

The Status Of Wetland Habitats In The Cambodia Lower Mekong Delta



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Contents

	Summary	3
1.	Background	8
1.1	Introduction	8
1.2	The Delta Region	9
	Geography	9
	Hydrology	11
	Original ecosystem	12
1.3	Key sites	13
1.4	Threats	19
2.	Land Use within the CLMD	21
2.1	Land use in 2020	21
2.2	Land use changes 1990-2020	23
3.	Biodiversity	27
3.1	Summary	27
3.2	Bird surveys and monitoring	29
3.3	Fish diversity	31
4.	Water quality	33
5.	Ecosystem services	34
5.1	Provisioning services	36
5.2	Regulating services	36
5.3	Cultural services	36
5.4	Supporting services	38
5.5	Scale of benefits	38
6.	Report recommendations	41



Summary



The Cambodia Lower Mekong Delta

The Cambodia Lower Mekong Delta (CLMD) is a vast wetland complex surrounding the main Mekong river channel downstream of Phnom Penh. Rapid development within the Mekong region over the past 50 years has led to the disappearance of much of the natural wetland habitat.

The Mekong Delta is defined by an annual flood cycle caused by upstream flow rates, and further influenced by the Tonle Sap system. Upstream river flows peak in August and September each year raising the water levels at Phnom Penh by around six metres and causing the Mekong and Bassac Rivers to overflow their banks. This annual cycle of flood and dry is a defining characteristic of the ecosystem. This ecosystem is divided further by the soil type (fertile alluvial soils close to the river, acid-sulphate peat soils further away and clay soils on higher ground). The main threats to the habitats of the CLMD are land use changes, mainly driven by agricultural intensification and commercial development closer to Phnom Penh. Many of these changes will weaken the hydrological cycle, holding back floodwaters in dams or dykes and canals causing them to drain away quicker. The effects of development upstream, particularly dams, will also weaken the hydrological cycle. The effects of climate change are highly uncertain, but may cause an intensification of the hydrological cycle.

This report provides a summary of the current status of wetlands in the Cambodian Lower Mekong Delta, including satellite-based identification of remaining natural wetlands, and assessments of their habitats, ecosystem services and biodiversity.

Land use and land use changes

Land cover maps were generated using satellite images dating from 1990 and 2020. The classification model estimates that in 2020, 10% of the CLMD was covered in natural wetland vegetation, contrasting with just 2% of the Vietnamese Mekong Delta (VMD). More than 50% of this remaining habitat is in one continuous wetland, the huge Bassac Marshes located between the Bassac and Mekong river channels. This study confirms that agriculture is less developed in the CLMD compared to the VMD. Single-crop rice, which does not require irrigation, remains the norm in Cambodia accounting for 50% of land overall (and 80% of agricultural land), whereas intensive triple-cropping accounts for 50% of the VMD (and 60% of agricultural land).

Comparison of the 2020 map with the 1990 map shows that in 30 years, approximately 1,600 km² of wetland vegetation have been lost from the CLMD. With 858 km² of wetland vegetation remaining in 2020, this equates to a loss of 65% over 30 years. The majority of this loss has occurred in the south of Takeo Province, on a vast alluvial plain that stretches from Takeo Town to Long Xuyen in Viet Nam. Boeung Prek Lapouv is the largest surviving remnant of this plain. Most of the remaining clearance has been in Prey Veng Province. Kampot Province, which contains the northern part of the acid-sulphate Ha Tien plain, was already largely cleared of natural vegetation by 1990, although the Vietnamese part of the plain has been extensively cleared in that time. Kandal Province has seen the least clearance, a reduction from 850km² to 680km². Nine key sites are identified, of which only four currently have protection.

Biodiversity

There is little monitoring of wildlife in the CLMD despite the many threats. Regular bird counts are made at two sites, Boeung Prek Lapouv and Anlung Pring, which are known to support 101 and 58 species of bird respectively, most notably large populations of the sarus crane *Grus antigone*. This information was supplemented with one-off bird count surveys at the other seven key sites. Analysis of eDNA samples taken from sites throughout the CLMD recorded 70 species of fish, and targeted fish catch surveys at Boeung Prek Lapouv showed the presence of the national fish of Cambodia, the Critically Endangered giant barb *Catlocarpio siamensis*.

Through project surveys and reviews of recent biodiversity survey records, other highly threatened species of note were; small scale mud carp *Cirrhinus microlepis*, striped catfish *Pangasianodon hypophthalmus*, yellow-breasted bunting *Emberiza aureola*, greater adjutant *Leptoptilos dubius*, and Bengal florican *Houbaropsis bengalensis*.

The survey results show that for both birds and fish, Boeung Prek Lapouv is the most biodiverse site in the CLMD. Boeung Snae in Prey Veng Province had by far the most abundant avifauna, with over 16,000 birds recorded in our surveys, and over 20,000 recorded in other counts, making it a wetland of international importance. Given its large size, the Bassac marshes has a relatively sparse avian fauna. It also has one of the least diverse fish faunas of any of the assessed sites. This could be due to a lack of diversity in habitat types across the site, or due to intense human usage and disturbance.

Ecosystem Services

Rapid Assessments of the Wetland Ecosystem Services (RAWES) workshops were conducted in the eight of the identified key sites from January to March 2022. Additionally, a RAWES survey had already been carried out at Anlung Pring in July 2019. There were 38 services assessed, grouped into four categories: Provisioning services comprise resources collected or harvested from the wetland; Regulating services maintain desired environmental conditions for human society; Cultural services enrich human society; Supporting services are necessary for the maintenance of ecosystem integrity, functioning and resilience.

Provisioning services, particularly freshwater and food, were important at all sites, but especially the huge Bassac Marshes. Communities near Bassac Marshes, particularly those in Saang and Koh Thom, fully rely on the wetland and its ecosystem services, and so people here are also interested in the wetland gaining protected status of some sort. Regulating and supporting services were important at the larger sites, and also at mangrove forests in Angkoul in Kampot Province. Cultural services were also considered highly important, particularly at sites where tourism is important (Anlung Pring, Phnom Tuek, Tonle Bati, Boeung Snae and Boeung Kadai).

Recommendations

Protection and effective conservation is needed for all the remaining natural habitat in the CLMD. The fast rate of clearance makes this a priority. Boeung Prek Lapouv is the most biodiverse site in the CLMD but is still being cleared at a fast rate and requires urgent protection. Bassac Marshes comprises the majority of the remaining natural habitat. The ecosystem services provided by the Bassac Marshes make it a key site to protect – water regulation from a site this size is important at a regional level, as well as the livelihoods supported at a local level.

Intensification of agriculture and within the CLMD should be limited. With Viet Nam moving away from intensive rice farming, there is an opportunity for Cambodian farmers to supply low-value rice. This may bring short-term benefits but in the long-term will cause the same problems that Viet Nam is now attempting to remedy. Alternative development opportunities, like sustainable agriculture, should be prioritised. An emphasis must be placed on mapping the drivers and impacts of unsustainable agriculture and understanding the political, socio-economic and practical pathways to transitions to sustainable practices. An agreed multi-stakeholder plan for sustainable agriculture and wetland conservation in the Cambodian Mekong Delta would help to bring together stakeholders in this endeavour.

