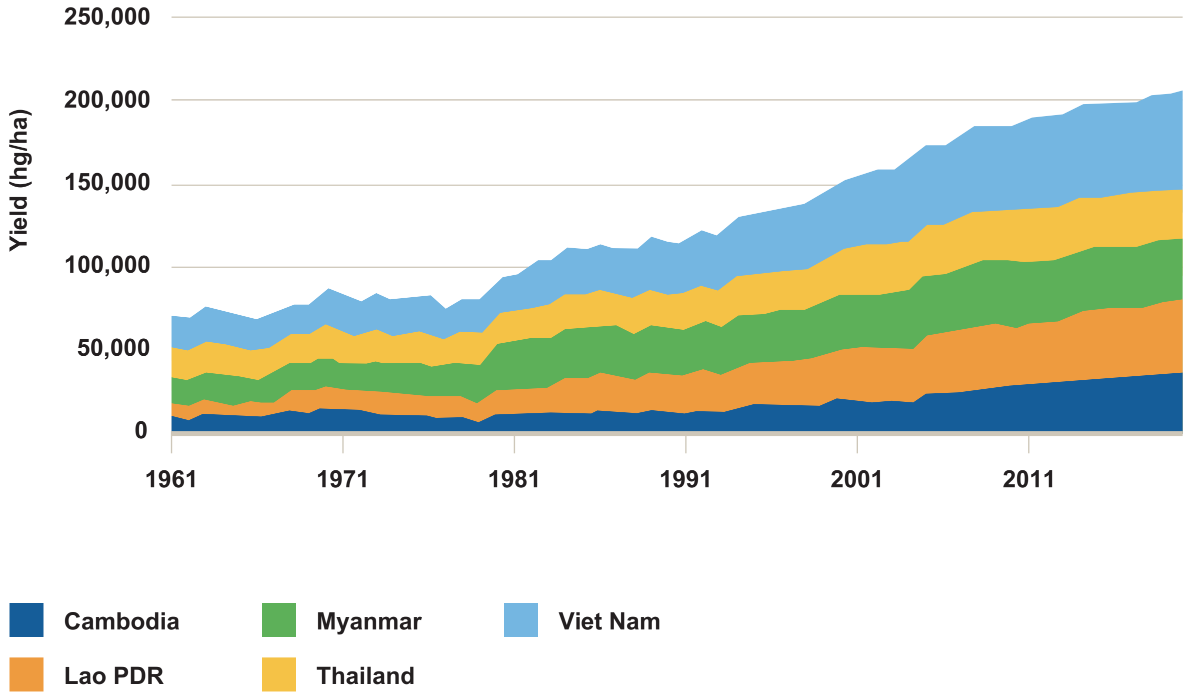


Figure B2.2

Trends in rice cultivation yield per hectare 1961-2020 (data from FAOSTAT).



Recommendations

- In line with the IBRRI Strategic Plan Target 1.2, using existing data held by government agencies, conduct targeted research on the impacts of intensive and extensive rice production methods and the possible co-benefits of different farming approaches, including enhancing biodiversity.
- In line with the IBRRI Strategic Plan Target 3.2, ensure that the contribution of wetlands to wider policy frameworks, such as food security, poverty reduction and human health is fully integrated through dissemination of best-practice examples.
- Through CEPA programmes, highlight both the implications of maximizing rice production at the expense of other wetland ecosystem services and the negative impacts of intensification of rice production on natural wetlands.

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Data Sources

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Rice fields near Anlung Pring, Cambodia © Andy Ball

B3 PROVISIONING SERVICE – FISHERIES AND AQUACULTURE

Key messages

- Capture fisheries and increasingly aquaculture play a vital role in the provision of protein, livelihoods and economic resources to a significant percentage of the population of the region.
- The Mekong River basin supports one of the largest inland transboundary fisheries in the world and is a significant component of food security in the region. Climate change, dam construction and operation and hydro-geomorphological changes all represent challenges to the long-term sustainability of inland capture fisheries.
- A lack of accurate or consistent approaches to data collection and the involvement of local ecological knowledge undermines the evaluation of importance and functioning of fisheries across the region.

Capture fisheries and aquaculture

The provision of fish for human consumption is a critical ecosystem service across the region. Both capture fisheries, including in the marine environment, and aquaculture are vitally important to the well-being, livelihoods and economy of the five countries of the Indo-Burma region. Fisheries provide a primary source of protein across the region, with small-scale fisheries being particularly important to local communities. The Mekong River basin supports one of, and possibly, the largest capture fisheries in the world (Baran and Myschowoda, 2008; Dugan et al., 2010). The capture fisheries in the Lower Mekong Basin produce approximately 2.3 million tonnes of fish per annum (Vu et al., 2020). However, properly assessing the status or economic value of wetland fisheries across the region is compromised by the paucity or inconsistency of data, particularly catch per unit effort (CPUE) estimates (Bartley et al. 2015) and the lack of integration of local ecological knowledge in assessments of fisheries (Baird and Flaherty, 2005).

Capture fisheries, in marine, nearshore and inland environments, are increasing slowly year on year in Viet Nam (in tonnes live weight caught) but remain static or slightly declining in other countries in the region. (Figure B3.1). A similar pattern is also observed for aquaculture across the region, with increases present in Viet Nam but a static or declining catch in the other countries (Figure B3.2). However, the situation is more nuanced within individual countries.

In 2016, Viet Nam was the fourth major producer of fish and aquaculture in the world with a total production of 6.4 million tonnes. Since 2007, aquaculture has been the major contributor to total fisheries production within the country and reached 3.6 million tonnes in 2016. The construction of dams and reservoirs has had significant negative impacts on inland capture fisheries. Furthermore, the productivity of the Mekong floodplain and delta has diminished due to widescale conversion to agriculture resulting in long-term declines in the inland fisheries observed since 2001.Similarly, recent studies on the marine fisheries along the Myanmar coast have indicated that the fisheries are in serious and gradual decline (Arkester, 2019). Around the Ayeyarwady Delta, 96% of the fish species landed are dependent on wetland habitats (Wah et al., 2016).

In Thailand, since the early 1960s, freshwater fish culture has developed rapidly. Since 1984, the artificially propagation of the hybrid catfish (*Clarias gariepinus* x *C. macrocephalus*) has gained commercial popularity among farmers and is now considered to be the second most important species for freshwater aquaculture in the country, behind Nile tilapia. In Thailand, freshwater aquaculture uses monoculture or polyculture systems, depending on the target species. A monoculture is commonly employed for the production of carnivorous species such as hybrid catfish and snake-head, but can also include freshwater prawn and other species. Polyculture is employed principally to raise herbivorous and filter-feeding species, such as tilapia and carp species. Traditionally, aquaculture was part of an integrated system with rice, pig, poultry and horticulture. However, in recent years, whilst integrated fish-rice systems persist, the integration of aquaculture with pig and poultry has been discouraged due to food safety concerns and the promotion of good aquaculture practices. In addition to aquaculture, production for food fish, the breeding and culture of ornamental fish and aquatic plants is becoming increasingly popular in Thailand. The production of

Figure B3.1

Capture fisheries (tonnes live weight) 1980-2019 (data from FAO Fisheries and Aquaculture Country Profiles).

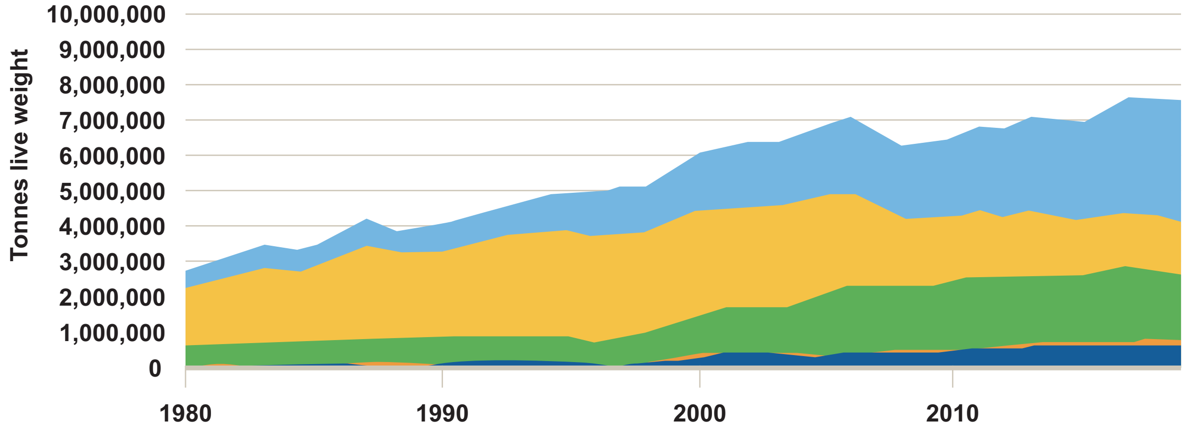
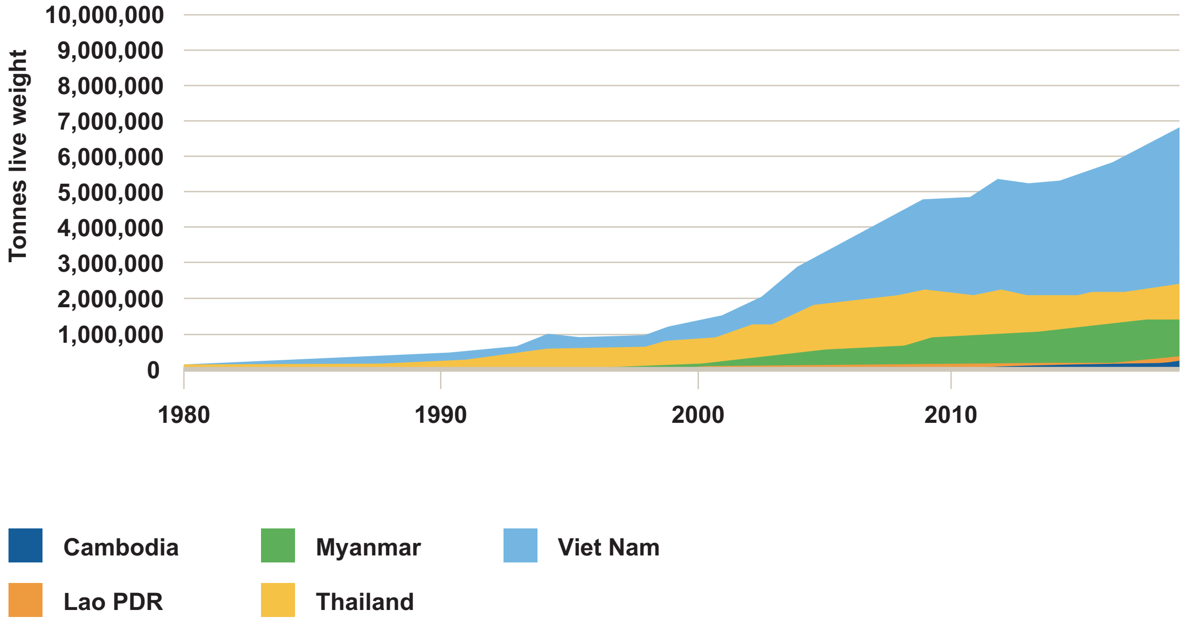


Figure B3.2

Aquaculture (tonnes live weight) 1980-2019 (data from FAO Fisheries and Aquaculture Country Profiles).



ornamental fish supplies a local and international market with farms, though small in size, realising a high rate of return on their investment.

Cambodia's capture fisheries produced about 650,000 tonnes in 2017. The country's freshwater fisheries are among the most productive in the world due to the hydro-geomorphologic functioning of large floodplains around the Tonle Sap (Great Lake) and along the Mekong and Bassac Rivers. It has been estimated that between 289,000 and 431,000 tonnes of fish are caught annually in the Tonle Sap alone. It is the fourth most productive captive fishery in the world, providing some 70% of the protein intake for the entire Cambodian population (Sok et al., 2019). Total inland capture fisheries are thought to have produced around 528,500 tonnes in 2017, while by comparison, the total marine fishery production was 121,000 tonnes, together producing an estimated 649,500 tonnes. However, in recent years, concerns have been raised regarding the impacts of dams (principally for hydropower) and climate change on the fishery at Tonle Sap and the implications on the delivery of this critical ecosystem service (Ngor et al., 2018; Wild et al., 2019; Campbell and Barlow, 2020; Hails and Hortle, 2021).

Cambodian aquaculture production was estimated by the government at 205,300 tonnes in 2017 and is dominated by fish farming in freshwater, including cage culture, pond culture and fish culture in rice fields. Whilst the aquaculture is still relatively small when compared to capture fisheries, the contribution of aquaculture to the total national fish production has increased steadily from 10.9% in 2010 to 24% in 2017.

Lao PDR is a land-locked country but supports an extensive freshwater resource associated with the Lower Mekong River Basin. The country is heavily reliant on its aquatic resources and biodiversity for food security and livelihoods. Inland fisheries, based on the Mekong River, rice fields, large and small reservoirs, and floodplains and lakes, is primarily a subsistence practice. Aquaculture has expanded in the country, with data showing that the total fish production in 2017 was approximately 175,000 tonnes, with aquaculture accounting for almost 60%. Aquaculture production is practiced in fish ponds, cages, rain-fed and irrigated rice fields.

Recommendations

- There is limited information available on the spatial distribution and area of aquaculture ponds across the region, therefore efforts are needed to address this data gap, particularly with regards to shifts from rice farming to aquaculture.
- Develop guidance and recommendations on integrated fish-rice systems and ecosystem-based approaches to sustainable fish production.
- In line with the IBRRI Strategic Plan Target 3.2, ensure that the contribution of wetlands to wider policy frameworks, such as food security, poverty reduction and human health is fully integrated through dissemination of best-practice examples.
- Enhance transboundary fisheries management measures, including the effectiveness of seasonal closures and fish conservation areas; the protection of migratory fish pathways and spawning grounds; and improving fisheries governance at local, national, and transboundary scales based on robust knowledge.

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FAO AQUASTAT https://www.fao.org/aquastat/statistics/query/index.html

B4 PROVISIONING SERVICE – OTHER FOOD PROVISION

Key messages

- Wetlands in the Indo-Burma region provide human society with a great variety of food resources. Without the provision of these resources, the health and well-being of society would be severely compromised.

- In addition to rice, many other plants and animals are harvested from wetlands and provide essential components of the human dietary needs.

- Whilst wetland provisioning services undoubtedly contribute greatly to human well-being across the region, unsustainable exploitation has resulted in some negative impacts. Concerns have been raised regarding intensive duck rearing, the proliferation of invasive species and pollution of the aquatic environment through intensification of food production.

Other food provision

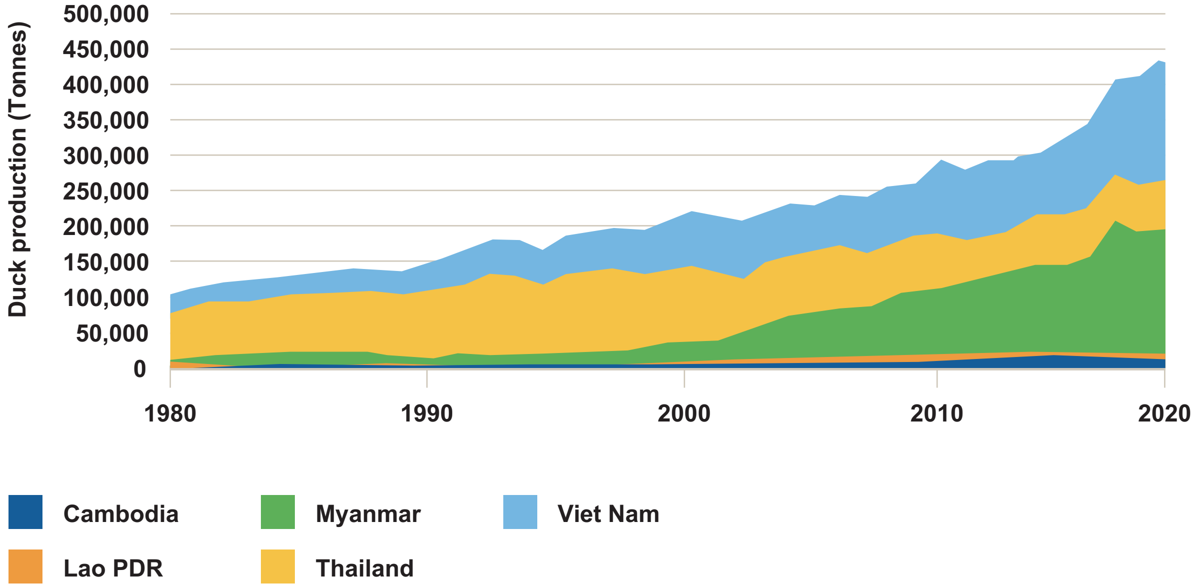
In addition to rice cultivation and fisheries, the wetlands of the Indo-Burma region provide a great variety of foodstuff. Numerous plants are collected and harvested for human consumption. In Inle Lake, floating gardens have been created to grow beds of tomatoes and other vegetables. Often considered to be a 'hidden harvest', in the rice fields of northeast Thailand and parts of Lao PDR, wild aquatic and emergent herbs, climbers and shrubs, which are often considered to be weeds or invasive species by agronomists, are routinely harvested as food, and also for medicinal purposes. More than half of the wild food plants routinely harvested from rice paddies in Thailand have many edible parts, including shoots, tips, stems and roots, and more than two thirds of the plant species harvested have additional uses such as use in medicines or as fodder for livestock (Cruz-Garcia and Price, 2011).

Wetlands also support a great variety of amphibians, insects, crustaceans and other animals that are routinely harvested and eaten. Water beetles *Cybister limbatus, C. rugosus and Eretes sticticus*, backswimmer *Anisops* spp., giant water bug *Lethocerus indicus*, water scorpion beetle *Laccotrephes ruber* and damselflies *Ceriagrion* spp. are all collected from wetland habitats in Lao PDR, Myanmar, Thailand and Viet Nam (Viwatpanich and Yhoung-aree, 2005). In Cambodia, the consumption of frogs among local people is essential to supplement their limited protein intake. A total of six frog species have been reported as being harvested on a regular basis for local consumption and trade. A similar situation is present in Viet Nam where many frog species are consumed and some, such as East Asian bullfrog, are considered a highly sought-after delicacy. Whilst in Lao PDR, frogs, turtles, snails and other aquatic animals provide a substantial portion of the animal protein consumed by the population and are critically important to national food security (Grano, 2020).

Duck farming is routinely carried out in wetland habitats across the Indo-Burma region, but particularly in Viet Nam, Thailand and Myanmar where domestic duck production has increased steadily since the early 1980s (Figure B4.1). In 1980, just over 100,000 tonnes of duck were reared, whereas by 2020 this figure had increased by more than four times to more than 430,000 tonnes. Much of the duck rearing is integrated with rice production, with the duck being reared for both local consumption and trade. However, as duck rearing has expanded, concerns have been raised in recent years regarding the positive association between avian influenza viruses (AIV) and duck density in the wetlands of the Viet Nam highlands and Thailand, and within rice landscapes in Thailand (Paul et al. 2014).

Figure B4.1

Duck production (tonnes) 1980-2020 (data from FAOSTAT).



Recommendations

- Ensure that the breadth of food substances harvested from wetlands is fully understood and the potential impacts of their provision are evaluated.
- In line with the IBRRI Strategic Plan Target 3.2, ensure that the contribution of wetlands to wider policy frameworks, such as food security, poverty reduction and human health is fully integrated through dissemination of best-practice examples.

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Data sources

FAO STAT. https://www.fao.org/faostat/en/

B5 PROVISIONING SERVICE – WATER USE

Key messages

- Agriculture is the single highest user of water withdrawn from wetlands. Despite a relative abundance of water resources, seasonal differences, driven by the prevailing climate, influence the availability of water in many parts of the region.
- The area of land equipped for irrigated agriculture appears to be stable, however accurate data are limited for the last ten years.
- Whilst wetland provisioning services undoubtedly contribute greatly to human well-being across the region, unsustainable exploitation has resulted in some negative impacts. Concerns have been raised regarding the challenges around competing water resource demands and the sustainability of the current trajectory of water uses.

Status of water uses in the Indo-Burma region

Wetlands provide water for a range of uses, including domestic water supply, irrigation of agricultural land or municipal uses. The sustainable and equitable co-management of water across different geographical scales and multiple users is essential for water and food security (Everard, 2016). Highlighting the importance of the provision of water, in April 2022, Hun Sen, the Cambodian Prime Minister, stated in an address to the 4th Asia-Pacific Water Summit: “For Cambodia, water is considered as White Gold – a driving force for sustainable and inclusive socio-economic progress and development”.

Water for agriculture

Agriculture is the main use of water across the region (Table B5.1). Water for agriculture primarily comes from surface water bodies (wetlands such as rivers, lakes and reservoirs) via diversion or pumping with a smaller percentage derived from groundwater (Table B5.2). For instance, in Thailand only 9.1% of water for irrigated agriculture was derived from groundwater in 2018. The overall area of land equipped for irrigated agriculture has generally increased since the 1960s (Figure B5.1). However, the FAOSTAT data are unreliable from 2007 to the present (the same values are replicated for each year) so recent trends are difficult to evaluate, and it is particularly difficult to understand differences in land equipped for irrigation as opposed to areas managed through flood recession practices. In Cambodia (57.7%) and Lao PDR (25.9%) flood recession rice cultivation still accounts for substantial proportions of the irrigated areas but data are unavailable for the other countries (Table B5.2). Locally, untreated municipal wastewater is used to irrigate some agricultural areas in Viet Nam in order to address water demand.

Table B5.1

Water withdrawal by sector for 2018 (% of total withdrawal) (data from FAOSTAT).

	Sector (% withdrawal)		
	Agriculture	Industry	Municipal
Cambodia	94.00	1.51	4.49
Lao PDR	95.90	2.32	1.78
Myanmar	88.56	1.49	9.95
Thailand	90.37	4.85	4.78
Viet Nam	94.78	3.75	1.47

Potentially, water demand for agriculture will increase in the coming years, particularly as there is a shift towards the planting of three rice crops per annum, which could lead to an unsustainable provisioning service and negative impacts on other ecosystem services (Lee and Dang, 2019). Impacts on the quality of surface and groundwaters from domestic wastewater and agricultural run-off have also been highlighted which have the potential to compromise water supply (Lap et al., 2021). In some countries, water-saving measures and practices have been introduced within rice farming communities. For instance, the “One Must Do, Five Reductions” (1M5R) program was certified in 2013, by Viet Nam Ministry of Agriculture and Rural Development, as a national approach to promoting the best management practices in lowland rice cultivation and to reduce water usage through alternate wetting and drying (Tho et al., 2021). However, whilst this program has been successful in increasing yields and reducing fertilizer application, challenges have remained with regard to reducing water use due to difficulties in applying the management practices and the patterns of cropping (Connor et al., 2021).

An insidious impact of water management for irrigated agriculture is the profusion of water control infrastructure, such as sluices or barrages, weirs and regulators. All of these structures create physical barriers that block migration routes of important fish species (Conallin et al., 2019). For instance, the migration of the hilsa shad (*Tenualosa* spp.), which is the national fish of Bangladesh and culturally and economically important to the people of Myanmar, is being impacted by irrigation infrastructure and river engineering works (Conallin et al., 2019). It has been suggested that the focus of water management attention should move away from fixating on large dams (for hydropower) and examine the impact of multiple small irrigation structures and road crossings on the fragmentation of habitat for fish and other aquatic species. (Baumgartner et al., 2021).

Figure B5.1

Area of land equipped for irrigation 1961-2019 (data from FAOSTAT).

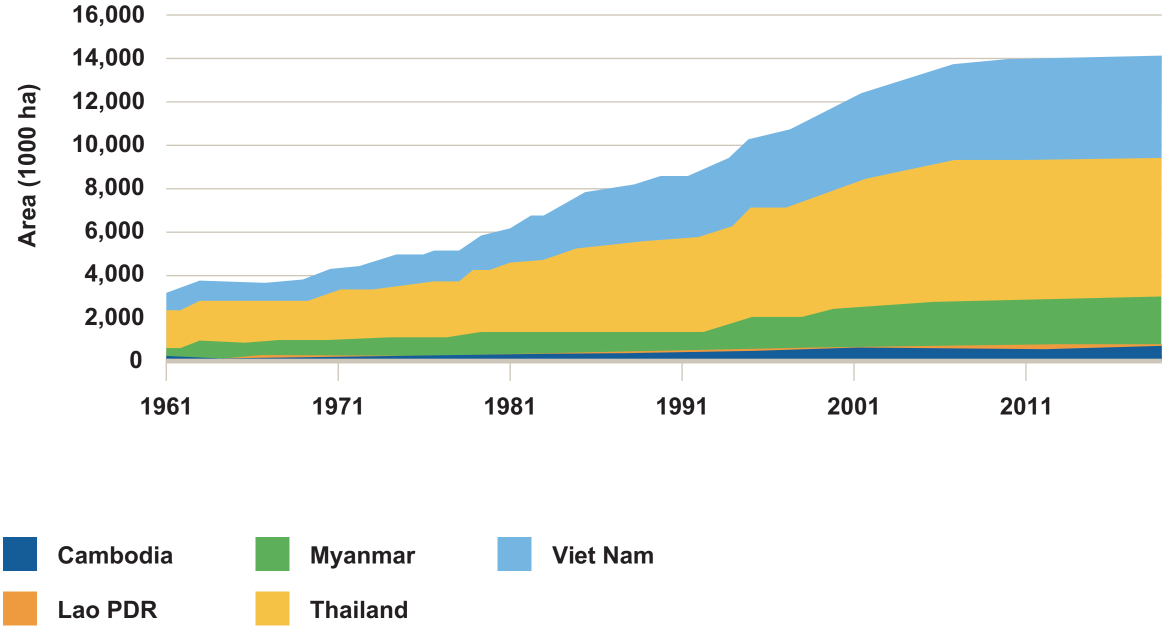

Table B5.2

Areas of irrigated land by source of irrigation 2018 (1000 ha) (data from FAOSTAT/AQUASTAT – blank cells indicate no data available).

	Area equipped for irrigation by surface water	Area equipped for irrigation by groundwater	Area equipped for irrigation by non-treated municipal wastewater	Flood recession cropping non-equipped	Total
Cambodia	269.5			367.7	637.2
Lao PDR	309.8	0.2		108.9	418.9
Myanmar	2010.0	100.0			2110.0
Thailand	5831.0	583.8			6414.8
Viet Nam	4539.0	45.9	5.9		4590.8

Water for industry and municipal use

The countries of the Indo-Burma region have abundant surface and groundwater. However, due to the climatic conditions, there is a tendency towards an overabundance in the wet season and droughts in the dry season. Wetlands play a critical role in providing stores for surface water and recharging groundwater aquifers. Time series data are limited on annual freshwater withdrawals over time or as a percentage of the available water resource. Data from 2018 suggest that Thailand and Viet Nam abstract a greater percentage of the available water resource in comparison to the other three countries in the region (Figure B5.2). However, for all five countries there is limited evidence of water stress conditions.

Withdrawals for industrial and municipal uses are limited in comparison to agricultural uses (Table B5.1). Whilst the data are limited, industrial water usage is characteristically between 1 and 5% of the total water withdrawn from wetlands. Whereas water withdrawals for municipal water supplies are slightly higher across the region being between 1 and 10% of all water usage. In Myanmar and Cambodia industrial water usage is less than the percentage taken for municipal supplies. These values are not static and the total water withdrawal per capita over time is changing. For instance, in Viet Nam, water withdrawals per capita increased from 665 m^3 per capita in 1980 to 956 m^3 in 2005. Similarly, in Lao PDR annual freshwater withdrawals increased from $4.4x10^9 m^3$ in 2007 to $7.32x10^9 m^3$ in 2017, a 66% increase in ten years.

Recommendations

- Improve the availability and quality of data on water usage especially by agriculture. Use the improved data to assess likely impacts of water abstraction on wetland systems.
- Pursue effective and sustainable water agricultural demand management programs, particularly with regards to rice production, that reduce abstraction rates and minimize the impacts on other wetland systems.
- Promote transition away from rice-growing towards less water-intensive and more profitable forms of agriculture
- In line with the IBRRI Strategic Plan Target 3.2, ensure that the contribution of wetlands to wider policy frameworks, such as food security and water resource management is fully integrated through dissemination of best-practice examples.

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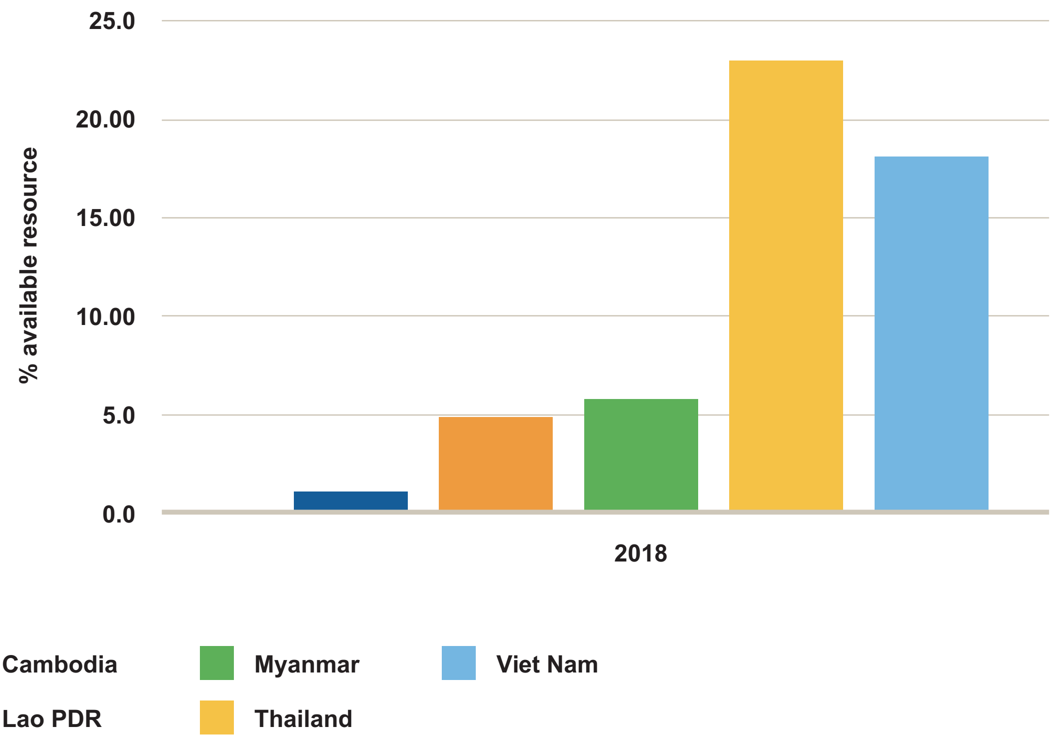
Figure B5.2

Level of water stress: freshwater withdrawal as a percentage of available freshwater resources (data from FAOSTAT).



and Consumption, 28, 1040-1049.

Data sources

FAO STAT. https://www.fao.org/faostat/en/

B6 PROVISIONING SERVICE – ENERGY GENERATION

Key messages

- Electricity generation through hydropower makes a substantial contribution to energy resources across the region. Electricty generation from hydropower will have an impact on the future development trajectory of the countries.

- Hydropower development can generate impacts on the physical, ecological and human elements of river ecosystems. Any future hydropower projects need to consider fully and objectively these issues, including cumulative impacts of multiple projects within the same river system, and transboundary impacts in shared river systems.

Energy production

Wetlands can provide a sustainable source of energy for human society through the flows of water. Across the Indo-Burma region flows of water have been harnessed to generate electricity through the development of hydropower schemes.

All countries in the region are promoting hydropower as a renewable energy source to enhance the provision of electricity across the region and to reduce carbon emissions. The first hydropower scheme in the region was constructed in north-eastern Thailand in 1965. However, since 2010, the region has experienced an increase in the amount of electricity generated by hydropower, with significant increases observed in Viet Nam (Figure B6.1).

All of the countries in the region have plans to increase hydropower generation over the coming years. Lao PDR is planning on increasing its energy generation through hydropower by 60% through an expansion from 46 functioning hydropower plants to 100 by 2040. Whilst hydropower schemes can be beneficial in terms of reduced carbon emissions during operation, concerns have been raised regarding the potential cumulative impacts on river hydrogeomorphology, ecological functioning, socio-economic viability of downstream communities and the integrated geographies across the region as a result of hydropower development (Soukhaphon et al. 2021). These are addressed in more detail in the IBWO through the assessment of direct drivers, pressures and threats.

Hydropower generation has, for a long time, been and remains a controversial and political issue across the region (White et al., 1962; Matthews and Geheb, 2014; Middleton, 2022). Governments across the region are recognising the various challenges that sustainable power generation bring. In Viet Nam, the government announced at 26th United Nations Climate Change Conference of the Parties (COP26) that they would cease issuing new permits for coal power generation. This will result in approximately 10,000 MW of coal power projects which have not yet begun development needing to be replaced with alternative power sources, such as hydropower. Opportunities exist to develop other renewable power sources, such as solar, as part of multi-sector approach to sustainable development and delivering on the challenges of the water-energy-food nexus (Tan et al., 2022).

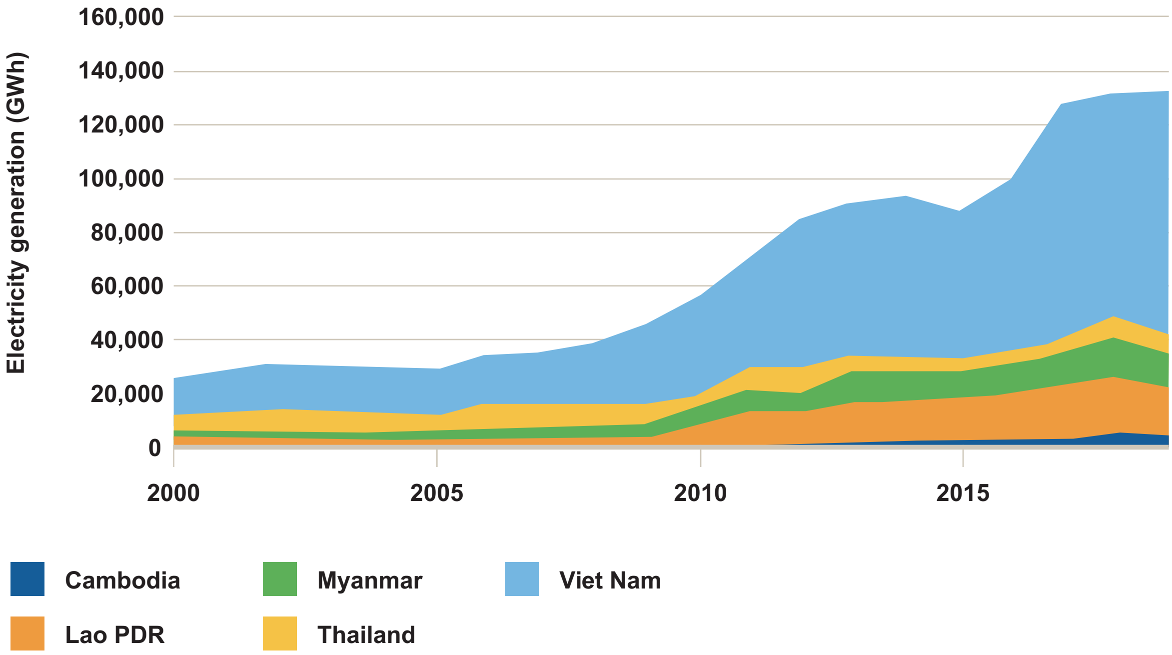
Recommendations

- In line with the IBRRI Strategic Plan Target 1.1, conduct specific research into the provision of energy through hydropower and the associated environmental and social impact of further development of this ecosystem service, including cumulative impacts of multiple hydropower schemes in the same river system, and transboundary impacts in shared river systems.

- Energy generation through hydropower needs to be set within a wider renewable energy generation strategy for the region and capitalizing on other forms of renewable energy production including solar and wind, as well as improvements in energy efficiency and conservation; and regional power trading supported by interconnectivity of the power grids of the Indo-Burma countries, in order to meet sustainable development targets and to address challenges around the water-energy-food nexus.

Figure B6.1

Electricity generation (GWh) from renewable hydropower 2000-2019 (data from IRENA).



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Data sources

IRENA
https://pxweb.irena.org/pxweb/en/IRENASTAT/

B7 PROVISIONING SERVICE – OTHER

Key messages

- Many wetlands across the region provide a variety of other materials and products which are utilized by local communities and are fundamental to their quality of life.
- The integration of multiple wetland products, such as medicinal plants, fuelwood and timber into wetland agricultural systems can deliver multiple benefits.
- The traditional knowledge of the medicinal uses of wetland plants is at risk of being lost and needs to be captured and maintained.

Timber and wood

Many wetlands across the region are important sources of timber and fuelwood. A study conducted in the Ayeyarwady Delta area of Myanmar indicated that 91% of all households depend on community forests established in mangroves for the collection of fuelwood, primarily for use in traditional stoves for cooking (Feurer et al. 2018). The mangrove forests of the Mekong River Delta provide timber for house building, building fishing boats as well as for fuelwood. Freshwater wetlands can also be a source of timber and fuelwood. A study conducted in Champasak Province, Lao PDR, concluded that trees in paddy fields were extensively used to provide timber for housing and furniture as well as for fuelwood provision (Natuhara et al., 2012).

Medicinal products

Medicinal plants and traditional medicines still play a critical role in the health management across the region. Numerous wetland plants have been traditionally harvested for their medicinal properties. For instance, a study in the Kiat Ngong wetlands and surrounding forests in Lao PDR revealed 250 species of plant were used by traditional healers to treat almost 100 symptoms of disease (Sydara et al. 2014).

Chemical compounds have long been extracted from mangroves for use in folk medicine. Rhizophora seedlings are known to treat a sore mouth whilst extracts from the bark and the leaf of Rhizophora have antiviral, anti-stringent, anti-diarrhoea and haemostatic properties (Aye et al., 2019). The lotus *Nelumbo nucifera* is widely distributed across the region. In Thailand many parts of the plant, including the stamens, leaves, pods, rhizomes and stalks, are used to treat a variety of ailments and conditions such as fever, sinusitis, rhinitis and allergies (La-Ongsri, 2009). Similarly, species of the floating aquatic genus Nymphoides are widely used in Ayurvedic medicine and are utilised by local healers to a variety of disorders including convulsions, jaundice, fever and headaches (Khan et al. 2018).

The use of traditional medicines derived from wetland plants often has significant cultural importance through knowledge systems that span many centuries. Concerns have been raised that this traditional knowledge is slowly being lost. Consequently, there is a need to ensure that traditional knowledge and practices continue to be handed down from generation to generation so that the health benefits derived from wetland plants are not lost.

Ornamental plants

The Asian lotus *Nelumbo nucifera* has a history of cultivation extending back more than 2,500 years. Whilst the rhizomes and seeds are harvested for food and medicinal use, the flower is widely reared for ornamental purposes. There is a strong association between the lotus and Buddhism. When Buddhist pilgrims visit a temple to worship, they usually use the lotus to pay tribute to Buddha and to leave as an offering on the altar of the Buddha.

In Long An Province of the upper Mekong Delta in Viet Nam, rice farmers around the Lang Sen Ramsar Site are experimenting with different models that involve lotus, as alternatives to simply growing two rice crops/year. The approaches include growing rice and lotus in rotation; lotus monoculture, and integrated lotus with fish aquaculture.

There can be challenges regarding the introduction of exotic plants as ornamental species. The invasive water hyacinth *Eichhornia crassipes* was introduced to some wetlands, for instance, Inle Lake in Myanmar, in the mid to late twentieth century as an ornamental plant and cash crop. Unfortunately, the plant has become so abundant that it now obstructs many waterways around Inle Lake and is a threat to the native biodiversity of the ecosystem.

Responses

- Promote the wise use of native medicinal plants and ensure cultural and knowledge links are protected maintained.

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Data sources

None used for this indicator.

B8 REGULATING SERVICE – CLIMATE REGULATION

Key messages

- Wetlands in the Indo-Burma region store and sequester vast amounts of carbon, which mitigate the impact of climate change.
- Land use changes and wetland degradation and loss are undermining this store and contributing to climate change.
- The loss of carbon stocks from inland wetlands is considered to be a great risk due to the challenges of restoring the net climate cooling effect of these systems.
- The restoration of coastal wetlands can deliver a net climate cooling effect in a relatively short time-term (less than 10 years), whereas the restoration of inland, freshwater wetlands will only achieve a net cooling effect across a decadal timeframe (potentially over 260 years).
- At the local scale, wetlands can mitigate increasing air temperatures, whilst their wise use, restoration and creation can contribute to reduce human mortality rates and improve the quality of life for local communities.

Status of the climate regulation service in the Indo-Burma region

The Millennium Ecosystem Assessment recognizes that wetlands regulate climate at two scales: the local and the global (Millennium Ecosystem Assessment, 2005). At the global scale, wetlands regulate the climate by storing and sequestering carbon and regulating greenhouse gas emissions to the atmosphere (Mitsch et al., 2013). At the local level, wetlands regulate the climate by reducing air temperatures, providing shade and influencing local climate processes.

Global climate regulation

Wetlands have a critical role to play in climate change mitigation and adaptation strategies. Ecosystem-based Adaptation can reduce climate risks to people as well as deliver multiple co-benefits. The importance of freshwater and coastal wetlands as significant carbon sinks is well known (Erwin, 2009). In recent years there has been a strong focus on 'blue carbon' (the carbon stored in coastal and marine ecosystems) but soil organic carbon stocks within freshwater systems within the region can also be significant (Chanlabut et al., 2020).

Different studies have tried to estimate the total carbon storage securely buried within wetland sediments and biomass (below ground carbon). Some wetland systems, such as mangroves and seagrass beds, are well studied across the region. Whereas studies on other wetlands, especially freshwater inland wetlands, are limited in the peer-reviewed literature. Table B8.1 demonstrates a range of values for the stock of carbon stored within different wetland types. The values variety greatly across different wetland types and also within similar wetland types. For instance, inland freshwater wetlands may store 13.39 $tCha^{-1}$ whereas coastal mangroves may store up to 397.65 $tCha^{-1}$, or almost 30 times as much carbon per hectare.

The estimates of carbon stocks demonstrate the need for further information to verify the values already published and to provide a more comprehensive insight into the range of carbon stocks and the implications of land use change or wetland degradation and loss. There is also a need to understand how innovative wetland management and restoration options, such as integrated mangrove-shrimp cultivation or aquaculture, function as carbon stores so that informed decisions can be made on multiple benefit wetland management systems.

Wetlands across the region can therefore be effective, long-term Nature-based Solutions to mitigate climate change. However, the success of this is partly down to the balance between the carbon they store and the methane (CH_4) they emit in terms of radiative forcing (or the net positive or negative effect they have on the energy balance in Earth's atmosphere). Most coastal and inland wetlands across the Indo-Burma region have a net cooling effect on the climate. This results from the limited CH_4 emissions generated by undisturbed coastal wetlands and the long-term carbon sequestration by older inland wetlands, such as lakes and flooded forests, in comparison to the relatively short lifetime of methane in the atmosphere. Over time, the restoration of degraded wetlands will result in a net cooling of the atmosphere. However, the effect of restoration on inland, freshwater wetlands may take in excess of

260 years before it generates a net cooling effect. Whereas, restored coastal wetlands, such as mangroves, may achieve net cooling in less than 10 years (Taillardat et. al., 2020). This highlights the cost-effectiveness of restoring degraded coastal wetlands as an effective climate change mitigation strategy. However, it also demonstrates the need to ensure that inland wetlands are robustly protected to ensure that their stocks of carbon are locked in place and to secure their current and future net cooling effect on the climate. This also demonstrates that restoration of degraded inland freshwater wetlands, due to the multi-decadal timeframe to achieve net cooling, should not be considered within short-term climate change mitigation strategies. This does not, however, preclude their restoration for other short-term societal benefits.

Local climate regulation

Whether in urban or agricultural landscapes, evapotranspiration from wetlands is known to act as a natural 'air conditioner' (Hesslerová et al., 2019) which can locally reduce air temperatures by several degrees. A study conducted in Ho Chi Minh City, Viet Nam, concluded that surface air temperatures in the city decrease as the area of wetland increases (Van and Bao, 2015), whilst work conducted outside of the region but relatively nearby in south-west China indicated that the most effective results for urban cooling were achieved through a widely distributed network of small wetlands across a cityscape (Wu et al, 2021). A similar local cooling effect of wetlands has been observed in Bangkok between 1991 and 2016. The mean land surface temperature was observed to be some 5.67°C cooler around wetland areas than in heavily built-up areas, and 3.16°C cooler than for vegetated areas (Khamchiangta and Dhakal, 2020).

Conversely, the draining, in-filling and conversion of wetlands will generate the opposite effect and raise local air temperatures. Given that there is good evidence that human mortality rates in South Asia are significantly correlated with higher temperature extremes in both rural and urban environments (Dimitrova et al., 2021), and that these impacts are likely to be exacerbated by climate change, urbanization and population growth, there is a strong moral imperative to reduce the loss of wetlands and to encourage their restoration and creation as climate change mitigation for local climate warming.

Recommendations

- Protect existing wetlands to ensure that carbon stocks are retained and not released into the atmosphere. Develop programmes of wetland restoration that form part of climate change mitigation strategies.
- Ensure that improved estimates of existing carbon stocks in different wetland types are generated from studies across the region.
- Evaluate the success of carbon accumulation and net climate cooling of wetland restoration projects in both coastal and inland areas.
- Ensure that wetlands are considered as mitigation for increasing local air temperatures and are effectively integrated into human health strategies and policies in both rural and urban environments.

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Table B8.1

Estimates of carbon stock in different wetland types in the Indo-Burma Region (values in tonnes C ha^{-1}).

Country	Wetland Type					
	Marine Coastal Wetlands				Inland wetlands	Human made wetlands
	Mangrove	Mangrove	Seagrass	Seagrass	Seasonal/intermittent and permanent freshwater marshes/forest/pools on inorganic soils	Rice paddy
Cambodia	n/a	176.32	96.32	n/a	129.001 [1]	17.00
Lao PDR	n/a	n/a	n/a	n/a	n/a	n/a
Myanmar	240.00	176.32	96.79	136.67	n/a	44.00
Thailand	84.85	141.53	96.79	134.20	13.39-69.05 [2]	42.00
Viet Nam	397.65	159.45	159.45	134.20	n/a	71.00
Source	Gevaña et al. (2018) – average values for each country	Thorhaug et al. (2020) – values for organic carbon	Thorhaug et al. (2020) – values for organic carbon	Stankovic et al. (2021)	[1] Kapos et al. (2010) [2] Chanlabut et al. (2020)	Liu et al. (2021) – values extrapolated

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Data sources

None used for this indicator

B9 REGULATING SERVICE – WATER REGULATION

Key messages

- Many wetlands play a critical role in recharging groundwater across the Indo-Burma region. This is particularly the case for floodplain wetlands in the great river systems of the region.

- The sustainable management of wetlands to facilitate groundwater recharge should be considered in the context of wider, linked socio-hydrological systems to understand the systemic interactions and to avoid undesired consequences.

- The role that different wetland types play in recharging groundwater and regulating surface water flows remains relatively poorly understood and generalizations can be inappropriate.

- There is good evidence that well managed wetlands can regulate surface water flows, reducing the impacts of flooding and droughts downstream.

- Climate change and other anthropogenic pressures are altering patterns and rates of groundwater recharge from wetlands and the role in wetlands in regulating surface water flow. However, the implications of these remain unclear and require greater investigation.

Status of the water regulation service in the Indo-Burma region

The water regulation ecosystem service provides benefits to humans through regulating the water cycle and moderating a variety of hydrological processes (McInnes, 2016). The information provided below demonstrates that the wetlands across the Indo-Burma region play a significant role in regulating the water cycle by receiving, storing and releasing water over time, moderating water flows, and providing the water required to support life. The hydrological regime of wetlands across the region will vary from place to place and from wetland type to wetland type but typically the regime is a function of changes in water levels, volumes, timing and frequency of flows.

Groundwater recharge

Historically, information on the importance of wetlands for recharging groundwater in Indo-Burma has been limited. Studies have highlighted the importance of seasonal flooding by the major rivers in the region for recharging groundwater resources. Impacts on flooding, through controlling and regulating the degree of inundation across the floodplain can significantly reduce groundwater recharge. In the Mekong River basin, studies conducted in the 1990s suggested that reductions in the extent of the inundated area could reduce groundwater recharge by up to 44% on an annual basis (Kazama et al., 2007). Locally, across the great river systems of the Indo-Burma region, farmers depend on the frequency of flood events to recharge shallow groundwater, as well as to provide nutrient and sediment inputs. Similarly, many of the important wetland systems, such as Inle Lake in Myanmar, are dependent on aquifer recharge during the wet season and groundwater discharge during the dry season (Re et al., 2021). Modelling studies have also shown that spatial variations in groundwater recharge across the region are controlled primarily by climate (rainfall and evapotranspiration) rather than the aquifer properties (Lacombe et al., 2017) but that they can locally be strongly influenced by changes to river flows and flooding regimes through, for instance, construction of upstream dams and water diversions for irrigated agriculture (Pokhrel et al., 2018).

In many parts of the region, groundwater is a largely untapped resource for agricultural development and particularly in Lao PDR where groundwater irrigation in 2010 represented just 0.1% of the total irrigated area in the country (Siebert et al., 2010). During the dry season in Thailand, some farmers cultivate a third rice crop by utilising groundwater abstraction from shallow tube wells (Wongprasittiporn, 2005). While even moderate groundwater extraction will systematically impact water table levels and wetlands, it is important to assess a tolerance threshold under which the socio-economic benefits derived from groundwater use outweigh the costs and the role wetlands play in maintaining groundwater supplies.

Under predicted climate change scenarios, groundwater demand is likely to increase as surface water availability decreases, driven by higher evapotranspiration rates, increases in human population and a concomitant increase in water demand. However, predicted increases in wet season rainfall may result in greater recharge rates. However, the impacts of climate change on groundwater recharge and discharge are poorly understood (Jayakumar and Lee, 2016) and whilst generic or conceptual models exist (IUCN 2011), understanding the role of different wetland types on controlling groundwater recharge and their role in these linked socio-hydrological systems remains a challenge (Re, 2021).

Surface water regulation

Wetlands can play a critical role in maintaining surface water regimes, both in terms of flood frequency, extent and hydrological connectivity. The Xe Champone River Basin in Lao PDR contains the internationally important Xe Champone Wetlands, designated as a Ramsar site in 2010. The wetlands play a critical role in maintaining the hydrological connectivity of the system, allowing water to be stored and released across the landscape (Voladet and Chaleusinh, 2019). Changes to these wetlands, and their ability to moderate surface water flows, will have significant impacts on the flood hydrology and the associated socio-economy across the wider river system (Vongmany et al., 2018). The internationally important Tonle Sap Lake in Cambodia plays a critical role in storing and releasing floodwaters. Through remote sensing and modelling, Wei et al. (2018) demonstrated that water storage in the lake increases rapidly from September to a peak storage in December. Thereafter, water storage decreases by 38.8 billion m^3 from December to January, followed by a period of relatively stable storage volumes. The modelling demonstrated that there is a time lag of two months between the maximum storage of water in Tonle Sap Lake and peak flooding in the Mekong River downstream, demonstrating the critical role the lake plays in regulating surface flows. (A peculiar aspect of the Tonle Sap-Mekong system is the subsequent reverse flow from the Mekong River in May and June as water moves upstream from the Mekong into Tonle Sap Lake (Masumoto, 2000)). Similar flow regulation benefits are present across the large floodplain wetland systems in the region, where wetland habitats store and release water, moderating peak flooding and contributing to dry season flows. However, detailed hydrological investigations are limited for some of these systems, such as the Ayeyarwady in Myanmar (Ketelsen et al., 2017).

However, some wetlands have limited connectivity with wider surface water systems. Within a predominantly dry Dipterocarp forest landscape, small depressional wetlands retain water within the catchment and contribute to both groundwater and surface water dynamics. A study of small depressional palustrine wetlands, characteristically with an individual surface area of less than 30ha, in the Mekong region demonstrated that only between 7 and 15% the wetlands were connected with the wider surface drainage network (Barzen et al., 2019). Despite this, the wetlands were still provided a range of other important ecosystem services and benefits to people and wildlife.

Anthropogenic changes to wetlands can significantly alter natural flood dynamics and result in wider socio-ecological impacts. The mining of riverbed sand from the Mekong River in Viet Nam for use in construction, resulted in a steady decrease in wetland flood frequency between 1995 and 2015 during both the wet and dry seasons, fundamentally altering the ecohydrological regime within the wetland (Park et al., 2020). The conversion of wetlands to other land uses can reduce their storage abilities and present challenges in both the wet season (by increasing flood peaks) and the dry season (by amplifying the impact of droughts). The loss and conversion of wetlands on the floodplain of the Chao Phraya River, Thailand, has been implicated as a reason for increasing the vulnerability of Bangkok to severe floods as a result of changes to the water storage regime (Ziegler et al., 2012). Current and future increases in glacier and snowmelt, as a result of climate change, will generally cause higher discharges and potentially more extreme flood events across the major rivers of the region (IPCC, 2014). Consequently, the critical role that wetlands can play in moderating and regulating surface water discharges, and protecting vulnerable communities from flooding and drought, will only increase over the coming years.

Recommendations

- Avoid making generalisations about the role of wetlands in moderating groundwater recharge and influencing surface water flow. Different wetlands, in different locations, may function very differently and empirical evidence should be used to demonstrate this.

- Improve knowledge on the hydrological functioning of different wetlands and their linkages with wider socio-ecological systems.

- Future proof human society from the potential impacts of climate change across the region through integrating the hydrological functioning of wetlands in cross-sectoral policies and decision-making, particularly around the water-food-energy nexus.

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Data sources

None used for this indicator

B10 REGULATING SERVICE – HAZARD REGULATION

Key messages

- Wetlands from the high-altitude headwaters, through the vast floodplains to the coastal systems all have the potential to mitigate flooding downstream through storing water, reducing the magnitude of floods and desynchronizing flood peaks.
- The drainage and conversion of wetlands across the various river basins of the Indo-Burma region will have increased flood risk and make human communities more vulnerable to flooding under a changing climate.
- In the coastal zone, mangrove forests have the ability to mitigate the impacts of storm surges and provide physical refugia during time of storms.
- Other coastal wetland systems, including seagrass beds and coral reefs attenuate the power of waves reaching the shoreline and offer some protection against storm surges.
- Low-lying deltaic areas are increasingly at risk of storm surge as a result of reductions in their sediment supply reducing accretion rates, rising sea levels and increased frequency of tropical cyclones associated with climate change. The presence of intact coastal wetland systems can provide a nature-based option for the protection of vulnerable communities.
- Increases in inland and coastal wetland loss and degradation will reduce the effectiveness of wetlands to mitigate hazards and potentially result in significant socio-economic impacts across the region. The protection and restoration of wetlands from the headwaters to the sea can provide cost-effective solutions to disaster risk management.

Status of the hazard regulation service in the Indo-Burma region

Under a changing climate, extreme flood events (Try et al., 2020) and storm surges associated with rising sea levels (Tung et al., 2019) are likely to increase across the Indo-Burma region. Snowmelt will drive an increase in fluvial flooding (Taft and Evers, 2016) and in the frequency and it has been predicted that the increased frequency and intensity of tropical cyclones will generate significant increases in storm surges around the low-lying coastal areas (Hirano, 2020). Without appropriate response strategies, the frequency and magnitude of these hazards will have severe consequences on the health and well-being of the human population within the region. Wetlands can play a critical role in moderating these impacts and should being integrated within robust disaster risk reduction strategies (Kumar et al., 2017).

Fluvial flooding

The drainage, conversion and loss of wetlands across the major fluvial systems of the Ayeyarwady and Mekong River basins has impacted the natural flood hydrology. Wetlands in the headwaters, the floodplain areas and the deltaic plains have all been altered generating changes in the hydrological regimes (Gopal, 2013). The headwaters of the Ayeyarwady and the Mekong are located in high-altitude areas. Many of these wetlands are relatively small swamps, marshes and lakes located in flat bottom land surrounded by elevated slopes and mountainous terrain (Chatterjee et al., 2010).

In the lower lying, major floodplain areas of the Mekong and the Ayeyarwady Rivers, extensive areas of natural and human-made wetlands persist. However, the role of these wetlands in mitigating the impacts of flooding is varied. The conversion of natural floodplain marshes and swamps for agriculture, even irrigated rice cultivation, has impacted flood regimes. Although the human-made rice paddies retain water in the landscape, the creation of dykes to prevent natural flooding, and to promote rice cropping, has had drastic impacts on downstream flooding (Arias et al., 2019). Dykes constructed between 2000 and 2013 to prevent flooding of agricultural land in the Viet Nam Mekong Delta, reduced the flooding area in the Long Xuyen Quadrangle by 36% and exacerbated flooding in unprotected areas downstream (Dang et al. 2016). Studies from Tonle Sap have demonstrated how this natural floodplain wetland can store vast amounts of water and reduce and delay flood peaks downstream by more than two months (Wei et al. 2018). Wetland features in the floodplain environment can play a vital role during flood events. Taung Tha Man Lake, on the floodplain of the Ayeyarwady River near Mandalay, Myanmar, is an oxbow lake covering some 380 ha. During flood events, it acts as a back swamp, storing water from the Ayeyarwady River and reducing the potential impact of flooding on the nearby city (Grzybowski et al. 2019).

Human alterations, and drainage in particular, has made flood patterns become more unpredictable and irregular than ever before for many wetlands. While there is little research into the changing patterns of flooding in the Mekong Delta in general, anecdotal evidence suggests that the rate of flooding has changed in some areas with floods rising faster and deeper. In other areas, the reverse experience of late and smaller floods has occurred (Nguyen and Wyatt, 2006). This has moved the Viet Namese government to restore controlled flooding in the Mekong system, providing an opportunity to enhance wetlands and to deliver multiple benefits to society (Van Staveren et al., 2018). However, the restoration of flooding regimes may not be sufficient to restore the historical ecological functioning of now modified wetlands.

Storm surge regulation

The coastal zone of the Indo-Burma region is routinely and increasingly, impacted by tropical cyclones. Climate change is also increasing sea levels around the great deltas of the region. It has been predicted that an area of almost 10,000 km² in the Mekong Delta will be impacted by storm surges with potentially serious damage to agriculture, infrastructure, and widespread threats to human lives (Syvitski et al., 2009). In May 2008, tropical cyclone Nargis caused the worst natural disaster in Myanmar's history, killing in excess of 138,000 people, severely impacting 2.4 million people and causing an estimated economic damage in the region of 10 billion US$ (Fritz et al., 2009). Changes to the coastal wetland systems, through alterations in their sediment supply, removal of native vegetation and conversion to agriculture all exacerbate the risk of storm surges.

A study that considered three delta systems in the Indo-Burma region, namely the Ayeyarwady, Mekong and Chao Phraya deltas, concluded that there was a significant positive correlation between an increasing tidal wetland area and an increase in the magnitude of flood risk mitigation for the land (Van Coppenolle et al., 2018). The location, orientation with regards to the cyclone path, the width of tidal wetlands, density and size of channels and the elevated state of mangrove vegetation all contribute to the degree of protection given to land in these deltaic regions. Interviews with survivors of cyclone Nargis have demonstrated, beyond the physical buffering of storm surge events by coastal wetlands, the importance of mangroves to human survival during such events. Numerous people survived by climbing the mangrove trees to escape the rapidly rising water. Within the Meinmahla Kyun Wildlife Sanctuary, a Ramsar site and the largest contiguous area of mangrove remaining in the Ayeyarwady Delta, all of the site staff survived and no fatalities were reported (Aung and MacDonnell, 2016).

Whilst there is limited data available from the region, modelling has also demonstrated that coral reefs and seagrass beds can provide protection from storm surges. A simulated study of seagrass beds demonstrated that wave heights reduce exponentially as waves propagate through seagrass beds due to frictional induced energy losses. The greatest reductions in wave height corresponded to the relative plant height and the width of the seagrass bed (John et al., 2016). Studies from elsewhere in the world indicate that under non-storm conditions, seagrass beds can reduce waves heights by 0.07m but have a limited, but detectable, impact on wave height and bed scour during storm surges (Guannel et al., 2016).

Approaches to seagrass restoration in Krabi, Thailand have started by focusing initially on *Enhalus acaroides* a species which leads to the engineering of the mudflat as their seedlings have strong root systems, and the leaf blades are large and robust which together contribute to attenuate wave impact, and capture more sediment, eventually facilitating the settlement of other more fragile species, such as *Halophila* sp., the favourite meals for dugongs. Seeds of *E. acaroides* are also easier to find and maintain in nursery settings with a survival rate so far of about 80%

Recommendations

- Improve understanding of the role of different wetland types across fluvial catchments in the mitigation of flooding.

- Improve the understanding of how coastal wetlands can mitigate storm surges around the different coastal areas and ensure that appropriate wetland management interventions are targeted where maximum benefits will accrue.

- Continue to protect and restore wetlands from the headwaters to the coast as vital nature-based solutions within integrated disaster risk reduction strategies.

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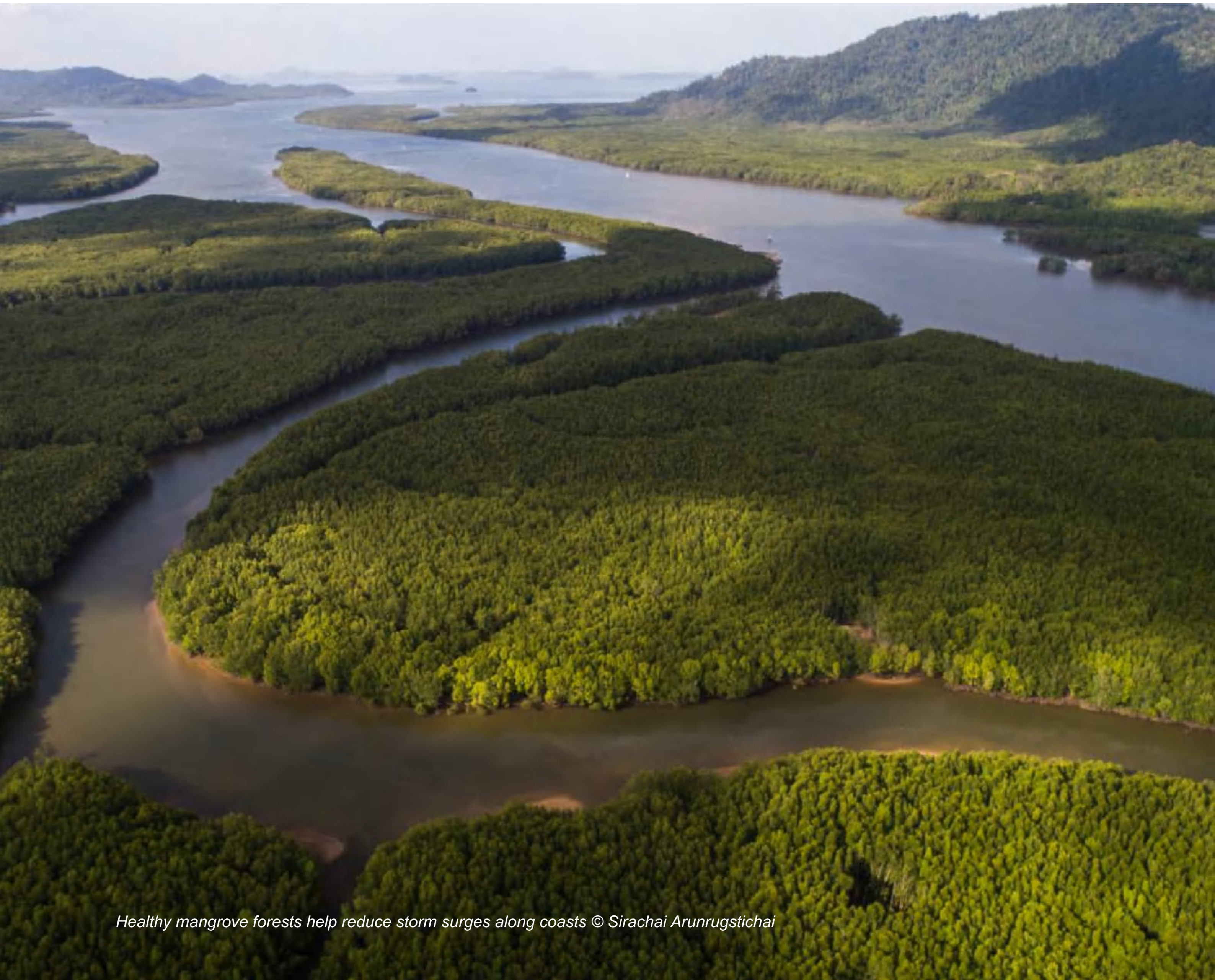
Data sources

None used for this indicator



Healthy mangrove forests help reduce storm surges along coasts © Sirachai Arunrugstichai

B11 REGULATING SERVICE – DISEASE REGULATION AND PEST CONTROL

Key messages

- Wetland-dependent species, such as mosquitoes, snails and flukes, can be vectors for a range of human diseases. Well-managed wetlands can help to attenuate the threats posed from these species to humans.
- Wetland degradation, pollution and inappropriate management can increase the incidence of disease and impact widely on human health.
- The specific role of wetland biodiversity in moderating health risks remains poorly understood and requires significant attention from both the environmental and health sectors.

Fluvial flooding

A well-functioning and managed wetland can minimise a range of wetland-dependent disease vectors and regulate negative impacts on human health (Dale and Connelly, 2012). However, wetlands can be a source of ill-health through the human exposure to intoxicants, pathogens and parasites, as well as invertebrate disease vectors (Cromie, 2018) and can present a risk of emerging or re-emerging diseases due to *inter alia* the following attributes (Cromie et al., 2012):

- Their association with high population densities of people, agriculture including aquaculture, and industry;
- Pollution from above;
- Sites providing interfaces between livestock, wildlife and people;
- Having been subject to substantial habitat modification;
- Sites rarely being isolated, instead usually being connected within catchments;
- Trade;
- The high diversity of host taxa;
- The high proportions of invasive alien species with their associated parasites; and
- The specific impacts of climate change on wetlands, their hosts, vectors and pathogens.

A range of waterborne or wetland-dependent species vectors are present within the Indo-Burma region (Walther et al., 2016). Many of the infectious or toxic diseases are shared among humans, domestic livestock and wild animals through environmental exposure of transmission between hosts (Cromie, 2018). Malaria, cholera and dengue fever are all a risk to humans across the Indo-Burma region, whereas *inter alia* avian influenza, bovine tuberculosis, harmful algal blooms, leptospirosis, schistosomiasis, tick borne diseases and West Nile virus affect all three sectors.

The degradation of wetlands across the Indo-Burma region directly disrupts the functioning and stability of ecosystems and has profound impacts on human health and the incidence of diseases (Walther et al., 2016). Agricultural intensification has been a significant driver of wetland degradation and loss and associated human health impacts (Lam et al., 2017). The post-Viet Nam War agricultural changes in the Red River Delta, increased food production but destroyed wetland habitats, polluted waterways, and increased incidents of human disease (Nguyen, 2017).

Malaria is a significant threat to human health across the region. Due to socio-economic and political differences among the countries of the Indo-Burma region, malarial cases often cluster along international boundaries (Ciu et al., 2012). This is particularly the case along the Thailand-Myanmar and Thailand-Lao PDR borders. The impacts of environmental changes, and especially to wetland habitats, resulting from human activities can have a major impact on malaria vector species within these border areas and more widely across the region (Ciu et al., 2012; Parker et al., 2015). The development of dams, drainage and agricultural irrigation, all drivers of wetland degradation and loss, have all been cited as factors that influence the patterns of malaria distribution and incidence of transmission within the Greater Mekong sub-region (Christofferson et al., 2020).

In addition to mosquitoes, other wetland-dependent invertebrates, such as trematodes, pose a threat to human health. In Thailand, human health risks have been linked to the parasitic Southeast Asian liver fluke *Opisthorchis viverrini* which can cause cancer of the bile duct in humans. More than 9 million people in northeast Thailand and Lao PDR have been infected by the parasite (Grundy-War et al., 2012). The fluke is intimately associated with several cyprinid species commonly found across the Mekong River system and utilised in a variety of food preparations. A critical approach to the control of opisthorchiasis is through better education and the development of participatory health education programmes that can fuse good science with local knowledge, focusing on differential raw attitudes between genders, generations and social groups (Ziegler et al., 2011). Similar concerns around *O. viverrine* have been raised in Cambodia where high incidence of parasites and elevated risks to human health were found in association with water discharges from treatment wetlands, especially Boeng Cheung Ek, Phnom Penh (Ngoen-klan et al., 2010).

The development of integrated strategies has been successful across the region in reducing the incidence of disease in the human population. Often such strategies involve various elements including habitat management, community engagement, treatment and education (Sripa et al., 2015). Similarly, reducing human-water contact, improving water quality (potentially through the use of well-managed wetlands), regulating water flows, introducing larvivorous fish and improving sanitation can all contribute to enhanced control of wetland-vectored diseases (Neogi et al., 2014).

A study on emerging infectious disease sought to explain how biodiversity could affect the incidence of disease (Morand, 2011). The study concluded that there was a strong case to preserve biodiversity in order to maintain high ecological health and to reduce the risk from pathogen transmission and zoonotic diseases. A knowledge gap remains, however, between the role of wetlands and the transmission of malaria, dengue and other water-vectored diseases within the region. At a meeting of 80 experts and government stakeholders from 14 countries across and beyond the Indo-Burma region held in 2019, one of the outstanding questions that remained unanswered was what is the role of biodiversity in shaping disease transmission both in endemic and epidemic scenarios (Christofferson et al., 2020)? Similarly, the basic role wetland biodiversity plays in shaping and moderating the overall transmission landscape was considered underappreciated and, as a result, could undermine future disease control strategies. Similar uncertainties have been raised with regards to the impacts of dam building on the Mekong River and the potential impacts on malaria and schistosomiasis transmission (Ziegler et al, 2013). Therefore, there is a clear need to increase collaboration between biodiversity scientists and the health sciences to protect human well-being (Morand, 2011) and to ensure that potentially conflicting management demands are appropriately considered and addressed (Dale and Knight, 2008).

Recommendations

- Wetland management planning should consider potential risks to human health and integrate appropriate management control or mitigation strategies.

- The health benefits of wetlands need to be better understood and integrated into cross-sectoral policies that embrace the optimization of ecosystem services including the management and mitigation of impacts on human health.

- Specific information on individual vectors, their environmental requirements and species-specific wetland management strategies need to be developed and integrated into comprehensive cross-sectoral practices.

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Endemic water onion (Crinum thaianum) in Kaper Estuary - Laemson Marine National Park - Kraburi Estuary, Thailand
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B12 REGULATING SERVICE – POLLINATION

Key messages

- Wetlands support abundant pollinators, such as hoverflies, bees, butterflies, birds and mammals that support plant fertilization and reproduction both within and beyond wetland ecosystems.
- Agriculture, and particularly rice and cash-crop production, depend on many wetland-dependent species for pollination.
- Robust scientific knowledge and local understanding of the roles and importance of pollinators is limited across the region.

Status of the pollination regulation service in the Indo-Burma region

Pollination is a fundamental fertilization and reproductive process for plants. Biotic vectors, such as birds, insects and mammals, pollinate almost 90% of all flowering plants (McInnes, 2016). In addition to the role of animals, abiotic factors such as wind and water dispersal can also be important forms of pollination.

The importance of pollinators on agricultural production has long been established, with pollinators moving from wetland habitats to surrounding croplands, and particularly insect-pollinated cash-crops (Ricketts, 2004; Klein et al., 2007; Mushet and Roth, 2020). Enhancing the margins of rice paddies and drainage channels by encouraging a diverse growth of wild plants has been advocated in Lao PDR and Viet Nam as a beneficial approach to attracting pollinators and enhancing crop production (Balasubramanian et al., 2008; Nguyen et al., 2018). Similarly, the role of pollinators in the success of taro production has been emphasised from Myanmar (Matthews and Naing, 2005).

Bees, hoverflies (Diptera), butterflies and birds are the most studied pollinators in the agricultural and conservation context (Orford et al., 2015). Many of these species are abundant in wetlands across the Indo-Burma region. However, sound scientific knowledge of plant-pollinator interactions in wetlands from the region, and Asia more generally, is very scattered (Funamoto, 2019). Local knowledge on the role of wetland habitats in supporting pollinators is also limited (Kaiser et al., 2013).

Knowledge of plant-pollinator relationships in different wetland habitats is sparse. Whilst studies have been conducted on food production systems, knowledge from other wetland types is minimal. For instance, detailed understanding of pollinators in mangrove forest is highly limited (Raju, 2019). A study of oriental mangrove *Bruguiera gymnorrhiza*, a member of the Rhizophora family, in Thailand indicated a dependence on bird pollination by the brown-throated songbird *Anthreptes malacensis* and the black-naped oriole *Oriolus chinensis* and only a minor importance of indirect pollination by wind (Kondo et al., 1991). This demonstrates the symbiotic relationships that exist in wetlands but which remain poorly studied. Additionally, the impacts on pollinators are poorly understood. There is some evidence that disruption of mutualism (symbiosis which is beneficial to both species) and the luring of pollinators away from native species as a result of invasive species can have impacts on pollinators (Charles and Dukes, 2008). Furthermore, the intensification of rice production through the use of pesticides and monocultures, can reduce the diversity of pollinators leaving a depauperate invertebrate community comprising a limited number of generalist species (Hass et al., 2018).

Recommendations

- The importance of wetland dependent species to agricultural production needs to be better understood and communicated to wetland managers.
- The creation of botanically diverse margins for wetland agricultural systems, such as a around the margins of rice paddy systems or irrigation channels, should be strongly encouraged to increase the diversity and abundance of pollinators.
- The use of pesticides and the control of invasive species is essential to protect populations of pollinators.

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B13 REGULATING SERVICE – EROSION REGULATION

Key messages

- Coastal wetlands, including mangroves, seagrass beds and coral reefs, can all help to prevent coastal erosion across the region.
- The role of wetlands in regulating coastal erosion, particularly in the Mekong Delta region, is being undermined by wider anthropogenic and hydro-geomorphological changes in the river systems of the region.
- Erosion is a natural process across the river systems of the region. Human activities are accelerating and altering fluvial erosion rates across the region.
- The role of riparian or floodplain wetlands in regulating erosion is poorly understood and reported from the region.

The status of the erosion regulation service in the Indo-Burma region

Erosion regulation is the ability of wetland ecosystems to prevent and mitigate the erosion of soil and substrates. Wetland plants have the physical ability to slow water velocity, reduce turbulence, and increase the deposition of sediments. Below ground, the dense network of plant roots can directly reduce rates of erosion by stabilizing and binding the soil substrate (McInnes, 2016).

Coastal erosion regulation

The coastline of the region is vulnerable to a number of threats, including shoreline erosion (DasGupta and Shaw, 2013; Duc et al. 2017). Often the threat of erosion is being exacerbated by sea level rise and increased storm intensity arising from climate change (Marks, 2011; Boateng, 2012). In the Mekong Delta region, erosion is exacerbated further by changes in the sediment dynamics and particularly the supply of fluvially derived material (Marchesiello et al., 2019).

Coastal wetland systems, including mangroves, seagrass beds and coral reefs, all provide the shoreline with protection and reduce the risk from erosion (Nakaoka et al., 2014). A study conducted in the Koh Kapik Ramsar Site, Cambodia, concluded that the presence of relatively intact mangroves stabilizes the coast against erosion from both storms and tidal bores. The mangrove systems also trap significant amounts of sediment delivered via the river and creek systems, further stabilizing the coastal system (Sorn and Veth, 2019). Studies conducted along the central and northern Vietnamese coast indicate that the presence of extensive seagrass beds and coral reefs provide a significant 'bioshield' against coastal erosion (Veettil et al., 2021). An economic evaluation of various ecosystem services provided by the mangrove systems of Myanmar concluded that the economic value of the erosion regulation service was 1,369.28 US$ ha−1 year−1 (at 2018 prices), the second highest estimated economic value of mangroves after the maintenance of fisheries population (Estoque et al., 2018). However, Besset et al. (2019) caution that without sufficient sediment supply from the river systems, the erosion protection service provided by mangroves around the Mekong Delta will ultimately be compromised.

River erosion regulation

The erosion of riverbanks is a natural fluvial geomorphological process in dynamic river systems (Kummu et al., 2008). Many reaches of the Mekong River are characterised by steep vertical eroded banks on one side of the channel and gentle alluviated and vegetated banks on the opposing side (Carling, 2009). However, severe erosion, as experienced in the Mekong Delta, the Chaktomuk confluence in the vicinity of Phnom Penh, and the meandering reach of the Mekong River between Vientiane and Nong Khai, highlights how a natural process can be altered by a variety of human activities. Similar issues are experienced along other river systems in the region, including along the Ayeyarwady and Chindwin Rivers in Myanmar (Vasconcelos et al., 2021). Human activities which accelerate fluvial erosion include, perversely, bank protection and riverbed excavation (Miyazawa et al., 2008), changes in the sediment dynamics through mining in-channel sediments (Hackney et al., 2020), and increasing boat traffic (Thang et al., 2020).

The role of wetlands, and particularly riparian or floodplain vegetated wetland systems, in mitigating riverbank erosion across the rivers of the region is not widely reported. For the large rivers, such as the Mekong, the lateral migration of the channel is a normal geomorphological process (Kummu et al, 2008) but the role of vegetated wetland habitats in regulating erosion is lacking or considered negligible in comparison to human activities such as reservoir construction, river channel alterations for navigation, bridge construction, and sand mining. However, the use of wetlands, through floodplain reconnection for instance, has been advocated as a 'designing with nature' approach that can reduce erosion risk and control river avulsion within the rivers of Myanmar (Brakenridge et al., 2017).

Recommendations

- Protect, maintain and increase the areas of coastal wetlands, particularly mangroves and seagrass beds, to regulate accelerating rates of coastal erosion, particularly around the Mekong Delta.
- Develop Nature-based Solutions, including floodplain reconnections, to mitigate fluvial erosion impacts and to provide additional societal benefits.

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The roots of mangroves and other wetland plants can secure soil and prevent erosion © Sirachai Arunrugstichai

B14 REGULATING SERVICE – WATER PURIFICATION

Key messages

- Wetlands are currently playing a critical role in improving water quality, whilst reducing waterborne disease and providing additional benefits in urban and rural settings across the region.
- To ensure that wetlands sustainably remove pollutants requires appropriate design and management.
- There is a direct link between the wise use of wetlands and human health benefits through the ability of wetlands to remove pathogens and other contaminants.

The status of the water purification service in the Indo-Burma region

Wetlands can be considered as natural waste water cleaning systems that improve water quality by trapping and processing a range of potential pollutants derived from human activities (McInnes, 2016). Across the region, a variety of wetlands, both natural and human-made, are regulating water quality and removing potentially damaging elements.

Human-made constructed wetlands

Constructed wetlands are human-made systems that are designed to tackle a particular water quality issue. Different applications are widespread across the region. In Viet Nam, inland shrimp and fish farming can be a highly profitable practice. However, the creation of aquaculture farms can cause a range of environmental impacts, including loss or conversion of natural wetlands and discharges of nutrients and other contaminants, including antibiotics and pesticides, into the environment (Henares et al., 2020). Constructed wetlands are considered to be a robust ecological technique that can be used in intensive aquaculture ponds, especially where recirculation of water is adopted, for the removal of sediment, nutrients, organic matter and pathogens. Laboratory and field trials of the application of constructed wetlands in shrimp culture and aquaculture farming in Viet Nam have demonstrated good results and sustainable improvements in water quality (Konnerup et al., 2011; Pham et al., 2021).

The use of constructed wetlands is also found in urban environments across the region. Three different hybrid constructed wetlands have been used to treat wastewater from the Viet Nam Academy of Science and Technology in Hanoi. These three systems have been effective in removing heavy metals and nutrients from wastewater (Huong et al., 2020a; Huong et al., 2020b). Constructed wetlands have been considered for the treatment of urban wastewater in Cambodia since the late 20th century (Titus, 1997). Whilst not commonly used in Viet Nam, a study of a hybrid constructed wetland system (comprising ponds, free surface water and sub-surface wetland components) in Thai Nguyen city demonstrated rates of pollutant removal in excess of 75% for total suspended solids, orthophosphate and ammonia for domestic wastewater treatment (Tran et al., 2019). There are several examples of constructed wetlands in urban environments in Thailand. In Sakon Nakhon city in the north east of the country, a constructed wetland system has been in operation as part of an integrated wastewater treatment system since 1997 (Møller et al., 2012). Constructed wetlands have also been integrated with tourism developments in Thailand. The island of Koh Phi Phi is a tourism hotspot. A constructed wetland was built in 2007 to demonstrate the potential of integrating an aesthetically pleasing Nature-based Solution within a built environment. The final wetland design, which was agreed through extensive stakeholder engagement, resembles a butterfly sitting on a flower (hence the colloquial name of the 'butterfly wetland'). Whilst initially a success in terms of water quality purification, longer-term challenges emerged relating to lack of management (Brix et al., 2011). This highlighted a key challenge for the future use of constructed wetlands within the region.

Natural wetlands for water purification

Natural wetlands distributed throughout a catchment or along a coastal zone can help to purify water, improve water quality and protect humans from disease. The city of Phnom Penh relies on system of natural wetlands to treat approximately 90% of all its wastewater (Irvine et al., 2008). Covering some 2,000 ha during the wet season, Boeng Cheung Ek is the largest wetland treating wastewater in Phnom Penh. Studies have indicated that this wetland can remove in excess of

99% of the potentially harmful bacteria *Escherichia coli* (*E. coli*) (Visoth et al., 2010). In addition to the water purification service, the Boeng Cheung Ek wetland also provides a multitude of other benefits to society (Ro et., 2020).

A study conducted along a tributary of the Mekong River in northern Lao PDR highlighted the importance of riparian vegetation along streams and rivers in maintaining and improving water quality, especially in terms of mitigating human impacts from domestic waste and intensification of land use (Ribolzi et al., 2011). Another study in the Houay Pano catchment in northern Lao PDR demonstrated the importance of headwater streams and their associated wetlands in moderating the levels of *E. coli* and acting as natural sanitation systems (Nakhle et al., 2021).

Whilst not wetlands *per se*, the role of integrated forest and wetland ecosystems can be important in maintaining and improving water quality, as well as provided other ecosystem services. For instance, in Thailand, it was calculated that a 1% increase in forest cover in a catchment reduces costs of water treatment for human use by approximately 0.6% (Vincent et al., 2020). When used in combination with natural wetlands, it has long been established that the benefits to human society demonstrate a concomitant increase (Whigham et al., 1988).

Recommendations

- Wetlands can play a strategic role in the management of urban and agricultural wastewaters and should be better integrated into water management planning processes across the region.

- Opportunities should be sought to create multi-benefit wetlands in urban and peri-urban environments to sustainably manage domestic, industrial and other wastewater streams.

- Rural land use planning should consider the protection and/or restoration/creation of areas of wetland (or integrated forest-wetland ecosystems) for the removal of sediments, nutrients and other contaminants to protect in-stream water quality and aquatic ecology.

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B15 CULTURAL SERVICE – RECREATION AND TOURISM

Key messages

- Before the COVID-19 pandemic, both international and domestic tourism was increasing in the region, and is starting to return again, as the pandemic wanes. Wetlands provide important destinations for this burgeoning population of tourists.
- Without appropriate environmental protection, infrastructure investment, regulation and enforcement and local capacity-building, wetland tourism can quickly become unsustainable and transition from an opportunity to a threat.
- The development of strategic approaches to wetland tourism needs to be cross-sectoral and ensure a balance between economic investment, social cohesion and environmental protection.

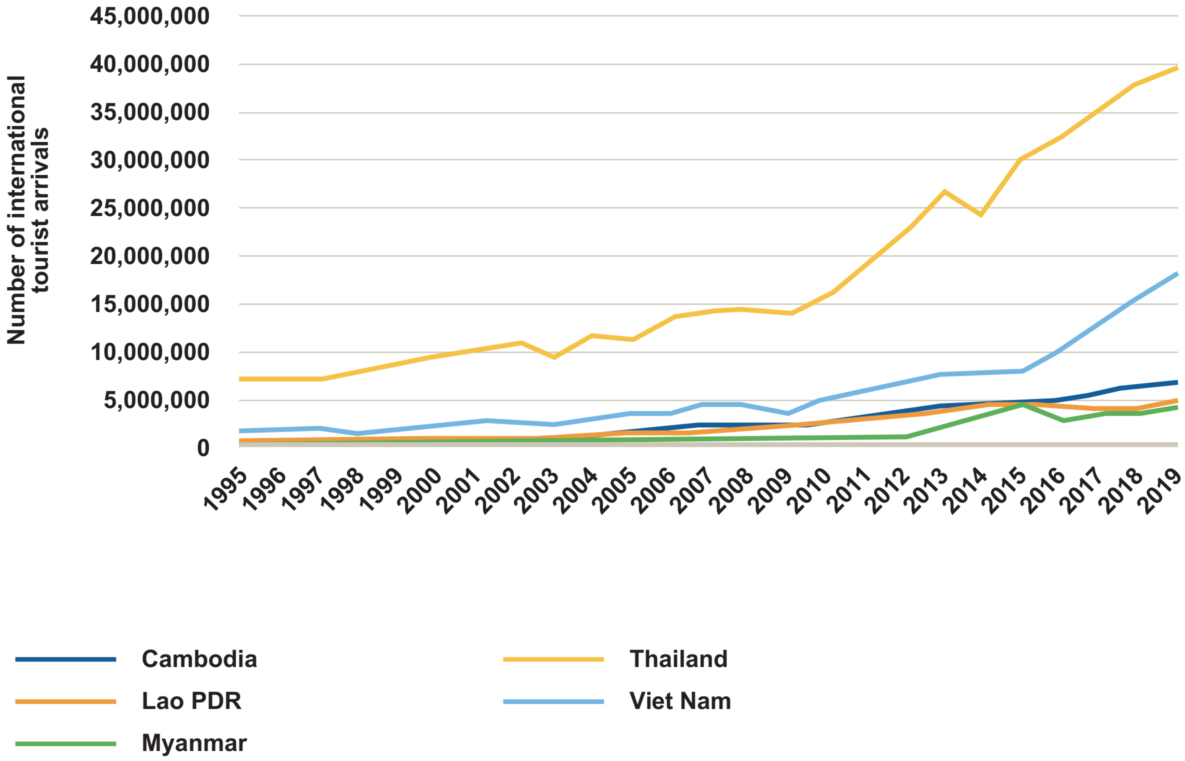
Wetlands are a significant part of the global tourism experience and are therefore a key part of the expansion of tourism locations. People are naturally attracted to water, to coastal wetlands such as coral reefs and beaches, and to inland wetlands such as lakes and rivers, reflecting the strong bond between people and nature as well as the unique aesthetic appeal of wetlands. Across the region, the number of international tourists arriving in each country has steadily increased over the last quarter of a century (Figure B15.1) until the COVID-19 pandemic took hold in early 2020. Rising incomes and improved infrastructure are fuelling a growth in domestic tourism and recreational visits to wetlands. For instance, a study on the Pru Lan Kwai freshwater wetlands in southern Thailand revealed that people in the community and nearby areas are increasingly visiting the wetland to enjoy the scenic views of sunsets (Aedasong et al., 2019). A similar situation is present at Moeyungyi Wetland Wildlife Sanctuary Ramsar Site (WWSRS), Myanmar, where people from communities around the site regularly visit to enjoy the environment and to relax in the site's restaurant and associated external spaces. However, at Moeyungyi the number of visitors, which primarily comprise local day-visitors, increased from less than 10,000 per annum in 2012 to more than 55,000 in 2016 placing pressures on the site management (NWCD, 2018).
Whilst tourism and recreation provide an opportunity for local people living in and around wetlands to prosper there also remains a risk of unintended consequences and impacts to the very wetlands that form the tourist destination. For instance, a study from 12 villages within Mekong River provinces in Lao PDR highlighted the importance of national and international tourists to the local economy. However, the work also highlighted the need for adequate preparation prior to the arrival of large numbers of tourists to minimize negative impacts on culture, the environment and social cohesion, and the requirement to develop partnerships between the government and the private sector to balance investment in the physical infrastructure needed to facilitate tourism access in rural areas with social investments in capacity building, education and training (Schipani, 2011).

In Cambodia, to address increasing demand and visitor numbers, strategic guidelines have been produced for the development of sustainable tourism on the Khmer coast. These call for appropriate legislation and enforcement, integrated planning, protecting natural and cultural heritage, improving public infrastructure, improving service delivery and capacity, and increasing community-based involvement to prevent the degradation and loss of vital natural resources critical to the visitor experience (Carter et., 2013). Tonle Sap, and the nearby cultural site of Angkor Wat, are significant tourism destinations that over 90% of international tourists would wish to visit once in their life (Baromey, 2008).

In Myanmar, 17% of all international tourists visit Inlay Lake. In 2012, about 100,000 international visitors arrived at the lake, and at least a similar number of domestic visitors (Ministry of Hotels and Tourism, 2014). This number has steadily increased over recent years (until the COVID-19 pandemic). This places pressures on this internationally important wetland site. Integrated destination management planning has been implemented in an attempt to address issues such as coordination among tourism management, distributing tourists to multiple locations, managing water pollution and solid waste, promoting sustainable practices and equitable benefit sharing amongst the area's poor and disadvantaged. However, it has been noted that, despite best intentions, often there may be a significant lag in tourism money getting through to local communities or funding conservation management activities at Inlay Lake (Sett and Liu,

Figure B15.1

Number of international tourist arrivals 1995-2019 (source Our world in Data).