An improved knowledge base on the CLMD is required to aid decision-making, including improved biodiversity monitoring, improved knowledge of wetland livelihoods, alternative livelihoods, and research on hydrological benefits of natural sites.



The Status Of Wetland Habitats In The Cambodia Lower Mekong Delta



1. Background

1.1. Introduction

The Cambodia Lower Mekong Delta is a vast wetland complex, broadly defined as the area lying at below roughly 15 metres above sea level, surrounding the main Mekong river channel downstream of Phnom Penh. The delta covers all of Kandal and Prey Veng Provinces, most of Takeo Province and the southern part of Kampot Province.

The wetlands of the Lower Mekong are broadly categorised as a seasonal flood plain and provide vital habitat for biodiversity and ecosystem service functions for millions of people. Healthy wetlands will regulate water flows, purify water, store carbon and reduce disaster risk by acting as a buffer against erosion and flooding.

Rapid development within the Lower Mekong region over the past 50 years has led to the disappearance of much of the natural wetland habitat. Development has included infrastructure, agricultural expansion and intensification, deforestation and urbanisation, and has led to depletion of natural habitats, natural resources including fisheries and a reduction in water quality.

Starting in the 1970s in Cambodia and the 1980s in Viet Nam, governments have pushed to expand rice production in the delta region. This process is more advanced in the Vietnamese Mekong Delta (VMD), where most rice fields now produce two or three crops per year. This agricultural intensification has required the construction of extensive infrastructure for flood prevention (during the rainy season) and irrigation (during the dry season), including dykes, canals and boreholes to extract groundwater. In Cambodia, single rice crops remain the norm, but this is changing as irrigation infrastructure is developed.

The more intensively developed VMD serves as a possible future scenario for the Cambodia Lower Mekong Delta (CLMD), but research over the last few years has shown that this development is unsustainable. Problems include loss of sediment input due to dams, reducing the quality of agricultural land; loss of agricultural land due to erosion; over-extraction of groundwater leading to subsidence; and increasing saltwater intrusion due to reduced dry season river flows. This is in addition to the almost total loss of natural wetland habitats, and substantially altered water dynamics in those that remain, causing potentially irreversible ecological changes. The government of Viet Nam has recognized the negative consequences of rice intensification and, under Government Resolution 120 for a Sustainable and Climate Resilient Mekong Delta, dated Nov 2017, and backed-up by Communist Party of Viet Nam (CPV) Resolution 13 in April 2022, provincial governments are taking action to conserve and restore the ecosystem functions of the floodplain. They are transitioning from three to two crops per year, restoring ecosystem functions, while also moving to reduce the use of pesticides through higher value clean/organic agriculture including flood-based crops. Whilst the Vietnamese government must now deal with these problems, the Cambodian government has the opportunity to avoid them altogether.

This report provides a summary of the current status of the Cambodian Lower Mekong Delta. Specific aims are:

- The first assessment of wetland habitats across the delta, identifying key sites using satellite imagery.
- Ecosystem services and biodiversity assessments of these sites.
- Identifying threats to the remaining wetland habitats.



Wetland community in Kandal Province

1.2. The Delta Region

1.2.1. Geography

The Mekong River system can be divided into 6 hydrological reaches¹. The 5th and 6th reaches make up the delta, where flow in a clearly identifiable main channel begins to spread across a floodplain, and study of flow rates turns to water levels and flood extents. In this report, we define the lower delta region as the 6th reach of the river, downstream of Phnom Penh. Here, the Mekong is joined by the Tonle Sap River and the great lake system, which strongly influence the hydrology of the delta. Also at Phnom Penh, the Mekong splits into two channels (distributaries), referred to as the Mekong and the (smaller) Bassac. These rivers cross a vast plain of 55,000km², which is generally flat and low lying which floods annually in the rainy season.

The delta region as considered in this report is the area directly affected by flooding of the river each rainy season. We have defined this as the area lying at below roughly 15 metres above sea level, surrounding the main river channel downstream of Phnom Penh (Figure 1). As well as Phnom Penh, the delta covers all of Kandal and Prey Veng Provinces, most of Takeo Province and the southern part of Kampot Province.

¹ Mekong River Commission (2005). Overview of the hydrology of the Mekong Basin. Mekong River Commission, Vientiane.

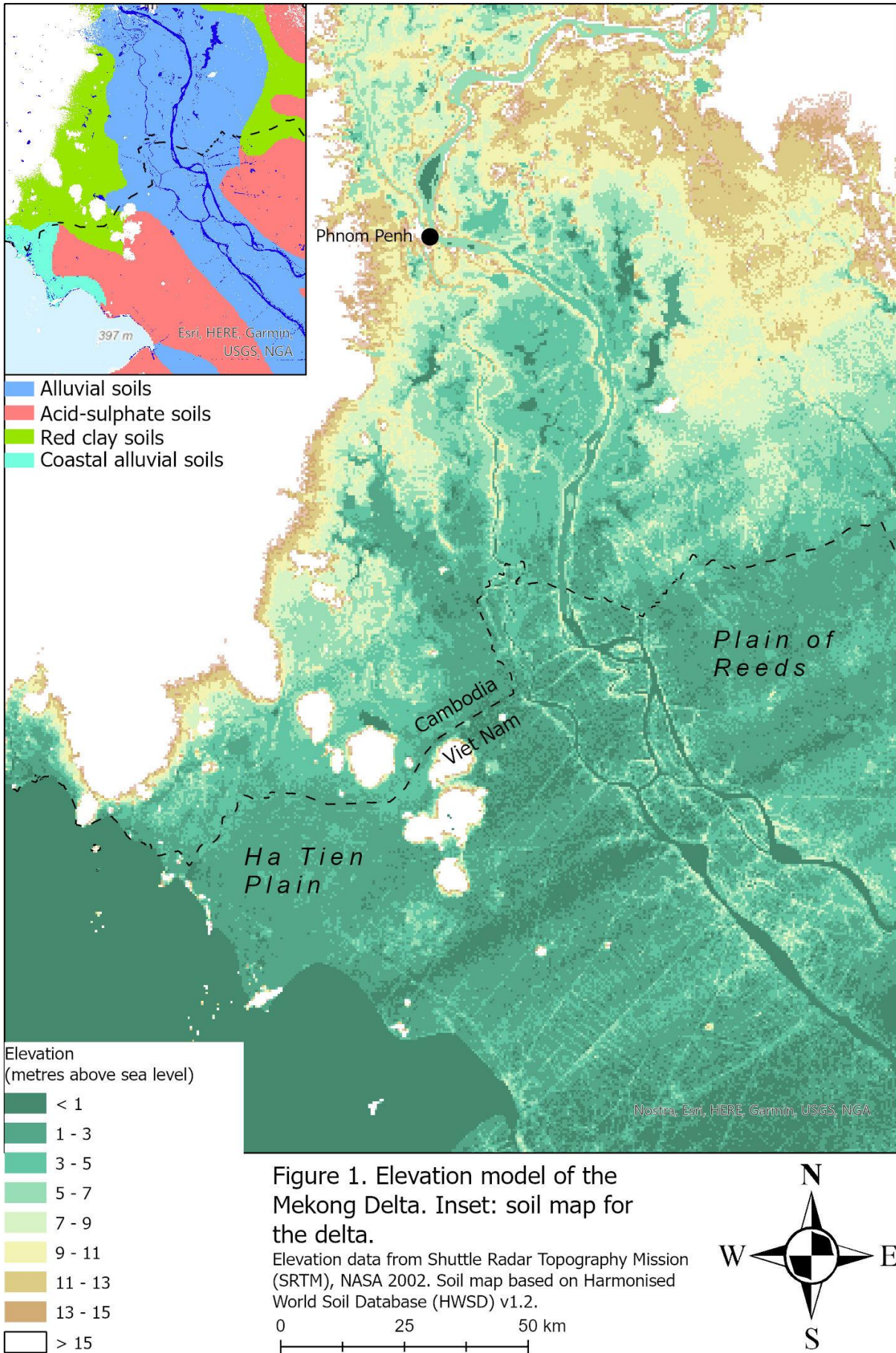


Figure 1. Elevation model of the Mekong Delta. Inset: soil map for the delta.

Elevation data from Shuttle Radar Topography Mission (SRTM), NASA 2002. Soil map based on Harmonised World Soil Database (HWSD) v1.2.

0 25 50 km

1.2.2. Hydrology

The Mekong Delta is defined by an annual flood cycle. This cycle relates to upstream flow rates, but is further influenced by the Tonle Sap system. Rainfall within the delta region plays a minor part in the hydrological cycle, accounting for approximately 5% of water in the river. Upstream river flows peak in August and September each year, raising the water levels at Phnom Penh by around 6 metres and causing the Mekong and Bassac Rivers to overflow their banks. The flat nature of the terrain and absence of natural channels means that this floodwater flows across the landscape as a sheet (termed 'sheetflow'). The result is that much of the Delta region has an annual cycle of flood and dry (Figure 1.1).

This annual cycle is a defining characteristic of the ecosystem. Many of the wetland plants found in the delta are adapted to this cycle, requiring the dry period to complete their lifecycle. The flood cycle in the delta, as compared with areas further upriver, has a substantial buffering influence provided by the Tonle Sap system, which joins the Mekong at Phnom Penh. The Tonle Sap River is noted for a major flow reversal during the wet season, so that from July to September water flows into the lake from the Mekong, while for the rest of the year water flows out of the lake back onto the delta. This has a buffering effect on water flows in the delta: peak rates of discharge in the Mekong are reduced, but more water is available in the dry season. The Tonle Sap effectively acts as a giant reservoir, regulating water levels downstream.

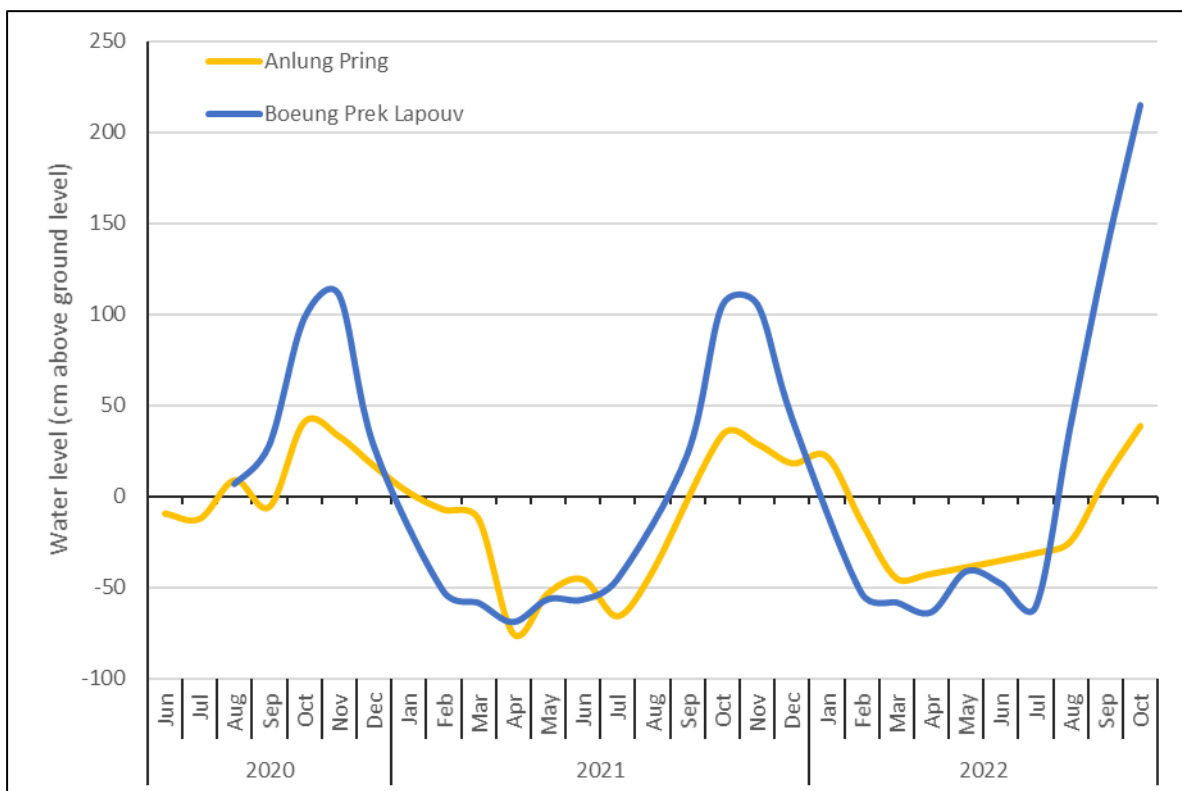


Figure 1.1. Annual flood cycle at two sites in the Cambodia Mekong Delta, Boeung Prek Lapouv (Takeo Province, close to the Bassac River) and Anlung Pring (Kampot Province)

1.2.3. Original Ecosystem

Past ecosystems of the Mekong Delta in Cambodia are not well documented, but the delta region of Viet Nam is better described. Wetland ecosystems in the delta depend on topography and soil types (Figure 1). The effect of topography is straightforward, as floodwaters will accumulate in low-lying areas.

The soil type is affected by distance from the main river channels. As well as slowing the sheetflow, wetland vegetation causes the rich sediments in the water to be filtered out. Close to the river channels, this results in rich alluvial soils (Figure 1. inset). Away from the main channels, the annual flood would consist of clear waters with few nutrients. Soils here are peat soils, largely composed of decaying vegetation. These soils are prone to turn acidic when exposed to oxygen.

This combination of topography and soil leads us to propose four main habitat types in the CLMD. These ecosystem types are shown in Figure 1.2.

1) *Long Xuyen-Takeo Plain*

To the west of the Bassac River, there is a large depression, average between 0 and 1 metres above sea level, on alluvial soils. This depression extends from Takeo town in Cambodia to Long Xuyen in Viet Nam, and covers a large area of south-eastern Takeo Province and most of An Giang Province in Viet Nam.

2) *Central alluvial zone*

In Kandal and Prey Veng Provinces, the alluvial soils near the Mekong and Bassac Rivers contain several other smaller depressions at slightly higher elevations than the Long Xuyen-Takeo Plain.

3) *Ha Tien Plain*

Acid sulphate soils are largely found in two huge plains, the Plain of Reeds to the east of the Mekong and the Ha Tien Plain to the west. These plains are mainly located within Viet Nam, but both just extend into Cambodia, in the south of Prey Veng Province and Kampot Province respectively.