2014). A further study at Inlay Lake concluded that tourism can either be a difficulty or an answer to conservation of the lake ecosystem (Ingelmo, 2013).

There are examples across the region where the impact of tourism on the local economy and nature conservation has been positive. In the case of the Can Gio Mangrove Biosphere Reserve and the Xuan Thuy National Park in Viet Nam, members of the local community are able to participate and benefit from tourist programs based on the recreational value of mangrove forest, partially through employment opportunities with the main tourist companies. In addition, some communities have also set up their own community-based ecological tourism (Van Tuyen, 2009).
All five countries have national guidelines, plans or strategies, which promote sustainable tourism (or in some cases 'eco-tourism'). These often place the natural environment, and wetlands in particular, at the heart of their country's key travel and recreation destinations.

They also highlight several similar issues that need to be considered in developing and promoting nature-based tourism. These include: strengthening institutional and cross-sector arrangements; integrating tourism plans with protected area plans to prevent unintended consequences and environmental degradation; engaging and involving local communities; investing in essential infrastructure; promoting responsible business practices and models; and strengthening research and monitoring frameworks to assess the potential impacts of tourism and recreation on wetlands. Positives examples can be seen in all five countries, but equally there are numerous examples of less-sustainable tourism and recreational activities. The IBRRI provides an excellent platform to share knowledge and experience and to ensure that the wetlands, their local communities and the wider national economies benefit from a growing tourism sector.

In a survey of 27 ASEAN Heritage Parks including Had Chao Mai, Koh Ang Tong, Koh Surin and

Tarutao coastal and marine wetlands in Thailand; as well as Inlay Lake and Mainmahla Kyun in Myanmar, conducted by the ASEAN Centre for Biodiversity (ACB) in 2020, 17 of the parks reported that COVID had reduced their income, with e.g. Had Chao Mai National Park estimating losses of $29,000 in the first three months of 2020 alone.

While the COVID-19 pandemic has resulted in a massive decline in income from international tourism from 2020-2022, with severe impacts on many protected areas, businesses and communities, nevertheless it has also provided an opportunity to address the issues highlighted above, before the tourism numbers once again return to their previous highs.

Recommendations

- Share experiences and best practice from across the region to develop site-level sustainable tourism and recreation plans and practices.
- Ensure local communities and civil society organizations are involved in the planning of tourism and recreational activities and that they benefit equitably from income and investment.
- Develop sustainable finance models that ensure money generated from tourism activities is invested in wetland management, monitoring and restoration.

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Source

Our World in Data:
https://ourworldindata.org/tourism

U Minh Thuong Ramsar Site Buffer Zone, Viet Nam © Kathryn Bimson, IUCN

B16 CULTURAL SERVICE – EDUCATION

Key messages

- Wetland visitor and education centres across the region are providing informal learning opportunities for local, national and international people, raising awareness of wetland issues and enriching people's knowledge of environmental issues.
- Informal learning is also taking place at a community scale at numerous wetlands resulting in enhanced understanding and delivery of wise use of wetlands.
- Wetlands play a critical role in formal education at all levels from schools to universities.

The status of wetland education in the Indo-Burma region

Wetlands across the region provide opportunities to enrich humans through formal and informal learning and education opportunities. Formal education is typically associated with schools, colleges and universities, whereas informal education is more commonly aligned to wetland education or visitor centres which provide a broad spectrum of learning experiences (Hails, 2016).

Informal education benefits

There are several wetland education or visitor centres across the Indo-Burma region. Some of these centres are members of Wetland Link International (WLI, see https://wli.wwt.org.uk/), a global network of wetland education centres. WLI defines wetland education centres as any wetland where there is interaction between people and wildlife and CEPA (communications, education and public awareness) activity occurs in support of wetland conservation aims. Such centres can range from a local community scale initiative to large-scale visitor centres that may attract hundreds of thousands of visitors each year (Rostron, 2106). Currently, Myanmar has four centres that are part of the WLI network (Indawgyi Wetland Education Centre, Inlay Lake Biosphere Reserve Environmental Education Centre, Meinmahla Kyun's Education centre and Environmental Education and Sustainable Centre (EESC) Myanmar). All of these centres provide informal education opportunities, through interpretative materials, guided walks, hides and walkways, for *inter alia* individuals, school groups, families and social visitors to enhance their knowledge and understanding of the importance of wetlands. Thailand has one WLI member, the Bangpu Nature Education Centre which attracts some 10,000 visitors each year. Membership of the WLI Asia initiative provides opportunities for improved cooperation and sharing of resources and experience to enhance informal education across the region. However, as important as wetland education or visitor centres can be, future efforts should be made to ensure that they are developed in line with best practice guidance such as that published by the Ramsar Secretariat (Ramsar Secretariat, 2014).

In addition to the formal members of the WLI network, there are numerous wetland sites where informal learning activities are delivered. Often, informal education opportunities arise through symbiotic tourism activities. For instance, providing tourists with information on biodiversity conservation, bird-watching opportunities or explaining local community wetland-interactions and values can all enhance the tourism experience. At Phu My protected wetland in Viet Nam, such an approach was highlighted as potential way to secure additional revenue for the site (Tran et al., 2015). Furthermore, informal education and local community awareness raising can be critical not just in providing learning opportunities as part of human development, but in empowering local conservation action and the delivery of wise use at the site scale (Parr et al., 2010).

Social media is increasingly playing a role in environmental education across the region. Initiatives such as the Sustainable Mekong Research Network (SUMERNET) have taken advantage of the proliferation of digital platforms and media to highlight the regional challenges around sustainable water management through the distribution of documentary films and photographic stories (Krittasudthacheewa et al., 2019). Unfortunately, social media can also be a threat to wetland-dependent species. For instance, in Thailand, Facebook has been used to facilitate the illegal trade in Asian small-clawed otter (*Aonyx cinereus*) and the smooth-coated otter (*Lutrogale perspicillata*) (Siriwat and Nijman, 2018).

Formal education benefits

The wetlands of the region have long been studied by university scholars and school children alike. Several sites host long-term data sets on aspects of wetland science. For instance, through the East Asian-Australasian Flyway Partnership (EAAFP), long-term waterbird monitoring datasets have been established for the wetlands of the region. Similarly, the Mekong River Commission have been conducting basin-wide monitoring across many disciplines to ensure that management decisions are based on robust data. These data are regularly utilised for university-related, and other practical research purposes. On a more local scale, the study of wetlands is used as an integral component of university education. For instance, third-year biology students at Mahidol University, Thailand have engaged with urban wetlands in Bangkok in order to understand general ecological concepts together with exploring wetland livelihoods, values and suburban ecology in a real-world context. (Sukhontapatipak and Srikosamatara, 2012).

Some initiatives across the region, for instance the interdisciplinary Wonders of the Mekong (WOM) (https://mekongwonders.org/) is integrating research, capacity building and education and outreach to contribute to maintaining the ecological, cultural and economic integrity of the Mekong River system (Loury et al., 2021). As part of the formal education element, the WOM is developing educational guides for school teachers to facilitate environmental learning through games, drawing and videos.

Around Indawgyi Ramsar Site in Myanmar, outreach from the Wetland Education Centre involves conducting formal education sessions in local schools and villages close to the lake (Htay et al., 2022). Similarly, education outreach programmes take place in village schools in the area around Ayeyarwady Delta to raise awareness about human-crocodile coexistence and wider wetland conservation issues (Than et al., 2022).

The peer-reviewed scientific literature is populated with numerous publications based on wetlands from across the region. The compilation of the IBWO would not have been possible with much of this knowledge. Much of the university-level research conducted across the region is of a high standard and there are sound educational links with universities from outside the region. It is possible that the educational benefits could be enhanced, along with the policy and practical conservation outcomes, through broader recognition of wetland wise use as a situational, transdisciplinary and multidisciplinary science (Horgan and Kudavidanage, 2021).

Recommendations

- The development of appropriate wetland education and visitor centres is to be encouraged across the region. The development of any such centre should adhere to published best-practice guidance.

- Existing wetland education and visitor centres are encouraged to become part of the WLI network and to share experiences and materials for mutual benefit.

- The integration of informal education programmes with tourism activities is to be encouraged to raise awareness of wetland wise use issues.

- The creation and implementation of formal wetland education programmes with local schools, colleges and universities is to be strongly recommended as way to develop future generations of wetland managers as well as to more widely raise awareness of wetlands.

- Existing collaborative links among universities should be maintained and strengthened to provide benefits to students, researchers and policy-makers in order to enhance the knowledge of wetland science and wise use.

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B17 CULTURAL SERVICE – RELIGIOUS AND SPIRITUAL

Key messages

- Across the region, wetlands play an integral role in the religious and spiritual belief systems of millions of people.
- Many spiritual and religious values are poorly recognized in government policies. Understanding and integrating spiritual beliefs into wetland policies and management planning is critical to maintaining their important cultural and relational values.
- Spiritual, cultural and religious wetland-related festivals are of vast importance across the region. The sustainable management of these festivals, through the application of wise use principles, is critical if undesirable and negative unintended consequences are not to occur.

The status of wetland religious and cultural services in the Indo-Burma region

Spiritual beliefs

Wetland spiritual and religious values are fundamental to human well-being but are often poorly recognized and/or undervalued. These values have been described as the qualities that inspire humans to relate with reverence to the sacredness of wetlands (Verschuuren, 2016). Across the Indo-Burma region there are numerous reports of the importance of religious and spiritual values to Indigenous communities and local people. Appreciation and consideration of these values can contribute to wetland wise across the region.

In Khong district, Lao PDR, many of the deep-water pools along the Mekong have been established as fish sanctuaries at the village-level due to associated Animist beliefs, particularly the respect and fear of spirits. In some cases, the pools represent ‘protected areas’ whilst not being explicitly labelled by local people as fish sanctuaries, they are, nevertheless, actively protected for religious reasons (Baird, 2006). Similarly, customary law, based on religious and spiritual beliefs, has created a network of protected areas in and around the Xe Champhone Ramsar site in Lao PDR (Moore, 2013; Glémet et al., 2016). In Cambodia, 88% of local communities living upstream of the Lower Se San 2 Dam on the Se San River said that their religious and spiritual traditions would be affected by the dam construction because the guardian spirit of their village, the guardian spirit of the forest (areak), and their ancestors’ graveyards would be flooded (Ham et al., 2013).

The Indigenous people in the Nongchaiwan wetland of the Lower Songkhram River Basin, north east Thailand, believe that natural gods and/or spirits having unique roles in regulating and using the wetland resources and express this through spiritual practices such as taboos, rituals, and sacred place zonation (Cox et al., 2014). The Indigenous people worshipped the Pu Ta spirit. To ensure that the fish catch was good, the local villagers would say, “Pu Ta, I ask for fish for dinner, please”. Furthermore, the Indigenous people only took from the wetland the resources that they need for their sustenance and consumption out of consideration for the holy spirit that protected the Nongchaiwan wetland (Chunhabunyatip et al., 2018).

Located in the Cardamom Mountains in the west of Cambodia, the O’Som Commune is one of country’s poorest and most remote communities. The Veal Veng Marsh drains into the Krau River and forms a tributary of the Koi River. In spite of the impacts of the Khmer Rouge on the population, the area remains rich in wetland-related traditional cultural values. 70% of the population belong to the Por, an ancient highland Khmer minority (Hammond and Hor, 2002). The Por community have strong beliefs and taboos relating to sacred animals, especially crocodiles. Whilst there are no formal records of any of the Por ever being killed, or even attacked by crocodiles, if a member of the community hurts or kills a crocodile, it is believed that ‘*Ta Jiruk*’, an ancestor who has become a forest spirit, will bring illness or death on that person or their family (Daltry et al., 2004).

In many parts of Viet Nam there is a long tradition of fishing communities that live on boats in coastal areas and rivers and operate through institutions known as ‘*van chai*’ (Nguyen and Ruddle, 2010). The *van chai* is a comprehensive institution that is structured to address community issues and aquatic resource management. Along the Viet Namese coast, each community cluster established a van chai to worship *Ca Voi* (the Whale God, considered to be the deity which protects fisherfolk at sea). The *van chai* is responsible for shrine festivals and ceremonies and in the veneration of whale bones. The fishers and their families pray at the shrines for safety at sea and to bring home a good catch. It remains that these fishing communities firmly belive that the sea gods and ancestral spirits exert a power over their welfare, good fortune and the sustainability of their fishery (Ruddle, 1998).

Religious beliefs and festivals

The Shwe Myint Zu Pagoda, Indawgyi Lake Wildlife Sanctuary, Myanmar, was built in 1868 following the request of U Thawbita, an esteemed yet secretive monk who spent most of his time meditating the forests west of lake. The pagoda symbolised his attempts to bring Buddhism to the area. Today, the pagoda is subject to an annual festival extending over 10 days in March and attracting up to 100,000 pilgrims each year. The pagoda is a tangible artefact of the cultural and religious heritage of the wetland area. However, it has been argued that the development of both tourism around Indawgyi, including the attraction of the pagoda festival, has compromised the cultural rights of children in the area (Htun, 2019).

Similar wetland-related religious festivals are widespread across the region. Atcharee et al. (2015) reviewed several traditional Buddhist festivals from the northeast of Thailand. These include the Loy Krathong festival that honours and thanks the water spirits for providing water during the rice growing season, and the Lai Ruea Fai, or illuminated boat procession, which originates from worshipping the footprint Buddha made on the bank of Nimmathanatee River when he returned to the earth after he ascended to heaven to preach to his mother.

Loss of cultural values

Across the region, there is evidence of a gradual, but not insubstantial, erosion of traditional wetland spiritual and religious values (Millar et al., 2017). Often this is due to poorly formulated policies, the pressure from formal markets, marginalization, subjugations or the influence, and commensurate deficiencies, of ‘pure science’ (Heis and Chayan, 2020). Concerns have been raised that for many communities, the loss of wetlands would be tantamount to losing their lifeline (Silvius et al., 2000). Understanding and integrating the cultural, relational values into decision-making has the potential to lead to improved outcomes for wetland ecosystems and the communities that depend on them (Bataille et al., 2020).

Recommendations

- National and local government policies must integrate local wetland spiritual and religious values and ensure their protection.

- Better attempts are needed to recognize and capture religious, spiritual and relational values, many of which are challenging to traditional resource economic approaches, so that their values can be maintained for future generations.

- Tourism development that targets wetland-related spiritual and religious communities, festivals, sites or events must ensure that wise use principles are strongly applied and that negative impacts on communities, Indigenous people and wetland ecosystems are avoided.

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B18 SUPPORTING SERVICES

Key messages

- Supporting services are poorly recognized and evaluated in the majority of studies conducted on wetland ecosystem services in the region. Where assessed, the emphasis is characteristically on the provision of habitat, soil formation and nutrient cycling.

- Supporting services are critical to maintain the functioning of wetlands and the delivery of provisioning, regulating and cultural services and need to be better considered in decision-making.

The status of supporting ecosystem services in the Indo-Burma region

Supporting services comprise the ecosystem services that are necessary for maintenance of ecosystem integrity and the delivery of provisioning, regulating and cultural services (Everard, 2016). Supporting services normally consider habitat provision, soil formation, nutrient cycling, water cycling and primary production. A global review of wetland ecosystem service literature suggested that habitat provision and nutrient cycling accounted for more than 90% of the literature on supporting services (Xu et al., 2020). A review of 50 ecosystem service assessments across the five countries of the Indo-Burman region) demonstrated that supporting services were considered in only 15 studies (Dang et al., 2021). It is suggested that there is a lack of representation and mapping of supporting services across the region, potentially as a result of data gaps or challenges around the quantification of intangibilities. The review concluded that further, more comprehensive assessments of supporting services are needed for policy-makers to properly assess trade-offs among different values that ecosystem services deliver to different beneficiaries. This conclusion was echoed in a review of the progress on integration of ecosystem services within government policies in Thailand, with a particular reference to Bangkok. This review highlighted challenges around the fragmentation of structural systems of organizations and agencies and, at best, a moderate integration of supporting services within policies (Loc et al., 2020). An assessment of the perception of rice farmers in Mekong Delta towards different ecosystem services, highlighted the importance of habitats for wildlife and soil formation (Berg et al., 2017) which perhaps demonstrates a knowledge gap between people managing wetlands on a daily basis and higher-level government policies and people.

Recommendations

- Ensure that supporting services, and their linkages to other wetland ecosystem services are better understood and more robustly integrated into future assessments.

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3C DIRECT DRIVERS, PRESSURES AND THREATS

Key messages

- Seven indicators form the basis of the status and trends of main direct drivers, pressures and threats to wetlands across the Indo-Burma region.

3C Status and Trends of direct drivers, pressures and threats	
C1 Threats to designated sites	↑
C2 Land use change	↑
C3 Natural resource utilisation	↑
C4 Hydropower	↑
C5 Invasive species	↑
C6 Climate change	↑
C7 Pollution	↑

Key messages

Indicator	Status & Trend	Key Messages
C1 Threats to designated sites	↑	• The internationally important sites across the region are all subjected to a variety of threats. • The most frequently reported threat to designated sites across the region was illegal or overfishing. • For the majority of the designated sites, the reporting on threats has not been substantiated by robust empirical evidence. Therefore, improved information and understanding of threats to designated sites is needed.
C2 Land use change	↑	• Land uses have changed significantly over the recent period in all five countries. • The area under agriculture (either cropland or pasture) has increased by over 60% since 1970. • The area of forest has decreased in Myanmar, Lao PDR and Cambodia, remained relatively static in Thailand but has increased in Viet Nam since 1990. The increases in Viet Nam demonstrate the positive impact of robust government policies. • The area of urban land has increased for all five countries but at the fastest rates in Thailand and Viet Nam.
C3 Natural resource utilisation	↑	• Illegal trade in plants and animals continues to threaten species of conservation concern across the region. • The illegal trade in orchids is increasing and threatening wild populations of these plants. However, legal trade in orchids, when properly regulated, can provide local economic benefits. • Viet Nam is the largest exporter of wildlife in the region. • Illegal trade in numerous animals, including reptiles, birds, mammals and corals poses a significant threat to biodiversity conservation across the region. • The illegal trade in natural resources is driven by the economics of supply and demand.
C4 Hydropower	↑	• The number of hydropower dams constructed across the rivers of the Indo-Burma region has steadily increased from the 1960s and is predicted to continue to increase up until 2040. • The construction of hydropower dams across the river systems will generate a range of environmental, ecological and social impacts. Some of these impacts will be perceived as being positive, whilst many others will be seen as being negative. Therefore, to genuinely evaluate the value of hydropower schemes requires holistic and systemic analysis, including consideration of cumulative and transboundary impacts

		• The information published on the impacts of hydropower generation is heavily politicized and the number of original empirical studies is limited. Much of the information published is based on opinion rather than on a robust, independent evidence base. • There is a genuine need for sharing of comprehensive, empirical data on a range of linked issues, so that societies can make informed choices regarding the future development of hydropower across the region.
C5 Invasive species		• Wetlands in the Indo-Burma region are impacted by a variety of invasive plants and animals. • The number, variety and distribution of invasive species is increasing. • Invasive species threaten native biodiversity, undermine food security and pose serious threats to human health. • Improved knowledge is essential to stem the spread of invasive species and to implement practical and successful control strategies. • Stable socio-political conditions, which can support long-term control strategies, are essential for benefits to be realized by local communities.
C6 Climate change		• Climate change is currently impacting wetlands, their biodiversity and human well-being across the region. These impacts are predicted to increase over time. • Understanding the climate change impacts on fluvial dynamics is compromised by wider changes resulting from dam construction, water abstraction and land use change. • For the major rivers systems of the region, the general pattern resulting from climate change will be higher flows in the wet season and increased frequency of low flows and drought in the dry season. • The distribution of wetland species and biomes is changing as a result of climate change. However, robust ecological data on the implications of climate change on freshwater species is limited for the region. • The existing protected area network may not be adequate to protect the wetland biodiversity of the region and efforts should be made to expand the network to provide climate complementary spaces. • Coral reefs are being negatively impacted by rising sea temperatures. Seagrass meadows are negatively impacted by rising sea level, increased water turbidity caused by more frequent and more intense storms and increased sediment run-off from the land caused by heavy rainfall events. The effects of climate change on marine ecosystems are further exacerbated by other human-induced impacts.

		• Human settlements, and all the major cities within the region, are highly vulnerable to climate change impacts. • Climate change is increasing the incidence of waterborne diseases and impacting human health across the region. • All of the impacts of climate change on wetlands and the human societies that depend on them are exacerbated by other human-induced impacts such as water abstraction, pollution, land use change and unregulated tourism.
C7 Pollution		• There are multiple sources and types of pollution impacting freshwater and coastal wetlands across the Indo-Burma region. • Water quality is being degraded in rivers and lakes due to excessive and increasing inputs of nutrients and pesticides from agriculture. Elevated nutrient levels are causing algal blooms and impacting freshwater ecology and human health. • The management of wastewater from a variety of sources including domestic sewage and industrial facilities is poor across the region, resulting in poor water quality and an increase in harmful pathogens. • Poor land and acid sulphate soil management can result in contamination from sulphuric acid production and acidification in coastal waters. • There are many emerging contaminants that have the potential to impact the aquatic environment, however the knowledge base is very low for the region. • The construction and operation of dams can generate thermal pollution and alter river ecology downstream. • Pollution of the freshwater, coastal and marine environment by plastics is a significant threat to the ecology of the region and beyond. However, the impact of plastics on freshwater species and ecology is poorly understood. • There is an inherent interconnectivity for all water-vectored pollution from land to river to sea, which requires robust and integrated policies to mitigate the impacts. There is limited evidence of such a response across the region. • The management of plastic pollution offers an opportunity to engage in novel citizen-led monitoring approaches and the development of sustainable local economic initiatives. • Direct and indirect light pollution threaten several important wetland species across the region. Uncontrolled or regulated development and poor tourism management are exacerbating the impacts from light pollution. However, research into light pollution remains limited across the region. • Research into the impacts of air and atmospheric pollution on wetland ecology is highly limited for region.

Recommended responses for decision-makers

Indicator	Recommended response
C1 Threats to designated sites	• Improved knowledge on the nature of threats is required for all designated sites. Knowledge should be evidential and not based on perceptions or received wisdom. • Information on threats needs to be robustly integrated into management plans for the designated sites to ensure that appropriate response mechanisms are implemented to mitigate the threats.
C2 Land use change	• Land use planning needs to be integrated across sectors and the implications of land use change on wetlands needs to be more formally embedded in policies and decision-making. • Urban land use planning needs to consider the positive role that wetlands can play to enhancing the quality of life for urban dwellers.
C3 Natural resource utilisation	• Enhanced regulation and enforcement are required across the region to reduce the impact of illegal hunting and trade on wildlife. • Education of local communities and the empowerment of local people can support a transition away from illegal activities and towards more sustainable livelihoods. • Develop social and behaviour change communications (SBCC) campaigns targeting consumers of illegally/unsustainably traded wetland-dependent species. • Promote participation of Ramsar site authorities in national and sub-national Wildlife Enforcment Networks (WENs) throughout Indo-Burma.
C4 Hydropower	• Comprehensive, robust data needs to be developed for all the river systems across the region. These data need to be shared widely so that empirical studies of the pros and cons of hydropower generation can be undertaken and evaluated. • There needs to be a move away from the politicisation of information and an increase in independent empirical studies across the region. • The development of future hydropower schemes needs to comprehensively and independently evaluate all the linked environmental-sociological dimensions so that society can make an informed choice with regards to energy generation. Any such evaluation needs to consider the net climate impacts of hydropower development (including embedded carbon and potential greenhouse gas emissions) against other forms of energy generation.
C5 Invasive species	• Improve knowledge on the distribution, variety and control strategies for invasive species • Provide options for knowledge sharing and co-learning to combat the challenges imposed by multiple invasive species. • Ensure early action and intervention when invasive species are initially identified at wetland sites. Introduce stronger legislation to prevent the introduction of further invasive alien species.

	• Investigate positive invasive species management strategies which have the potential to transition a problem into a socio-economic benefit for local communities.
C6 Climate change	• There is a need to improve transboundary knowledge of the impact of climate change on the fluvial dynamics of the major rivers within the region and to disentangle the impacts arising from other factors, critically dams and land use change. • Improved knowledge on the implications for changing thermal and physical environmental regimes on freshwater species is critical. This is not only vital to understand potential impacts on the biodiversity but also with regards to understanding the implications on the provision of food across the region. • The protected area network needs to be future-proofed through the designation of climate complementary areas that will allow the redistribution of species and biomes under a changing climate. Any such protected areas will need to be supported by robust management practices. • Coral reef resilience assessments should be widely applied throughout the region to identify priority management actions for enhanced resilience • Wetlands need to be more strongly integrated into climate resilience strategies across the region, nationally and at local, and especially, city scales. Such resilience strategies need to consider drought, floods, cyclones and health pandemics.
C7 Pollution	• Integrated basin-wide (including transboundary) and coastal zone management strategies need to be developed to manage the impact of water-vectored wastes, particularly nutrients and plastics. • Wetland restoration and creation should be considered as an appropriate approach to the management of water-vectored wastes and the development of multiple benefits for society. • Research is required to improve understanding across significant knowledge gaps relating to emerging water pollutants, the impact of plastics on freshwater ecology, air and atmospheric pollution and light pollution on sensitive ecological receptors. • Opportunities to utilize novel monitoring platforms and media and to engage with citizen scientists should be developed to improve the knowledge on the type, distribution and impacts of a range of pollutants. • The development of sustainable livelihoods and circular economies should be expanded based on best-practice examples being implemented elsewhere in Asia. • A network of dark sky wetland reserves should be developed

C1 DIRECT DRIVERS, PRESSURES AND THREATS

Key messages

- The internationally important sites across the region are all subjected to a variety of threats.
- The most frequently reported threat to designated sites across the region was illegal or overfishing.
- For the majority of the designated sites, the reporting on threats has not been substantiated by robust empirical evidence. Therefore, improved information and understanding of threats to designated sites is needed.

The status of threats to internationally designated sites

The Indo-Burma region currently (August 2022) supports 40 designated sites (Table C1.1). Eight of these sites are designated as both Ramsar sites (Wetlands of International Importance) and Flyway Network Sites (FNS) (designated under the East Asian-Australasian Flyway Partnership (EAAFP)). 29 of these sites are designated as Ramsar sites only and a further three only hold FNS designation. Thailand hosts the most designated sites (n=17) and Lao PDR supports the least (n=2).

Information on the threats to the designated sites has been collected through interviews with Ramsar site managers and international and national civil society organisations working at site-level, where possible. In sites where it was not possible to speak directly with stakeholders working at site-level, the descriptions are drafted from a review of the literature and the site's Ramsar Information Sheets, which are often long out of date.

A total of twenty different threats were identified for the sites (Fig. C1.1). Every site in the region was subject to at least two threats. The most frequently reported threat was illegal or overfishing (75% of sites). Illegal or overfishing was reported from all designated sites in Myanmar and Viet Nam. The next most frequently reported threat to designated sites was (illegal) hunting or poaching (47.5% of sites). This threat was recorded at both the designated sites in Lao PDR and at five out of six sites in Myanmar. In Myanmar, birds were identified as the target of hunting. Pollution of water from a variety of contaminants, including nutrients from agricultural, domestic wastewater and industrial pollution was reported as threat from 40% of sites. Tourism was reported as threat from more than a third of all designated sites and was identified as a particular concern in Thailand and Viet Nam. In many cases, tourists are attracted to watch birds, but this is now being classified as a threat to the site. Agricultural encroachment, whereby natural wetlands are either converted to rice paddy (an alternative wetland type) or drained for an alternative agricultural use, was a particular threat to both the Lao PDR sites and also within the Cambodian sites.

Table C1.1

Ramsar and FNS sites across Indo-Burma (August 2022).

	Cambodia	Lao PDR	Myanmar	Thailand	Viet Nam	Total
Ramsar Sites (RS) only	5	2	0	14	8	**29**
Flyway network Sites (FNS) only	1	-	0	2	0	**3**
Both RS & FNS	0	0	6	1	1	**8**
Total	**6**	**2**	**6**	**17**	**9**	**40**

Numerous other threats were reported as being of concern, including hydrological changes, both associated with dam construction or wider catchment changes, invasive species (particularly *Mimosa pigra*) and deforestation within the catchment. Climate change was only reported as a threat from sites in Cambodia.

Responses

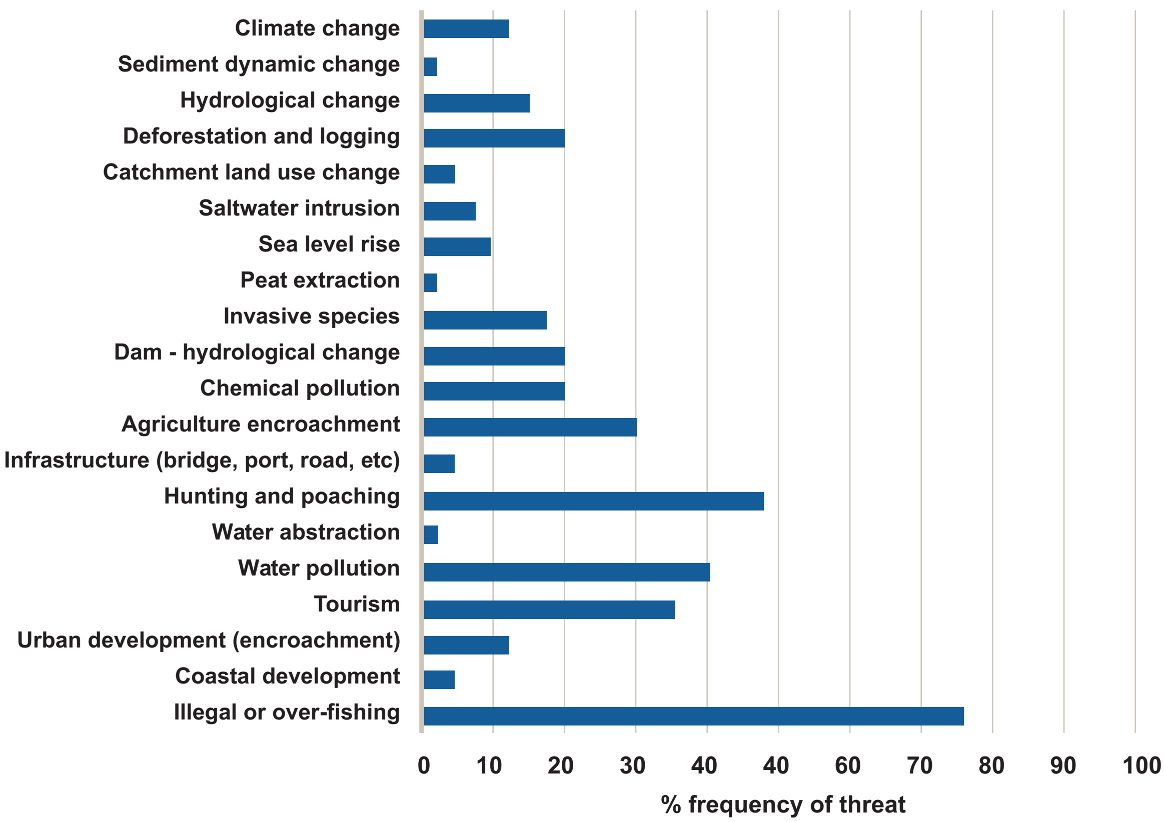
- Improved knowledge on the nature of threats is required for all designated sites. Knowledge should be evidential and not based on perceptions or received wisdom.
- Information on threats needs to be robustly integrated into management plans for the designated sites to ensure that appropriate response mechanisms are implemented to mitigate the threats.

Data source:

Zöckler, C. et al. 2021b. Indo-Burma Ramsar and Flyway Network Site Descriptions. Unpublished report to IUCN, Bangkok, Thailand.

Figure C1.1

Percentage frequency of threats at designated sites.



C2 LAND USE CHANGE

Key messages

- Land uses have changed significantly over the recent period in all five countries.
- The area under agriculture (either cropland or pasture) has increased by over 60% since 1970.
- The area of forest has decreased in Myanmar, Lao PDR and Cambodia, remained relatively static in Thailand, but has increased in Viet Nam since 1990. The increases in Viet Nam demonstrate the positive impact of robust government policies.
- The area of urban land has increased for all five countries but at the fastest rates in Thailand and Viet Nam.

Status of land use in the Indo-Burma Region

Land use is changing across the Indo-Burma region, causing significant ecological impacts (Zhao et al., 2006). Catchment land use can have a strong influence on the functioning and wise use of both coastal and inland wetlands (Sodhi et al., 2004). In some parts of Myanmar, cropland has replaced natural habitats and now covers some two thirds of catchments surrounding internationally important wetlands (Karki et al., 2018).

Data has been extracted from the FAO database to investigate rates and patterns of land use change across the five Indo-Burma countries. Since 1970, overall, the area of cropland across the region has increased by almost 60%. The greatest increase in cropland has been in Cambodia (129% increase since 1970), Lao PDR (100% increase since 1970) and Viet Nam (91% increase since 1970). The rate of cropland increase in Viet Nam has increased steadily since the mid-1990s whereas cropland increases in Cambodia primarily took place rapidly in the mid-1980s (Figure C2.1). Conversion to pasture land is less significant in the region in terms of total land area, but large percentage increases are recorded for Cambodia (159% increase since 1970) and Viet Nam (136% increase since 1970 (Figure C2.1).

The total area of forest cover has also changed in the five countries. The FAO data indicates that Myanmar and Cambodia have experienced the greatest loss of forest cover since 1990 (both countries have lost approximately 27%). However, in terms of total area lost, Myanmar has lost a considerably greater area (some 10,700,000 ha) over the same time period. Annually, forest decline in Myanmar has been by about 0.3%. However, the pattern of loss is not uniform and significant losses are observed in the mangrove areas of the Ayeyarwady delta region (Leimgruber et al., 2005). Conversely, the FAO data indicate that Viet Nam has seen an increase in forested land since 1900 of some 56% (or 5,267,000 ha). This increase has been the result of government-driven forest reforms and particularly the ban on logging and a nationwide rehabilitation programme (Dang, 2022).

Between 1974 and 2014, the amount of land under urban land use has increased in all five countries. The greatest and most rapid expansion of urban land, in terms of area covered, is observed in Thailand and Viet Nam (Figure C2.3). However, with regards to rates of annual change, the FAO data suggest that annual increases in Lao PDR between 1974 and 2014 have been approximately 3.75% per annum, representing the greatest rate of expansion of urban land in the region. Li et al. (2017) also reported that the fastest rate of urbanisation in the region was occurring in Lao PDR at a rate of 3.22% per annum between 2000 and 2010. A similar picture emerges for Cambodia with an annual increase in land under urban land use of approximately 2.91 to 3.15% reported by Li et al. (2017) and the FAO data respectively. The two data sets demonstrate different rates of urban expansion for Myanmar. The FAO data indicate that the annual rate of increase is 2.72% whereas Li et al. (2017) report that the annual rate of increase was 0.96%, the lowest rate for the five countries. This is considered to represent an artefact of the time period over which the two datasets are evaluating land use change.

The expansion of urban land use can generate a range of impacts on wetlands and people. A study conducted in Thailand indicated that the expansion of urban areas accounted for 40.5% of the overall warming of air temperatures across the country (Khamchiangta and Dhakal, 2021). The creation of urban areas, and particularly impermeable surfaces, has been implicated in increases in flood risk in urban areas within the region, as well as negative impacts on water quality and human health (Jalilov et al., 2018). Conversely, this can drive

Figure C2.1

Area of cropland and pasture cover 1990-2020 (in '000 ha)
(Source https://www.fao.org/faostat/en/#data/RL)

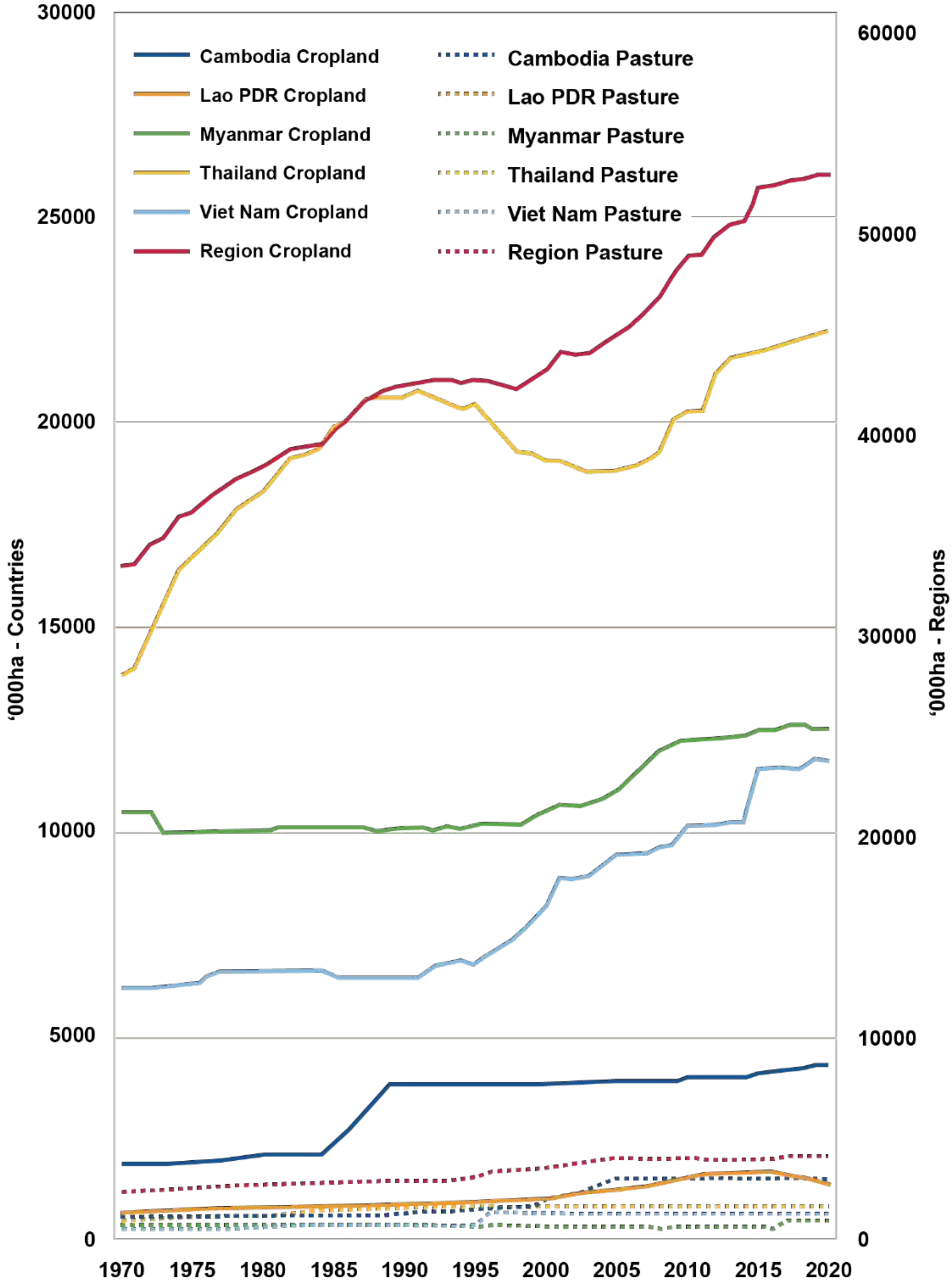
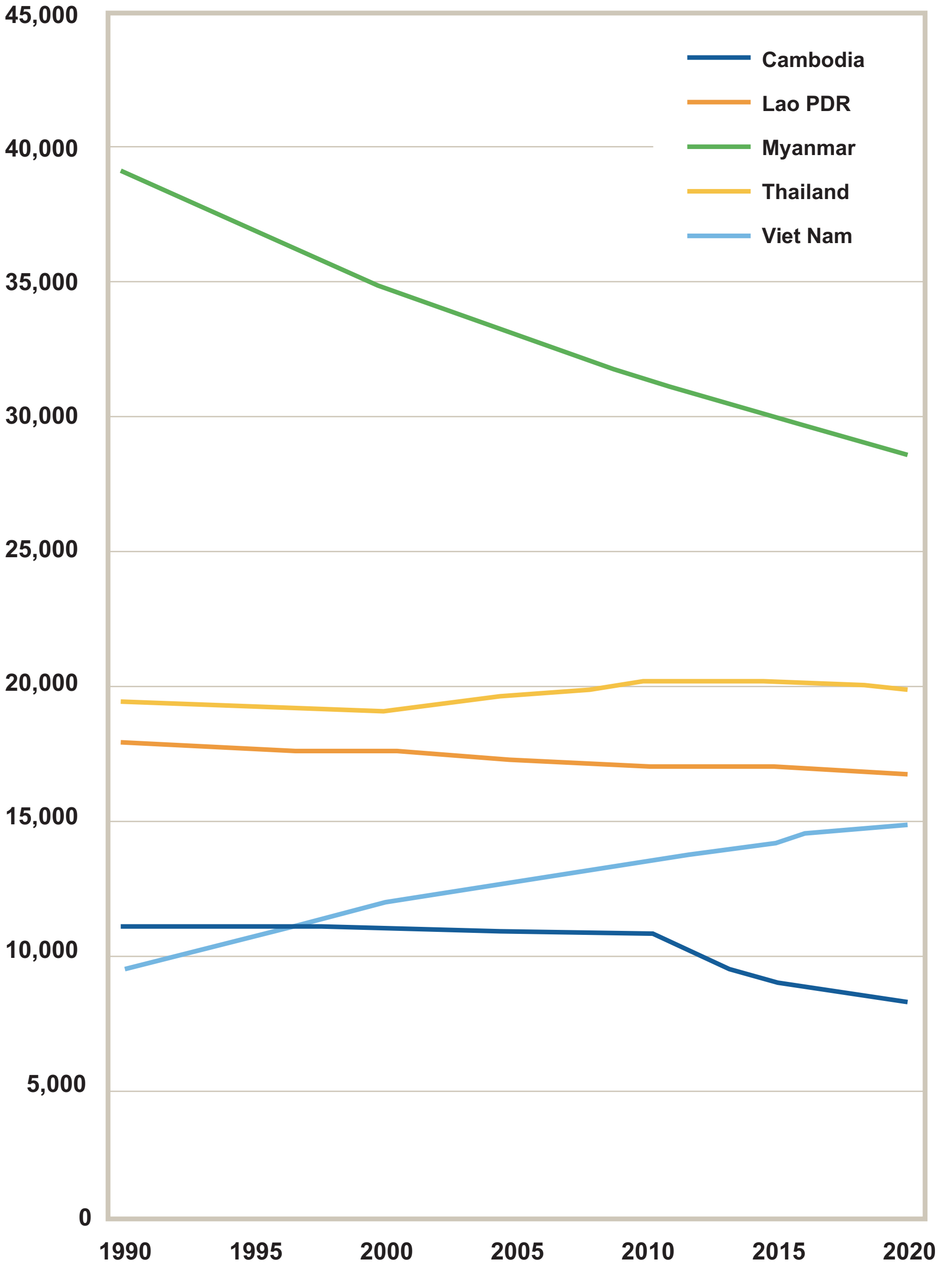


Figure C2.2

Area of forest cover 1990-2020 (in ‘000 ha)
(Source https://www.fao.org/faostat/en/#data/RL)



economic growth, with some estimates suggesting that the urban areas may generate up to 80% of the countries' gross domestic product (UN-Habitat, 2010).

Land use changes across the region should be considered in governmental land use policies. However, wetlands have been poorly considered in land use policies, and the implications of land use change on the functioning of wetlands is poorly understood (Sudmeier-Rieux et al., 2015; Dohong et al, 2017).

Responses

- Land use planning needs to be integrated across sectors and the implications of land use change on wetlands needs to be more formally embedded in policies and decision-making.
- Urban land use planning needs to consider the positive role that wetlands can play to enhancing the quality of life for urban dwellers.