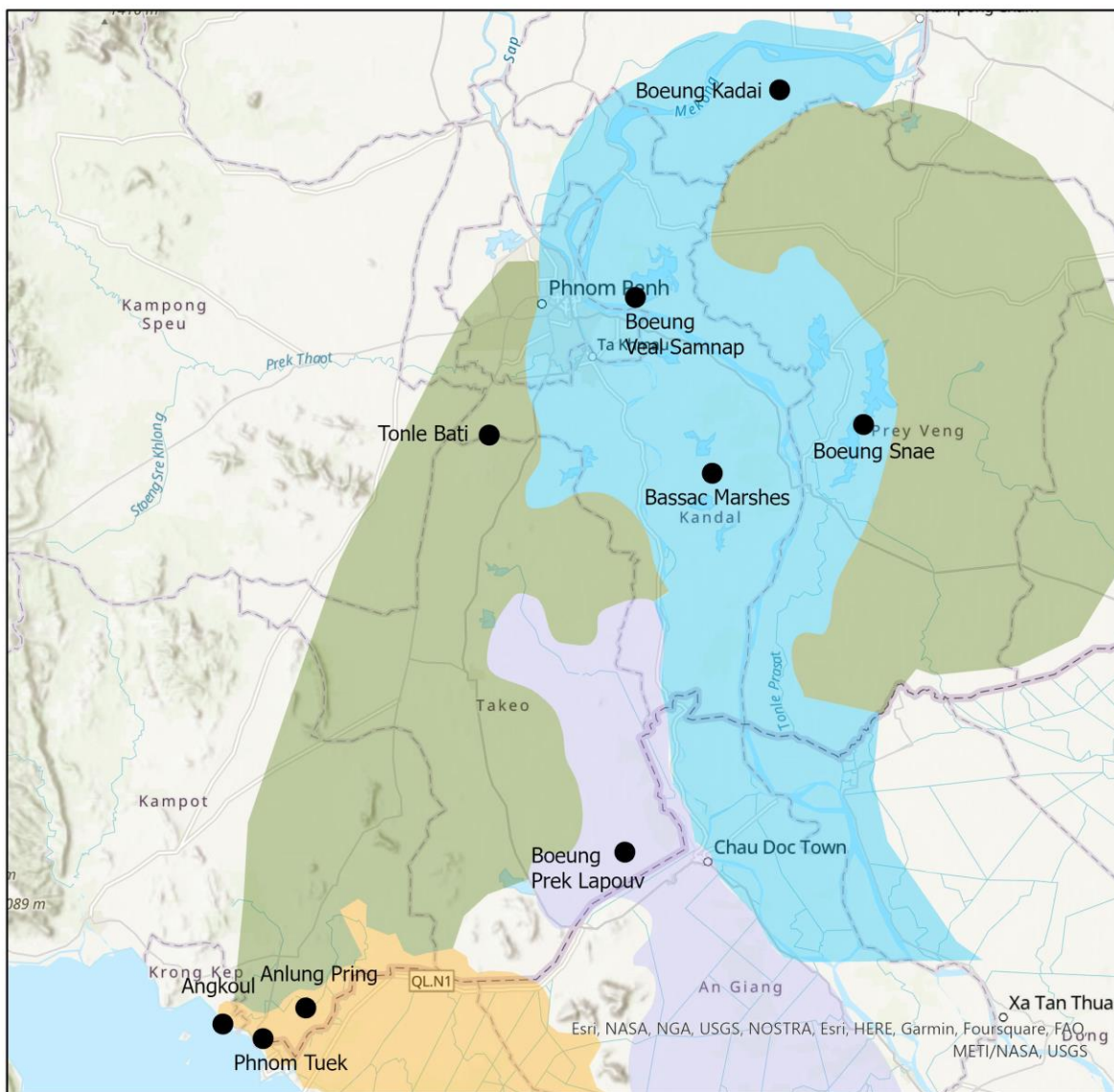
4) *Forested regions*

The higher ground (between 8 and 15 metres above sea level) of the Cambodian Mekong Delta is less flood prone, although this landscape is still very flat and would have contained many small permanent and ephemeral lakes. These higher areas lie to both east and west of the Mekong and have clay soils, suggesting that these areas were historically forested.

1.3. Key Sites

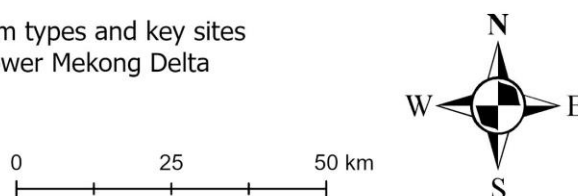
Based on examination of satellite images and the analyses presented in sections 2 and 3 of this report, we propose the following key sites for conservation in the Cambodian Mekong Delta.

The protection status of these sites is summarised in Table 1.



- Original ecosystem**
- Central alluvial zone
 - Forested regions
 - Ha Tien Plain
 - Takeo Plain

Figure 1.2. Ecosystem types and key sites in the Cambodian Lower Mekong Delta



Forested regions:

- **Tonle Bati**, one of the few remaining permanent lakes in the higher ground of the CLMD. Tonle Bati is a National Wetland, but is not currently protected. This is an area with mainly open water, a few flooded forests and some grassland. Surrounding the wetland there are settlements which are experiencing rapid development due to their proximity to the new airport which is near to completion. This is also a site for local natural and cultural tourism.

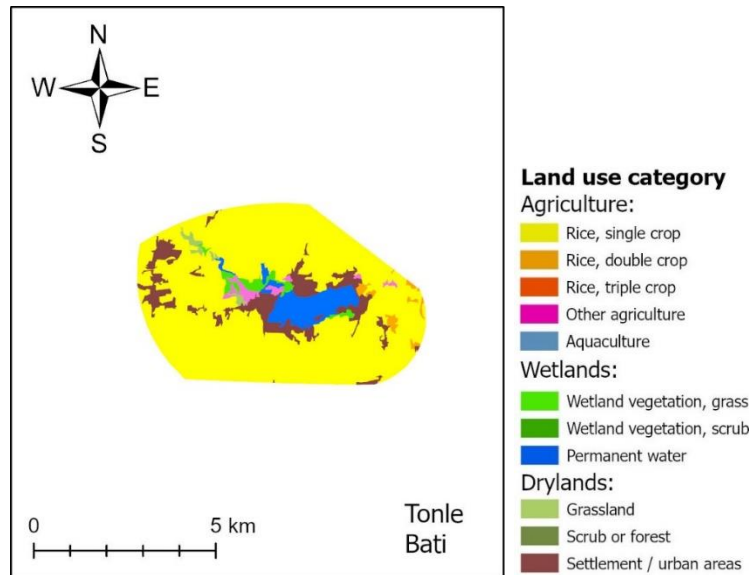


Figure 1.3. Habitat types in Tonle Bati

Central alluvial zone:

- **Bassac Marshes**. An extensive area of seasonally inundated wetlands located between the Mekong and Bassac Rivers, stretching across four different districts: Ken Svay, Lerk Dek, Saang and Koh Thom. The wetlands are characterised by scrub and savanna. The communities are very dependent on the wetland ecosystem. The Bassac marshes are a KBA, but not under any legal protection, with some parts under state ownership and other areas belonging to private owners.

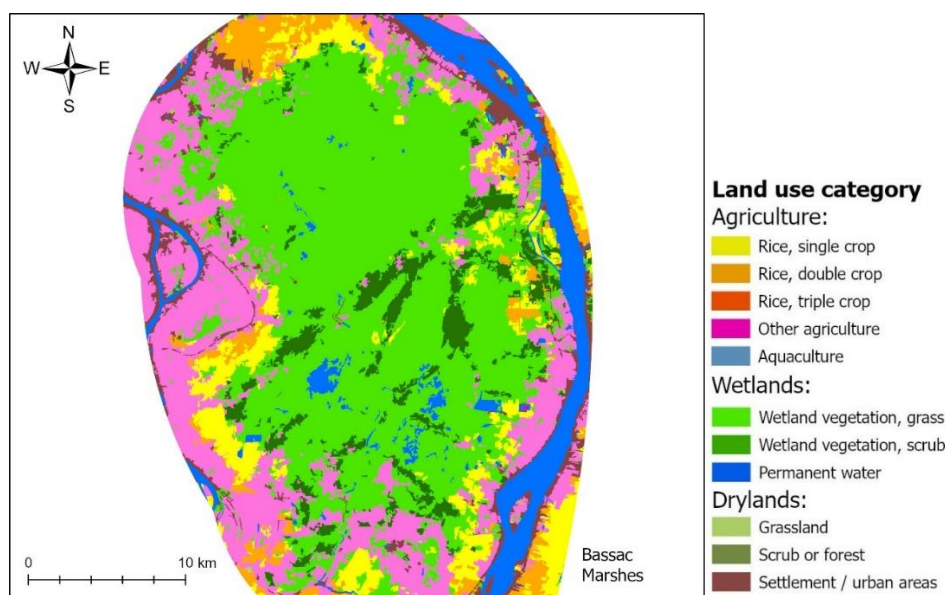


Figure 1.4. Habitat types in the Bassac Marshes

- Boeung Sne** is a large permanent lake in Prey Veng Province, south-east of Phnom Penh. The lake is surrounded by agriculture, with some natural forest remaining and some limited tourism to the area. There is little natural vegetation remaining at the lake, but a forested peninsula in the south of the lake is home to a large waterbird roost, mainly consisting of Open-bill storks (*Anastomus oscitans*). The site was designated as a Protected Area in 2021, covering 3557ha of land area and located in 3 districts namely Svay Antor, Peam Ro and Ba Phnom.

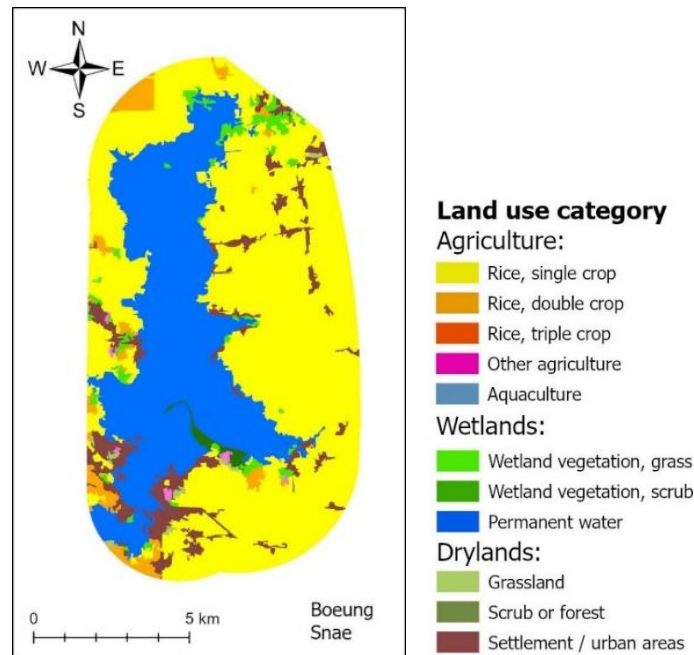


Figure 1.5. Habitat types in Boeung Snae

- Boeung Veal Samnap.** Another large (c5,000 hectares) permanent lake in Kandal Province, directly east of Phnom Penh. The lake is surrounded by seasonally inundated wetlands, mainly grassland, and agriculture. There are many communities living around the lake, and villages who mainly rely on the lake resources such as fishing. It is a KBA but otherwise unprotected. Approximately 1,000 hectares is owned by the state.

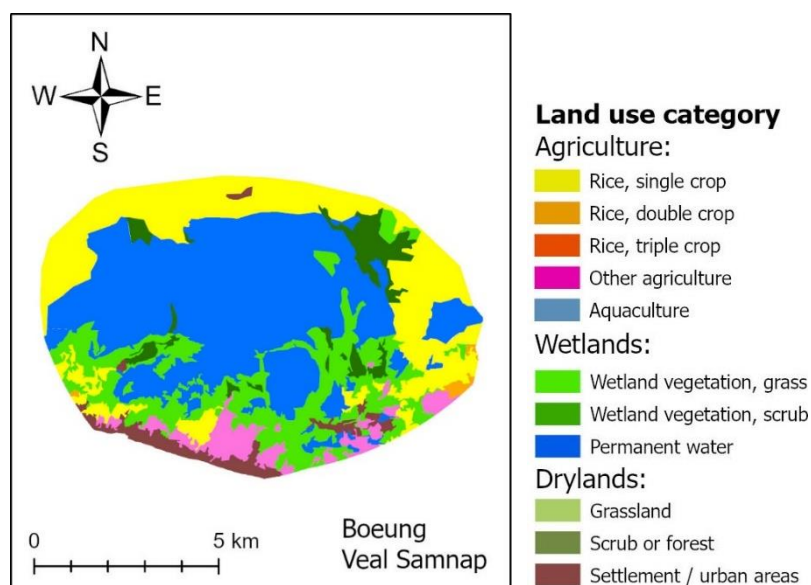


Figure 1.6. Habitat types in Boeung Veal Samnap.

- **Boeung Kadai.** A small permanent lake north of Phnom Penh, surrounded by a large area of seasonally inundated wetlands including flooded forest. An important source of freshwater for local communities, with main sources of livelihoods being fishing and livestock. Protected in 2021.



Figure 1.7. Boeung Kadai wetland

Takeo-Long Xuyen Plain:

- **Boeung Prek Lapouv.** Seasonally inundated grasslands close to the Bassac River, supporting high biodiversity, including numerous threatened species. A KBA and Protected Landscape. It is a large wetland site of 8,305 hectares, with numerous villages surrounding it, providing important ecosystem services to almost 2,500 families. Most people in this area rely directly on the wetland resources, through agricultural and fishing activities.