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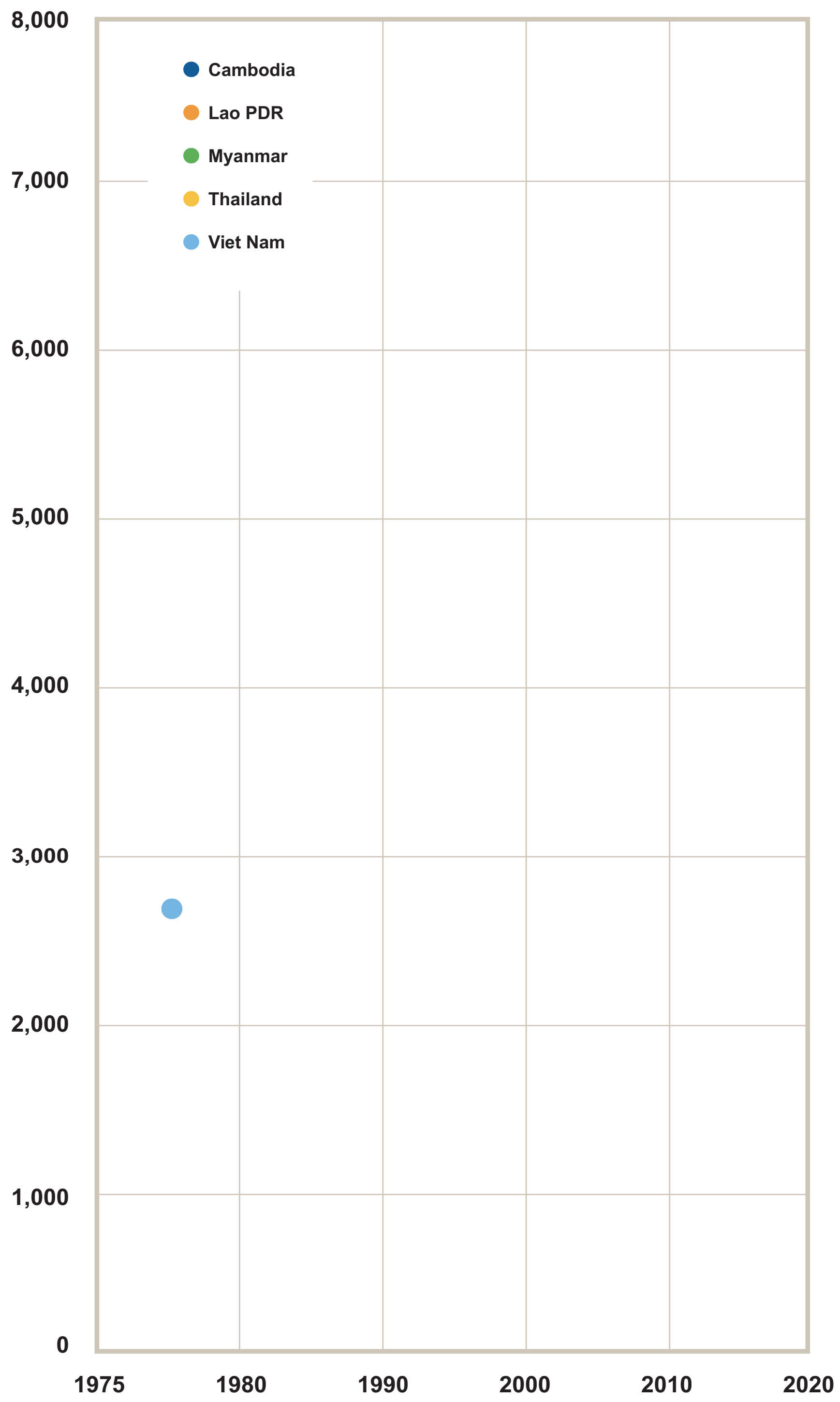
Figure C2.3

Urban land cover 1974-2014 (km²)
(source: https://stats.oecd.org/Index.aspx?DataSetCode=LAND_COVER#)



C3 NATURAL RESOURCE UTILISATION

Key messages

- Illegal trade in plants and animals continues to threaten species of conservation concern across the region.
- The illegal trade in orchids is increasing and threatening wild populations of these plants. However, legal trade in orchids, when properly regulated can provide local economic benefits.
- Viet Nam is the largest exporter of wildlife in the region.
- Illegal trade in numerous animals, including reptiles, birds, mammals and corals poses a significant threat to biodiversity conservation across the region.
- The illegal trade in natural resources is driven by the economics of supply and demand.

In Southeast Asia, the unsustainable trade in wildlife has been identified as one of the region's main conservation challenges (Nijman, 2010). The capturing and trade in a variety of wildlife species is expanding across the Indo-Burma region, primarily due to both domestic and international demands (Banjade et al., 2020). Often the trade is driven by both local needs, but also due to international economic benefits particularly to China in the north (Krishnasamy et al., 2018). National use and international trade affect both flora and fauna (Nijman, 2010; Phelps and Webb, 2015).

The trade in animal species in Indo-Burma occurs to meet demand of different consumer groups for a number of different purposes. The hunting of birds for wild meat is widespread across the region, however, information on its magnitude and impact is severely underestimated (Yong et al., 2022). Often wild caught meat is traded from communities living in or near wetlands to the nearest local urban centre, although some of it may be transported further to larger cities within the same country or even across borders to a neighbouring country (Nash, 2019).It has been argued that some animal species have experienced no significant decline in numbers, despite decades of hunting pressure, and consequently it is important to ensure that conservation efforts are targeted appropriately and do not alienate local people (Xayyasith et al., 2020). Therefore, there is an urgent need to improve the understanding of both the socio-economic drivers of wild meat hunting and the implementation of appropriate conservation responses (Yong et al., 2022).

A key, and often overlooked, driver behind wildlife trade is the demand for pets (Tingley et al., 2017). In Thailand, in recent years there has been an emerging trend of otters being caught for the commercial pet trade within and beyond the region (Gomez and Bouhuys, 2018). The influence of the internet in facilitating the illegal pet trade has been identified as an increasing challenge (Siriwat and Nijman, 2018). Similar concerns have been raised regarding the trade in amphibians via the internet, with demand for the Lao Newt *Laotriton laoensis* increasing threefold across social media (Choquette et al., 2020).

Harvesting wild plants

The illegal harvesting and trade in plants has tended to attract less attention than faunal trade (Perdue, 2021). However, botanical surveys conducted in the 2010s highlighted a significant and previously undocumented commercial trade in wild, protected ornamental plants from Thailand, Lao PDR and Myanmar (Phelps and Webb, 2015). The trade primarily focussed on orchids, with 347 different species noted as being traded. Whilst the legal trade in orchids species can provide important local economic benefit, the market also includes the trade in, and unsustainable harvesting of, numerous endangered varieties (Hinsley et al., 2018). Increasingly, concerns are being raised over the role of the internet in facilitating the trade in tropical ornamental plants (Perdue, 2021).

Hunting, trapping and poaching

Hunting, trapping and poaching for trade and wildmeat consumption is widespread and intense across many countries of the region (McEvoy et al., 2019). Numerous species are involved in wildlife trade across the region including invertebrates, reptiles, mammals, birds, corals and fish (Nijman, 2010). Based on data held in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) database, Viet Nam is the most significant exporter of wildlife from the region (Nijman, 2010).

Turtles are particularly under threat from illegal capture and trade (Cheung and Dudgeon, 2006). As an example, the countries of Cambodia, Lao PDR, and Viet Nam act as source areas for many turtle species and they export to numerous countries, including the United States of America, China and Hong Kong (Van Dijk et al., 2000). Viet Nam also functions as a small-scale domestic market for farm-bred softshell turtles and provides a corridor for chelonian species captured in Lao PDR and Cambodia to enter China (Van Dijk et al., 2000). In twelve surveys of turtles trading in the Chatuchak market in Bangkok, a total of 1,235 individuals from 20 different species were observed. Globally threatened species were recorded during every survey (Nijman and Shepherd, 2014). The illegal trade in turtles, as well as their medicinal use by local people, has also been reported in parts of Lao PDR, raising concern that the scale of the issue across the region is not fully understood (Banjade, et al., 2020).

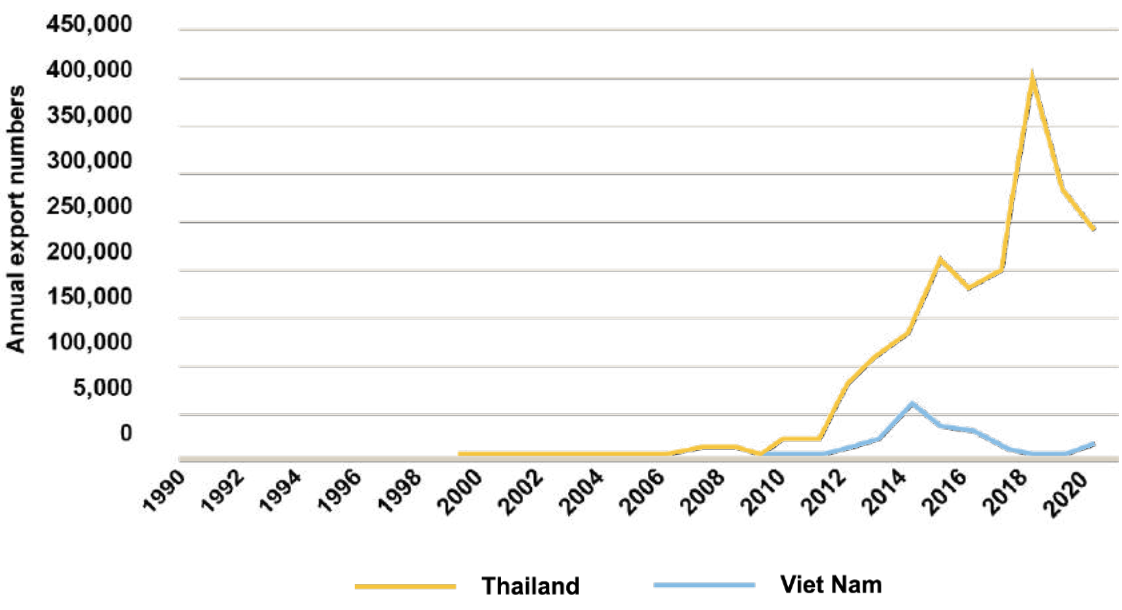
The trade in crocodile species, for their meat, skin and alleged medicinal properties, is considered to be a significant threat to their conservation status (Mitra et al., 2022). Data from CITES, suggests that eleven crocodile, caiman and alligator species captured in the wild are exported primarily through Thailand, with a small amount of trade through Viet Nam (Figure C3.1). All of these species are protected under CITES.

Significant concerns have been raised about the illegal trapping and capturing of birds in the region for trade and local food (Harrison et al., 2016). This has been termed an ‘avian defaunation crisis’ (Yong et al., 2021). Often the trapping involves mist nets which are insidious threats and also indiscriminately capture birds and other flying species such as invertebrates (Yong et al., 2021). The use of mist nets has been implicated in the rapid decline of the critically endangered Spoon-billed Sandpiper *Calidris pygmaea* in coastal Myanmar (Zöckler et al., 2010). The widespread impacts of hunting, particularly of birds, has been suggested by some authors as representing a greater direct threat to faunal communities than habitat degradation (Tilker at al., 2019).

To address both illegal wildlife trade supply and demand, a more nuanced understanding of motivations and profiles of consumption is required to help arrest the illegal practices (Margulies et al., 2019). Often the barriers to change are embedded within socio-cultural or political contexts and require substantial educational, as well legal, shifts to motivate individuals to cease their illegal activities and move towards protection of endangered species (Wallen and Daut, 2018).

Figure C3.1

Annual export of Crocodylia from Thailand and Viet Nam 1990-2022. (Source: https://trade.cites.org).



Social and behaviour change communications campaign approaches have a successful track-record in the health sector (for instance in addressing HIV prevention, Bose et al., 2022) and are increasingly being employed to support demand-reduction efforts in anti-wildlife trafficking in Southeast Asia and elsewhere (Burgess et al., 2020). TRAFFIC has targeted wild meat consumption in Thailand through a “Kind Dining” campaign in 2021-2022 (https://www.traffic.org/news/kind-dining-campaign/), and in 2022 Cambodia WWF launched a “Zero Snaring” campaign (https://www.wwf.org.kh/?373295/Local-people-participation-is-critical-to-ending-snaring-crisis-and-illegal-wildlife-trade-in-Cambodia). Both these initiatives set out to change human behaviours and to reduce the impacts on wetland wildlife.

At a regional level, the Heads of ASEAN Member States have demonstrated strong political will to enhance international cooperation in order to protect endangered species. The ASEAN Wildlife Enforcement network (ASEAN-WEN) was established in Bangkok, Thailand in 2005. Working in cooperation with national agencies, ASEAN-WEN has yielded significant seizures of illegal wildlife products and led to the detainment of hundreds of wildlife criminals (Jiao et al., 2021).

Responses

- Enhanced regulation, enforcement and prosecution are required across the region to reduce the impact of illegal hunting and trade on wildlife.
- Education of local communities and the empowerment of local people to transition them away from illegal activities and towards more sustainable livelihoods.
- Develop social and behaviour change communications (SBCC) campaigns targeting consumers of illegally/unsustainably traded wetland-dependent species.
- Promote participation of Ramsar site authorities in National and sub-national Wildlife Enforcment Networks (WENs) throughout Indo-Burma.

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C4 HYDROPOWER

Key messages

- The number of hydropower dams constructed across the rivers of the Indo-Burma region has steadily increased from the 1960s and is predicted to continue to increase up until 2040.

- The construction of hydropower dams across the river systems is generating a range of environmental, ecological and social impacts. Some of these impacts are perceived as being positive, whilst many others are seen as being negative. Therefore, to genuinely evaluate the value of hydropower schemes requires holistic and systemic analysis.

- The information published on the impacts of hydropower generation is heavily politicized and the number of original empirical studies is limited. Much of the information published is based on opinion rather than on a robust, independent evidence base.

- There is a genuine need for sharing of comprehensive, empirical data on a range of linked issues, so that societies can make informed choices regarding the future development of hydropower across the region.

The status and trend of hydropower in the Indo-Burma region

Hydropower – a geopolitical issue?

The harnessing of energy from river flows is almost as old as human civilisation itself (Everard, 2013). Small-scale bunds and dams across rivers and streams have been features of the Indo-Burma landscape for more than 1000 years (Van Liere, 1980). The pursuit of major dam development and hydropower generation across the region started in earnest in the mid-1960s (Soukhaphon et al., 2021) and understanding the challenges around balancing the need for water and energy and delivering on wetland wise use commitments is not a new phenomenon (see Maltby, 1986 or McNeely, 1987).

The understanding and objective evaluation of the benefits derived from dam construction for hydropower generation is inextricably entwined with the broader geopolitics of the region (Hirsch, 2016). Consequently, even the peer-reviewed literature is prone to different viewpoints on the nature of positive and negative impacts of hydropower dams (Feng et al., 2022). Navigating through the published literature is further complicated by the long-recognised opaque role of geopolitics in the motivation of different scholars (Bakker, 1999) and the wider politicisation of science (Wang et al., 2021).

The landscapes of the Indo-Burma region are not static. Through population growth, economic development, political changes, and climate change, humans are the major drivers of impacts on the wise use of wetlands (Woodruff, 2010). All these factors influence the inherent tensions that exist among the energy security-poverty-climate change-conservation nexus (Kaisti and Käkönen, 2020) and the evaluation of the temporalities and temporal politics that shape the assessment of the threats posed by hydropower dams across the region (Lord et al., 2020).

The status of hydropower development across the region

The main river systems of the region, the Ayeyarwady, Salween, Chao Phraya, Mekong and Red rivers, have all been modified, to a lesser or greater extent, for hydropower generation (Hennig, 2016; Middleton et al., 2019; Charoenlerkthawin et al., 2021; Soukhaphon et al., 2021; Harlan et al., 2021). These great river systems have immense hydropower potential (Siala et al., 2021) and the countries of the region have ambitions to develop further hydropower projects at various levels in order to improve energy supply (Zhang et al., 2018).

Untangling the data and the environmental facts around hydropower development across these different river systems is challenging, not least due to geopolitical perspectives (Lord et al., 2020), as outlined above, but also from the way that information is reported. Dams can be classified on their energy generating capacity (in MW), on the area inundated behind the impoundment, on their mode of operating, or on their physical size. Therefore, a key challenge across the region is to understand the eco-hydrological responses of different impoundment structures in different locations (McManamay et al., 2016) and their wider environmental and climate impacts (Ocko and Hamburg, 2019).

The number of hydropower dams across the region has changed over time. Data from the Mekong River Commission (MRC) indicate that that the number of operational and future dams has steadily increased (Table C4.1). The MRC has predicted that by 2040 there may be 146 hydropower dams operational within the Mekong basin. Alternative data sources suggest that the figure could be as high as 476 dams within the Mekong River basin alone[2] (Fig. C4.1). The current predictions suggest that hydropower dam building has peaked, in terms of absolute numbers of dams (Table C4.1).

The number of hydropower dams is not evenly distributed across the five countries of the region (and in the case of the river systems that have their sources beyond the five countries, beyond the region). The greatest number of currently operational hydropower dams occur in Lao PDR (n=70). However, there are differences in the types of dams currently operating in the different countries (Table C4.2). In Lao PDR the majority of dams have an operational capacity of less than 100MW. This situation is similar in Viet Nam where almost 80% of all hydropower dams have an energy generation capacity of less than 100MW. Whereas in China, all of dams on the Mekong-Lancang have an operating capacity in excess of 400MW, with several having a capacity well in excess of 1000MW. However, the environmental and social impacts of dams will also be cumulative, irrespective of size, depending on the number and locations of dams. Often these cumulative impacts are poorly recognised in planning and operational decisions (Baird and Barney, 2017).

Table C4.1

Operational and future dams in the Mekong River basin (source: https://portal.mrcmekong.org/hydropower/table).

Period	Operational	Under construction	Planned
<2000	14	0	0
2000-2010	18	0	0
2010-2020	60	0	0
2020-2030	8	15	29
2030-2040	0	0	2

Table C4.2

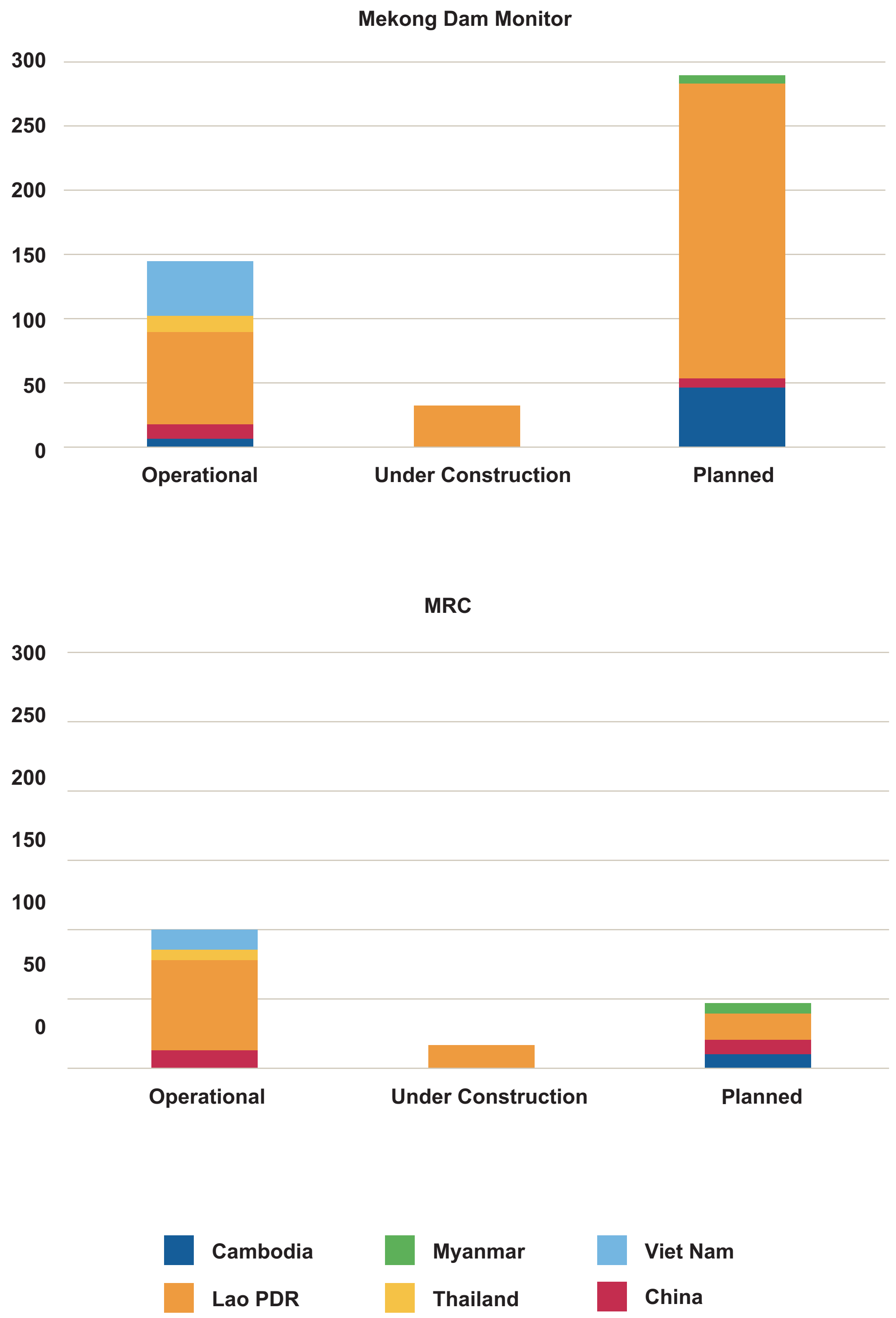
Number of existing dams for different operational capacities (in MW) in the Mekong River basin (% in parenthesis) (source: https://www.stimson.org/project/mekong-dam-monitor/).

Capacity (MW)	Cambodia	China	Lao PDR	Myanmar	Thailand	Viet Nam
<100	3 (75.0)	0 (0.0)	42 (60.0)	1 (100.0)	6 (66.7)	31 (79.5)
100-400	0 (0.0)	0 (0.0)	23 (32.9)	0 (0.0)	1 (11.1)	7 (17.9)
>400	1 (25.0)	11 (100.0)	5 (7.1)	0 (0.0)	2 (22.2)	1 (2.6)

[2] *https://www.stimson.org/project/mekong-dam-monitor/*

Figure C4.1

Operational, under construction and planned dams in the Mekong River basin. Data from https://www.stimson.org/project/mekong-dam-monitor/ and https://portal.mrcmekong.org/hydropower/table.



It is well documented that whilst electricity generation through hydropower can have a role to play in energy security (Kumar, 2016; Llamosas and Sovacool, 2021), the construction of dams can also negatively impact water resources, ecosystems and livelihoods, including water and food security, at the impoundment area or at some distance downstream of the dam (Dombrowsky and Hensengerth, 2018). However, objectively evaluating the impact of hydropower dams on wetlands in the region is challenging. The following generic negative impacts arising from hydropower development have been identified from the peer-reviewed literature:

- Hydrological changes: Increases in dry season flows (between December and May) and decreases in wet season flow (June-October) (Lauri et al., 2012; Li et al., 2017); changes in the flood pulse and natural flood dynamics (Pokhrel et al., 2018a).

- Sediment dynamics: Reductions in the movement and supply of sediment from the upper basin to the lower basin and delta areas (Kummu and Varis, 2007; Kondolf et al., 2014); declining sediment loads generating in-channel erosion and downstream sedimentation impacts (Bussi et al., 2020).

- Water thermal changes: Cooling of water downstream of dams, particularly in the dry season changes (Bonnema et al., 2020).

- Catastrophic failure: Inundation of communities due to failure of dam infrastructure causing significant human fatalities (Latrubesse et al., 2020).

- Greenhouse gas emissions: The production of greenhouse gases, such as methane (CH_4), carbon dioxide (CO_2) and nitrous oxide (N_2O), which offset the net radiative forcing benefits of hydropower energy generation (Räsänen et al., 2018).

- Fish populations: Declines in fish species richness and abundance and shifts from seasonal assemblages to aseasonal assemblages characterized by generalist fish species (Ngor et al., 2018); creation of barriers to fish migration (Vu et al., 2021).

- Provision of fish: Changes to the availability of wild fish as a protein source for millions of people (Orr et al., 2012; Golden et al., 2019).

- Changes in ecosystem services: loss of fisheries, resettlement and changes to social and community structures, land use changes and loss of biodiversity (Intralawan et al., 2018).

It is important to note that differing studies (and authors) provide differing results, and subsequently conclusions. For instance, Lu et al. (2014) suggest that downstream of the Chinese dams on the Mekong decreases in dry season flow and increases in wet season may be attributable to the presence of the dams. Furthermore, some hydrological changes have been attributed to climate change or to local land use changes, increased irrigation of agricultural land and in-channel sand mining (Chua et al., 2022). Similarly, hydrological variation within the Mekong River basin has also been attributed to El Niño-Southern Oscillation (ENSO) effects (Räsänen and Kummu, 2013) and changes in water temperature assigned to latitudinal variations along north to south flowing rivers (Zhang et al. 2007). Furthermore, there are significant challenges to unravel the impacts of climate change on the Indo-Burma environment, and particularly with regards to linked human-hydrological-ecological systems, and the influence of dam infrastructure and operation (Pokhrel et al., 2018b).

Undoubtedly, the construction of hydropower dams on the rivers of the Indo-Burma region has changed the hydrogeomorphology, ecology and resultant societal dynamics across the area. However, much of the literature reviewed presents descriptive narratives and robust, verifiable studies are limited. Data-sharing and collaborative research are needed to shift the discourse on the impacts of hydropower dams across the region towards a more systematic approach rather than focusing on politically expedient causal factors (Keovilignavong et al., 2021).

Responses

- Comprehensive, robust data needs to be developed for all the river systems across the region. These data need to be shared widely so that empirical studies of the pros and cons of hydropower generation can be undertaken and evaluated.
- There needs to be a move away from the politicisation of information and an increase in independent empirical studies across the region.
- The development of future hydropower schemes needs to comprehensively and independently evaluate all the linked environmental-sociological dimensions so that society can make an informed choice with regards to energy generation. Any such evaluation needs to consider the net climate impacts of hydropower development (including embedded carbon and potential greenhouse gas emissions) against other forms of energy generation.

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Invasive water hyacinth (Pontederia crassipes) in Tonle Sap, Cambodia (C) Pheakdey Sorn, IUCN Cambodia

C5 INVASIVE SPECIES

Key messages

- Wetlands in the Indo-Burma region are impacted by a variety of invasive plants and animals.
- The number, variety and distribution of invasive species is increasing.
- Invasive species threaten native biodiversity, undermine food security and pose serious threats to human health.
- Improved knowledge is essential to stem the spread of invasive species and to implement practical and successful control strategies.
- Stable socio-political conditions, which can support long-term control strategies, are essential for benefits to be realized by local communities.

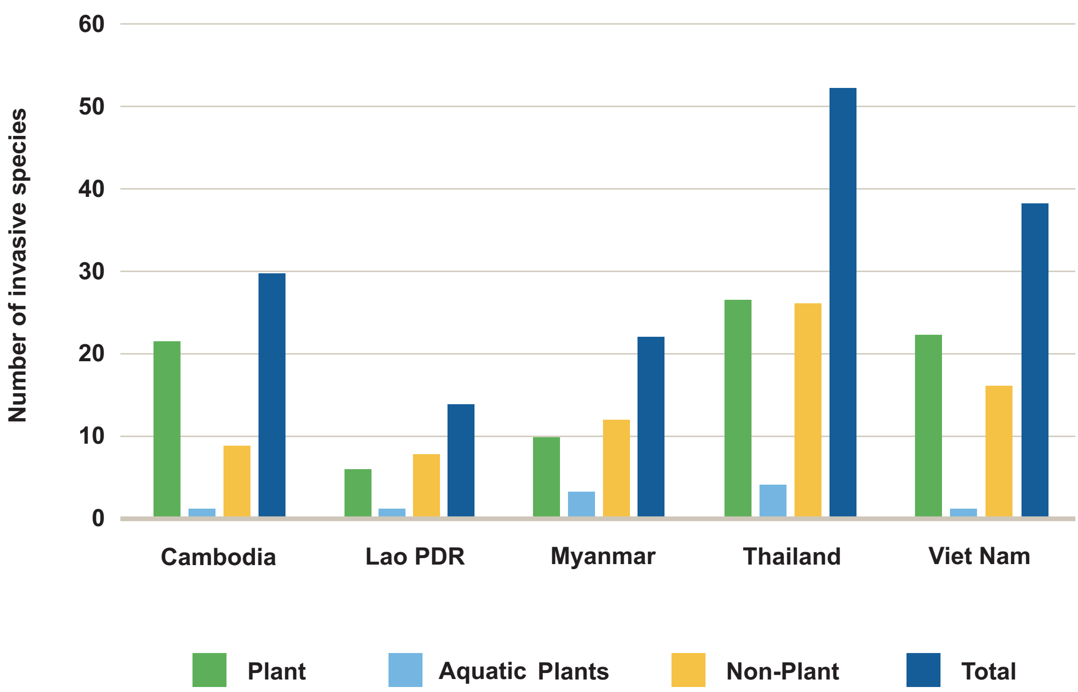
Status of the invasive species impacts in the Indo-Burma region

An invasive species is an animal or plant that harms an environment, usually after being introduced on purpose or by accident by humans. In some places, invasive species have changed the natural world beyond recognition. There are numerous invasive plant and animal species well established across the Indo-Burma region. Areas most impacted by alien invasive species include islands, coastlines, agricultural areas and large cities. There is some evidence that the number and range of alien invasive species are increasing across the region.

Data analysed Global Invasive Species Database for wetland and non-wetland habitats indicated that in 2009, Thailand supported the most invasive species (n=52) of the Indo-Burma countries comprised equally of plants and non-plant species (Fig.C5.1). Earlier, Zungsontiporn (2006) reported that there were 15 invasive alien aquatic plants recorded in Thailand including water hyacinth (*Eichhornia crassipes*), narrowleaf cattail (*Typha angustifolia*), water milfoil (*Myriophyllum brasilliensis*), Florida

Figure C5.1

Number of invasive species found in the countries of the Indo-Burma region (data from Peh, 2010)



type water lettuce (*Pistia stratiotes*), dollarweed (*Hydrocotyle umbellata*) and giant salvinia (*Salvinia molesta*). This suggests that more than 57% of all invasive plants are aquatic plants, whereas Peh (2010) only reported a maximum of four invasive aquatic plant species in Thailand.

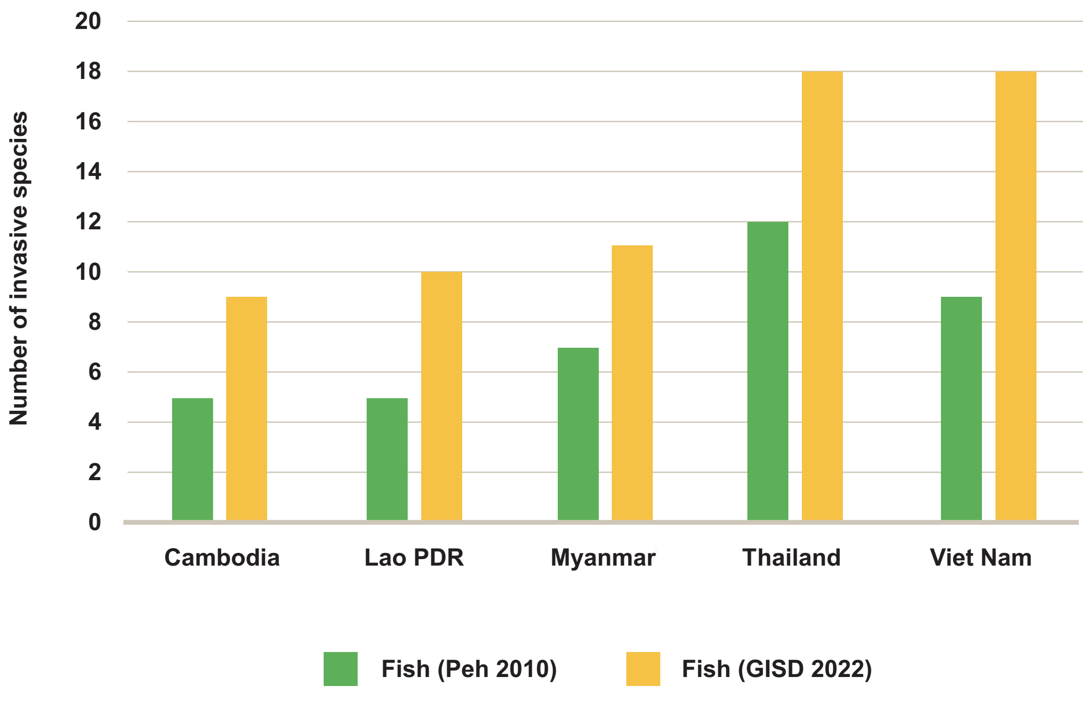
Many of the aquatic plants recorded across the region can be highly problematic. For instance, water hyacinth is a pernicious invasive plant found across the Indo-Burma region. It routinely chokes waterways and forms extensive monospecific floating mats. Management efforts have considered harvesting the plant for bioenergy generation, animal feed, horticulture practices and fertiliser production (Wimalarathne and Perera, 2019).

Whilst not a true aquatic plant, *Mimosa pigra*, a prickly shrub species native to Tropical America, is widespread across Asia and northern Australia. Due to its high dispersal capacity, through abundant buoyant seed pods, and its ability to tolerate flooding, the plant is now considered to be a problem across much of the floodplain and riparian areas in the Lower Mekong Basin (Triet et al., 2004) and more broadly across the Indo-Burma region (Heard and Paynter, 2012). By forming dense thickets with a relatively closed canopy, *Mimosa pigra* out-competes native vegetation, restricts access to waterbodies for animals and inflicts economic losses to human societies. In parts of Cambodia, up to 98% of farmers consider *Mimosa pigra* as a serious problem that negatively affected their livelihoods (Rijal and Cochard, 2016). A variety of control measures have been applied, including clearing, burning, weeding and biological control. However, the success, or otherwise, of these strategies depends on the prevalence of a socio-politically stable and benign institutional environment over an extended period for effective results to be realised and for benefits of *Mimosa pigra* control to be realised by local communities (Rijal and Cochard, 2016).

Peh (2010) reported that Thailand supported the maximum number of invasive fish species (n=12). However, a review of invasive fish species conducted utilising the Global Invasive Species Database (http://www.iucngisd.org/gisd/) in April 2022, indicates that for freshwater and brackish water wetlands across the Indo-Burma region, a total of 23 different species are reported (including

Figure C5.2

Number of wetland-dependent invasive species found in the countries of the Indo-Burma region (data from Peh, 2010 and Global Invasive Species Database (GISD), April 2022).



18 for Thailand - Fig. C5.2.). This increase between 2010 and 2022 suggests that the across region, the number of invasive fish species is increasing in all five countries.

Invasive amphibians are present across the region. The Asian common toad (*Duttaphrynus melanostictus*) is found in all five countries. Another three species are found less evenly distributed across the region. The North American bullfrog (*Lithobates catesbeianus*) and the cane toad (*Rhinella marina*) are found in Thailand, whereas the Asiatic toad (*Bufo gargarizans*) is only reported from Viet Nam. The invasive amphibians all present management challenges. The Asian common toad is toxic to humans and has been known to cause human fatalities. The North American bullfrog carries the disease Chytridiomycosis, which is caused by the fungus *Batrachochytrium dendrobatidis*. This is still considered an emerging disease of amphibians but it has been implicated in population declines and even extinctions globally (Hanselmann et al., 2004).

The most widespread and problematic species of gastropod is the invasive golden apple snail (*Pomacea canaliculata*). The snail is found in wetlands across the region. Originally introduced from South America in the early 1980s as a local food resource, the snail has a voracious appetite for water plants including lotus, water chestnut, taro and rice. It has now become a major crop pest in rice paddies across the Indo-Burma region and represents a serious threat to many wetlands through potential habitat modification and competition with native species. A survey of 143 farmers conducted in Myanmar reported that 77% of those interviewed indicated that golden apple snail was the most significant pest species present in their rice fields (Win et al., 2018). In addition to concerns raised regarding the damage to crops, recent research has highlighted human health risks associated with ingestion of the snail. Lv et al. (2018) reported that the invasive golden apple snails can be important intermediate hosts for the rat lungworm *Angiostrongylus cantonensis* which causes eosinophilic meningitis in humans. Infected snails were found at multiple sites in Cambodia, Lao PDR and Viet Nam highlighting the health concern regarding eosinophilic meningitis caused by consumption of these snails.

Many new invasive species are still entering the region. Species arrive via a variety of pathways including physical transportation, international trade, by improved and more frequent human cross-border migration and poor biosecurity. To assess the genuine scope and impact of the multiple invasive species present within the region will require better surveillance, enhanced knowledge-sharing and proven, practical management interventions.

Recommendations

- Improve knowledge on the distribution, variety and control strategies for invasive species.
- Provide options for knowledge sharing and co-learning to combat the challenges imposed by multiple invasive species.
- Ensure early action and intervention when invasive species are initially identified at wetland sites. Introduce stronger legislation to prevent the introduction of further invasive alien species.
- Investigate positive invasive species management strategies which have the potential to transition a problem into a socio-economic benefit for local communities.

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Data source

Global Invasive Species Database: http://www.iucngisd.org/gisd/

C6 CLIMATE CHANGE

Key messages

- Climate change is currently impacting wetlands, their biodiversity and human well-being across the region. These impacts are predicted to increase over time.

- Understanding of the climate change impacts on fluvial dynamics is compromised of wider changes resulting from dam construction, water abstraction and land use change.

- For the major rivers systems of the region, the general pattern resulting from climate change will be higher flows in the wet season and increased frequency of low flows and drought in the dry season.

- The distribution of wetland species and biomes is changing as a result of climate change. However, robust ecological data on the implications of climate change on freshwater species is limited for the region.

- The existing protected area network may not be adequate to protect the wetland biodiversity of the region and efforts should be made to expand the network to provide climate complementary spaces.

- Coral reefs are being negatively impacted by rising sea temperatures. Seagrass meadows are negatively impacted by rising sea level, increased water turbidity caused by more frequent and more intense storms and increased sediment run-off from the land caused by heavy rainfall events. The effects of climate change on marine ecosystems are further exacerbated by other human-induced impacts.

- Human settlements, and all the major cities within the region, are highly vulnerable to climate change impacts.

- Climate change is increasing the incidence of waterborne diseases and impacting human health across the region.

- All of the impacts of climate change on wetlands and the human societies that depend on them are exacerbated by other human-induced impacts such as water abstraction, pollution, land use change and unregulated tourism.

Observed and predicted impacts of climate change in the Indo-Burma region

The 5th Assessment conducted by the Intergovernmental Panel on Climate Change (IPCC) (IPCC, 2014; Yin et al., 2014) highlighted a variety of expected impacts arising from a changing climate across the Indo-Burma region. These include:

- Increased run off in glacial-fed rivers.

- Increased flood damage to infrastructure, livelihoods and settlements.

- An increased frequency of heat waves and associated heat-related human mortality across the region.

- Increased water scarcity and drought-related food shortages.

It is clear that the region is, and will be, undergoing impacts from a changing climate. Whilst the evidence may not always be clear for observed and predicted impacts (Table C6.1), both freshwater and coastal wetlands face ongoing challenges arising from climate change.

There is high confidence that water demand across all river basins in the Indo-Burma region will increase due to increases in human population, irrigated agriculture and industry (Yin et al., 2014). However, the impacts of climate change on river flow are less clear, and for many basins, are complicated by the role dams and land use change play on the hydrograph (Sirisena et al., 2021). In Thailand, modelling under a range of climate change scenarios clearly demonstrated that the projected river discharge will decrease, particularly in January, with a dramatic 60% drop in the Chao Phraya River basin (Champathong et al., 2013). Modelling of different climate change scenarios on the flow in the Mekong River demonstrated a high consistency of predicted future flooding patterns. The flood pulse in the Tonle Sap and Cambodian floodplains, as well as in the Mekong Delta, are predicted to be greater in the 21st century than historically, with annual average water levels,

Figure C6.1

The amount of information supporting conclusions regarding observed and projected impacts in Southeast Asia (extracted from Yin et al., 2014).

Sector	Topic/Issue	Observed Impact	Predicted Impact
Freshwater resources	Major river run off	✓	✗
	Water supply	✗	✗
Terrestrial and inland water systems	Phenology and growth rates	✗	✗
	Distribution of species and biomes	✗	✓
	Inland waters	✗	✗
Coastal systems and low-lying areas	Coral reefs	✓	✓
	Other coastal ecosystems	✗	✗
Food production systems and food security	Rice yield	✗	✓
	Fisheries and aquaculture production	✗	✗
	Water demand for irrigation	✗	✓
	Pest and disease occurrence	✗	✓
Human settlements, industry and infrastructure	Floodplains	✓	✓
	Coastal areas	✓	✓
Human health, security, livelihoods and poverty	Health effects of floods	✓	✗
	Health effects of heat	✗	✗
	Health effects of drought	✗	✗
	Waterborne diseases	✓	✗
	Livelihoods and poverty	✓	✗

KEY

✓ = Relatively abundant / sufficient information; knowledge gaps need to be addressed but conclusions can be drawn based on existing information.

✗ = Limited information / no data; critical knowledge gaps, difficult to draw conclusions.

cumulative flooded areas and inundation duration projected to rise in every scenario for both the Tonle Sap area and the Mekong Delta (Keskinen et al., 2010; Västilä et al., 2010). As a consequence of climate change across the Mekong Basin, predictions suggest that increased streamflow in wet season will result in soil degradation whilst water shortages will be common in the dry season (Khoi and Thang, 2017). Several studies have attempted to simulate the impacts of climate change on flows in the Ayeyarwady and Chindwin river basins (Ghimire et al. 2019; Oo et al. 2020; Sirisena et al. (2021). These studies have generated relatively consistent results predicting that, without further dam construction, wet seasons will become wetter with increased river flows, whilst the dry seasons will become drier with a greater prevalence of water scarcity and drought.

Whilst there is a lack of research on the impacts of climate change on freshwater biodiversity, it is postulated that changes in the distribution of species and biomes associated with climate change induced warming will result in shifts both upwards in elevation and poleward (Yin et al., 2014). Changes in temperature regimes may result in certain freshwater species adapting by moving to higher elevations or latitudes (Bickford et al., 2010). However, this adaptation strategy may only be available to species that are not at the limit of their thermal regimes, that have the capacity to be mobile and, in the case of riverine species, movement is not impeded by dams and other infrastructure. Additionally, the efficacy of such a strategy is also dependent on the availability of suitable habitats and minimal risks from invasive species or predators (Allen et al., 2012). The paucity of ecological data on different freshwater species and their response to warming thermal regimes undermines the ability to predict a variety of potential changes, including *inter alia* impacts on the timing of recruitment and fish migration, alterations in sex ratios (particularly of concern for turtles and crocodiles), increases in metabolic costs and energy budgets and responses to changing oxygen levels in warmer water. An additional challenge under a changing climate is the squeeze on space available for species and biomes (Gienapp et al., 2008). Potentially, the boundaries of protected areas may become redundant or obsolete as faunal and floral distributions change, undermining the fragile effectiveness and integrity of the network of sites. Therefore, to mitigate the impacts of climate change the countries of the Indo-Burma regions should consider establishing new protected areas in portions of complementary climate space that are currently underrepresented by protected areas (Elsen at al., 2020).

Observed and predicted impacts are clear on coral reefs, where temporal and spatial patterns of bleaching correlate positively with higher-than-normal sea temperatures (Yara, 2014) and some researchers have raised concerns that coral bleaching could become annual event in the seas around Indo-Burma (Hoegh-Guldberg, 1999). The IPCC has suggested that reefs are projected to decline by 70–90% at 1.5°C and increasing global temperatures to 2°C above pre-industrial levels may result in irreversible loss of marine ecosystems (IPCC, 2018). By 2050, 90% of all reef locations may experience mass coral bleaching annually (Van Hooidonk et al., 2016), while changes in ocean chemistry are also reducing coral calcification and growth, weakening coral skeletons and making them more vulnerable to storms (Albright et al., 2016).

The impacts of elevated sea surface temperatures, which drive coral bleaching, are further exacerbated by human driven impacts arising from increased seawater turbidity and direct pressures from tourism (Phongsuwan and Chansang, 2012).

Adaptation to the impacts of climate change includes resilience-based management of coral reefs. This requires assessing spatial variation in resilience potential and implementing appropriate management actions (Anthony, et. al. 2015; McClanahan et.al. 2012; Graham et.al. 2013). Resilience assessments were developed to help marine managers and decision makers to identify reefs most likely to survive climate change and prioritize management actions to support resilience (McClanahan et al., 2012; Weeks and Jupiter, 2013; Conway-Cranos, 2012; Maynard et al., 2015). Resilience assessments quantify the ecological, social, and environmental context of reefs through the lens of resilience, i.e., the capacity of a system to absorb or withstand stressors such that the system maintains its structure and functions and has the capacity to adapt to future disturbances and changes.

Since 2007, resilience assessments have been conducted in all major coral reef areas. McCleod et.al. (2021) identified a total of 65 reef resilience assessments that have been implemented in all major coral reef regions across 44 countries and territories. They found that most of the resilience assessments have been completed in the Indian Ocean (n = 20) and Southeast Asia (n = 16) regions, two highly threatened reef areas globally based on human impacts and thermal stress. In addition, they found that overall, 52% of resilience assessments were used to inform coral reef management, 37% were not used to inform management actions, and for 11% any conservation application remains unknown. They further identified that management planning and actions resulting from resilience assessments included the following five categories: 1) spatial planning (e.g., designing MPAs and LMMAs; zoning plans); 2) monitoring and evaluation; 3) local threat management (e.g., anchor damage, invasive species, pollution); 4) fisheries management; and 5) reef restoration (McCleod et.al., 2021).