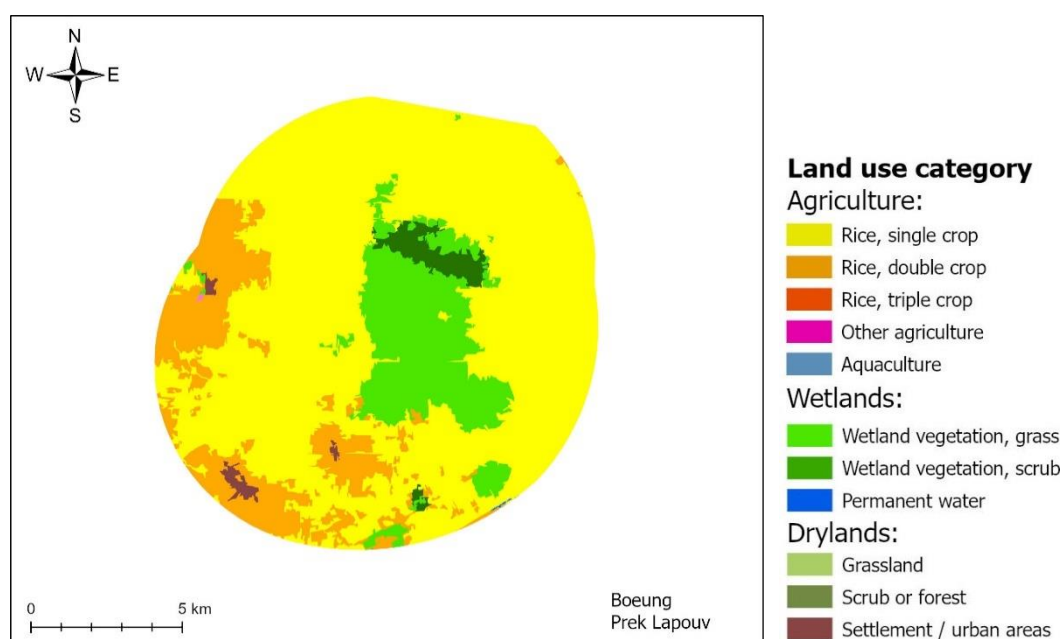


Figure 1.8. Habitat types in Boeung Prek Lapouv.

Ha Tien Plain:

- **Anlung Pring.** A small area of seasonally inundated grasslands and scrub. A KBA, Protected Landscape, also designated an East-Asian Australasian Flyway site due to its importance for migratory birds. The site is also a hub for community-based ecotourism.

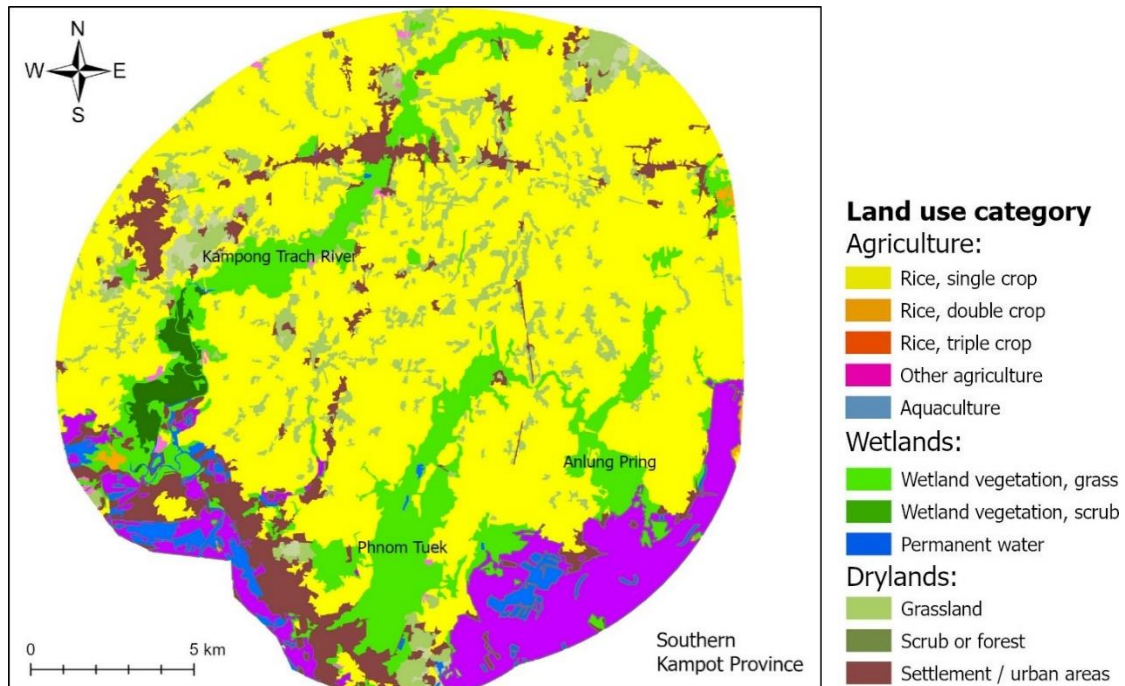


Figure 1.9. Habitat types in southern Kampot Province, showing three sites of interest.

- **Phnom Tuek.** A small area of seasonally inundated grasslands in Kampot Province, which is currently unprotected. It is close to the Protected Area of Anlung Pring, and sarus crane (*Aves antigone*) are found in both locations. The wetland is important for subsistence fishing, particularly in the wet season.



Figure 1.10 Phnom Tuek wetland

- **Angkoul (Kampong Trach River).** Permanently inundated wetlands and mangrove forests surrounding the Kampong Trach River, currently unprotected. This river contains brackish water, with most people relying on fishing as their main source of livelihood. The wetland is habitat to fish and birds of conservation interest.

Table 1. Official designations of areas within the CLMD.

KBA = Key Biodiversity Area; FNS = Flyway Network Site within the East-Asian Australasian Flyway.

Name	Area (ha.)*	Designation(s)	Legal protection
Boeung Kadai	1,643	KBA (Prek Chhlong)	Yes
Boeung Snae	3,557	Multiple-Use Area	Yes
Bassac Marshes	52,428	KBA	No
Boeung Veal Samnap	12,388	KBA	No
Boeung Prek Lapouv	9,677	Protected Landscape KBA	Yes
Anlung Pring	2,022	Protected Landscape FNS KBA	Yes

* Total area of natural habitat. Not all of this area would necessarily be within the designated protected areas/KBAs

1.3. Threats

In the Cambodia Lower Mekong Delta, fishing and hunting of birds are both important subsistence activities. However, there is little data on the extent of either activity and their impacts on fish and bird populations locally. Fish yields are declining throughout the delta, and many subsistence fishers believe that overfishing is responsible for this, but other factors may also be influencing this decline, in particular land-use changes and reduced flooding extent and duration (see references in Appendix 1). Bird hunting across Southeast Asia, including Cambodia, seems to be having a major negative impact on bird populations, but further research is needed to understand bird hunting in the CLMD. Further research on fishing and hunting livelihoods dynamics across our focus sites would be extremely useful.

As mentioned, habitat modification poses a serious threat to biodiversity of the delta. The ecosystem has been extensively modified over the past 60 years, as has the greater Mekong River system generally. These modifications, summarised below, create several threats to wetland habitats within the CLMD (Table 1.2).

Land use changes. The most obvious change over the last 60 years has been the clearance of natural wetland vegetation and its replacement with agriculture, mostly rice. Development within the Delta Region itself poses the most urgent threat to habitats and wildlife. Agricultural intensification has historically been more of a problem in the VMD, but is occurring in the CLMD too. Starting in the 1960s, an extensive network of canals has been constructed in Viet Nam and later in Cambodia, enhancing drainage and lowering water levels in the delta. Canals have led to a shift from sheet water flow to channel flow, causing floodwaters to recede more quickly. Large-scale dyke infrastructure projects in Viet Nam, designed to hold back floodwater to prevent inundation during the rainy season, have facilitated an increased number of potential crops per year. But this infrastructure has also increased wider flood risk, decreased deposition of fertile sediments (thus decreasing crop yields over the longer-term), and altered the functioning of any remaining natural habitat.

Infrastructure development. Development of dams upstream has reduced the difference between dry season and rainy season flows by storing water in the rainy season and releasing it in the dry season. The delta region already receives a buffering effect on water flows due to the Tonle Sap system and this has prevented major changes in the flow regime downstream of the great lake. However, the increased buffering caused by dam construction has reduced flood extents over recent years and threatens the Tonle Sap system itself, as its size varies less throughout the year.

Climate change. Given the large size of the Mekong catchment, which covers several climatic zones, there is huge uncertainty in the effect that climate change will have on the Mekong Delta system. The most likely scenarios involve an intensification of the hydrological cycle, with greater rainfall leading to a stronger flood pulse and increased water levels in the delta. It is possible that the buffering effect of dams will be offset by this strengthening flood pulse due to climate change, but the uncertainty of climate predictions for the Mekong make the future of flow rates in the river extremely difficult to predict. Rising sea levels are already causing saltwater intrusion into agricultural areas of Viet Nam. Sea levels would have to rise around 2 metres to affect much of Cambodia (with the exception of coastal Kampot Province), which is within the range of plausibility of current projections for this century.

Table 1.2. Summary of threats to habitats in the CLMD.

Threat	Potential changes	Consequences	Overall threat rating
Climate change			
Altered hydrological cycle	Strengthened flood pulse. Increased river flow and precipitation leading to increased flood severity and duration.	Species adapt to specific flood pulse duration, so change would favour different species. Wetland habitats would remain (risk is low) but specific species may be at risk (risk is high).	Medium
Sea level rise	Rise in sea levels of 2 metre would begin to affect Cambodia.	Saline water intrusion, changing the habitat type.	Medium
Infrastructure development			
Construction of hydropower dams upstream	Weakened flood pulse. Water storage in the rainy season and release in the dry season will smooth flow.	Reduction in area of seasonally flooded wetlands (risk to habitats and species is high).	High
	Reduced sediment input to the Delta.	Lowered soil fertility, changes to habitats.	High
Rice intensification: construction of dykes and canals	Weakened flood pulse. Quicker drainage in the rainy season plus water storage for release in the dry to create uniform water level.	Reduction in area of seasonally flooded wetlands. Risk to habitats and species is high.	High
	Agricultural run-off – fertilisers, pesticides.	Lowered water quality, reduced invertebrate numbers, eutrophication and shift to plankton dominance.	High
Resource extraction			
Gravel and sand extraction from river channels	Weakened flood pulse. Channel deepening leads to increased flow capacity in the main river channels.	Reduction in area of seasonally flooded wetlands (risk to habitats and species is high).	Low (in Cambodia)
Groundwater extraction	Causes subsidence.	Lowered ground level, increasing the effect of sea level rises.	Low (in Cambodia)
Land use changes			
Forest loss in Mekong catchment	Decreased water quality. Increased sedimentation and pollution.	Reduction in invertebrate numbers and fish nursery habitat.	Medium
Conversion of delta wetlands to agriculture	Habitat loss.	Reduction in area of natural habitat.	High

2. Land use in the Cambodia Lower Mekong Delta

2.1. Land use in 2020

A land cover map was generated using satellite images dating from January to December 2020 (see Appendix 2 for methods), covering the entire CLMD and the north-west portion of the VMD. Overall, this classification confirms the expected picture, showing less agriculture and more natural wetland habitats within the CLMD (Table 2.1 and Figure 2.1) compared to the VMD. The classification model estimates that 10% of the CLMD is still covered in natural wetland vegetation. This contrasts with just 2% of the VMD.

More than half of the remaining wetland vegetation in the CLMD is accounted for by the huge Bassac Marshes, situated between the Bassac and Mekong Rivers.

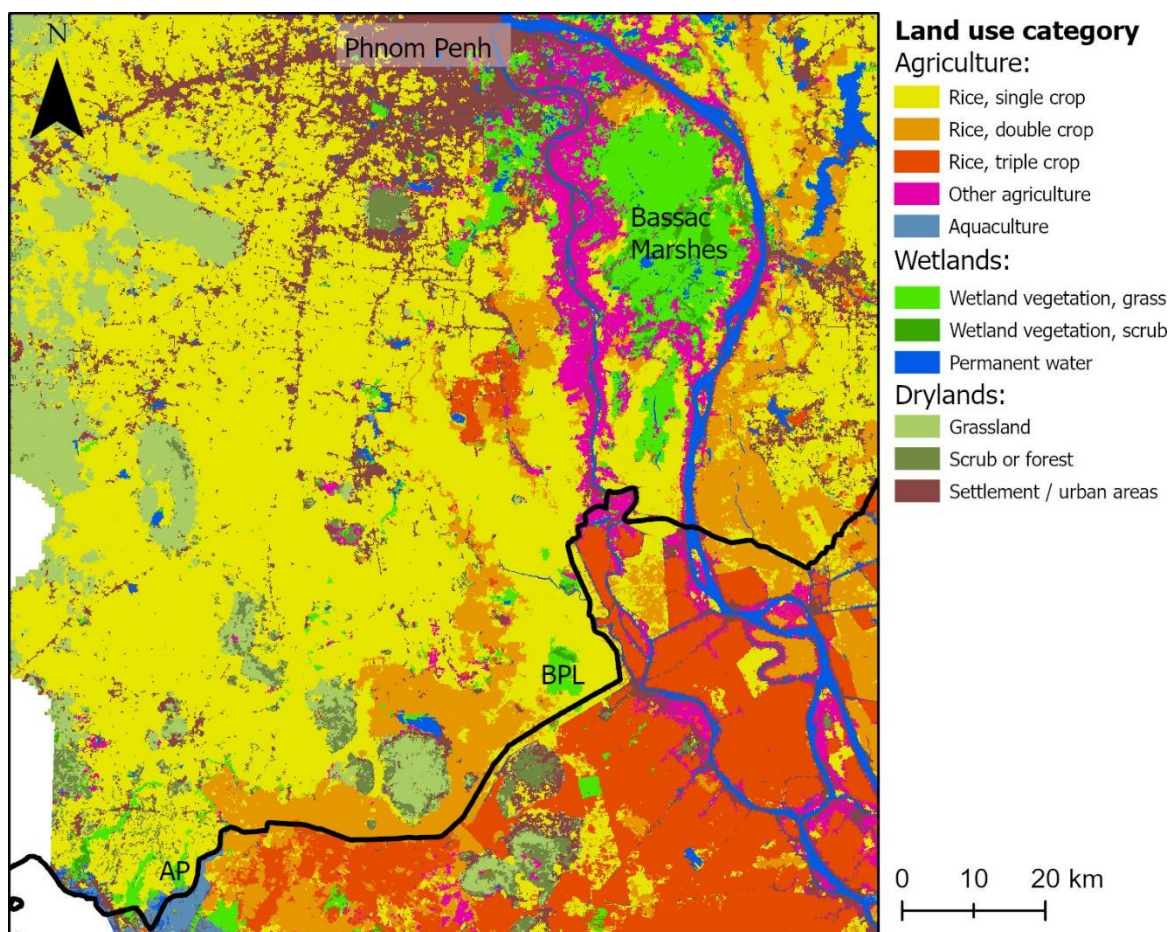


Figure 2.1. Land use in the CLMD in 2020. This classification is based on satellite images dated from Jan to Dec 2020. BPL = Boeung Prek Lapouv, AP = Anlung Pring.