All of the region's major cities are located in areas with high risk of fluvial and/or coastal floods. The management of water and wetlands is critical for protecting human well-being in these areas of high population density within the context of a changing climate. Many cities in coastal areas are prone to subsidence resulting from changes in sediment supply and over-abstraction of groundwater resources and increased exposure to storm surges resulting from sea level rise, with Haiphong, Ho Chi Minh and Bangkok assessed at being at the highest risk from climate change related impacts (Nicholls et al., 2008). Climate change impacts in these areas of settlement are both direct, such as changes in extreme rainfall events causing flash flooding in Bangkok and Hanoi (Saraswat et al., 2016), and indirect, through changes in fluvial hydrology across a wider catchment, for instance within the Mekong basin (Hoang et al., 2019) and sea level rise, such as for Ho Chi Minh City (Scussolini et al., 2017).

Box C6.1

Coral Bleaching in Thailand

Mass coral bleaching events in the Gulf of Thailand were reported in 1998, 2010 and 2016 (Yeemin et.al, 2012; Sutthacheep et.al., 2013; Yeemin, 2018). There were significant differences in the susceptibility of coral species to these bleaching events. The 2010 coral bleaching phenomenon at some reef sites, such as Ko Samui in the Western Gulf of Thailand, was more severe than the 1998 bleaching event (Yeemin et.al., 2012) The intensive study of coral bleaching in the Gulf of Thailand in the year 2016 revealed that the levels of coral bleaching varied significantly among different reef sites. A high severity level of coral bleaching, of about 70%, was recorded at Ko Ngam Noi, in Chumphon Province, in the south of Thailand. The coral mortality following the 2016 bleaching event was approximately 18%, which was much lower than that of the 2010 coral bleaching event because the south-west monsoon started earlier, and therefore the seawater temperature dropped rapidly (Yeemin, 2018). Manopawitr (2021) presented use of 22 resilience indictors in an assessment of resilience of 11 coral reefs in Mu Ko Surin Marine National Park. Scores ranged between 92-117 with four sites categorized as highly resilient, three as moderately resilient, and four with low resilience. In 2022-23 the ASEAN Centre for Biodiversity is piloting a coral reef resilience assessment approach for Marine ASEAN Heritage Parks at Tarutao Marine National Park in Thailand.

Many pathogens and parasites multiply at quicker rates in warmer climates. Increases in air and water temperatures have been correlated with increased incidence of waterborne diseases in Asia (Hashizume et al., 2007). A review of climate change driven droughts, floods and typhoons concluded that Cambodia faces escalating challenges to overcome the human health impacts associated with waterborne and water-related diseases (Davies et al., 2015). The importance of managing wetlands as service-providing ecosystems which can form part of an integrated health-risk management strategy (Derne et al., 2015), particularly in urban and peri-urban areas, is critical to future human well-being across the region.

Climate change will increase the frequency and magnitude of floods, storm surges, droughts and disease across the region (Yusuf and Francisco, 2009).). The effect of these events will disproportionally impact the poorest and most vulnerable members of society (Mirza, 2011). These impacts will have knock effects on livelihoods, poverty and human migration across the region (Lin et al., 2014). Therefore, integrating wetlands in climate resilience strategies will be critical for governments across the region.

Recommendations

- There is a need to improve transboundary knowledge of the impact of climate change on the fluvial dynamics of the major rivers within the region and to disentangle the impacts arising from other factors, critically dams and land use change.
- Improved knowledge on the implications for changing thermal and physical environmental regimes on freshwater species is critical. This is not only vital to understand potential impacts on the biodiversity, but also with regards to understanding the implications on the provision of food across the region.
- The protected area network needs to be future-proofed through the designation of climate complementary areas that will allow the redistribution of species and biomes under a changing climate. Any such protected areas will need to be supported by robust management practices.
- Coral reef resilience assessments should be widely applied throughout the region to identify priority management actions for enhanced resilience
- Wetlands need to be more strongly integrated into climate resilience strategies across the region, nationally and at local, and especially, city scales. Such resilience strategies need to consider drought, floods, cyclones and health pandemics.

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C7 POLLUTION

Key messages

- There are multiple sources and types of pollution impacting freshwater and coastal wetlands across the Indo-Burma region.
- Water quality is being degraded in rivers and lakes due to excessive and increasing inputs of nutrients and pesticides from agriculture. Elevated nutrient levels are causing algal blooms and impacting freshwater ecology and human health.
- The management of wastewater from a variety of sources including domestic sewage and industrial facilities is poor across the region, resulting in poor water quality and an increase in harmful pathogens.
- Poor land and acid sulphate soil management can result in contamination from sulphuric acid production and acidification in coastal waters.
- There are many emerging contaminants that have the potential to impact the aquatic environment, however the knowledge base is very low for the region.
- The construction and operation of dams can generate thermal pollution and alter river ecology downstream.
- Pollution of the freshwater, coastal and marine environment by plastics is a significant threat to the ecology of the region and beyond. However, the impact of plastics on freshwater species and ecology is poorly understood.
- There is an inherent interconnectivity for all water-vectored pollution from land to river to sea, which requires robust and integrated policies to mitigate the impacts. There is limited evidence of such a response across the region.
- The management of plastic pollution offers an opportunity to engage in novel citizen-led monitoring approaches and the development of sustainable local economic initiatives.
- Direct and indirect light pollution threaten several important wetland species across the region. Uncontrolled or regulated development and poor tourism management are exacerbating the impacts from light pollution. However, research into light pollution remains limited across the region.
- Research into the impacts of air and atmospheric pollution on wetland ecology is highly limited for region.

Status of the pollution impacts in the Indo-Burma region

Pollution is the contamination of the environment by any substance or energy. Pollution can take many forms including air, water, light and thermal. Studies conducted across the region have highlighted that pollution is a major threat affecting wetland biodiversity within Indo-Burma (Allen et al., 2012).

Water pollution

Water quality in many of the lakes, rivers, streams and coastal waters of the Indo-Burma region is impacted by a variety of pollutants (Allen et al., 2012). Nutrient inputs to agricultural land have been progressively increasing across the region (Figures C7.1 and C7.2). Viet Nam and Thailand experienced an increase in nitrogen fertiliser inputs from the late 1970s onwards. Myanmar has experienced an increase in nitrogen inputs since 2015, whilst nitrogen inputs to agricultural land in Cambodia have remained relatively low since the 1960s. Phosphate inputs in Thailand and Viet Nam have followed a similar trajectory to nitrogen, but have levelled out since the mid-2000s. As with nitrogen inputs, phosphorus inputs have slowly increased in Myanmar since 2015.

There is concern regarding the impact of agriculture-derived nutrients, primarily nitrogen and phosphorus, on water quality and aquatic systems across the region (Allen et al., 2012; Evans et al., 2012; Sebesvari et al., 2012; Liu et al., 2021). Intensification of agriculture and land use change have resulted in excessive nutrients draining into aquatic environments. A study conducted in the Vietnamese Mekong Delta concluded that more than 95% of all samples failed to reach drinking water standards as a result of nitrogen levels (Thu Minh et al., 2020). In Myanmar, agricultural inputs

Figure C7.1

Nitrogen fertilizer inputs for the countries of the Indo-Burma region, 1961-2020 (data from FAOSTAT – No data available for Lao PDR).

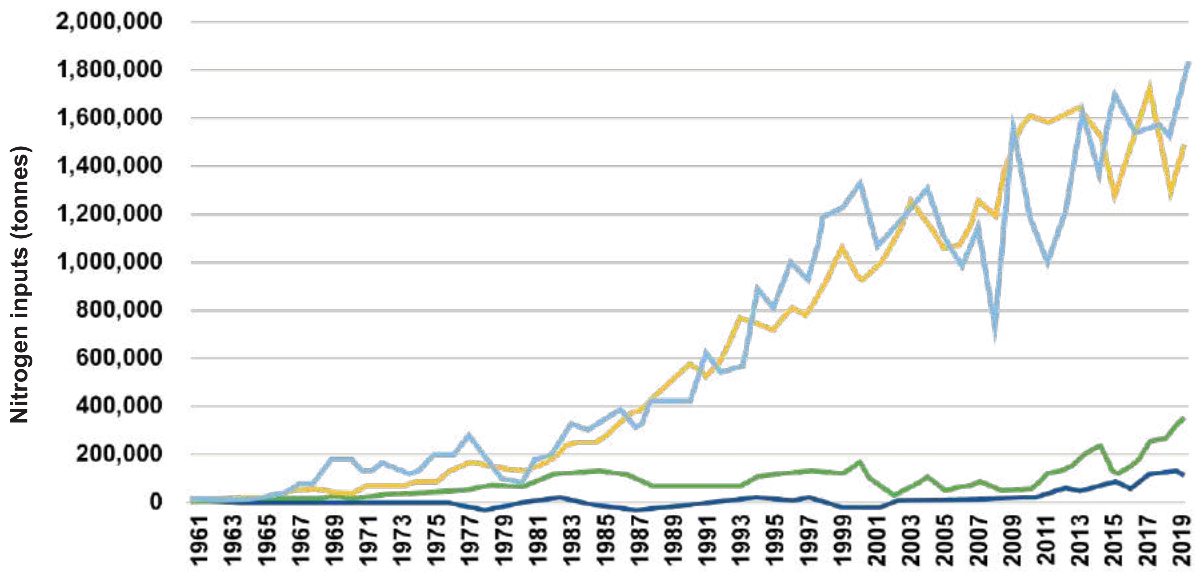
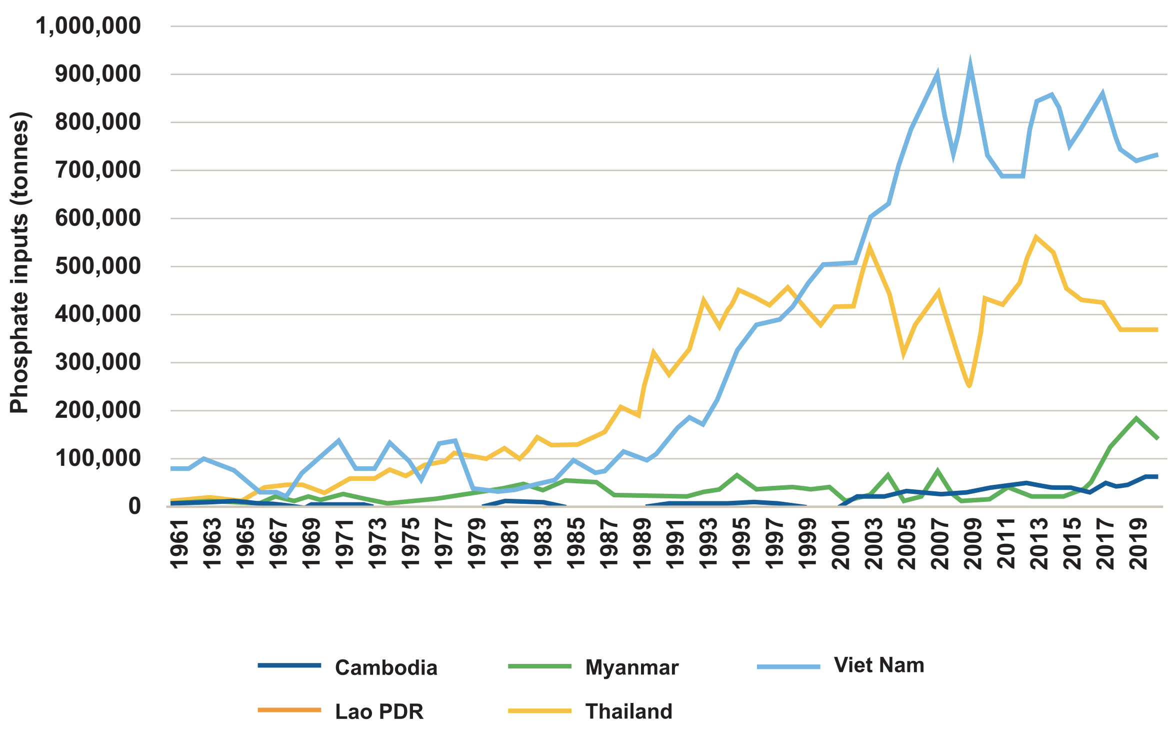


Figure C7.2

Phosphate fertilizer inputs for the countries of the Indo-Burma region, 1961-2020 (data from FAOSTAT – No data available for Lao PDR).



of phosphorus from farmland and livestock are is expected to increase from 55x10³ metric tons (MT) in 2010 to between 128x10³ and 141 x10³ MT in 2100 (Myo Lwin et al., 2017). In addition to inputs from land, direct inputs of nutrients from traditional floating agricultural practices, exemplified by the floating gardens at Inle Lake, Myanmar, (Khaung et al., 2021; Iwai et al., 2022) or from aquaculture (Anh et al., 2010; Sampantamit et al., 2020) have further degraded water quality. In addition to nutrient-related impacts resulting from agricultural practices, pesticide use is widespread resulting in impacts on the aquatic environment but also increased risks to human health (Chau et al., 2015).

Within urban environments, untreated domestic wastewater, chemical and industrial pollution and solid wastes degrade water quality and aquatic biodiversity. For instance, in Ho Chi Minh City many homes are not equipped with or connected to wastewater treatment facilities; industrial plants, including oil refining and chemical and food processing discharge directly to surface waters and solid wastes are routinely dumped in watercourses (Vo, 2007). A similar situation is reported for Can Tho, Viet Nam, where numerous watercourses are considered highly polluted for a range of contaminants including nutrients and pathogens (Neumann et al., 2011).

The Indo-Burma region supports areas with acid sulphate soils (Michael, 2013). Unless appropriate management is imparted, acid sulphate soils can exert a range of environmental impacts including soil acidification and the production of sulphuric acid (Michael et al., 2017). In coastal areas, leaching from acid sulphate soils has been implicated in exacerbating acidification of seawaters and contributing to impacts on mollusc shell biomineralization (Fitzer et al., 2018).

Across the region, there are many emerging contaminants, such as pharmaceuticals, and synthetic musks and UV-filters in personal care products and that pose a risk to aquatic organisms in riverine and aquatic environments (Tewari et al., 2013; Juksu et al., 2020). There is very limited research on these contaminants and their potential ecological risks on aquatic fauna.

Temperature is an important factor in the functioning of aquatic ecosystems. The presence of dams across the rivers of the Indo-Burma region can have a negative impact on the thermal regime of rivers, causing thermal pollution downstream of dam discharge points (Michie et al., 2020). Studies from the Mekong basin have indicated that the presence of dams may reduce dry season river temperatures by almost 1°C (Bonnema et al. 2020), generating impacts on biogeochemical cycling and fish ecology (Wang et al., 2018).

Impacts on river water quality ultimately manifest themselves in the coastal and marine environments. The Gulf of Thailand has long suffered degradation resulting from nutrients, and untreated municipal and industrial waste water resulting in ‘red tides’ caused by blooms of dinoflagellates (Cheevaporn and Menasveta, 2003). Similar red tides and harmful algal blooms have been observed off the coast of Myanmar (Su-Myat, 2013) and elsewhere along the Andaman coast of Thailand (Wattayakorn, 2006). Such blooms can result in rapid reduction of dissolved oxygen and a high ammonia concentration in the water, which has been known to generate fish kills and mortality to caged fish and lobsters (Soon Eong and Sulit, 2017).

Wetlands have a role to play in the management of water-vectored wastes. There are several examples of wetlands being restored or created to treat wastewater. In Thailand, constructed wetlands are widely used, including addressing tourism-generated wastewater at Koh Phi Phi (Møller et al., 2012) or for the management of fish production waste (Kantawanichkul et al., 2009). Similar approaches to farmed-fish waste have also been implemented in Myanmar (Kieu et al., 2021). Not only can the use of constructed wetlands be a low-cost option to water treatment, through appropriate design processes, there is the potential to deliver multiple benefits to society (Harrington and McInnes, 2009).

Plastic pollution

The review of the status and distribution of freshwater biodiversity in the Indo-Burma region (Allen et al., 2012) did not mention plastic pollution, highlighting its status as an emerging issue affecting wetlands in the region. However, Southeast Asia is considered to have some of the highest levels of plastic pollution in the world. The rivers across the Indo-Burma region represent major transport pathways for plastic pollution to enter coastal wetlands and the wider marine environment. Myanmar, Viet Nam and Thailand have over 2,700 rivers annually delivering more than 9.0×10^4 metric tons (MT) of plastic into the marine environment (Meijer et al., 2021). In addition to riverine inputs, entry points from land to sea include densely populated coastal regions, industrial estates, port facilities, landfill sites and beaches (Omeyer et al., 2022). However, the potential impact of plastics on freshwater fauna remains largely undetermined, despite documentation of negative impacts in similar marine species. Similarly, within the freshwater environment, there is a predominance of microplastic studies over macroplastic ones, even though there is no reason to assume that freshwater ecosystems remain unaffected by macro-debris (Blettler et al., 2018).

One of the limited number of comprehensive studies undertaken at the confluence of the Mekong, Tonle Sap, and Bassac rivers in the vicinity of Phnom Penh suggested that 42% of all the plastic waste generated by the city found its way into the river environment. Most of the plastic waste moved downstream on the surface of the watercourses, but a smaller proportion extended through the water column, potentially being retained in suspension, breaking down and resuspending over time (Haberstroh et al., 2021). Within the wider Tonle Sap basin, it has been estimated that between 2000 and 2020 approximately 221,700 MT of plastic entered the aquatic environment. Under a business-as-usual scenario, it is projected that a further 282,300 ±8,700 MT will enter the system by 2030. Plastic bags account for almost 70% of all the plastic waste recorded (Finnegan and Gouramanis, 2021) reflecting similar results regarding the dominance of plastic bag waste from elsewhere in the region (Thanh et al., 2011). The increasing rate of plastic inputs to the river system has been a clarion call for the development of appropriate policy responses, such as the ban on single use plastic bags in Thailand which commenced at the beginning of 2021. Modelling has suggested that the implementation of a stringent policy, including eliminating foam plastic and implementing waste collection from 80% of the population, could prevent 99% of the annual plastic waste entering the river system. The scenario modelling emphasises the need for integrated waste management strategies which address plastic wastes within a wider societal and circular economy context, as has been considered elsewhere in Asia (Wu et al., 2021), such as in the Philippines where coastal plastic litter and waste is recycled and upcycled to supply raw materials for carpet manufacturing whilst building social cohesion and access to finance for local communities (UNEP, 2017).

Coastal wetlands within the region which contain high densities of sessile biota in mangrove, seagrass, and coral habitats, accumulate plastics by snagging, filtering and adhesion. For instance, the mangrove areas along the Myanmar coastline are commonly polluted with macroplastics such as ghost nets, which damage and uproot young mangrove seedlings (Zöckler and Aung, 2019); and in the Mu Ko Similan National Park, Thailand, it has been demonstrated that the density of accumulated plastics in both marine waters and benthic sediments may be correlated with mass tourism activities along the shoreline. The fate of plastics entering and accumulating in the coastal wetlands will depend on the prevailing morphology and the hydrodynamics of the environment; the trapping efficiency of the habitats; and the characteristics of the plastic waste, and particularly the particle size (Omeyer et al., 2022). Once plastic wastes have entered the coastal wetland environment their subsequent movement and redistribution will depend on ocean currents, which, in turn, are mediated by characteristics of the plastic, in combination with the coastal, sea-surface and seabed interactions.

There is a pressing need across the region to not just reduce the mass of plastics moving from the land to water, but to understand the linkage between freshwater and marine plastic pollution. Improvements in monitoring and tracking pollutants are critical to address the complexity of future challenges (van Calcar et al., 2019). In some parts of the region, social media has been used as a novel and effective monitoring approach to report on the impact of plastics on cetaceans, including the Irrawaddy dolphin (Coram et al., 2021), or the role of citizen science could be utilised (Cook et al., 2021). Robust and novel approaches are required to understand the temporal and spatial variability of plastic across the region's river systems in order to mitigate the impact on the coastal wetlands and the wider marine environment.

Air and atmospheric pollution

Air pollutants comprise both particulate matter (PM) and gaseous pollutants, which may cause adverse health effects in humans, plants and wildlife (Rai, 2016). Whilst there is some published research into the human health effects of air pollution from sources such as the burning of fossil fuels for the Indo-Burma region (Pawankar et al., 2020; Taghizadeh-Hesary and Taghizadeh-Hesary, 2020), there is very limited information on the impact of air pollution on wetlands and their biodiversity. This is potentially an important knowledge gap. There are reports of increases in PM in southern Thailand arising from peat and biomass fires in Indonesia, particularly in the pre-monsoon season (Phairuang et al., 2020).

Light pollution

Light pollution can take many forms including direct lighting that may impact on a localized area, including street lights, sports arenas, commercial signage, billboards, industrial plants and window lights, to more diffuse light such as skyglow that can exceed full moon light levels and spread far beyond urban light sources (Owens and Lewis, 2018).

Artificial light at night (ALAN) has been rated as the most serious threat to wetland-dependent fireflies (Coleoptera: Lampyridae) in parts of Asia (Lewis et al., 2020). Firefly tourism, including nighttime boat rides through mangrove systems to observe displays of bioluminescence, is becoming increasingly popular in the region (for instance in Thailand). Tourism-related activities can impact larval habitats through boat wash and erosion, but also generate light pollution (Thancharoen, 2012). Thancharoen and Masoh (2019) demonstrated the impact of flash photography associated with commercial tourism operations on the courtship behaviour of *Pteropytx malaccae*, impacting on courtship signals and reducing fecundity.

Light pollution is also known to impact frogs, turtles, mammals, birds, fish, invertebrates, zooplankton and bacterial communities (Secondi et al., 2017). Light within 1km of a wetland may be critical to the ecology of some wetland-dependent species (Choi et al. 2009), or skyglow impacts may persist at considerably greater distances (Secondi et al., 2017). However, despite recent advances in the science, the understanding of the impacts of light pollution on a range of wetland species, particularly in the Indo-Burma region, is poorly understood. Similarly, the effects on wetland ecosystem services and functions, such as the role of light as a barrier to seed dispersal by bats through wet forests, remains poorly researched (Gaston et al. 2015).

Recommendations

- Integrated basin-wide (including transboundary) and coastal zone management strategies need to be developed to manage the impact of water-vectored wastes, particularly nutrients and plastics.
- Wetland restoration and creation should be considered as an appropriate approach to the management of water-vectored wastes and the development of multiple benefits for society.
- Research is required to improve understanding across significant knowledge gaps relating to emerging water pollutants, the impact of plastics on freshwater ecology, air and atmospheric pollution and light pollution on sensitive ecological receptors.
- Opportunities to utilize novel monitoring platforms and media and to engage with citizen scientists should be developed to improve the knowledge on the type, distribution and impacts of a range of pollutants.
- The development of sustainable livelihoods and circular economies should be expanded based on best-practice examples being implemented elsewhere in Asia.
- A network of dark sky wetland reserves should be developed.

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3D INDIRECT DRIVERS, PRESSURES AND THREATS

Overview

Three indicators provide the evidence base for indirect drivers, pressures and threats in the Indo-Burma region. These indicators, and their status and trends in the region, are:

3D Indirect drivers, pressures and threats	
D1 Demographics	
D2 Governance	
D3 Economic	

Key messages

Indicator	Trend	Key Messages
D1 Demographics		• The human population across the Indo-Burma region has steadily increased over the past 50 years. • In general terms, the population has effectively doubled over the last 50 years. • Rates of human population increase over the last 50 years are similar for the five countries but slightly higher in Lao PDR and slightly lower in Thailand. • Annual population growth rates are similar for the five countries and are steadily decreasing since the 1990s. • The relative proportion of the population living in the urban environment has increased over the last ten years. More than half of the population of Thailand now live in the urban environment.
D2 Governance		• Wetlands in the Indo-Burma region require robust and effective governance to stem their loss and to deliver on wise use obligations. • Governance is relatively weak in all Indo-Burma countries. • With the exception of advances made in Myanmar from about 2010 until 2021, progress towards good governance, high regulatory quality and the control of corruption across the region is static.

D3 Economic	↑	• The economies of the five countries, as measured by gross domestic product (GDP), across the Indo-Burma region have all grown, in total and in per capita values, over the past 50 years. • Thailand has the largest total GDP and Cambodia and Lao PDR have the smallest, however Myanmar and Cambodia have the smallest GDP per capita. • The relative contribution of the agricultural sector to the economy of the region has been reducing over the last ten years.

Recommended responses for decision-makers

Indicator	Recommended responses
D1 Demographics	None
D2 Governance	Improve governance effectiveness in countries across the Indo-Burma region to better support implementing wetland wise use
D3 Economic	None

Ramsar National Focal Points from the IBRRI countries discussion national wetlands policies and governance at a regional dialogue in Bangkok. © Ramsar Regional Centre East Asia

D1 DEMOGRAPHICS

Key messages

- The human population across the Indo-Burma region has steadily increased over the past 50 years.
- In general terms, the population has effectively doubled over the last 50 years.
- Rates of human population increase over the last 50 years are similar for the five countries but slightly higher in Lao PDR and slightly lower in Thailand.
- Annual population growth rates are similar for the five countries and are steadily decreasing since the 1990s.
- The relative proportion of the population living in the urban environment has increased over the last ten years. More than half of the population of Thailand now live in the urban environment.

Status of the demographic changes in the Indo-Burma region

The overall human population within the Indo-Burma region has steadily increased over the last 50 years. Viet Nam is the most populous country (97,338,583 in 2020) and Lao PDR supports the smallest population (7,275,556 in 2020) (Fig. D1.1). Across the region, the population has slightly more than doubled over the past 50 years from120,262,965 in 1971 to 245,542,882 in 2020. The pattern of population increase is similar across the five countries, but population has increased slightly more in Lao PDR (with the population in 2020 being 2.64 times the 1971 population), whereas the population in Thailand in 2020 is 1.84 times the 1971 population.

Annual rates of population growth are similar for the five countries between 1971 and 2020 (with the exception of the impact of Cambodian genocide in the 1970s) (Fig. D1.2). Since the mid-1990s, the annual population growth rate across the region has steadily declined from in excess of 2% per annum to 0.94% per annum in 2020.

The distribution of the population has changed over time. Since 2010, there has been a shift from the rural environment to the urban (Figure D1.3). Across the region, the relative proportion of the total population living in the urban environment has increased by approximately 5% from 2010 to 2021. The greatest relative increase in the urban population has been in Thailand (an increase of 6.8% between 2010 and 2021, with smallest relative increase observed in Myanmar (an increase of 2.2% between 2010 and 2021). Today, more than half of the population of Thailand live in the urban environment.

Data sources

World Bank database: https://databank.worldbank.org/

Figure D1.1

Total human population 1971-2020 in the Indo-Burma countries.

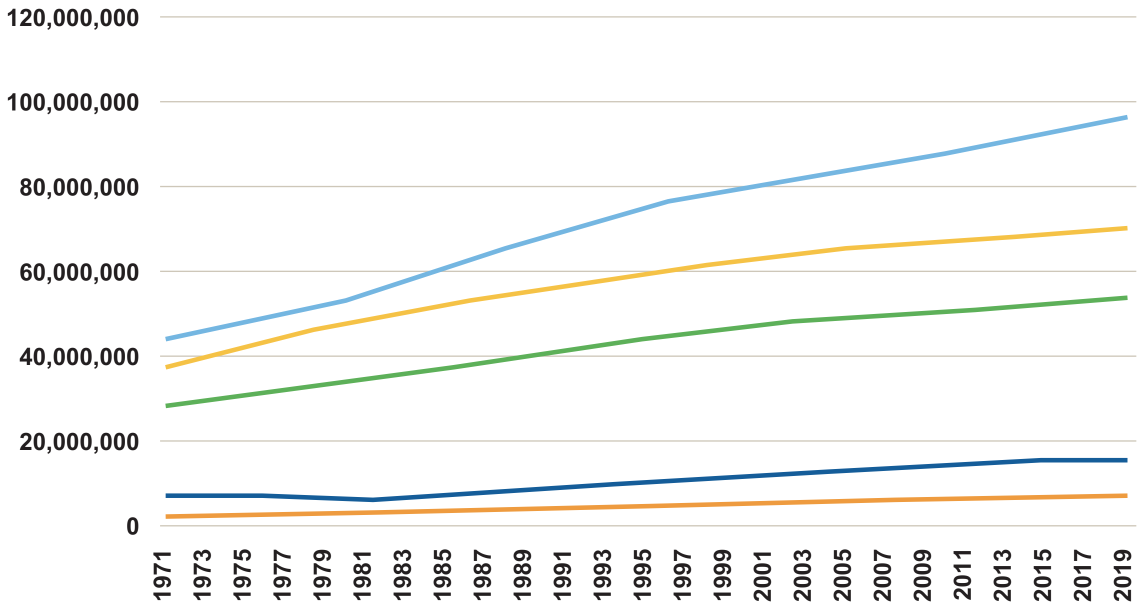


Figure D1.2

Annual percentage growth rate in the human population 1971-2020 in the Indo-Burma countries.

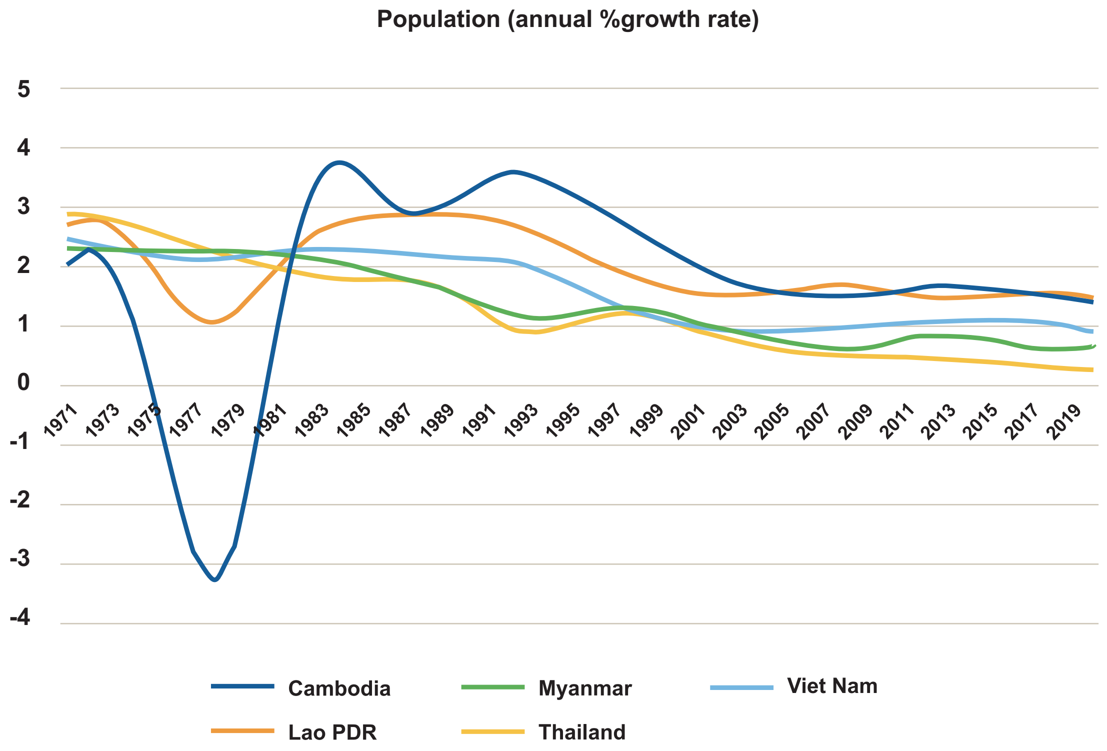
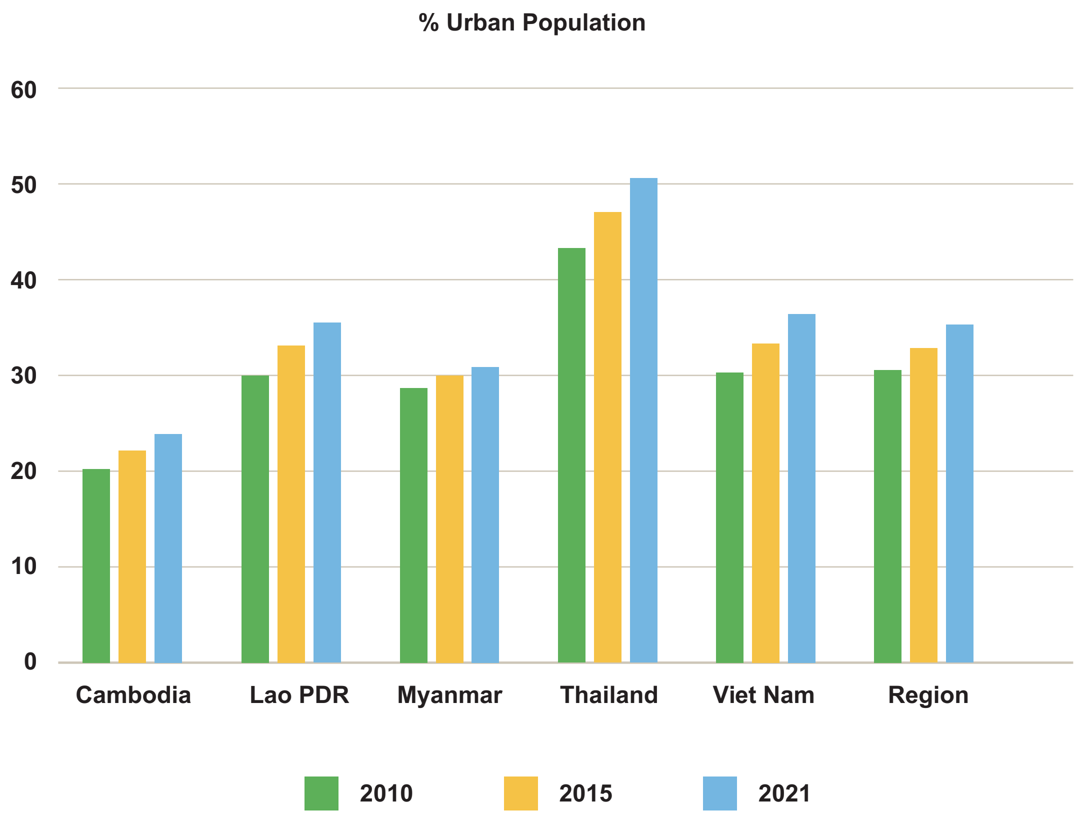


Figure D1.3

Changes in the percentage of the population living in the urban environment (2010-2021).



D2 GOVERNANCE

Key messages

- Wetlands in the Indo-Burma region require robust and effective governance to stem their loss and to deliver on wise use obligations.
- With the exception of advances made in Myanmar since about 2010, progress towards good governance, high regulatory quality and the control of corruption across the region is static.

Status of governance in the Indo-Burma region

It has been argued that good governance, achieved through effective exercising of rules and enforcement mechanisms, is a prerequisite for sustainable development and sound environmental protection (Graham et al., 2003). Through the use of birds as surrogate for wetland biodiversity, it has been demonstrated that the most robust predictor of changes in waterbird abundance, as well as the benefits of conservation efforts, is the effectiveness of governance (Amano et al., 2018). Gebert (2017) concluded that for Lao PDR that an effective policy, legal and regulatory framework is essential to ensure that the obligations under the Ramsar Convention are to be delivered. At Tonle Sap Lake, Cambodia, segmented management and poor inter-agency coordination has been cited as resulting in weak governance (Sithirith, 2015).

The World Bank indicator of government effectiveness captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. Whilst ‘government’ is not synonymous with ‘governance’, the latter being primarily about how governments and other social organizations interact, how they relate to citizens, and how decisions are taken in a complex world, the indicator is a useful metric to track effectiveness across the region (Figure D2.1).

Government effectiveness is greatest in Thailand and lowest in Myanmar. However, government effectiveness has been generally improving in all countries, except Thailand, over the last ten years.

The successful formulation and implementation of policy and legal instruments are essential to stem wetland loss and deliver on wise use obligations (Finlayson et al., 2019). The World Bank Regulatory Quality index captures perceptions of the ability of governments to formulate and implement sound policies and regulations that permit and promote private sector development (Figure D2.2). Since 2010, Myanmar has exhibited a significant improvement in the regulatory quality. Lao PDR, Cambodia and Viet Nam have also observed a gradual improvement over the same period. The regulatory quality indicator for Thailand is the highest for the region but has remained relatively constant for the last 20 years.

Corruption can hasten environmental degradation in wetlands. However, the control of corruption has been demonstrated to increase wetland values elsewhere in Asia (Chaikumbung et al., 2019). The World Bank Indicator, Control of Corruption, captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests. With the exception of Myanmar, which has been improving since 2011, the control of corruption in the Indo-Burma region has been relatively stable or very slowly improving (Figure D2.3). However, the mean value of the indicator for the region in 2020 was -0.745, suggesting that low-level corruption is endemic. Experience from Viet Nam suggests that this may be the case in the management of mangroves due to profit-seeking activities of local authorities and individuals (Orchard et al., 2014).

In addition to national governance, the Mekong River Commission (MRC) provides strong and integrated governance across the Mekong River Basin. The MRC is an intergovernmental organisation which aids regional dialogue and cooperation in the Lower Mekong River Basin between Cambodia, Lao PDR, Thailand and Viet Nam. China, although a Mekong riparian state, is not formally part of the MRC. The organisation serves as a regional platform for water diplomacy and a knowledge hub of water resources management for the sustainable development of the region. It has been argued that the MRC has been robust in collecting and disseminating data, but has been less effective in influencing policy and practice among its member states (Backer Bruzelius, 2007). The major challenge for the MRC is to maintain its own legitimacy whilst ensuring collaboration with China under the Lancang-Mekong Cooperation and resisting politicization of river narratives.

Figure D2.1

Government effectiveness indicator 1996-2020. (Estimate gives the country's score on the aggregate indicator, in units of a standard normal distribution, i.e., ranging from -2.5 to 2.5).

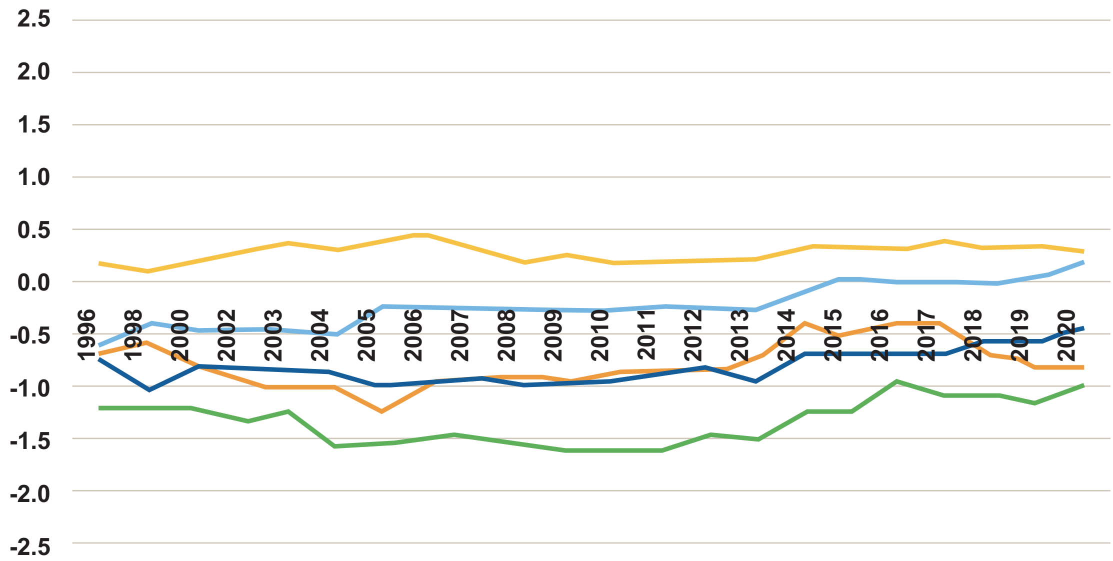


Figure D2.2

Regulatory quality indicator 2002-2020. (Estimate gives the country's score on the aggregate indicator, in units of a standard normal distribution, i.e., ranging from approximately -2.5 to 2.5).

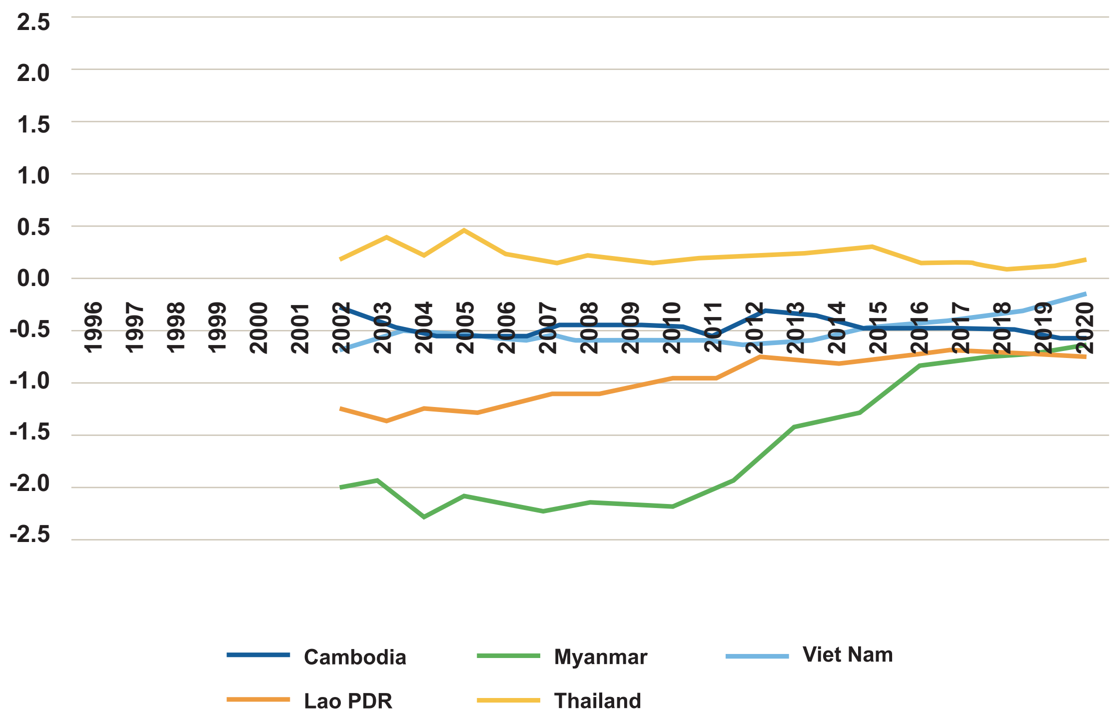
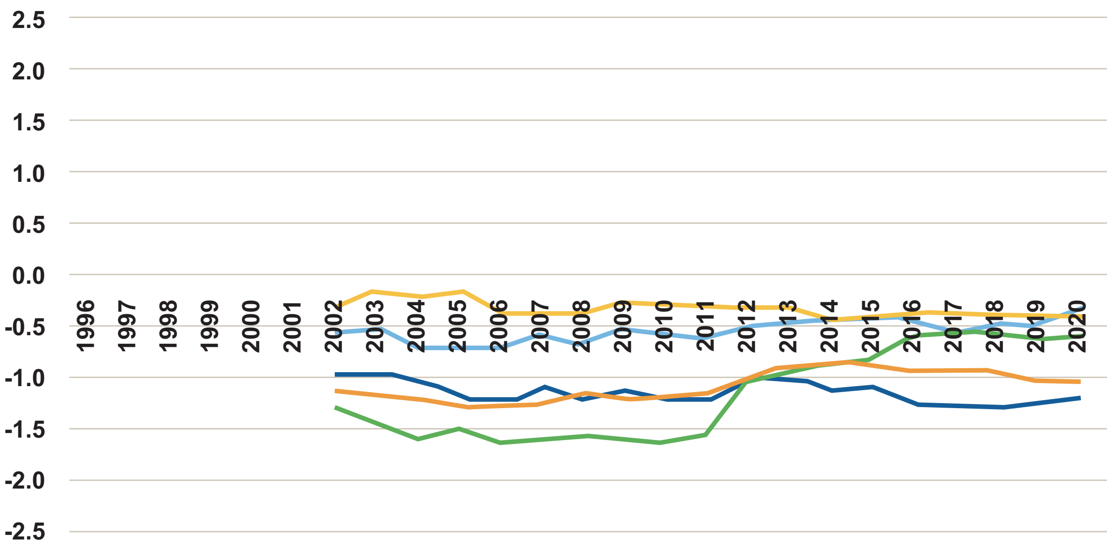


Figure D2.3

Control of corruption indicator 2002-2020. (Estimate gives the country's score on the aggregate indicator, in units of a standard normal distribution, i.e., ranging from approximately -2.5 to 2.5).



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Data sources

World Bank database: https://databank.worldbank.org/

D3 ECONOMIC

Key messages

- The economies of the five countries, as measured by gross domestic product (GDP), across the Indo-Burma region have all grown, in total and in per capita values, over the past 50 years.
- Thailand has the largest total GDP and Cambodia and Lao PDR have the smallest, however Myanmar and Cambodia have the smallest GDP per capita.
- The relative contribution of the agricultural sector to the economy of the region has been reducing over the last ten years.

Status of the economic development in the Indo-Burma region

Gross domestic product (GDP) is the standard measure of the value added created through the production of goods and services in a country during a certain timeframe. It measures the income earned from production, or the total amount spent on final goods and services (less imports). In general, all of the countries of the Indo-Burma region have experienced an increase in gross domestic product (GDP) since the 1970s (Figure D3.1). Thailand and Viet Nam have experienced a higher rate of increase in GDP compared to the other three countries. Lao PDR and Cambodia have the lowest GDP of the five countries.

GDP per capita is the GDP divided by midyear population. Thailand has the highest GDP per capita of the Indo-Burma countries (Figure D3.2). Viet Nam and Lao PDR have a similar value of GDP per capita. Whereas Myanmar and Cambodia have the lowest values of GDP per capita of the five countries. All countries have experienced a sustained and increasing rate of GDP per capita since the beginning of the 2000s.

The gross value added (GVA) measures the contribution to the economy of individual sectors in a country. The relative proportion that different sectors are contributing to the overall economy have changed over time (Figure D3.3). Across the region, the relative contribution made by agriculture to the overall economy has diminished, whereas the contribution made by the service sector and other activity has slowly increased. Differences are observed among the countries, with the largest relative reduction in the contribution of agriculture to the economy observed in Cambodia (14% change between 2010 and 2021) and the smallest change in Thailand (2.2% change between 2010 and 2021).

Data sources

World Bank database: https://databank.worldbank.org/

UN Data: https://data.un.org/en/index.html

Figure D3.1

Annual gross domestic product (GDP) in US dollars (source: World Bank).

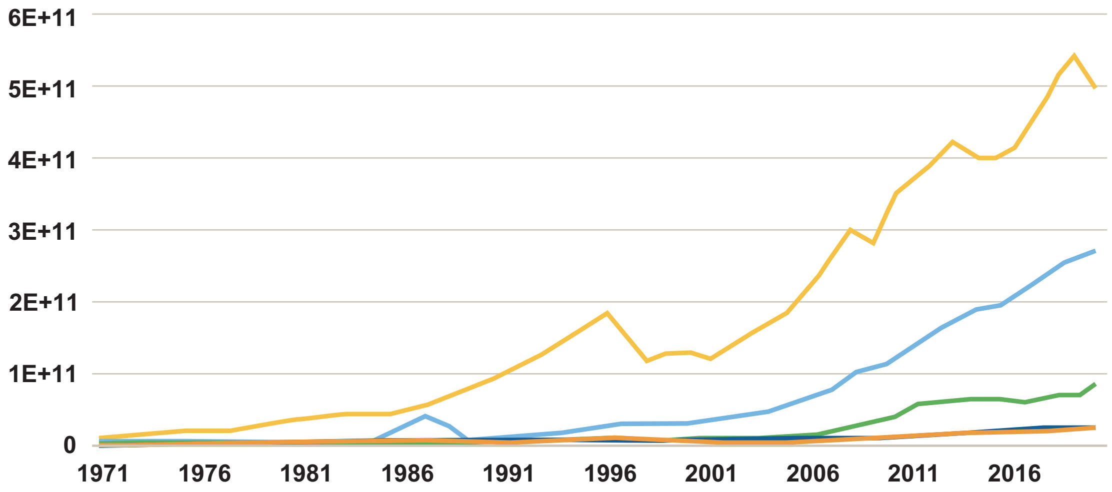


Figure D3.2

Annual gross domestic product (GDP) per capita in US dollars (source: World Bank).

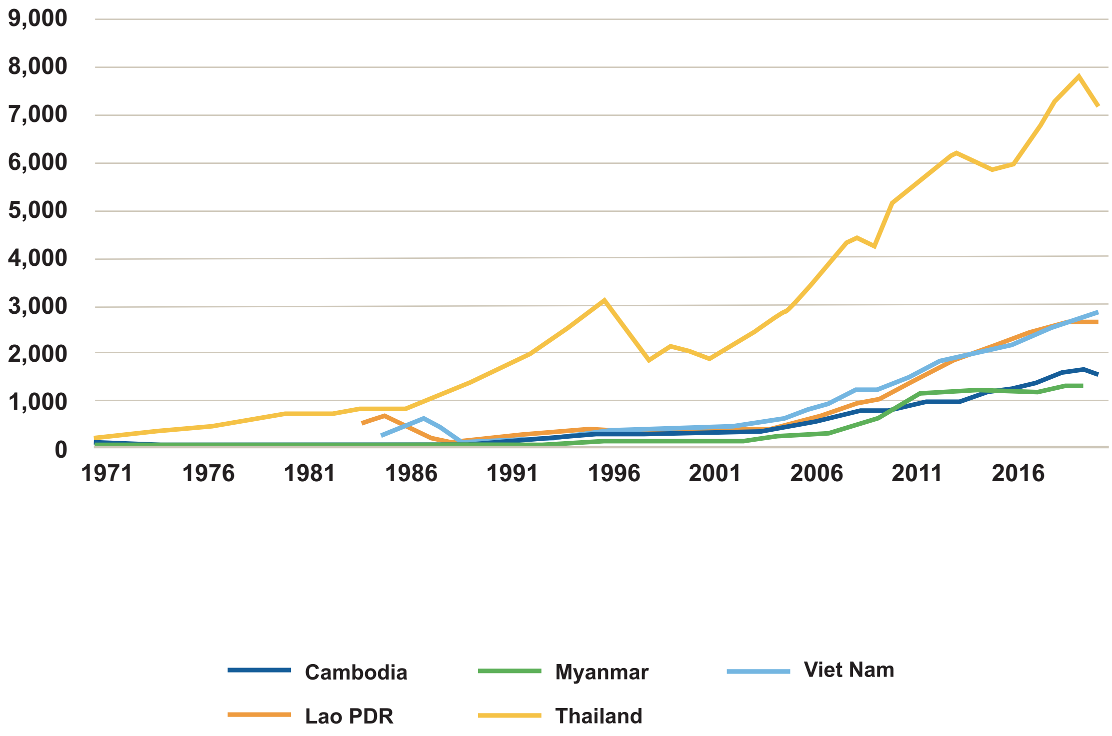
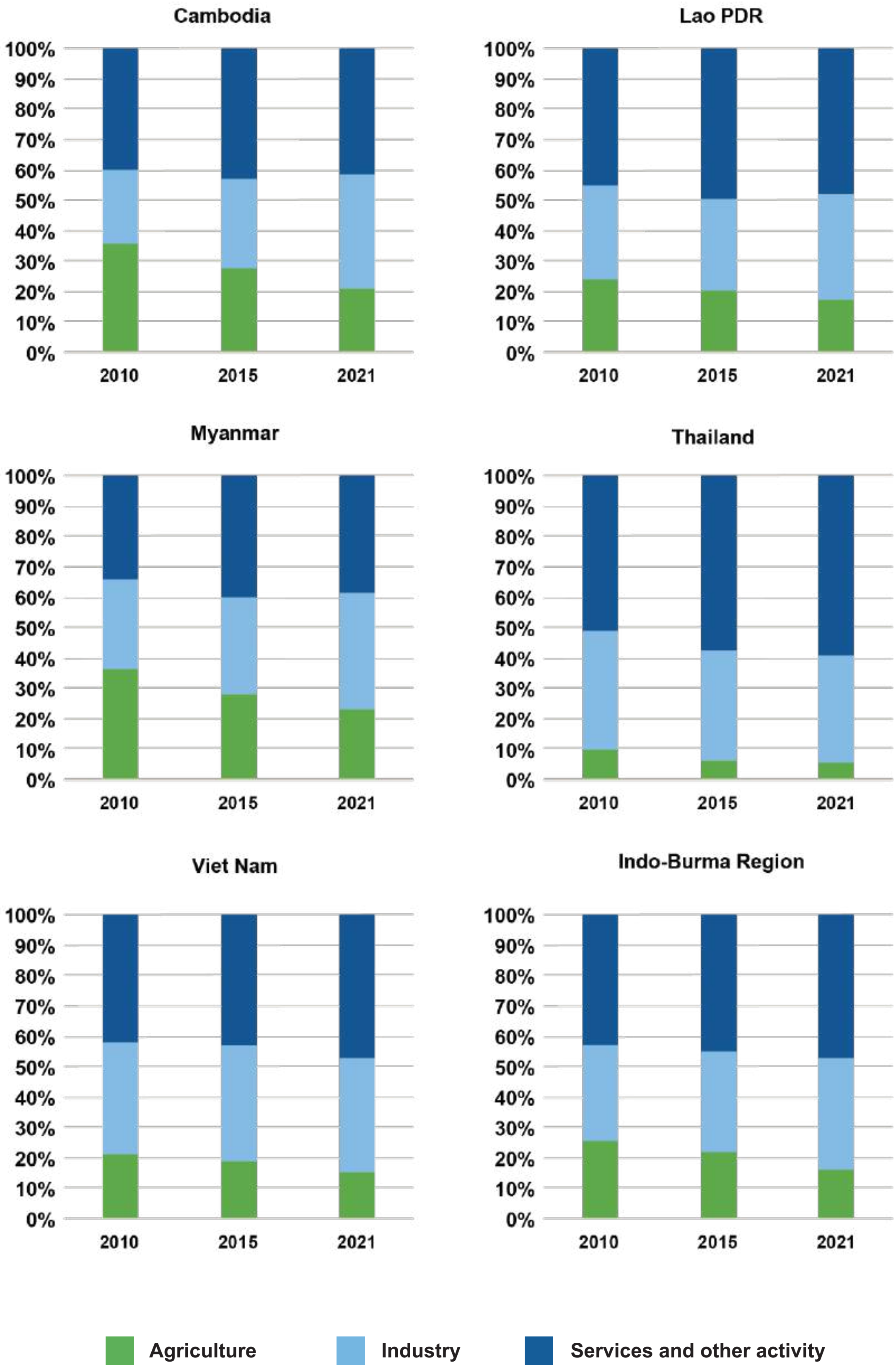


Figure D3.3

% gross added value of economic sectors (source: UN Data).



Boeung Chhmar Ramsar Site, Cambodia © Pheakdey Sorn, IUCN Cambodia

3E RESPONSES

Overview

Seven Indicators provide an evidence-base for the extent of national responses to address wetland biodiversity loss so as to achieve wetland conservation and wise use in the Indo-Burma region.

Overall, these indicators indicate that the extent of responses designed to address continuing wetland loss and degradation in the region are not sufficient and in some cases are reducing.

3E Responses	
E1 Ramsar Strategic Plan implementation	→
E2 Sustainable Development Goal (SDG) indicators	○
E3 National Wetland Policies and Committees	→
E4 Status of national wetland inventory	→
E5 Designation of Ramsar and EAAFP FNS Sites	→
E6 Topicality of information on Ramsar and Flyway Network Sites	↓
E7 Management planning for Ramsar Sites	↓

Key messages

Indicator	Trend	Key Messages
E1 Ramsar Strategic Plan implementation		• The reported extent of implementation of Ramsar Strategic Plan actions varies greatly between Indo-Burma countries: in 2018 from only 30% in Cambodia and Lao PDR and 31% in Myanmar to 54% in Thailand and 72% in Viet Nam. • Between 2012 and 2018, reported implementation extent remained the same in Cambodia, decreased in Lao PDR and Myanmar and increased in Thailand and Viet Nam. • There are many implementation difficulties and challenges identified by Indo-Burma countries, notably a lack of capacity, resources, knowledge and institutional frameworks and mechanisms. • Common to all five Indo-Burma countries is a general lack of implementation capacity and funding.
E2 Sustainable Development Goal (SDG) indicators		• Current SDG mechanisms appear inadequate to report accurately on national wetland areas. • To report more accurately on their progress against the SDGs, particularly SDG Indicator 6.6.1, countries of the Indo-Burma region need more robust and verifiable data on the area and trend in area of wetlands in their country.
E3 National Wetland Policies and Committees		• Only one (Myanmar) of the five IBRRI countries has both a specific national wetland policy and a cross-sectoral national wetland committee. • Two IBRRI countries (Cambodia, Lao PDR) do not have either a national wetland policy or a national wetland committee.
E4 Status of national wetland inventory		• Wetland inventory is inadequate in the Indo-Burma region: only two of the five IBRRI countries (Myanmar and Viet Nam) have a full national wetland inventory. • Not all existing national wetland inventory data and information is publicly available.
E5 Designation of Ramsar and EAAFP FNS Sites		• Few (40) Ramsar Sites and/or EAAFP Flyway Network Sites have so far been designated by IBRRI countries. • Most Ramsar Sites have been designated for globally threatened species (Criterion 2), wetland types (Criterion 1) and their importance for fish (Criterion 8), with fewer having been designated for waterbirds and other taxa. • Of wetlands provisionally recognised as internationally important, only 13.9% of internationally important wetlands have been designated under Ramsar provisions, and only 10.3% under the EAAFP for migratory waterbirds.

E6 Topicality of information on Ramsar and Flyway Network Sites		• Well-organized and relevant information on Ramsar sites is essential if their ecological character is to be maintained through active management planning. Ramsar Information Sheets (RISs) provide key information for the sites. • Many information sheets are now very out-of-date: there is an urgent need to update RISs and FNS SISs across the region. • Targeted financial support from donors may have a role to play in facilitating the updating of RISs.
E7 Management planning for Ramsar Sites		• Only ten out of 37 Ramsar internationally important wetlands in the region have active management plans. • Historically, several additional sites have had management plans but these have expired. • Without robust management plans, and their effective implementation, maintaining the ecological character of internationally important wetlands will remain a significant challenge.

Recommended responses for decision-makers

Indicator	Recommended responses
E1 Ramsar Strategic Plan implementation	• Seek ways and means to enhance capacity and resourcing to Indo-Burma countries, especially those countries with below average extent of implementation (Cambodia, Lao PDR, Myanmar), so as to increase the range of their implementation activities for achieving wetland wise use.
E2 Sustainable Development Goal (SDG) indicators	• Clarify with the SDG 6.6.1 process what types of wetlands are, and are not, included in their datasets. • If areas and or trends in areas of some types of wetlands are not included in the SDG analyses, work with the SDG process to help identify and include these so as to have a more robust basis for assessing SDG indicator 6.6.1. • Improve wetland inventory and monitoring in the Indo-Burma region to inform SDG 6.6.1 assessment.
E3 National Wetland Policies and Committees	• In line with the IBRRI Strategic Plan Target 3.1, the four IBRRI countries without a wetlands/Ramsar-specific national wetland policy should review their existing policy frameworks and consider developing such wetland-specific policies. • IBRRI countries without a national wetland committee should work to establish such a wetland-specific committee, including a membership including all relevant ministries.
E4 Status of national wetland inventory	• In line with the IBRRI Strategic Plan Target 1.3, develop a programme for consistent and comprehensive national wetland inventory in Cambodia, Lao PDR and Thailand, following the low-cost methodology already implemented for Myanmar. • Ensure that all existing national wetland inventory information and results are made publicly available.
E5 Designation of Ramsar and EAAFP FNS Sites	• Develop a list of internationally important wetlands in Cambodia for potential Ramsar Site designation. • Update, for the Indo-Burma region, the assessment of wetlands qualifying as EAAFP Flyway Network Sites. • Across all IBRRI countries, increase the rate of new Ramsar Site and EAAFP Flyway Network Site designations, particularly in Cambodia, Lao PDR and Myanmar.
E6 Topicality of information on Ramsar and Flyway Network Sites	• Ensure that the Ramsar Site RISs and EAAFP FNS Site Information Sheets (SISs) are regularly updated, at intervals of not more than six years.
E7 Management planning for Ramsar Sites	• In line with IBRRI Strategic Plan Operational Objective 2.2, target management planning at the Ramsar sites that do not have management plans. • Ensure that a robust programme of management plan development and effectiveness training is developed across the region.

E1 RAMSAR STRATEGIC PLAN IMPLEMENTATION

Key messages

- The reported extent of implementation of Ramsar Strategic Plan actions varies greatly between Indo-Burma countries: in 2018 from only 30% in Cambodia and Lao PDR and 31% in Myanmar to 54% in Thailand and 72% in Viet Nam.
- Between 2012 and 2018, reported implementation extent remained the same in Cambodia, decreased in Lao PDR and Myanmar and increased in Thailand and Viet Nam.
- There are many implementation difficulties and challenges identified by Indo-Burma countries, notably a lack of capacity, resources, knowledge and institutional frameworks and mechanisms.
- Common to all five Indo-Burma countries is a general lack of implementation capacity and funding.

Contracting Parties to the Ramsar Convention have, since 1997, adopted successive Strategic Plans, with goals, targets and implementation actions designed to help guide their national implementation of their commitments to achieve the conservation and wise use of wetlands. It is anticipated that full implementation of all Strategic Plan actions would lead to this achievement. The current (4th) Strategic Plan runs from 2016-2024. Ramsar Parties report triennially on their Strategic Plan implementation in their National Reports to each meeting of the Conference of Contracting Parties (COP).

This assessment of the extent of Strategic Plan implementation by Indo-Burma countries is derived largely from a situation assessment prepared to inform the development of the Indo-Burma Ramsar Regional Initiative (IBRRI) Strategic Plan 2019 – 2024 (IUCN 2019), from Parties' National Reports to COP11 (2012), COP12 (2015) and COP13 (2018), of National Report indicators applying to all countries. Analyses of the most recent National Reports, to COP14 (2022) have not yet been made.

The IBRRI Strategic Plan 2019-2024 (IUCN 2019) is aligned with, and consistent with, the Ramsar Strategic Plan 2016-2024. But IBRRI countries have not yet reported on the extent of their implementation of the IBRRI Strategic Plan.

Extent of implementation (Ramsar COP12 National Reports)

Globally, on average, Contracting Parties reported to COP12 that they were implementing only half (51.1%) of the actions they commit to in the 3rd Ramsar Strategic Plan (Table E1.1). Asia Ramsar Region (51.1%) and Indo-Burma (51.4%) Parties reported very similar average extents of implementation (Table E1.1). In the Indo-Burma region, the most extensive implementation concerned Ramsar Site designation and management (SP Goal 2: 60%) and the least extensive for the broader wise use provisions of SP Goal 1 (46%).

But these averages mask very large differences in the implementation extent of different Parties (Figure E1.1). Myanmar, Lao PDR and Cambodia each reported to COP12 less than 40% implementation, well below the regional average of 51%, with Cambodia reporting the least implementation (27%). Thailand (70%) and, perhaps surprisingly, Viet Nam (84%) reported very extensive implementation (Figure E1.1).

Trends in extent of implementation (COP11 – COP13 Ramsar National Reports)

It is encouraging that comparison between the extent of Ramsar implementation reported to COP11 (2012) and COP12 (2015) indicates that four Indo-Burma CPs reported an increased implementation extent to COP12: Thailand (+21%), Viet Nam (+18%), Myanmar (+11%), and Lao PDR (+10%). But it is a concern that Cambodia reported much less implementation (-27%) to COP12 compared to COP11.

In contrast to the implementation extent changes between COP11 and COP12, four Indo-Burma Parties reported a reduced implementation extent to COP13 (2018): Lao PDR (-17%), Myanmar (-16%), Thailand (-18%) and Viet Nam (-6%). However, encouragingly the Indo-Burma Party with the lowest COP12 implementation extent, Cambodia, reported a 27% increase in implementation to COP13.

Overall, between COP11 and COP13 implementation extent reported to COP13 has

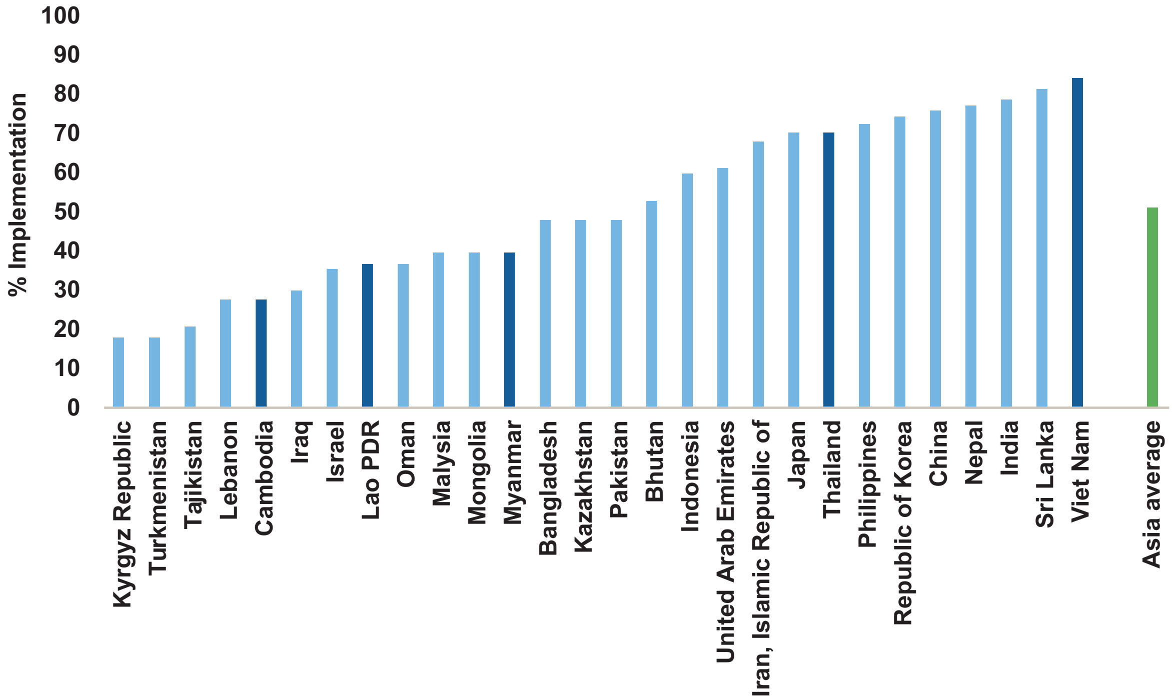
Table E1.1

Extent of Strategic Plan (SP) implementation reported by Ramsar Contracting Parties (CPs) in their National Reports to COP12 (2015).

	Average % implementation		
	Global (148 CPs)	**Asia Region** (28 CPs)	**Indo-Burma** (5 CPs)
Strategic Plan Goals 1–4	**51.08**	**51.09**	**51.35**
SP Goal 1: Wise use	53.42	53.38	46.12
SP Goal 2: Ramsar Sites	53.94	56.79	60.00
SP Goal 3: International cooperation	50.19	47.81	52.73
SP Goal 4: Implementation capacity	46.87	49.66	52.73

Figure E1.1

Extent of Strategic Plan implementation reported by Asia and Indo-Burma Ramsar Contracting Parties (CPs) in their National Reports to COP12 (2015). Dark blue columns are Indo-Burma countries.



remained the same since COP11 in Cambodia, decreased in Lao PDR and Myanmar and increased in Thailand and Myanmar (Figure E1.2). Note that the implementation extent reported by Myanmar to COP13 may now be an underestimate because a number of major implementation actions (e.g. national wetland policy, establishment of a national wetland committee and a national wetland inventory) were completed by Myanmar shortly after their COP13 reporting.

It is concerning that all five Indo-Burma Parties reported to COP13 a reduction in their implementation of Strategic Plan Goal 4 (Enhancing implementation), suggesting that within-country implementation capacity may be decreasing.

Constraints to Strategic Plan implementation in Indo-Burma countries

In their COP12 and COP13 National Reports, Indo-Burma Contracting Parties reported a wide range of implementation difficulties and challenges as a consequence of lack of capacity, resources, knowledge and institutional frameworks and mechanisms. Common to all five Indo-Burma countries was a general lack of implementation capacity and funding. Other frequent implementation challenges included a lack of wetland/spatial planning laws and regulations, and difficulties in addressing urban, industrial and agricultural conversion of wetlands.

Future Strategic Plan implementation priorities in Indo-Burma countries

In their COP12 and COP13 National Reports, Indo-Burma Contracting Parties reported a wide range of future implementation priorities. The eight most frequently reported priorities are for: wetland inventory; national wetland policies and strategies; national wetland legislation; Ramsar Site designation; Ramsar Site management planning and implementation; participatory management; wetlands manager training and capacity-building; and Communication, Education, Participation and Awareness (CEPA).

Despite all five Indo-Burma Contracting Parties identifying lack of capacity and funding for implementation as one of their greatest implementation difficulties, curiously no Parties identified accessing increased funding as a future priority.

The IBRRI Strategic Plan 2019–2024 (IUCN 2019) has Operational Objectives, Targets and Activities supporting Indo-Burma Contracting Parties in addressing these and other implementation challenges and priorities.

Recommendation

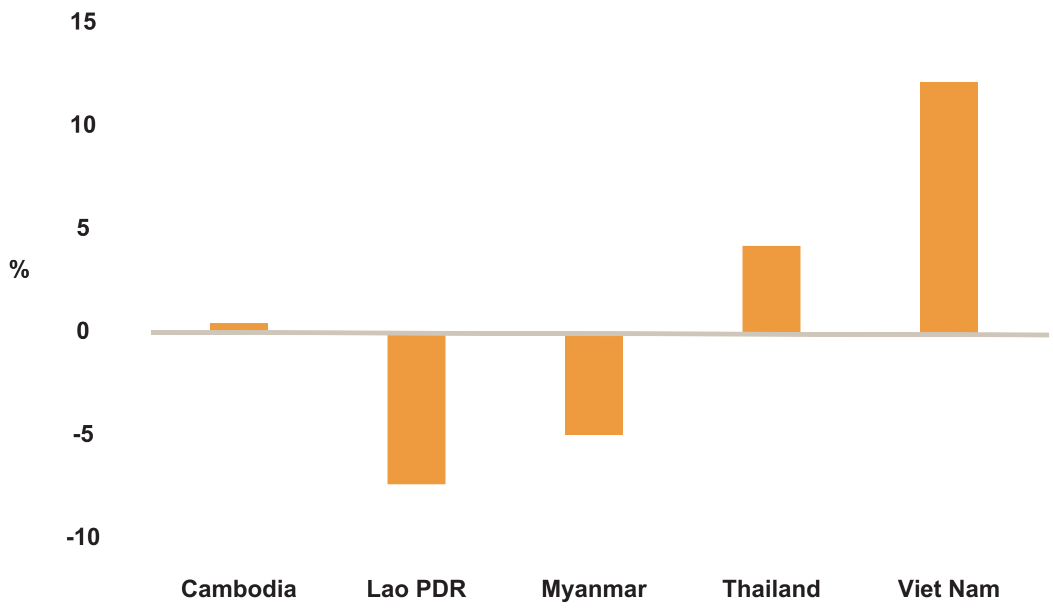
- Seek ways and means to enhance capacity and resourcing to Indo-Burma countries, especially those countries with below average extent of implementation (Cambodia, Lao PDR, Myanmar), so as to increase the range of their implementation activities for achieving wetland wise use.

Source

IUCN. 2019. Indo-Burma Ramsar Regional Initiative (IBRRI) Strategic Plan 2019 – 2024. IUCN, Bangkok, Thailand.

Figure E1.2

Overall change in the extent of Strategic Plan implementation reported by Indo-Burma Ramsar Contracting Parties (CPs) in their National Reports between COP11 (2012) and COP13 (2018).



E2 SUSTAINABLE DEVELOPMENT GOAL (SDG) INDICATORS

Key messages

- Current SDG mechanisms appear inadequate to report accurately on national wetland areas.
- To report more accurately on their progress against the SDGs, particularly SDG Indicator 6.6.1, countries of the Indo-Burma region need more robust and verifiable data on the area and trend in area of wetlands in their country.

The Sustainable Development Goals (SDGs) are a call for action by all countries to promote prosperity while protecting the planet.

The maintenance and restoration of wetlands form key elements of especially SDG Goals 6, 14 and 15:

- Goal 6: Ensure access to water and sanitation for all;
- Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development;
- Goal 15: Protect, restore and promote the sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation and halt biodiversity loss.

The ambition under SDG Goal 6 Target 6.6 is to protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes. The Ramsar Convention is a co-custodian of SDG Indicator 6.6.1 that monitors the change in the extent of water-related ecosystems over time. The Convention provides data submitted by Contracting Parties on wetlands critical to monitoring the status and taking decisions on managing water ecosystems.

The existing reporting on SDG Indicator 6.6.1 highlights the state of wetlands and the progress made towards the overall SDG. A key metric underpinning the reporting of progress against Indicator 6.6.1 in the Indo-Burma region is the extent, and trend in the extent, of wetlands. Countries within the region provide information on the Indicator through their Ramsar National Reports to the Conference of the Parties or through global database reporting mechanisms, such as those held by the United Nations Environment Programme.

However, in their most recent National Reports, to Ramsar COP14, IBRRI Parties have provided limited data on national wetland areas and none on area trends. This is unsurprising given the limited extent of national wetland inventory (see Indicator E4) and national trends in wetland area (see Indicator A3).

Table E2.1 compares the national wetland area information currently used within the SDG reporting on the extent and trend in extent of wetlands across the region with wetlands areas reported in Ramsar National Reports and areas compiled for this Indo-Burma Wetland Outlook (see Indicator A2).

From the UN SDG database it is very unclear how, and from what inventory sources, the 2017 SDG national wetland areas (Table E2.1) have been derived. These reported SDG national wetland areas are consistently very much smaller than even those partially reported from national wetland inventories reported by Ramsar Parties and particularly those from the Wetland Outlook compilation from different wetland class sources (Indicator A2) (Table E2.1). It may be that the SDG source(s) do not include coastal wetlands, which form a large and important area in the Indo-Burma region (see Indicator A2). It is also possible that the very large areas of inland human-made wetlands such as rice cultivation areas and aquaculture ponds are not, or not fully, included.

Table E2.1

National and regional extent of wetlands reported under SDG reporting, from Ramsar National Reports and in this Indo-Burma Wetland Outlook (Indicator A2).

Country	SDG reporting 2017 Area (km²)	Ramsar National Reports* Area (km²)	Indo-Burma WO Indicator A2 Area (km²)
Cambodia	30,130.74	-	35,212.75
Lao PDR	1,370.02	-	10,864.43
Myanmar	13,282.84	84,119.94	109,665.42
Thailand	28,887.65	>36,413.00**	125,601.32
Viet Nam	41,139.00	119,482.69	112,041.77
Total	**114,810.25**	**203,602.63**	**383,161.06**

** COP14 National Reports except for Lao PDR (COP13 National Report).*
*** Partial inventory: important sites only*

These issues need clarifying with the SDG processes, if reliable and verifiable wetland areas, and trends in areas, are to be provided by Indo-Burma countries as a valid basis for national assessment of SDG Indicator 6.6.1.

Recommendations

- Clarify with the SDG 6.6.1 process what types of wetland are, and are not, included in their datasets.
- If areas and or trends in areas of some types of wetland are not included in the SDG analyses, work with the SDG process to help identify and include these so as to have a more robust basis for assessing SDG indicator 6.6.1.
- Improve wetland inventory and monitoring in the Indo-Burma region better to inform SDG 6.6.1 assessment.

Data sources

UN SDG database
https://unstats.un.org/sdgs/dataportal/database

Ramsar COP14 National Reports.
https://www.ramsar.org/documents?field_quick_search=2964

E3 NATIONAL WETLAND POLICIES AND COMMITTEES

Key messages

- Only one (Myanmar) of the five IBRRI countries has both a specific national wetland policy and a cross-sectoral national wetland committee.
- Two IBRRI countries (Cambodia, Lao PDR) do not have either a national wetland policy or a national wetland committee.

The Ramsar Convention has long recognized the importance of its Contracting Parties adopting a national wetland policy, to provide an authorising environment for national and on-the-ground implementation for wetland conservation and wise use. The Convention has adopted guidance on developing and implementing National Wetland Policies (Ramsar Convention 1999; Ramsar Convention Secretariat 2010). The Ramsar Strategic Plan 2019-2024 (Key Result Area 1.3.i) calls on Parties to adopt a national wetland policy (or equivalent instrument). It also expects Parties to establish a cross-sectoral National Ramsar or Wetland Committee (Key Result Area 4.3.v.) with a role to *inter alia* guide and oversee implementation of their National Wetland Policy.

The IBRRI Strategic Plan 2019-2024 Target 3.1 is “All IBRRI countries have adopted an effective policy framework ensuring the wise use of all wetlands”. Several activities are identified to achieve this, including: 3.1.1 “Review the status of regional, national and local policies across the region and their inclusiveness of wetland wise use”; and 3.1.3 “Support the revisions and/or drafting of national and local policies in all five IBRRI countries”. IBRRI has issued a policy brief on national wetland policies in the region (IBRRI undated).

Although globally the number of Ramsar Parties reporting that they have a national wetland policy and a national wetland committee has progressively increased over time, as of 2018 (COP13 national reporting) only half (52%) of Parties reported having adopted a national wetland policy and only 49% reported having established a cross-sectoral national wetland committee (Ramsar Convention Secretariat 2018).

Status of national wetland policies and committees in the Indo-Burma region

Table E3.1 summarizes information on the current status of national wetland policies and national wetland committees in the Indo-Burma region.

Table E3.1

Summary of the status of national wetland policies and national wetland committees in the Indo-Burma region. Source: Ramsar National Reports.

Country	National Wetland Policy (or equivalent instrument)	Cross-sectoral National Ramsar/ Wetlands Committee	Cross-sectoral body equivalent to a National Ramsar/Wetlands Committee
Cambodia	No	No	No
Lao PDR	Planned	Partially	No
Myanmar	Yes	Yes	Yes
Thailand	Yes	Yes	Yes
Viet Nam	Yes	Planned	Yes

Wetland policies

Three IBRRI countries (Myanmar, Thailand, Viet Nam) report having established a national wetland policy or an equivalent policy instrument (Table E3.1). However, only one of these is a 'stand-alone' national wetland policy: Myanmar's National Wetland Policy and Strategic Actions was approved by the Myanmar Cabinet in 2018. The other two countries have incorporated wetland issues into broader policy instruments. Thailand addresses wetland issues in its Master Plan for Integrated Biodiversity Management (2015-2021) and Biodiversity Management Action Plan (2017-2021). Viet Nam's wetlands policies are reflected in its Strategy for Environmental Protection, and its National Strategy on Biodiversity. A 2019 government decree addresses the sustainable use of wetlands.

Wetland committees

Two IBRRI countries (Myanmar, Thailand) report having established national Ramsar/wetland committees (Table E3.1). Myanmar established a multi-ministerial national wetland committee in 2016. Thailand has established a Wetland Management sub-committee, presided over by the Permanent Secretary of the Ministry of Natural Resources and Environment, and involving environmental experts from governmental and non-governmental agencies. Lao PDR reports having established a notional committee but that it is not yet fully operational.

Overall, only two (Myanmar, Thailand) of the five IBRRI countries have both national policies for wetlands and a national committee concerned with implementation of these wetland policies. Only Myanmar has both a national policy and a national committee specifically for wetlands and Ramsar Convention implementation.

Recommendations

- In line with the IBRRI Strategic Plan Target 3.1, the four IBRRI countries without a wetlands/Ramsar-specific national wetland policy should review their existing policy frameworks and consider developing such wetland-specific policies.

- IBRRI countries without a national wetland committee should work to establish such a wetland-specific committee, including a membership including all relevant ministries.

References

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Data sources

Ramsar Contracting Party National Reports. https://www.ramsar.org/documents?field_quick_search=2964

E4 STATUS OF NATIONAL WETLAND INVENTORY

Key messages

- Wetland inventory is inadequate in the Indo-Burma region: only two of the five IBRRI countries (Myanmar and Viet Nam) have a full national wetland inventory.
- Not all existing national wetland inventory data and information is publicly available.

The Ramsar Convention has long stressed the importance of its Contracting Parties preparing a comprehensive national inventory of all their wetlands, in recognition that without knowledge of where a country's wetlands are, and their importance, it is not possible to fully plan for and implement their conservation and wise use. The Ramsar Strategic Plan 2016-2024 also expects Parties to publish or otherwise make accessible their wetland inventories. The IBRRI Strategic Plan (Target 1.3) calls for a standardised wetland inventory to be established across the Indo-Burma Region and based on an harmonised wetlands classification system.

However, progress by Contracting Parties in undertaking national wetland inventories has been slow. From Ramsar COP13 (2018) National Reports, globally at most only 34% of Parties report having a comprehensive national wetland inventory. Other Parties have reported having a partial national inventory: either an inventory of some types of wetlands or a directory of internationally/nationally important wetland sites only.

Status of national wetland inventory in the Indo-Burma region

The extent of national wetland inventory in the Indo-Burma region appears to be poor. Table E4.1 summarizes information on the current status of national wetland inventory in the region.

Only two (Myanmar and Viet Nam) of the five Indo-Burma region countries have a national wetland inventory covering all or most of the wetland types covered by the Ramsar Convention definition of wetlands.

The low-cost geospatial inventory approach developed for Myanmar (NWCD 2019; 2020) provides national areas/lengths/point locations for 15 broad classes of wetlands (five inland natural wetland classes; eight coastal natural wetland classes; and two human-made wetland classes), together covering much of the Ramsar scope of wetlands. Its methods are transferable for application by other IBRRI countries (in implementation pf IBRRI Strategic Plan Target 1.3), and potentially more widely.

The 2016 Viet Nam wetland inventory (UNEP/GEF 2016) provides national areas/lengths/point locations for 26 'types' of wetlands (eight types of inland natural wetlands; nine of coastal natural wetlands; and nine of human-made wetlands). Taken together, these cover most of the scope of Ramsar Convention wetlands, but not shallow marine waters. In relation to the Ramsar Classification of Wetland Types, some of these 26 'types' of wetlands are aggregations of two or more Ramsar types, but others are dis-aggregations (e.g. inland and coastal aquaculture areas are provided separately).

Two other Indo-Burma countries (Thailand and Lao PDR) appear to have inventories of only important wetlands and/or some wetland types. Inventory scope and coverage in Cambodia is unclear.

Table E4.1

Summary of the status and availability of national wetland inventories in Indo-Burma countries. Information is from Ramsar COP13 and COP14 National Reports (COP13 National Report only for Lao PDR – COP14 National Report not available), and other referenced sources.

Country	Type and status of inventory	Wetland type coverage	Availability of inventory	Comments
Cambodia	Not clear: inventory reported in 2021 as “in progress”	Not known	Not known	
Myanmar	Geospatial, comprehensive (2019-2020).	All wetland classes: inland natural, coastal natural, human-made	Geospatial wetland class data layers provided to Myanmar NWCD and reported as available on OneMap Myanmar. Vol 1 (NWCD 2019a); Vol 2 (NWCD 2020). Vol 3 (NWCD 2019b). Reports not yet available on line.	Find ways and means of posting reports online
Lao PDR	1996 inventory of 30 important sites. New methodology for an updated wetland inventory was completed in 2011/2012 but seemingly not yet implemented.	Inland natural wetlands, some human-made wetlands.	1996 inventory published (Claridge 1996); available online	
Thailand	Internationally (69) and nationally (47) important wetlands only (2009). Update underway 2020 reported as due 2021.	Most wetland classes, but not yet main rivers, lower central floodplain, and some types of marine and coastal wetlands. Extent of coverage of human-made wetlands unclear but may be limited.	2002 inventory published in printed form in English (Office of Environmental Policy and Planning 2002). All data now available online on: http://wetlands.onep.go.th (Thai language only)	
Viet Nam	2016 inventory comprehensive. 2016 inventory also identifies (with maps) 74 nationally important wetlands. Earlier (Viet Nam Environmental Protection Agency 2005) summary identified up to 42 important sites.	26 types of inland natural (eight types), coastal natural (nine types) and human-made (nine types) wetlands, together covering Ramsar scope of wetlands	Earlier summary (Viet Nam Environmental Protection Agency 2005) available online. 2016 summary report published (UNDP/GEF 2016). Not clear if available online.	

Recommendations

- In line with the IBRRI Strategic Plan Target 1.3, develop a programme for consistent and comprehensive national wetland inventory in Cambodia, Lao PDR and Thailand, following the low-cost methodology already implemented for Myanmar.

- Ensure that all existing national wetland inventory information and results are made publicly available.

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Data sources

Ramsar National Reports. https://www.ramsar.org/documents?field_quick_search=2964

E5 DESIGNATION OF RAMSAR AND EAAFP FNS SITES

Key messages

- Few (40) Ramsar Sites and/or EAAFP Flyway Network Sites have so far been designated by IBRRI countries.
- Most Ramsar Sites have been designated for globally threatened species (Criterion 2), wetland types (Criterion 1) and their importance for fish (Criterion 8), with fewer having been designated for waterbirds and other taxa.
- Of wetlands provisionally recognized as internationally important, only 13.9% of internationally important wetlands have been designated under Ramsar provisions, and only 10.3% under the EAAFP for migratory waterbirds.

Identification and designation of internationally important wetlands is a key aspect of implementation of Ramsar, IBRRI and EAAFP Strategic Plans. Although the designated Ramsar Site (Wetlands of International Importance) network is recognised as the largest global network of protected areas (as at 8 September 2022 comprising 2,455 sites covering 259.8 million km²), it is also widely recognised that many other wetlands also qualify for such designation. The Ramsar Sites 2012 Strategic Framework (Ramsar Convention 2012) expects each Ramsar Contracting Party to designate a complete and comprehensive network of wetlands qualifying as Ramsar Sites in their territory.

The IBRRI Strategic Plan 2019-2024 calls for (Target 2.1) “A representative network of internationally important wetland sites is established” through activities including *inter alia* 2.1.1 Review existing network of Ramsar Sites and other internationally important wetlands and make recommendations for enhancing the site network; 2.1.2 Develop a regionwide prioritised Ramsar Site designation strategy; and 2.1.3 Designate new Ramsar Sites and (wherever required) extend existing sites.

The East Asia-Australasia Flyway Partnership (EAAFP) Strategic Plan 2019-2028 Key Result Area 1.1 is “A comprehensive and coherent Flyway Network of Sites is developed for migratory waterbirds, including sites that are not currently Protected Areas”.

Progress in the designation of Ramsar Sites and Flyway Network Sites in the Indo-Burma region

Designation progress in the Indo-Burma region has been slow. To date (September 2022), only 40 wetlands have been designated as Ramsar Sites and/or Flyway Network Sites (FNS) in the region (Table E5.1). Twenty-nine have been designated as Ramsar Sites only, three as FNS only, and eight as both Ramsar and FNS Sites.

The rate of new Ramsar Site designations by Indo-Burma countries has generally been slow (Table E5.2). The average annual number of designations

Table E5.1

Numbers of Ramsar Sites and EAAFP Flyway Network Sites designated in the Indo-Burma region.

	Cambodia	Lao PDR	Myanmar	Thailand	Viet Nam	Total
Ramsar Sites (RS) only	5	2	0	14	8	**29**
Flyway network Sites (FNS) only	1	0	0	2	0	**3**
Both RS & FNS	0	0	6	1	1	**8**
Total	**6**	**2**	**6**	**17**	**9**	**40**

in different Indo-Burma countries ranges from 0.17 (Lao PDR) to 0.63 (Thailand).

Given the number of wetlands recognised as potentially qualifying as internationally important (see Table E5.3), there is an urgent need for Indo-Burma countries to accelerate their future designation of Ramsar Sites, particularly in Cambodia, Lao PDR and Viet Nam (see Table E5.2).

Under which Ramsar Criteria have Indo-Burma Ramsar Sites been designated?

For qualification as internationally important under the Ramsar Convention, a wetland must meet at least one of nine Criteria (Box E5.1). For qualification as an EAAFP Flyway Network Site (FNS) a wetland must meet at least one of five Criteria, for migratory waterbirds only, four of which are consistent with Ramsar Criteria 2, 4, 5 and 6 but with an additional Criterion concerning migratory waterbird population sizes during migratory staging periods.

The most frequently applied Criteria for Ramsar Site designation for the 37 Sites in the Indo-Burma region (Figure E5.1) have been Criterion 2 (globally threatened species: 100% of designated Sites and Criterion 1 (wetland types): 87% of designated Sites. Over half (59%) have been designated under fish Criterion 8. Far fewer Sites have been designated under waterbird Criteria: 35% under Criterion 6 (>1% of waterbird populations) and 24% under Criterion 5 (>20,000 waterbirds).

Numbers of important wetlands identified as potentially qualifying for Ramsar Site designation

Four (Lao PDR, Myanmar, Thailand and Viet Nam) of the five IBRRI countries have identified lists of wetlands potentially qualifying as internationally important for Ramsar Site designation (Table E5.3). No information is available for Cambodia.
A total of 266 wetlands have been identified by the four IBRRI countries as internationally important and so qualifying for Ramsar Site designation (Table E5.3). To date, only 37 (13.9%) of these wetlands have been Ramsar Site designated. The extent of Ramsar Site designation of qualifying sites varies between IBRRI countries, from 21.7% in Thailand and 13.0% in Viet Nam to only 6.7% in Lao PDR and 6.1% in Myanmar.

Table E5.2

The average annual number of Ramsar Site designations by Indo-Burma countries since their accession to the Ramsar Convention.

Country	Year of Ramsar accession	No. of Ramsar sites	Average annual no. of Ramsar Site designations
Cambodia	1999	5	0.22
Lao PDR	2010	2	0.17
Myanmar	2005	6	0.35
Thailand	1998	15	0.63
Viet Nam	1989	9	0.27

Box E5.1

Ramsar Site Designation Criteria

Criterion 1: A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.

Criterion 2: A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.

Criterion 3: A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.

Criterion 4: A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.

Criterion 5: A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds.

Criterion 6: A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird.

Criterion 7: A wetland should be considered internationally important if it supports a significant proportion of Indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.

Criterion 8: A wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.

Criterion 9: A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of wetland-dependent non- avian animal species.

Extent of designation of EAAFP Flyway Network Sites (FNSs)

To date, national Partners in the EAAFP in Indo-Burma have designated only 11 Flyway Network Sites (Cambodia 1, Myanmar 6, Thailand 3 and Viet Nam 1) for migratory waterbirds. This is far fewer than the number of wetlands potentially qualifying for FNS designation for migratory waterbirds. A 2013 assessment of candidate FNSs in the Indo-Burma region identified 107 wetlands as qualifying for designation at that time, so to date only 10.3% of those qualifying wetlands have been designated (Table E5.4).

This assessment indicates the limited extent to date of EAAFP FNS designations, but it is now out of date. Since 2013 many waterbird population sizes have changed and many are in decline – see Indicator A8). Updated population sizes and 1% population thresholds for Ramsar and FNS qualification for migratory waterbird populations have now been issued (EAAFP Secretariat 2022). A reappraisal of sites currently qualifying for FNS designation in the Indo-Burma region could be valuably undertaken. Note that wetlands qualifying for FNS designation also qualify for Ramsar Site designation (especially under Ramsar Criteria 5 and 6 for waterbirds).

Figure E5.1

The frequency of the designation of Ramsar Sites in the Indo-Burma region under different designation Criteria. Source Ramsar Sites information Service (RSIS).

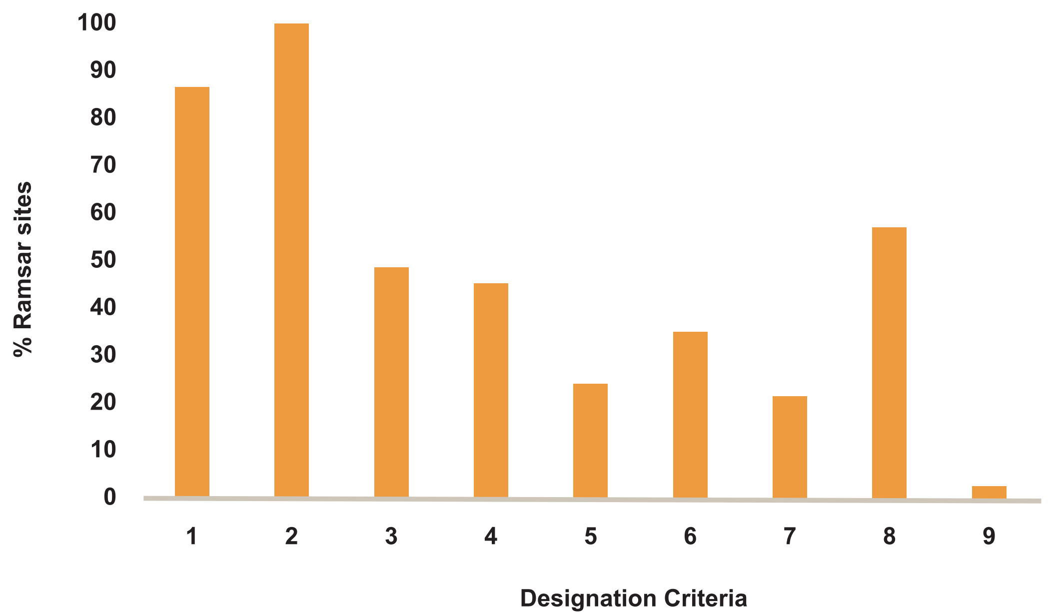

Table E5.3

Summary of the numbers of wetlands identified as potentially qualifying for Ramsar Site designation in Indo-Burma countries. Note that numbers of sites for some countries should be considered as a minimum. No information is available for Cambodia.

	Main wetland category*			
Country	**Inland natural wetlands**	**Coastal natural wetlands**	**Human-made wetlands**	**Total**
Cambodia	-	-	-	n/a
Lao PDR	26	Not applicable	4	30
Myanmar	49	39	11	99
Thailand**	29	28	4	69
Viet Nam	20	24	24	68
TOTAL	**124**	**91**	**43**	**266**

Sources. Lao PDR: Claridge (1996); Myanmar: Davidson et al. (2019); Thailand: Office of Environmental Policy and Planning (2002).; Viet Nam Environmental Protection Agency (2005).
** Note that some wetlands include more than one broad wetland category*
*** The 2016 Viet Nam national wetland inventory (UNDP/GEF 2016) identifies 74 wetlands as being nationally important, but it is not clear how many of these potentially qualify as internationally important for Ramsar designation.*

Table E5.4

Numbers of wetlands meeting FNS qualifying criteria (Jaensch 2013) and the number of sites designated to date in the Indo-Burma region.

Country	No. FNS qualifying sites (2013)	No. FNS designated to date	% qualifying FNS designated
Cambodia	15	1	6.7
Myanmar	39	6	15.4
Thailand	39	3	7.7
Viet Nam	14	1	7.1
TOTAL	**107**	**11**	**10.3**

Note that no information was available for Lao PDR in the 2013 assessment, and that Lao PDR is not an EAAFP Partner.

Recommendations

- Develop a list of internationally important wetlands in Cambodia for potential Ramsar Site designation.
- Update, for the Indo-Burma region, the assessment of wetlands qualifying as EAAFP Flyway Network Sites.
- Across all IBRRI countries, increase the rate of new Ramsar Site and EAAFP Flyway Network Site designations, particularly in Cambodia, Lao PDR and Myanmar.

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E6 TOPICALITY OF INFORMATION ON RAMSAR AND FLYWAY NETWORK SITES

Key messages

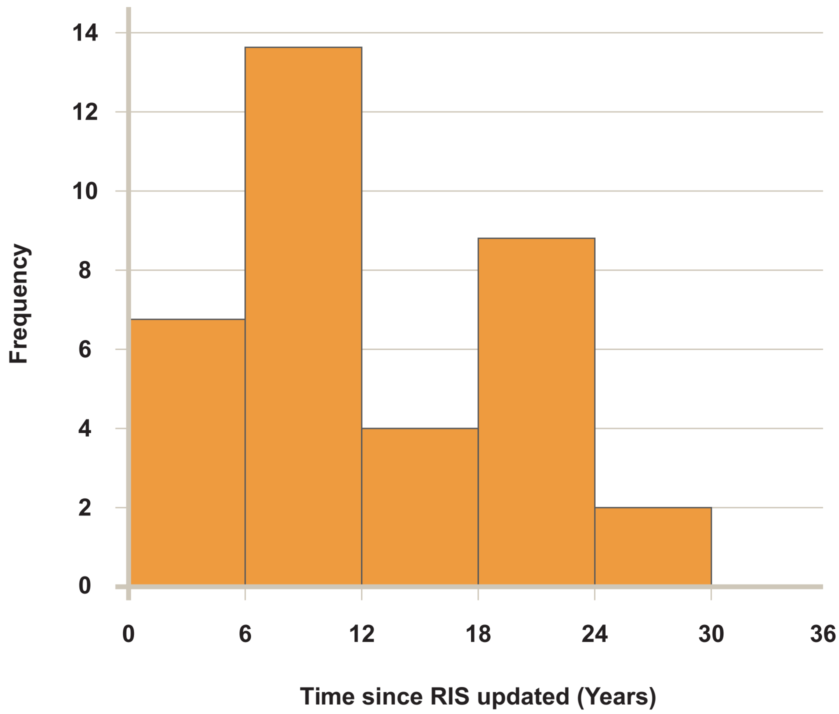
- Well-organized and relevant information on Ramsar sites is essential if their ecological character is to be maintained through active management planning. Ramsar Information Sheets (RISs) provide key information for the sites. There is an urgent need to update RIS across the region.
- Targeted financial support from donors may have a role to play in facilitating the updating of RISs.

Well-organized data and information on wetlands, and particularly those of international importance, is fundamental to the delivery of ecologically and cost-effective management measures, which are necessary for the continued provision of ecosystem services to human populations and direct economic benefits. Contracting Parties to the Ramsar Convention have been encouraged to review and update the information provided on the Ramsar Site Information Sheet (RIS) for each designated Ramsar site at least every six years.

There are 37 Ramsar sites within the Indo-Burma region. A review of the RISs for these sites[3] indicates that the across the region, the average time since the RIS was updated was in excess of 12 years. Only seven sites have an RIS that is less than six years old. The RIS for nine sites have not been updated for at least 18 years, and two sites have an RIS that was last updated more than 24 years ago (Figure E6.1).

Figure E6.1

Time since RISs has been updated for Ramsar Sites in the Indo-Burma region.



3 RIS were only available for 36 sites. No RIS was available for Stung Sen Ramsar site, Cambodia on the Ramsar Sites Information Service - https://rsis.ramsar.org/ris/2365.

There are differences from country to country across the region (Table E6.1). All the RIS for Ramsar sites in both Cambodia and Lao PDR are more than six years old and in Thailand and Viet Nam the RISs require updating for all bar one of the sites of the sites. The situation in Myanmar is different, with two thirds of the RIS being less than six years old. The progress made in Myanmar is a result of significant, targeted funding provided by the Norwegian Government, through the Norwegian Environment Agency, on the Conservation of biodiversity and improved management of protected areas in Myanmar: An action plan for the delivery of improved management and wise use of valuable wetlands[4]. This potentially demonstrates the relevance of third-party financial support to deliver on targeted Ramsar-related outcomes.

Recommendation

- Ensure that the Ramsar Site RISs and EAAFP FNS Site Information Sheets (SISs) are regularly updated, at intervals of not more than six years.

Data source:

Ramsar Site Information Service: https://rsis.ramsar.org/

Table E6.1

Time since RISs has been updated for Ramsar Sites in the Indo-Burma region.

Country	Number of Ramsar sites	Number of sites with an RIS more than six years old	% of sites with an RIS more than six years old
Cambodia	4	4	100.0
Lao PDR	2	2	100.0
Myanmar	6	2	33.3
Thailand	15	14	93.3
Viet Nam	9	8	88.9

4 *https://www.ramsar.org/news/cooperating-on-biodiversity-and-protected-areas-in-myanmar*

E7 MANAGEMENT PLANNING FOR RAMSAR SITES

Key messages

- Only ten out of 37 Ramsar sites internationally important wetlands in the region have active management plans.
- Historically, several additional sites have had management plans, but these have expired.
- Without robust management plans, and their effective implementation, maintaining the ecological character of internationally important wetlands will remain a significant challenge.

Contracting Parties within the Indo-Burma region have committed themselves to make efforts to protect and effectively manage the existing Ramsar Sites. Wetlands are dynamic areas, open to influence from natural and human factors. In order to maintain their ecological character, and to permit the wise use of their resources by people, an overall agreement is essential between the various managers, owners, occupiers and other stakeholders.

The management planning process provides the mechanism to achieve this agreement. Therefore, management planning, and the implementation of a robust management plan are critical actions at the site level. The Ramsar Convention has published robust guidance on management planning including Ramsar Convention Secretariat (2010) and Ramsar Regional Center – East Asia (2017).

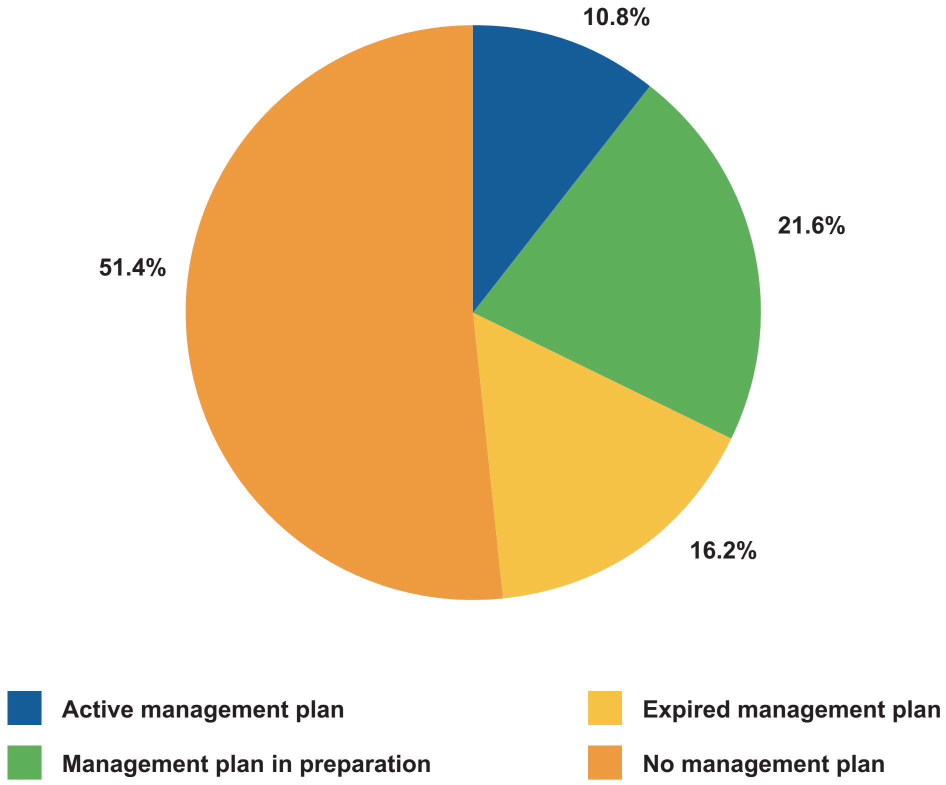
The Ramsar Information Sheets (RISs) have been reviewed for the 37 Ramsar sites and the eleven Flyway Network sites designated in the region to identify the reported status of management plans, i.e., whether they are active and being implemented, in preparation, expired or whether there is no management plan. But it is important to recognise that many RISs are now considerably out-of-date so that the current management planning situation may now be different,

For some sites, additional expert knowledge was used to confirm the status of management planning. The review indicates that more than half of the internationally important wetlands in the region (51.4%) do not have a management plan. Only ten sites (10.8%) have an active management plan that is currently being implemented. Some sites have historically had a management plan that has now expired (16.2%) or have a plan in preparation (21.6%) (Figure E7.1).

The RIS review provides insights into the presence or absence of management plans but does not evaluate the pedigree of existing plans. The reported presence of an active management plan does not necessarily indicate that the plan is being fully implemented or that it is sufficiently comprehensive to protect and effectively manage the site. This is not unique to the wetlands of the Indo-Burma region as the absence of effective management plans is recognised as a significant challenge globally (Kingsford et al., 2021).

Figure E7.1

Status of management planning for Ramsar Sites in the Indo-Burma region.



Recommendations

- In line with IBRRI Strategic Plan Operational Objective 2.2, target management planning at the Ramsar sites that do not have management plans.

- Ensure that a robust programme of management plan development and effectiveness training is developed across the region.

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Data source

Ramsar Information Sheets: available from Ramsar Sites information Service (RSIS) https://rsis.ramsar.org

Harvesting mud crabs in the Gulf of Mottama, Myanmar © Tara Whitty

4 Appendices

APPENDIX 1

AREAS AND DISTRIBUTION OF DIFFERENT CLASSES OF WETLANDS IN INDO-BURMA COUNTRIES

Table A1.1

Estimated areas of different wetland classes in each Indo-Burma country and the Indo-Burma region. Global wetland classes and global area estimates are from Davidson & Finlayson (2018, 2019).
P = recorded as present but area unknown. n/a = not available

Wetland class	Global wetland class area (10^6 km^2)	Cambodia km^2	Lao PDR km^2	Myanmar km^2	Thailand km^2	Viet Nam km^2	Indo-Burma total km^2	% Indo-Burma of global area	Source(s)
Inland natural wetlands									
Lakes (>0.1 km^2)	2.67-2.91	3,240.00	76	1,875.00	2,424.00	957	8,572.00	2.95-3.21	Global Lakes & Wetlands database (GLWD) levels 1 & 2.
Lakes & rivers (permanent)	n/a	3,372.04	1,059.47	3,094.14	2,193.42	2,585.57	12,304.64	n/a	Global Water Surface Explorer (GWSE); 2021 data
Non-forested peatlands	3.12		101	3,903.55	350.5	1,582.00	5,937.05	0.19	Joosten (2009). 2008 data. Myanmar: NWCD 2020

Forested peatlands	0.7		90	565.8	280	800	1,735.80	0.25	Joosten (2009). 2008 data. Myanmar: NWCD 2020
Marshes & swamps on alluvial soils	n/a	P	P	P	P	141.11	141.11	n/a	Viet Nam: UNDP/ GEF (2016)
Forested wetlands on alluvial soil	n/a	P	P	P	P	160.1	160.1	n/a	Viet Nam: UNDP/ GEF (2016)
Karst and caves	n/a	P	P	P	P	1,294.72	1,294.72	n/a	Viet Nam: UNDP/ GEF (2016)
Inland natural wetlands: minimum total		**3,372.04**	**1,250.47**	**7,563.49**	**2,823.92**	**6,563.50**	**21,573.42**		

Wetland class	Global wetland class area (10^6 km^2)	Cambodia km^2	Lao PDR km^2	Myanmar km^2	Thailand km^2	Viet Nam km^2	Indo-Burma total km^2	% Indo-Burma of global area	Source(s)
Coastal/marine natural wetlands									
Unvegetated tidal flats	0.12-0.13	102		3,493.00	585	1,429.00	5,609.00	4.32-4.67	Global Intertidal Change database. Murray et al. (2019).

Saltmarshes	0.06	P		500	0	P	500	>0.83	Mcowan et al. 2017. Myanmar: Zöckler et al. (2021a)
Mangroves	0.14	585.6		4953.45	2246.87	1578.49	9364.41	6.69	Global Mangrove Watch (GMW)
Seagrass beds	0.16-0.27	324.92		3,147.10	255.81	196.1	3,923.93	1.44-2.44	Myanmar: BOBLME (2015); Thailand & Viet Nam: Stankovich et al. (2021); UNEP-WCMC & Short F.T. (2021). Cambodia: Vibol, O. undated
Coral reefs (warm water systems)	0.28	50		1,870.00	2,130.00	1,270.00	5,270.00	1.88	Spalding et al. (2001) in Zöckler et al. (2021a)
Shallow marine systems <6m depth	n/a	1,332.00		8,499.00	7,631.00	10,919.00	28,381.00	n/a	BODC.
Coastal lagoons	n/a	P		P	P	4,187.80	4,187.80	n/a	Viet Nam: UNDP/ GEF (2016)
Karst and cave systems	n/a				P	26.56	26.56		Viet Nam: UNDP/ GEF (2016)
Coastal natural wetlands: minimum total	**n/a**	**2,394.52**	**0**	**22,462.55**	**12,848.68**	**19,606.95**	**57,262.70**		

Wetland class	Global wetland class area (10^6 km^2)	Cambodia km^2	Lao PDR km^2	Myanmar km^2	Thailand km^2	Viet Nam km^2	Indo-Burma total km^2	% Indo-Burma of global area	Source(s)
Human-made wetlands									
Reservoirs	0.44	348	1,106.00	1,277.57	2,691.00	1,597.00	7,019.57	1.6	GRanD v1.3. 2016 data. Myanmar: Myanmar: NWCD 2020
Reservoirs (maximum water area)	0.44	240.54	1,181.96	1,083.85	3,845.61	1,727.64	8,079.60	1.84	Global Water Surface Explorer; 2016-2020 average data
Rice production areas*	1.28	29,174.00	8,212.00	66,558.00	104,017.00	72,226.00	280,187.00	21.88	FAOSTAT 2020 areas
Aquaculture ponds	0.11	31.65	220	>1,822.90	2,066.11	11,683.67	15,824.33	14.28	Verdegem & Bosma (2009); Cambodia: Agri-Farming (2019); Lao PDR: Funge-Smith (1997); Myanmar: Belton et al. (2015), FAO RAP (2003); Thailand: FAO undated; Viet Nam: Can undated.

Saltpans	n/a	P		P	P	167	167	Viet Nam: UNDP/GEF (2016)
Wastewater treatment ponds	n/a					0.01	0.01	Viet Nam: UNDP/GEF (2016)
Sedge farms	n/a					67	67	Viet Nam: UNDP/GEF (2016)
Human-made wetlands: minimum total		**29,446.19**	**9,613.96**	**79,639.38**	**109,928.72**	**85,871.32**	**304,324.94**	
Minimum total wetland area		**35,212.75**	**10,864.43**	**109,665.42**	**125,601.32**	**112,041.77**	**383,161.06**	

** includes irrigated and flood recession areas*

Data source

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APPENDIX 2

THE AREAS AND DISTRIBUTION OF EACH DIFFERENT WETLAND CLASS IN INDO-BURMA COUNTRIES

Inland natural wetlands

There is an estimated minimum total area of only 21,573.42 km² remaining of inland natural wetlands in the Indo-Burma region (Appendix A1). Largest remaining areas of inland natural wetlands are in Myanmar (35% of Indo-Burma total), Viet Nam (30%) and Cambodia (16%), with smaller areas in Thailand and Lao PDR (Figure A.2.1).

The largest area of inland natural wetlands is of permanent lakes and rivers (61% of total area), with 30% being non-forested peatlands and only 9% being forested peatlands (Figure A.2.2). The remaining area of floodplain wetlands on alluvial soils is not known for most Indo-Burma countries but is believed to now be small (see Indicator A3).

Permanent lakes and rivers occur throughout the Indo-Burma region, with an estimated total area of 12,305 km² (Table A1). The area of all lakes (>0.1 km²) is estimated as 8,572 km² (Table A1). Largest areas (Figure A2.3) are in Cambodia (27% of Indo-Burma area), notably Tonle Sap Lake - the largest lake in the Indo-Burma region and Southeast Asia - and Myanmar (25% of Indo-Burma area), including the large Inlay Lake and Indawgyi Lake.

There are nine major rivers that flow wholly or largely through the Indo-Burma region. The largest rivers (by river basin area) are the Mekong, the Ayeyarwady, the Salween, the Hong Ha (Red) and the Chao Phraya. The longest rivers are the Mekong, the Salween and the Ayeyarwady (Table A.2.1).

Areas of peatlands are not well assessed for the Indo-Burma region. Figures in Joosten (2009) suggest that areas are relatively small: c. 7,673 km² in total, with largest areas in Viet Nam and Myanmar, of which approximately 40% are forested and 60% non-forested (Table A1). The Myanmar National Wetland Inventory (NWCD 2020) reported 566 km² of forested peatlands and 3,904 km² of non-forested peatlands.

Figure Appendix 2.1

The distribution of inland natural wetland area across Indo-Burma countries. Source. Table A1.1.

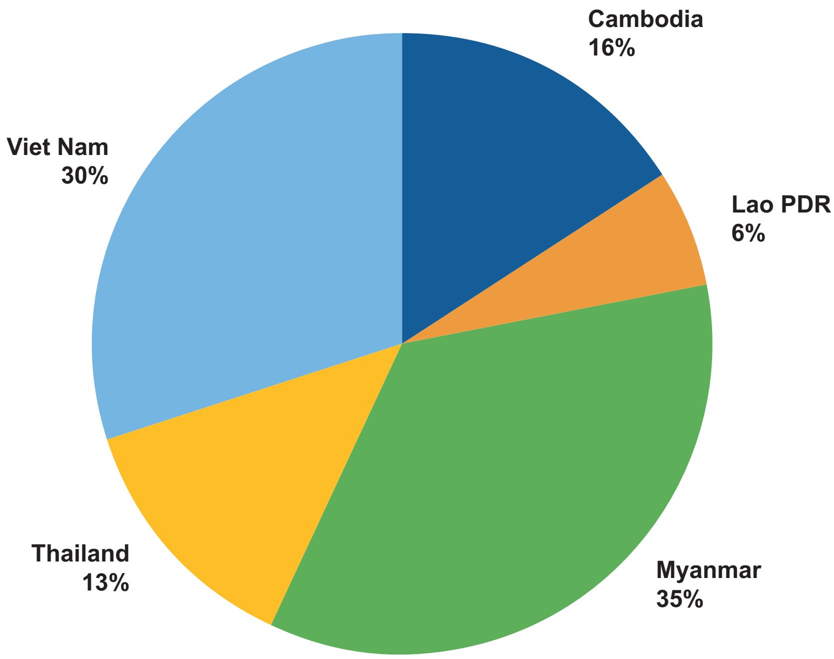


Figure Appendix 2.2

The percentages of the area of different inland natural wetland classes in the Indo-Burma region. Source. Table A1.1.

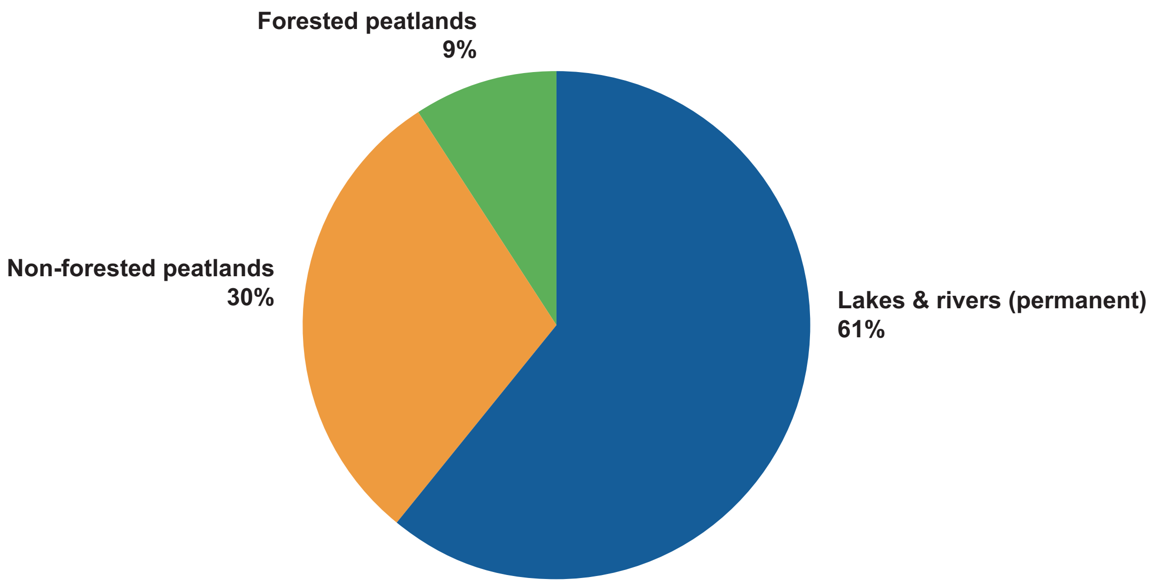


Figure Appendix 2.3

The distribution of permanent lake and river area across Indo-Burma countries. Source. Global Water Surface Explorer; Table A1.1.

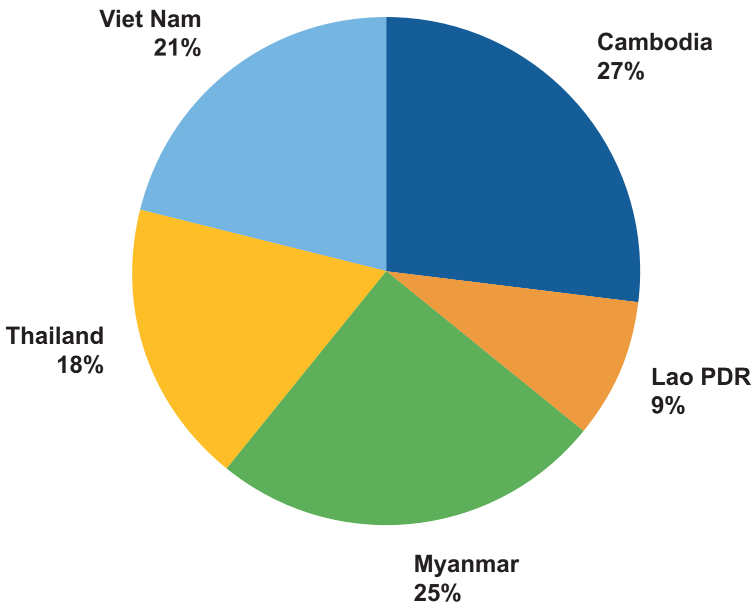


Table Appendix 2.1

Major rivers in the Indo-Burma Region. Source. Zöckler et al. (2021a).

River	Basin Area km²	Length km	Indo-Burma countries	Other countries	Average discharge cubic metre/ second
Mekong	811,000	4,909	Cambodia, Lao PDR, Myanmar, Thailand, Viet Nam	China	16,000
Ayeyarwady	411,000	2,288	Myanmar	China, India	15,112
Salween	324,000	3,289	Myanmar, Thailand	China	6,600
Chao Phraya	160,400	372	Thailand		718
Hong Ha (Red)	143,700	1,149	Viet Nam	China	2,640
Kaladan	40,000	450	Myanmar	India	3,468
Nam Ma	36,000	512	Viet Nam, Lao PDR		?
Sittaung	31,000	420	Myanmar		1,542
Ca	28,500	513	Viet Nam		?

Coastal/marine natural wetlands

There are extensive, diverse and important areas of coastal and nearshore marine wetlands around the coasts of the Indo-Burma countries, with an estimated minimum total area of 57,263 km² (Table A1) with the largest areas being in Myanmar (39% of Indo-Burma area) and Viet Nam (34%) and smaller areas in Thailand (23%) and Cambodia (4%) (Figure A2.4). Lao PDR has no coastline.

By far the largest area of coastal/marine natural wetlands are shallow marine systems <6m depth of permanent inundation (53% of the coastal/marine natural wetland areas in the region) (Table A1; Figure A2.5), Although smaller in area, there are major and important areas of mangroves (6.7% of global area), unvegetated tidal flats (4.3-4.7% of global area), coral reefs (1.9% of global area) and seagrass beds (1.4-2.4% of global area) (Table A1).

Although wetlands are widely distributed around the Indo-Burma coastline, the coasts of Myanmar are of particular importance for wetlands (Figure A2.6; Table A1). Myanmar coasts have 80% of the Indo-Burma seagrass bed area, 62% of unvegetated tidal flats area (the 8th largest national tidal flats area in the world – Murray et al. (2018)), 53% of mangrove area (the 7th largest national mangrove area in the world – Bunting et al. (2018)), 36% of coral reef area and 30% of the regional area of shallow marine waters.

Viet Nam (38%) and Thailand (27%) have major areas of shallow marine waters in the Indo-Burma region (Table A1; Figure A2.6). Thailand is also important for coral reefs (40% of the Indo-Burma area) and mangroves (24%).

Figure Appendix 2.4

The distribution of coastal/marine natural wetland area across Indo-Burma countries. Source. Table A1.1.

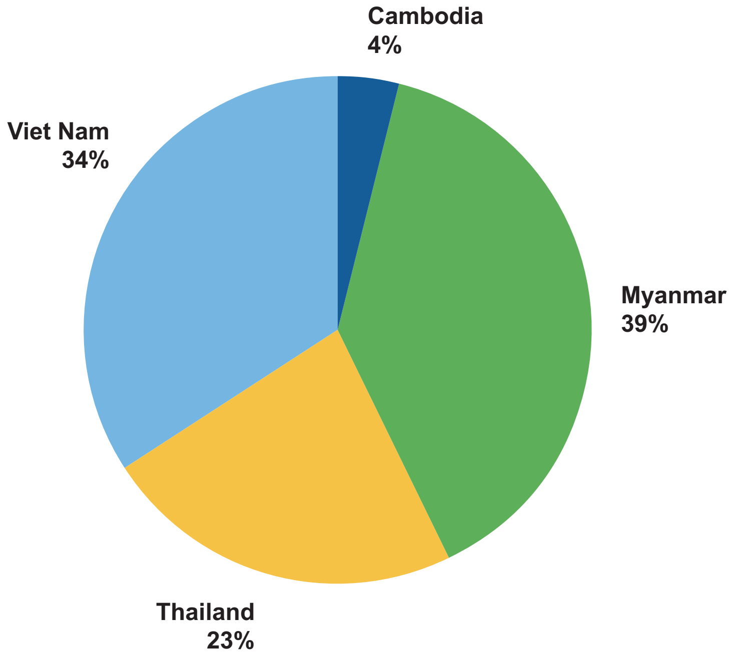


Figure Appendix 2.5

The percentage areas of different coastal/marine natural wetland classes in the Indo-Burma region.

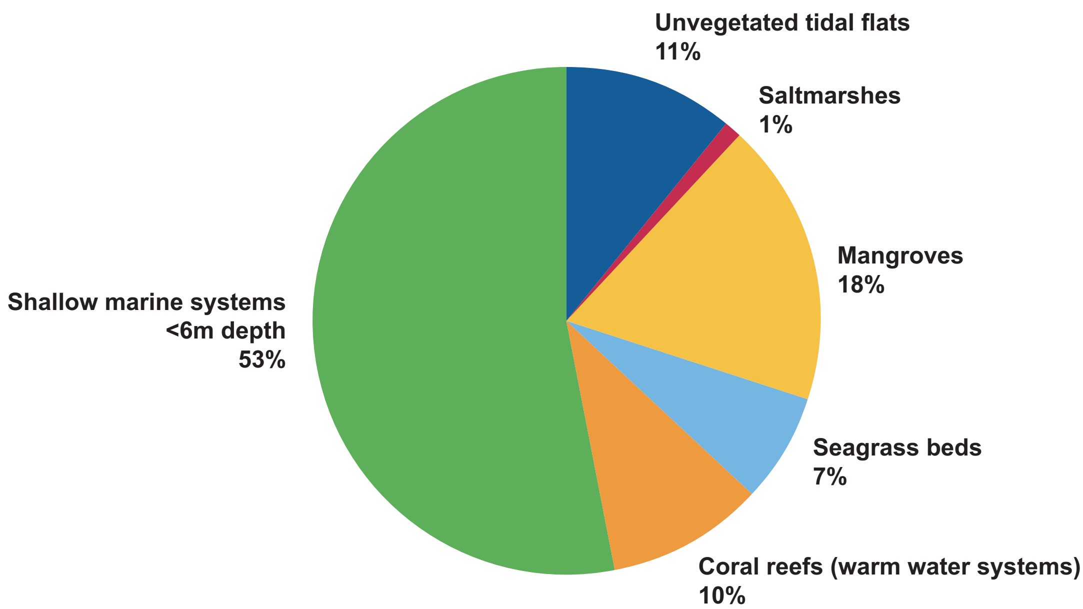
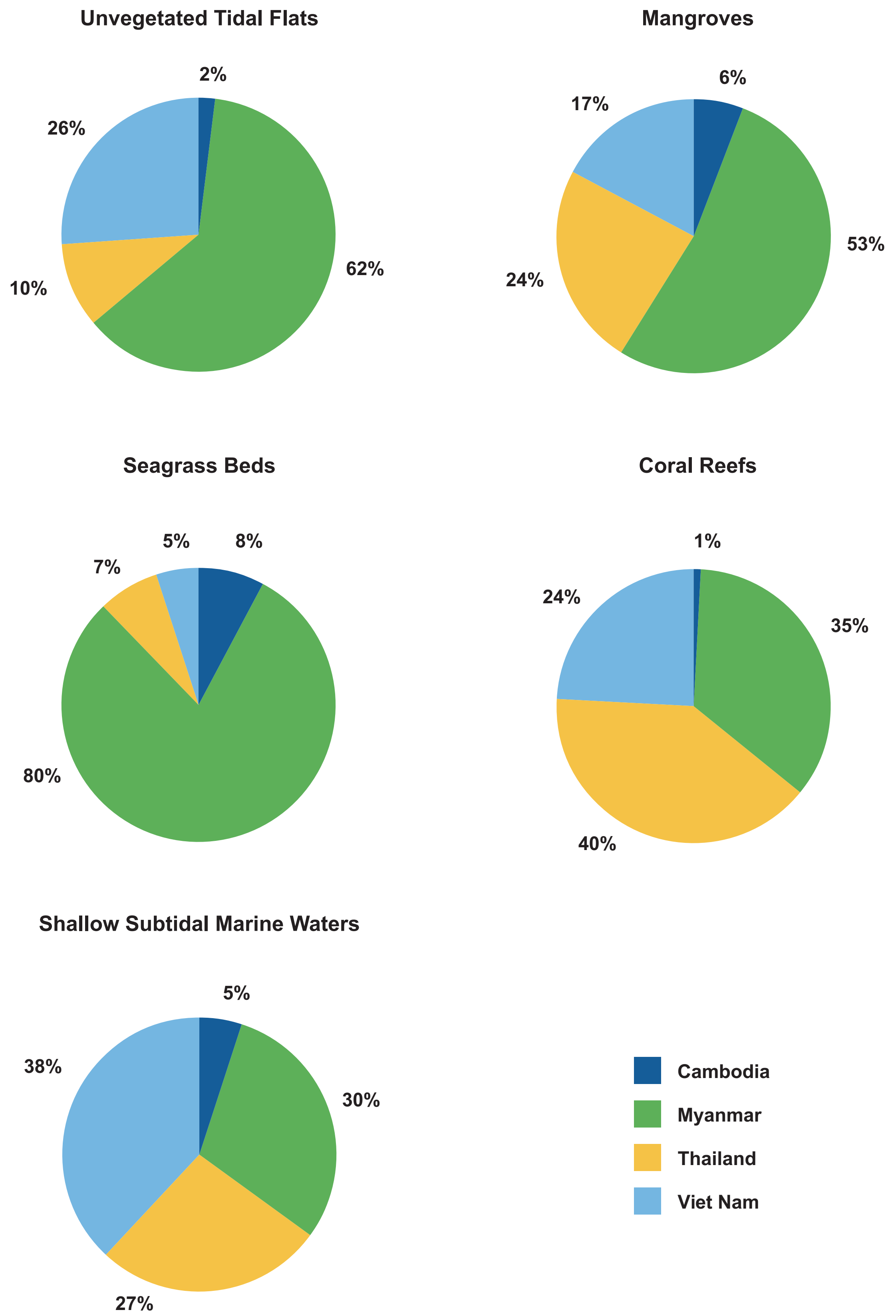


Figure Appendix 2.6

The area distribution of different coastal/marine natural wetland classes in the Indo-Burma region.



Human-made wetlands

Human-made wetlands now dominate the wetland area in the Indo-Burma region. There is an estimated minimum total area of 304,324.94 km² of human-made wetlands (reservoirs, rice production and aquaculture ponds) in the Indo-Burma region (Table A1). By far the largest area is of rice production (92% of total human-made wetland area), with much smaller areas of aquaculture ponds (5%) and reservoirs (3%).

The largest areas of human-made wetlands are in Thailand (35% of Indo-Burma total), Viet Nam (27%) and Myanmar (25%), with smaller areas in Cambodia and Lao PDR (Figure A2.7).
All Indo-Burma countries have large rice (including irrigated and flood recession) production areas. The total rice production area (in 2020) was 280,187 km² (21.9% of global rice production area), covering 14.5% of the Indo-Burma region land area. By Indo-Burma country this ranges from 3.5% of Cambodia's land area to 20.3% of Thailand's land area and 21.8% of Viet Nam's land area. The largest rice production areas are in Thailand (37% of Indo-Burma area), Viet Nam (26%) and Myanmar (24%) (Figure A2.8).

Open water reservoirs created behind dams for hydropower generation, agricultural irrigation and industrial and drinking water purposes are widespread in the Indo-Burma region. The largest reservoir areas are in Thailand (48% of Indo-Burma area) and Viet Nam (21%). Cambodia has a small reservoir area (3% of the Indo-Burma area) (Figure A2.9).

The global area of aquaculture ponds has been estimated as 110,830 km² (Verdegem and Bosma 2009), of which 78.9% by area are freshwater (inland) ponds with the remaining 21.1% being brackish (coastal) ponds. There are large and increasing numbers of aquaculture ponds in the Indo-Burma region, many created by conversion of mangroves and rice cultivation areas (see Indicator A3). Three Indo-Burma countries (Viet Nam, Myanmar and Thailand) are amongst the top ten aquaculture producers in the world (FAO 2021). There are estimates for aquaculture pond areas for each of the Indo-Burma countries (Table A1) but as most date from the late 1990s/early 2000s these are now out-of-date – current areas can be expected to be considerably larger.

The minimum area of Indo-Burma aquaculture ponds is 15,824 km², approximately 14% of global area (Table A1). In the Indo-Burma region, 56% of aquaculture pond area is inland (freshwater) and 44% coastal (brackish). By far the largest area of aquaculture ponds (74%) in the Indo-Burma region is in Viet Nam (Figure A2.10), with large areas also in Thailand (13%) and Myanmar (12%). In part of the Mekong Delta (Viet Nam), by 2020 aquaculture pond area was over 3,122 km² – now the largest area of any wetland class in that region, following extensive conversion from rice cultivation areas (Dang et al. 2021).

Figure Appendix 2.7

The distribution of human-made wetland area across Indo-Burma countries. Source. Table A1.

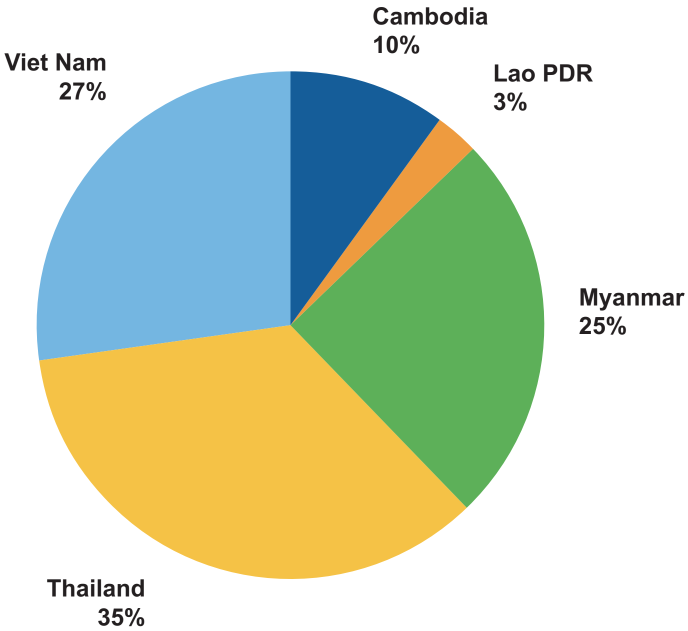


Figure Appendix 2.8

The distribution of rice production area across Indo-Burma countries. Source. FAOSTAT.

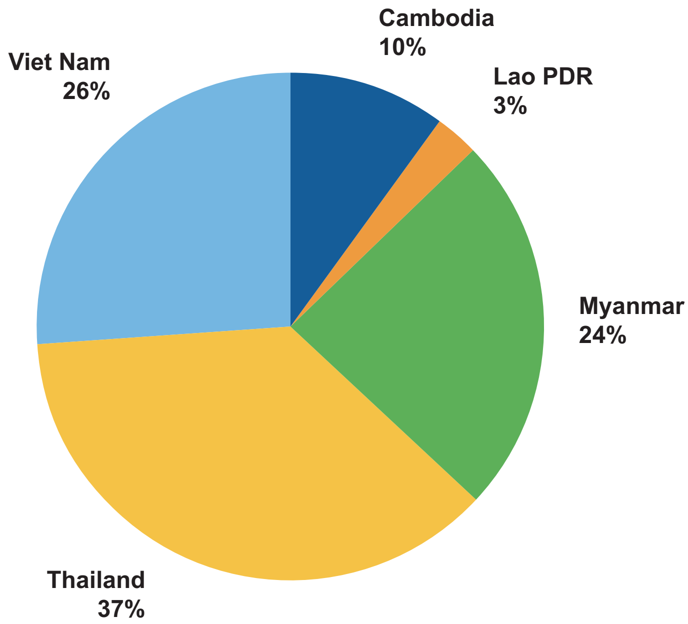


Figure Appendix 2.9

The distribution of reservoir (maximum water) area across Indo-Burma countries. Source. Global Water Surface Explorer.

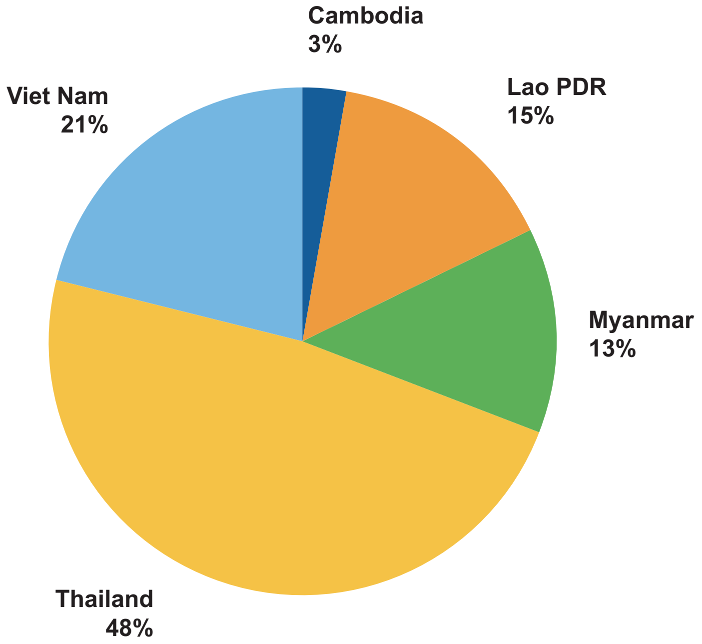
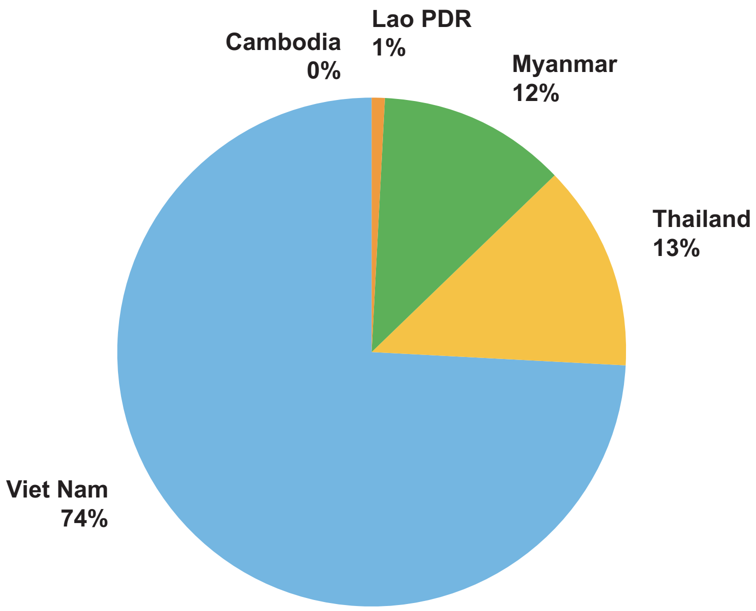


Figure Appendix 2.10

The distribution of aquaculture pond area across Indo-Burma countries. Sources. Multiple – see Table A1.



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APPENDIX 3

AREA CHANGES OF DIFFERENT WETLAND CLASSES IN THE INDO-BURMA REGION

Inland natural wetlands

Lakes

The open water area of at least some lakes in the Indo-Burma region is reducing. This is likely to be mostly due to a combination of changes in sedimentation, water abstraction and catchment precipitation. Trends in lake inundation areas have not been assessed for many Indo-Burma lakes.

At Tonle Sap Lake (Cambodia), the largest lake in the Indo-Burma region (and in Southeast Asia), inundation area was largely stable between 1988 and 2000, but between 2000 and 2018 fluctuated annually but decreased overall, at an average rate of 8.22 $km^2\ yr^{-1}$ (Wang et al. 2020). This was linked to patterns of precipitation in parts of the Mekong River basin and increases in sedimentation, but the contribution of dam construction in China was relatively insignificant (Wang et al. 2020). Inland water bodies in the Mekong Delta (Viet Nam) decreased in area by 6.2% between 1995 and 2020 (Dang et al. 2021). The inundation area of Indawgyi Lake (Myanmar) is reported to have decreased by 10% over the past 15 years (Zöckler et al. 2021a).

Floodplain wetlands/seasonally flooded grasslands

Floodplain wetlands including seasonally flooded grasslands were formerly very extensive and widespread across the Indo-Burma region particularly on river floodplains and in delta areas. However, these wetlands have almost wholly disappeared (although the remaining extent has not been assessed), largely because of long-term and continuing conversion to rice production areas as well as to aquaculture ponds (CEPF 2020). These wetlands are now one of the most threatened ecosystems in the Indo-Burma Hotspot (CEPF 2020).

Examples of reported loss of floodplain wetlands in the Indo-Burma region include:

- About one-third of the extensive seasonally flooded grassland and scrubland around Tonle Sap Lake (Cambodia) was converted to rice cultivation between 2003 and 2018 (Learn 2020);
- In the Mekong Delta, Viet Nam, almost all natural seasonally flooded grasslands have been converted for intensive rice cultivation (CEPF 2020);
- The formerly extensive floodplain wetlands in the Chao Phraya Basin of central Thailand have been converted to rice cultivation (P. D. Round in litt. 2002 in CEPF 2020).
- No trace remains of the natural floodplain wetlands of the Red River delta (Viet Nam), which originally covered 1.75 million hectares (UNEP 2004).
- Seasonally flooded grasslands (and natural Melaleuca forests) on the Plain of Reeds (Viet Nam) have also been disappearing and are being replaced by rice fields and planted Melaleuca forests (Viet Nam Environment Protection Agency 2005);
- An estimated 92.4% of area of Central Ayeyarwady floodplain grasslands (Myanmar) has been converted to cropland (rice paddy) (Murray et al. 2020).
- At least 70.1% of Ayeyarwady floodplain wetlands (Myanmar) have been transformed to agriculture (rice paddy) since the 1750s. (Murray et al. 2020).

Swamp forests

Seasonally inundated swamp forests were formerly extensive and widely distributed in Indo-Burma river floodplains and delta systems. But there has been extensive clearance because of their coincidence with areas of high human population and suitability for conversion to agricultural land, and in many places are now restricted to isolated fragments (CEPF 2020).

Examples of reported losses of floodplain wetlands in the Indo-Burma region include:

- 31% of the extensive floodplain forests surrounding Tonle Sap Lake (Cambodia) felled since 1993. In addition, in 2016, massive fires burned as much as a third of the 3,000 km^2 of remaining flooded forest in the Tonle Sap region (Lohani et al. 2020).

- Conversion of natural *Melaleuca cajuputi* forests in the Plain of Reeds (Viet Nam) to rice cultivation and planted Melaleuca forests (Viet Nam Environment Protection Agency 2005).

- In the Mekong Delta (Viet Nam), a reduction of forested wetland area of 32% from 1995-2020, including a 14.5% area decrease between 2002 and 2013 through conversion to rice cultivation (Dang et al. 2021).

- Estimated up to 97.4% loss of Myanmar central dry evergreen riparian forest since 1750, with losses ongoing and the remaining forest heavily degraded (murray et al. 2020).

Peatlands

Trends in the areas of forested and non-forested peatlands are not well established, but available evidence points to decreases in area. Examples include:

- A 5% loss of peatland area in the Indo-Burma region between 1990 and 2008, including a 30% loss of forested peatland area over that period (Joosten 2009).

- In the U Minh region of Viet Nam, an 86.7% peatland area loss between 1990 and 2005 [Viet Nam Environment Protection Agency 2005].

- A loss of 82% of peatland area in Thailand (Immirzi et al. 1992).

Coastal natural wetlands

Some classes of coastal natural wetlands are dynamic and can change rapidly in area and location. An assessment of changes in the areas of tidal flats, mangroves and tidal marshes between 1999 and 2019 demonstrates this (Murray et al. 2022). In the Indo-Burma region there have been some gains (offsetting losses) of mangrove area through deliberate mangrove planting, but at the expense of loss of areas of unvegetated tidal flats (CEPF 2020).

However, in the Indo-Burma region between 1999 and 2019 there have been more losses than gains of intertidal area, in each of the four Indo-Burma countries with a coastline (Murray et al. 2022) (Table 1). The largest net losses have been in Myanmar (-475 km²) and Viet Nam (-203 km²), with smaller net losses in Cambodia and Thailand. The net loss of Myanmar coastal wetlands is the third largest in the world, after Indonesia and China.

Overall, in the Indo-Burma region there has been a net loss of -712 km² of tidal wetlands between 1999 and 2019, contributing a large proportion (18.0%) of global area change of tidal wetlands (Table 1).

Tidal flats

Globally, the area of tidal flats has decreased by 16% between 1984 and 2016 (Murray et al. 2019). Trends in unvegetated tidal flat area in the Indo-Burma region are not well established. On some parts of the Indo-Burma region coast, such as the Inner Gulf of Thailand and the Red River Delta (Viet Nam), the area of tidal flats is reported as decreasing because of the piecemeal planting of mangroves (CEPF 2020). However, not all tidal flats in the Indo-Burma region are decreasing: in north-west Myanmar ((central-north Rakhine State) there was an increase in tidal flat areas between 1992 and 2016 of 3.36% per year (Murray et al. 2020).

Mangroves

Globally, the area of mangroves decreased between 1996 and 2016 by 4.27% (Bunting et al. 2018). The area of mangroves in the Indo-Burma region has been in long-term and generally continuing decline (Figure A3.1). The overall loss of mangrove area in the Indo-Burma region over the 1996 - 2016 time period has been considerably higher (7.19%) than the global average (Table A3.2).

Area losses have been greatest in Myanmar (-8.0%), which has the largest area of mangroves in the Indo-Burma region, Viet Nam (-7.5%) and Cambodia (-7.5%). The smallest overall change was in Thailand (-5.0%) (Table 2). Friess et al. (2019) report that between 2000 and 2012 Myanmar had the highest annual rate of mangrove loss (-0.7% per year) of any country globally, over four times the global average rate. Similarly, between 1975 and 2005 Giri et al. (2008) report a 35% decrease in Myanmar mangrove area.

Table A3.A1

Losses and gains of coastal wetland area (tidal flats, mangroves and tidal marshes) in Indo-Burma countries between 1999 and 2019. Source. Extracted from data in from Murray et al. (2022) supplementary materials.

Country	Area loss km²	Area gain km²	Net area change km²	Contribution to global net area change %
Cambodia	-16	+6	-10	0.3
Myanmar	-896	+421	-475	12.0
Thailand	-89	+64	-24	0.6
Viet Nam	-347	+144	-203	5.1
Indo-Burma total	**-1,348**	**+635**	**-712**	**18.0**

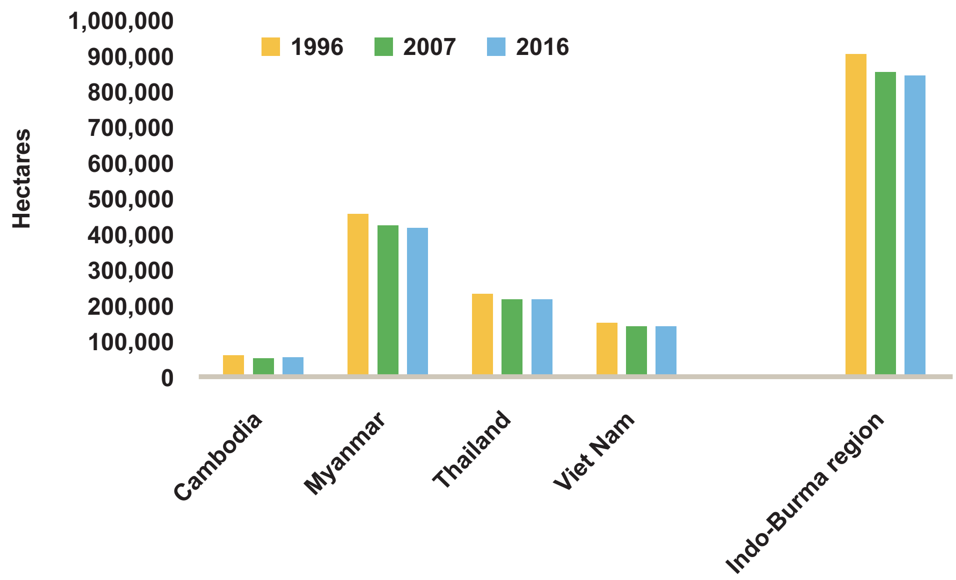
Table A3.A2

Losses and gains of coastal wetland area (tidal flats, mangroves and tidal marshes) in Indo-Burma countries between 1999 and 2019. Source. Extracted from data in from Murray et al. (2022) supplementary materials.

Country	1996 (km²)	2016 (km²)	% change 1996-2016	average annual % change
Cambodia	632.99	585.60	-7.49	-0.37
Myanmar	5,385.10	4,953.45	-8.02	-0.40
Thailand	2,364.63	2,246.87	-4.98	-0.25
Viet Nam	1,706.93	1,578.49	-7.52	-0.38
Indo-Burma region	**10,089.65**	**9,364.41**	**-7.19**	**-0.36**

Figure A3.1

Trends in the area of mangroves in Indo-Burma countries.
Source. Global Mangrove Watch .https://data.unep-wcmc.org/datasets/45



Mangrove area decreased progressively from 1996 to 2016 in Cambodia, Myanmar and Viet Nam, but mangrove area has largely stabilised since 2007 in Thailand (Figure A3.1). This trend in Thailand has been attributed to the piecemeal planting (or re-planting) of mangrove areas (Critical Ecosystem Partnership Fund 2020). Longer-term trends in Viet Nam mangrove area also show a continuing area loss between 1943 and 2000, of 2,522 km² (-61.7% loss), with the fastest rates of loss being between 1943-1962 and then between 1982-2000 (Viet Nam Environment Protection Agency 2005). In the Mekong Delta (Viet Nam) there was a 5% decrease in mangrove area between 1995 and 2020 (Dang et al. 2021).

In Myanmar, the largest losses have occurred in the northern Rakhine State and the Ayeyarwady Delta. Net mangrove extent has remained relatively stable over the past 30 years in the south (Tanintharyi State), although substantial losses and gains in mangrove area have occurred there. The Myanmar Red List of Ecosystems (Murray et al. 2020) assessed Rakhine mangroves and Ayeyarwady mangroves as at particularly high risk of ecosystem collapse:

- Rakhine mangroves (Critically Endangered): Extensive declines in extent - less than 10% of the original extent may remain, and a predicted further 38% loss of area by 2038. A 12% degradation of the ecosystem is estimated since 2000, and projected to a 50-year time frame about 40% of the ecosystem may become degraded by 2050.

- Ayeyarwady Delta mangroves (Endangered): Extensive losses have occurred and are ongoing: a decrease in extent of around 79.5% is predicted over the 50-year period between 1978 and 2028.

- Tanintharyi mangroves (Near Threatened): Recent deforestation reported. Overall little net area change, but substantial gains (302 km²) and losses (384 km²) between 1989-2014 in different areas.

Two other Myanmar mangrove ecosystems were also assessed as Critically Endangered (Murray et al. 2020):

- Ayeyarwady kanazo swamp forest: Kanazo forest is formed of the Endangered mangrove species *Heritiera fomes*, growing on the landward margins of mangrove forests. There were formerly large areas in the Ayeyarwady Delta, but as little as 2.6% may remain, as a consequence of conversion to rice cultivation and aquaculture ponds, sea-level rise and fuelwood extraction.

- Dwarf mangrove on shingle: Highly restricted: known from only two very small patches considered at risk of collapse when subject to catastrophic tropical storms.

There are multiple causes of the continuing loss and degradation of mangroves in different parts of the Indo-Burma region. Major reported causes include the conversion to rice cultivation, aquaculture ponds and tourist facilities, logging and fuelwood cutting, and coastal erosion through sea-level rise (Viet Nam Environment Protection Agency 2005; Friess et al. 2019; Dang et al. 2021); Zöckler et al. 2021a).

Seagrass beds

No Indo-Burma regional estimates of change in the area of seagrass beds are available. However, Stanckovic et al. (2021) estimate a recent average annual loss of seagrass area of -2.82% per year in Southeast Asia. Viet Nam is reported to have lost over 50% of its seagrass area since the 1990s, and more in some areas, particularly intertidal seagrass beds (Luong et al. 2012) but area changes have not been reported for Cambodia, Myanmar or Thailand. Seagrass losses and degradation are reported as being a combined consequence of eutrophication, pollution, sedimentation, physical disturbance, trawling and aquaculture (Zöckler et al. 2021a).

Coral reefs

Changes in coral reef area or live coral coverage have not been widely reported for the Indo-Burma region, but available evidence is of declines. In Viet Nam, since the 1990s about 15-20% of coral coverage has been lost, with losses of live coral coverage ranging from -2% to -32% in different areas (Viet Nam Environment Protection Agency 2005). Recent studies suggest that Myanmar coral reefs have declined by over 56% (ICRI undated). A major coral bleaching event in 2010 affected corals in large parts of Thailand (Phongsuwan et al. 2013). Monitoring suggests that the condition of coral reefs in the Gulf of Thailand has worsened since the late 1980s, while the condition of reefs in the Andaman Sea has remained stable or improved slightly (Burke et al. 2002). As well as coral bleaching events, destructive fishing methods, increased sedimentation and seaweed farming are reported as leading to coral reef degradation in the Indo-Burma region.

Human-made wetlands

Reservoirs

The area of human-made open-water reservoirs has been steadily and progressively increasing throughout the Indo-Burma region, particularly since the early 2000s (Figure 2). Between the late 1990s and late 2010s the total Indo-Burma reservoir area increased by 4,480 km², a 124.4% area increase.

Increases in reservoir area have occurred since the late 1990s in all five Indo-Burma countries (Figure A3.A3). The largest increases in reservoir area have been in Thailand (1,472 km²) and Viet Nam (1,215 km²), and the smallest in Cambodia (209 km²).

About 41% (1,138 km²) of new permanent inundation area in Indo-Burma has been on previously dry (i.e. non-wetland) areas. A smaller area (102 km²) has transitioned from seasonal to permanent water inundation.

Figure A3.2

Trends in reservoir area (maximum extent) in the Indo-Burma region. (source. Global Surface Water Explorer – see also Pekel et al. (2016).

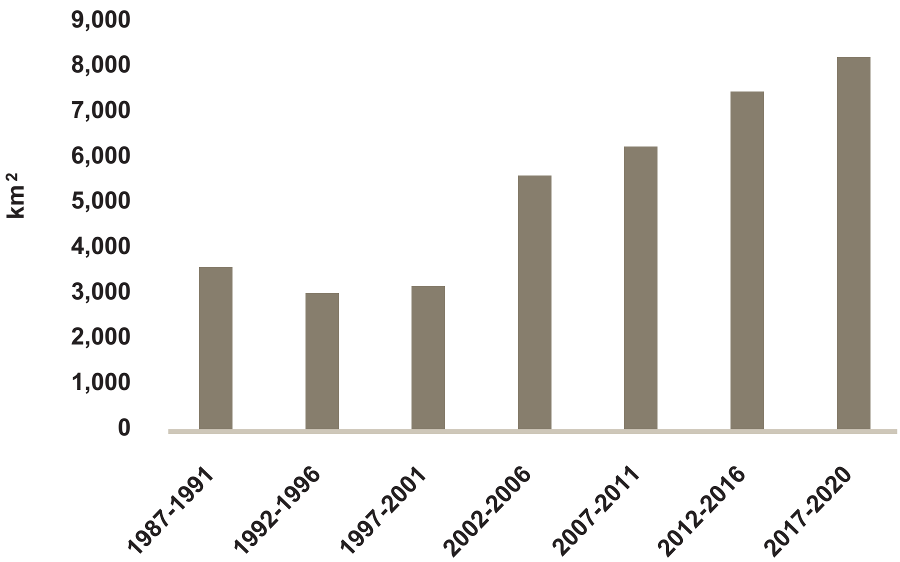
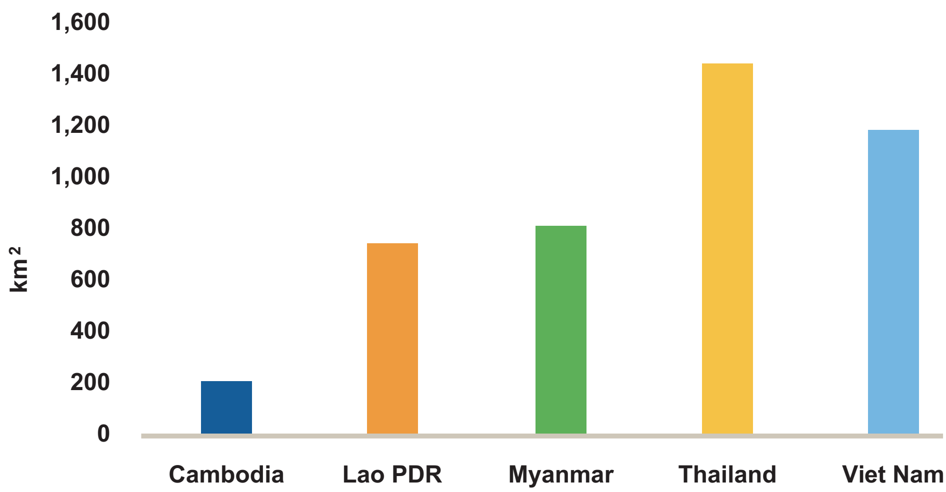


Figure A3.3

Increases in reservoir area (maximum extent) between 1987-91 and 2017-20 in each Indo-Burma country. (source. Global Surface Water Explorer)



Rice production area

Lowland rice cultivation began in Southeast Asia about 6,500 years ago UNEP 2004). Rice is the dominant agricultural crop in the Indo-Burma region, and rice production areas (including irrigated rice and flood recession cultivation) are the largest area of any wetland class in the region, now covering 14.5% of the region's land area (see Indicator 2). Over the last 60 years (1961-2020) the area under rice cultivation has progressively and steadily increased in the Indo-Burma region (Figure A3.4), with a 56.4% area increase since 1961.

Area increases have occurred in all five Indo-Burma countries (Figure A3.5) and have been greatest in the three Indo-Burma countries with the largest rice production areas: Thailand (+70.0%), Viet Nam (+52.3%) and Myanmar (+56.5%), with smaller area increases in Cambodia (+33.7%) and Lao PDR (+32.5%).

Much of the increase in rice production area is reported as being through the conversion of natural wetlands, notably seasonally flooded floodplain wetlands, deltas and mangroves. For example, 81% of the loss of mangroves in the Ayeyarwady Delta (Myanmar) between 1978 and 2011 was through conversion to rice paddy (Webb et al. 2014). About one-third of the area of seasonally flooded wetlands surrounding Tonle Sap Lake (Cambodia) were converted to rice production between 2003 and 2018 (Learn 2020).

In recent years there have been decreases in the area under rice production in the three countries with largest production areas (Figure A3.A5): Myanmar -17.6% since 2006; Thailand -13.0% since 2012; and Viet Nam -8.6% since 2013. There have been more recent area decreases in the other two Indo-Burma countries: Lao PDR -15.6% since 2016 and Cambodia -1.6% since 2019. It is not clear why these recent decreases in area are occurring, but in the Mekong Delta (Viet Nam) a 73% reduction in rice production area between 1995 and 2020 was largely because of conversion to aquaculture ponds (Dang et al. 2019).

Aquaculture ponds

Aquaculture pond areas, both inland and coastally (largely for shrimp production), are widely reported as progressively increasing in area, but area changes are not well established, throughout the Indo-Burma region, which (particularly Viet Nam, Myanmar and Thailand) is one of the largest regions of aquaculture production in the world. Many aquaculture ponds have been created from conversion of inland rice cultivation areas and coastally from mangroves: for example, an estimated 20% to 50% of mangrove loss in Thailand and 30% of mangrove loss in south Viet Nam (Zöckler et al. 2021a).

Examples include:

- Cambodia: Aquaculture farming is reported as growing fast in Cambodia, with a major increase in production from 2005 to 2014 (Agri-Farming 2019; FAO undated).
- Myanmar: between just early 2000 and 2002 the coastal shrimp farming area in Myanmar increased from 272.9 km^{2}to 782.1 km^2 (an increase of 508.2 km^2– a 186.6% area increase), as a consequence of a special government three-year plan initiated to encourage shrimp farming (FAO RAP 2003).
- Myanmar: particularly in the Ayeyarwady Region, over the 11 years from 2004 to 2014 inland aquaculture pond area grew by 43%, with areal expansion averaging 2.7% per year. Reported annual areal expansion of ponds was rapid from 2004-2007 (10.6%), but was almost static at <1% per annum from 2008 onwards (Belton et al. 2015).
- Viet Nam: a progressive increase in inland aquaculture between 1990 and 2004; and coastally a major area increase from c. 2,400 ha in 1991 to c. 5,500 ha in 2003, a 129% increase (Phuong and Minh 2005)
- Viet Nam: In the Mekong Delta (Viet Nam) over the 25-year period from 1995-2020 an aquaculture pond area increase of over 370%, from 661.4 km^2 to 3,122.8 km^2. Most of this aquaculture pond area increase has been through conversion from rice cultivation, but some was from the conversion of mangroves (Dang et al. 2021).

Figure A3.4

The trend in rice production area in the Indo-Burma region 1961-2020. Source. FAOSTAT.

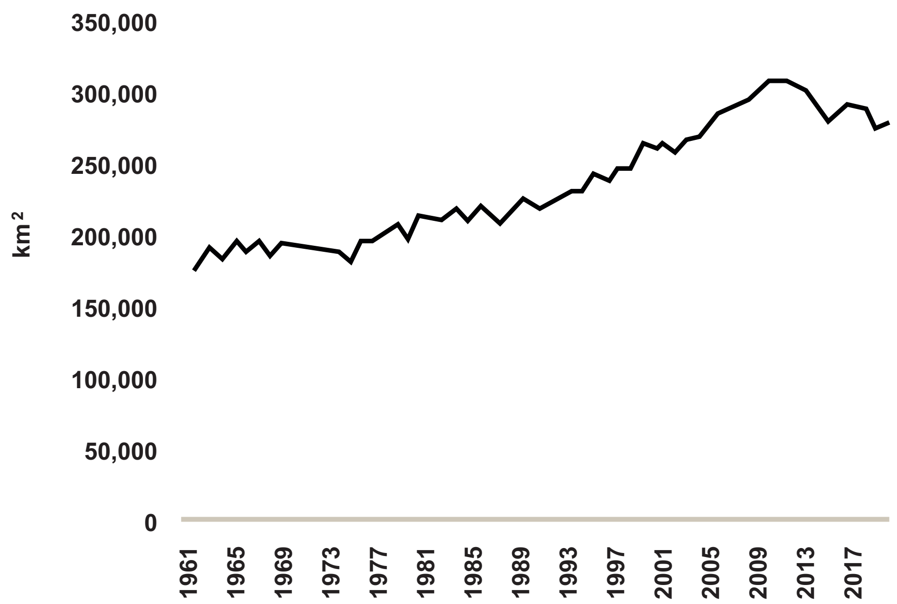
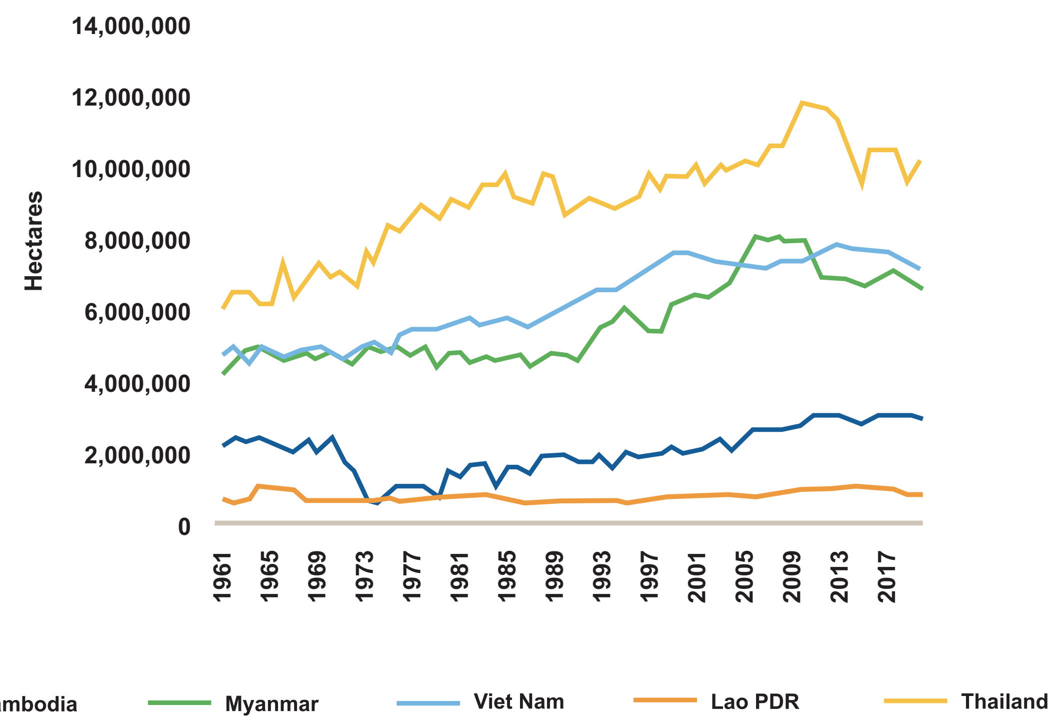


Figure A3.5

Trends in rice production areas in each of the five Indo-Burma countries. Source. FAOSTAT.



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APPENDIX 4

STATUS AND TRENDS OF SELECTED GLOBALLY-THREATENED WETLAND-DEPENDENT SPECIES IN INDO-BURMA

Marine mammals

Limited surveys and the difficulty of estimating numbers, means that knowledge of the distribution and populations of globally threatened marine mammals in the Indo-Burma region is poor. However, it appears that many populations and subpopulations of these species are small, threatened and declining.

Populations of the Irrawaddy Dolphin *Orcaella brevirostris* (EN) occur in scattered populations across South and Southeast Asia in coastal and brackish/freshwater rivers and estuaries. Those in the Indo-Burma region include in:

- a 190 km freshwater stretch of the Mekong river (92 individuals);
- a freshwater stretch of the Ayeyarwady River in Myanmar (58-72 Individuals); and
- Songhkla Lake, Thailand (less than 50 individuals).

Recently, additional populations of Irrawaddy Dolphin, Indo-Pacific Finless Porpoise *Neophocaena phocaenoides* (VU) and Indo-Pacific Humpback Dolphin *Sousa chinensis* (VU) have been confirmed in the Gulf of Mottama, Myanmar (Myanmar Coastal Conservation Lab 2019). Irrawaddy Dolphins have also recently (in 2020) been confirmed in coastal waters off Ho Chi Minh City, Viet Nam (Long Vu, pers. comm.).

Waterbirds

Coastal species

Coastal and estuarine wetlands in the Indo-Burma region are important for supporting populations of several globally threatened waterbirds, especially shorebirds (Charadrii). Notable amongst these is the Critically Endangered (CR) Spoon-billed sandpiper *Calidris pygmaea*, whose population is recognised as being in rapid decline. Coasts in the Indo-Burma region supports much of the wintering population of this species, with the most important site being the Gulf of Mottama, Myanmar which supports an estimated over 40% of the total wintering population of the species. However, in the nine years from 2009-2016 Spoon-billed Sandpiper numbers at this site decreased by an estimated 50% (Aung et al. 2020). Spoon-billed Sandpiper numbers have also declined (between 2008 and 2020) at its other main Myanmar wintering area, Nanthar Island and Mayyu Estuary Ramsar Site (N. Davidson, in litt.).

Other globally threatened shorebirds supported by Indo-Burma coastal wetlands include Spotted Greenshank *Tringa guttifer* (EN) with a recent possibly stable trend, and Great Knot *Calidris tenuirostris* (EN) with a decreasing population trend.

Inland species

Although still widespread in South Asia and Australia, the Black-necked Stork *Ephippiorhynchus asiaticus* (NT) has become increasingly rare in the Indo-Burma region where it now occurs in only a few sites in Cambodia around Tonle Sap and the Cardamon region, where the population is considered stable.

Formerly widespread across Southeast Asia, including the Indo-Burma region, the population of Masked Finfoot *Heliopais personatus* (EN) is in rapid decline, and may now breed only in Bangladesh and Cambodia (Chowdhury et al. 2020), with probably less than 100 individuals left in Indo-Burma. It is now regularly recorded only around Tonle Sap in Cambodia. It may still occur in parts of Myanmar, but was last recorded in Viet Nam in 2003 (Eames et al. 2003) and Thailand over 20 years ago. On the basis of Chowdhury et al. (2020) advice and given its rapidly declining population, the Masked Finfoot is now treated by IUCN as Critically Endangered (CR).

The Indian Skimmer *Rynchops albicollis* (EN) nests almost exclusively on riverine sandbanks in South and Southeast Asia, and spends its non-breeding season on estuaries. Its population is in long-term decline, with most of the remaining population being in India and Bangladesh. It has disappeared from much of the Indo-Burma region, with no recent records from Cambodia, Lao PDR or Viet Nam. At its last known regular non-breeding site in the Indo-Burma region, the Kaladan estuary, Myanmar, none have been recorded since 2012 (Zöckler et al. 2014). Its disappearance from this site is likely to be linked to riverine and estuarine habitat loss, particularly through the development of the Kaladan

Multipurpose Project, which making the river navigable for larger ships.

The Black-bellied Tern (*Sterna acuticauda*) (EN) is widespread but declining on large rivers from Pakistan to Myanmar. In Indo-Burma it has been declining very rapidly and is now considered extinct in Thailand, Lao PDR, Cambodia and Viet Nam. Of two remaining populations in Myanmar, that on the Mekong River is reported to have gone (Claassen et al. 2017). On the Ayeyarwady River there are only three to seven breeding pairs remaining (Zöckler et al. 2020) and the species may soon be extinct in Indo-Burma.

The River Tern *Sterna acuticauda* (VU), widely distributed across south and Southeast Asia, is declining, including declining rapidly in the Indo-Burma region. For example, only two breeding pairs remain in the Stung Treng Ramsar site in Cambodia (Mittermeier et al. 2019) compared with 100 or more pairs only a decade earlier (Timmins 2008).

Reptiles

Twenty-eight species of wetland-dependent reptiles occurring in the Indo-Burma region are globally threatened, of which 12 are Critically Endangered, nine are Endangered and seven are Vulnerable (Table 1). All species occur in one or more designated Ramsar Sites in the region (Table A4.1).

Qualitative assessments of trends in the status of reptiles in 40 Ramsar Sites in the Indo-Burma region suggests that these species are declining in 20 Sites and are stable or increasing at only 12 Sites (Zöckler et al. 2021b). Five of the six Sites with an increasing trend are coastal and marine.

Nineteen of globally threatened reptiles are riverine turtles. Four riverine turtles, all of which are Critically Endangered, are endemic to the Indo-Burma region: the Softshell Turtles *Nilssonia Formosa* and *Chitra vandyiki* and the two Batagur spp. (River Terrapin *Batagur baska* and Burmese Roofed Turtle *Batagur trivittata*). There are few recent observations of these species and all are considered to be in decline. *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.

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

Fish

Of 3,423 fish species in the Indo-Burma region assessed by the IUCN Red List, 250 species have been assessed as globally threatened (CR, EN, VU). There is a high diversity of fish in Indo-Burma rivers and high levels of endemism. There are at least 1,178 fish species in the Chao Phraya, Mekong and Viet Namese rivers (Kottelat et al 2012) and at least 388 fish species in the Ayeyarwady River, of which 193 species are endemic Kottelat (2017). The rivers of the region support some of the world's largest freshwater fish, including the Mekong Giant Catfish *Pangasianodon gigas* (CR) with a rapidly declining population, and the declining Giant Freshwater Stingray *Himanthura polylepis* (EN) - the largest freshwater fish in the region, with a width of over two metres.

Table A4.1

Globally threatened wetland-dependent reptile species, and their known occurrence in Ramsar Sites, in the Indo-Burma region. Red List status: CR Critically Endangered; EN Endangered; VU Vulnerable. (Source. Zockler et al. 2021a).

Common name	Scientific name	RL status	No. of Ramsar sites
Burmese Narrow-headed Softshell Turtle	*Chitra vandiyki*	CR	2
River terrapin	*Batagur baska*	CR	3
Burmese roofed turtle	*Batagur trivittata*	CR	1
Giant Asian pond turtle	*Heosemys grandis*	CR	5
Yellow-headed Temple Turtle	*Heosemys annandalii*	CR	8
Yellow Pond Turtle	*Mauremys mutica*	CR	1
Wattle-necked Softshell Turtle	*Palea steindachneri.*	CR	1
Elongated Tortoise	*Indotestudo elongata*	CR	7
Burmese Mountain Tortoise	*Manouria emys*	CR	1
Burmese Peacock Softshell Turtle	*Nilssonia formosa*	CR	2
Hawksbill Turtle	*Eretmochelys imbricata*	CR	8
Siamese Crocodile	*Crocodylus siamensis*	CR	5
Keeled Box Turtle	*Cuora mouhotii*	EN	2
Big-headed Turtle	*Platysternon megacephalum*	EN	1
Asian Giant Soft-shell Turtle	*Pelochelys cantorii*	EN	2
Green Turtle	*Chelonia mydas*	EN	10
Black-breasted Leaf Turtle	*Geoemyda spengleri*	EN	1
Southeast Asian Box Turtle	*Cuora amboinensis*	EN	14
Black Marsh Turtle	*Siebenrockiella crassicollis*	EN	9
Asian Leaf Turtle	*Cyclemys oldhamii*	EN	2
Voris's Water Snake	*Enhydris vorosei*	EN	1
Asiatic Softshell Turtle	*Amyda cartilaginea*	VU	15
King Cobra	*Ophiophagus hannah*	VU	7
Olive Ridley Turtle	*Lepidochelys olivacea*	VU	7
Leatherback Turtle	*Dermochelys coriacea*	VU	6
Loggerhead Turtle	*Caretta caretta*	VU	1
Burmese Python	*Python bivittatus*	VU	1
Chinese Soft-shell Turtle	*Pelodiscus sinensis*	VU	2

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APPENDIX 5

ESTIMATED AREA CHANGES AND DEGRADATION OF MYANMAR WETLAND ECOSYSTEMS

Table Appendix 5.1 summarizes the IUCN Red List of Ecosystems (RLE) assessments for wetland ecosystems in Myanmar.

Table Appendix 5.1

Estimated area changes and degradation of Myanmar wetland ecosystems (from Murray et al. 2020). Threat status categories are: CR Critically Endangered; EN Endangered; VU Vulnerable; NT Near Threatened; LC Least Concern.

Wetland ecosystem	Threat status	Estimated extent of loss and degradation
A. Globally threatened ecosystems		
Central dry evergreen riparian forest	CR	Heavily degraded. Estimated up to 97.4% lost since 1750, with losses ongoing.
Central Ayeyarwady floodplain grasslands	CR	An estimated 92.4% of area has been converted to cropland (rice paddy). An estimated only 190 km² remaining.
Ayeyarwady kanazo swamp forest	CR	Major decline in extent around the early 20th (overexploitation for fuelwood and urban development of Yangon). Continues to be threatened by coastal development for aquaculture and agriculture, sea level rise and fuelwood extraction. As little as 2.6% of this ecosystem may remain.
Dwarf mangrove (shrubland) on shingle	CR	Highly restricted: known from only two very small patches considered at risk of collapse when subject to catastrophic tropical storms.
Rakhine mangrove forest on mud	CR	Extensive declines in extent - less than 10% of the original extent may remain, and a predicted further 38% loss of area by 2038. A 12% degradation of the ecosystem is estimated since 2000 , and projected to a 50-year time frame about 40% of the ecosystem may become degraded by 2050.
Ayeyarwady floodplain wetlands	EN	At least 70.1% transformed to agriculture (rice paddy) since the 1750s.
Ayeyarwady delta mangrove forest	EN	Extensive losses have occurred and are ongoing: a decrease in extent of around 79.5% is predicted over the 50-year period between 1978 and 2028.

B. Lower threat status ecosystems*		
Tanintharyi mangrove forest	NT	Recent deforestation reported. Overall little net area change, but substantial gains (302 km^2) and losses (384 km^2) between 1989-2014 in different areas.
Coastal mudflat	LC	For 26% of coastline (central-north Rakhine State) 1992-2016 expansion of 3.36% per year.
Sandy shoreline	LC	Earth observation transect surveys: median net erosion -0.044m per year.
Aerobic karst caves	LC	No information
Mixed delta scrub	LC	No information
Glacial lakes	LC	No information

** No information for Data Deficient (DD) wetland ecosystems assessed: Tanintharyi coastal dune forest; Rakhine coastal dune forest; Grassy saltmarsh.*

Data source

IUCN Red List of Ecosystems – Myanmar. https://www.myanmar-ecosystems.org/myanmar-ecosystems

APPENDIX 6

TRENDS IN THE BIOGEOGRAPHIC POPULATION SIZES OF GLOBALLY THREATENED WATERBIRDS IN THE INDO-BURMA REGION

Table Appendix 6.1

Global threat statuses (IUCN Red List) are: Vulnerable (VU); Endangered (EN); Critically Endangered (CR). Trends are: DEC decreasing; STA stable; INC increasing. Data are from Waterbird Population Estimates 5th edition (2012) and EAAFP CSR1 (2022).

Species	Scientific name	Biogeographic population	Resident (R or Migratory M)	Global threat status	Biogeographic population trend
Scaly-sided Merganser	*Mergus squamatus*	E & SE Asia	M	EN	STA?
White-winged Duck	*Asarcornis scutulata*	India- Myanmar	R	EN	DEC
		SE Asia	R	EN	DEC
Common Pochard	*Aythya ferina*	E Asia (non-bre)	M	VU	STA/DEC?
Baer's Pochard	*Aythya baeri*	C, E, SE & S Asia	M	CR	DEC
White-eared Night-heron	*Oroanassa magnifica*	SE Asia	M	EN	DEC
White-bellied Heron	*Ardea insignis*	S &SE Asia	R	CR	DEC
Chinese Egret	*Egretta eulophotes*	E & SE Asia	M	VU	STA
Lesser Adjutant	*Leptoptilos javanicus*	S & SE Asia	R	VU	DEC
Greater Adjutant	*Leptoptilos dubius*	Cambodia (bre)	M	EN	DEC
Asian Woollyneck	*Ciconia episcopus*	episcopus	R	VU	DEC
Milky Stork	*Mycteria cinerea*	Cambodia	R	EN	DEC
Oriental White Stork	*Ciconia boyciana*	E Asia	M	EN	INC?
Sarus Crane	*Antigone antigone*	sharpie, Myanmar	R	VU	STA/DEC?
Masked Finfoot	*Heliopais personatus*	S, SE Asia	R	EN	DEC

Indian Skimmer	*Rhyncops albicollis*	S & SE Asia	R	VU	DEC
River Tern	*Sterna aurantia*	S & SE Asia	R	VU	DEC
Black-bellied Tern	*Sterna acuticauda*	S & SE Asia	R	EN	DEC
Far Eastern Curlew	*Numenius madagascariensis*	C & E Asia (bre)	M	EN	DEC
Great Knot	*Calidris tenuirostris*	SE Asia, Australasia non-br	M	EN	DEC
Spoon-billed Sandpiper	*Calidris pygmaea*	E Siberia br	M	CR	DEC
Wood Snipe	*Gallinago nemoricola*	S & SE Asia non-br	M	VU	Unknown
Spotted Greenshank	*Tringa guttifer*	NE Asia bre	M	EN	STA?
White-shouldered Ibis	*Pseudibis davisoni*	Indochina	R	CR	DEC

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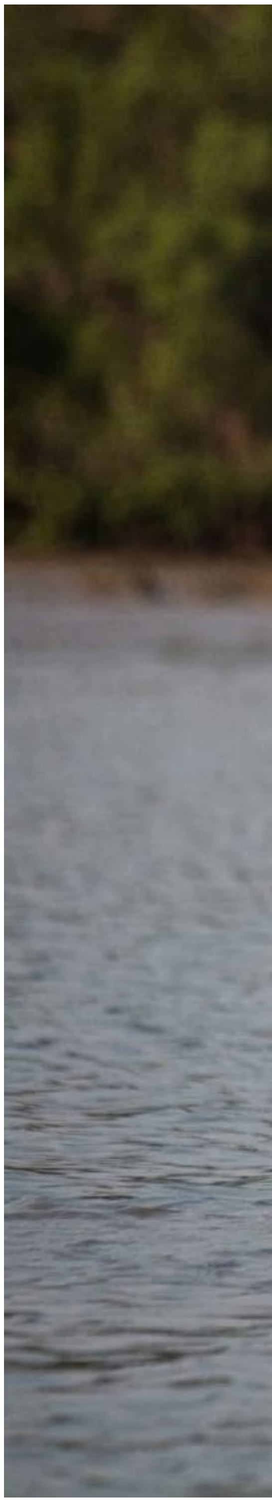
BANCA and collaborators preparing to conduct shorebird surveys on the mud flats of Mon State, Myanmar © Tara Whitty



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