Table 2.1. Areas covered by land use classes in the CLMD and part of the VMD. All percentages are rounded, so may not total exactly 100%.

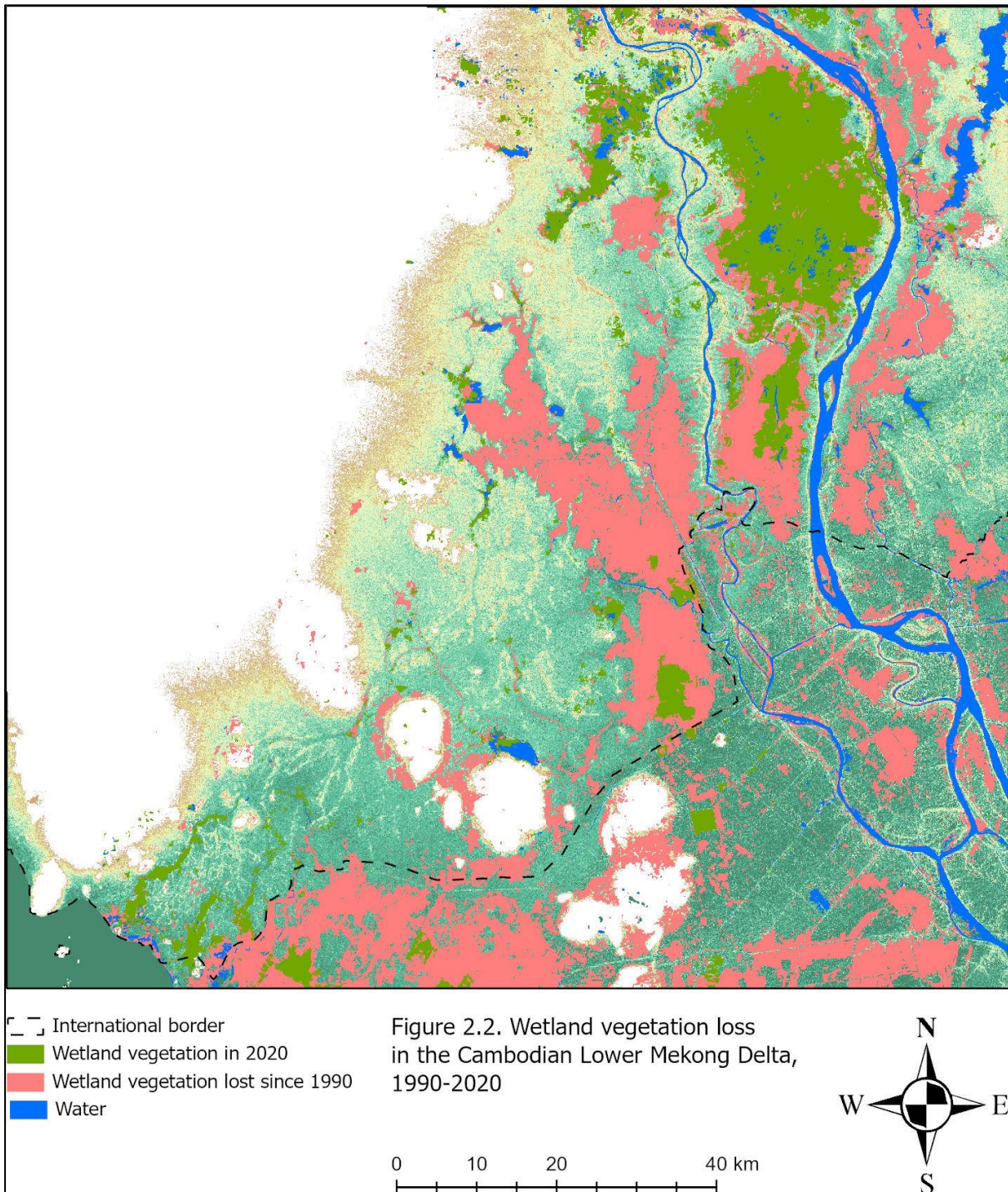
Land use class	VMD		CLMD	
Agriculture	km ²		km ²	
Rice, single crop	804	7%	4,554	51%
Rice, double crop	2,736	25%	1,119	13%
Rice, triple crop	5,156	46%	101	1%
Other agriculture	548	5%	556	6%
Aquaculture	391	4%	20	0%
Total agriculture	9,636	86%	6,350	71%
Wetlands				
Permanent water	434	4%	351	4%
Wetland vegetation, grass	166	1.5%	784	9%
Wetland vegetation, scrub	30	0.5%	74	1%
Total wetland vegetation	195	2%	858	10%
Drylands				
Grassland	71	0%	170	2%
Scrub or Forest	116	1%	191	2%
Settlements / urban	712	6%	991	11%

Furthermore, this study confirms that agriculture is far less developed in the CLMD compared to the VMD. Single-crop rice, which does not require irrigation, remains the norm in Cambodia, whereas triple-cropping accounts for most of the land given to rice growing in the VMD (Table 2.2). The lack of need for irrigation across much of the CLMD means the canal network in Cambodia is less developed than that in Viet Nam, and there is little groundwater extraction.

Table 2.2. Rice intensification. Percentage of rice growing land dedicated to cropping systems in Viet Nam and Cambodia.

Rice cropping system	VMD	CLMD
Single crop	9%	79%
Double crop	31%	19%
Triple crop	60%	2%

2.2. Land use changes 1990 - 2020



Analysis of Landsat 5 images from 1989/90 suggest that in the last 30 years, approximately 1,600 km² of wetland vegetation have been lost from the CLMD. With 858 km² of wetland vegetation remaining in 2020, this equates to a loss of 65% over 30 years. This loss of natural habitat has not been equally distributed across the four main ecosystem types outlined in Section 1.2.

Forested Regions: This landscape was heavily modified during the Khmer Rouge era in the 1970s, with forests cleared and the landscape drained for rice cultivation. Little forest remained in the Mekong

Delta by the 1990s. Few lakes remain either, although Tonle Bati is a notable exception.

Central Depressions: This region of the CLMD, on alluvial soils close to the Mekong and Bassac channels in Kandal and Prey Veng Provinces, has seen the least vegetation clearance of the main ecosystems of the CLMD (Figure 2.2.). The total area covered by this ecosystem is approximately 300,000 hectares. Between 1990 and 2020, natural vegetation cover shrank from 85,000 hectares to 68,000, a loss of 20%. Most of this clearance has been in Prey Veng Province, to the east of the Mekong Channel. The Bassac Marshes, located between the Mekong and Bassac channels, has suffered very little clearance.

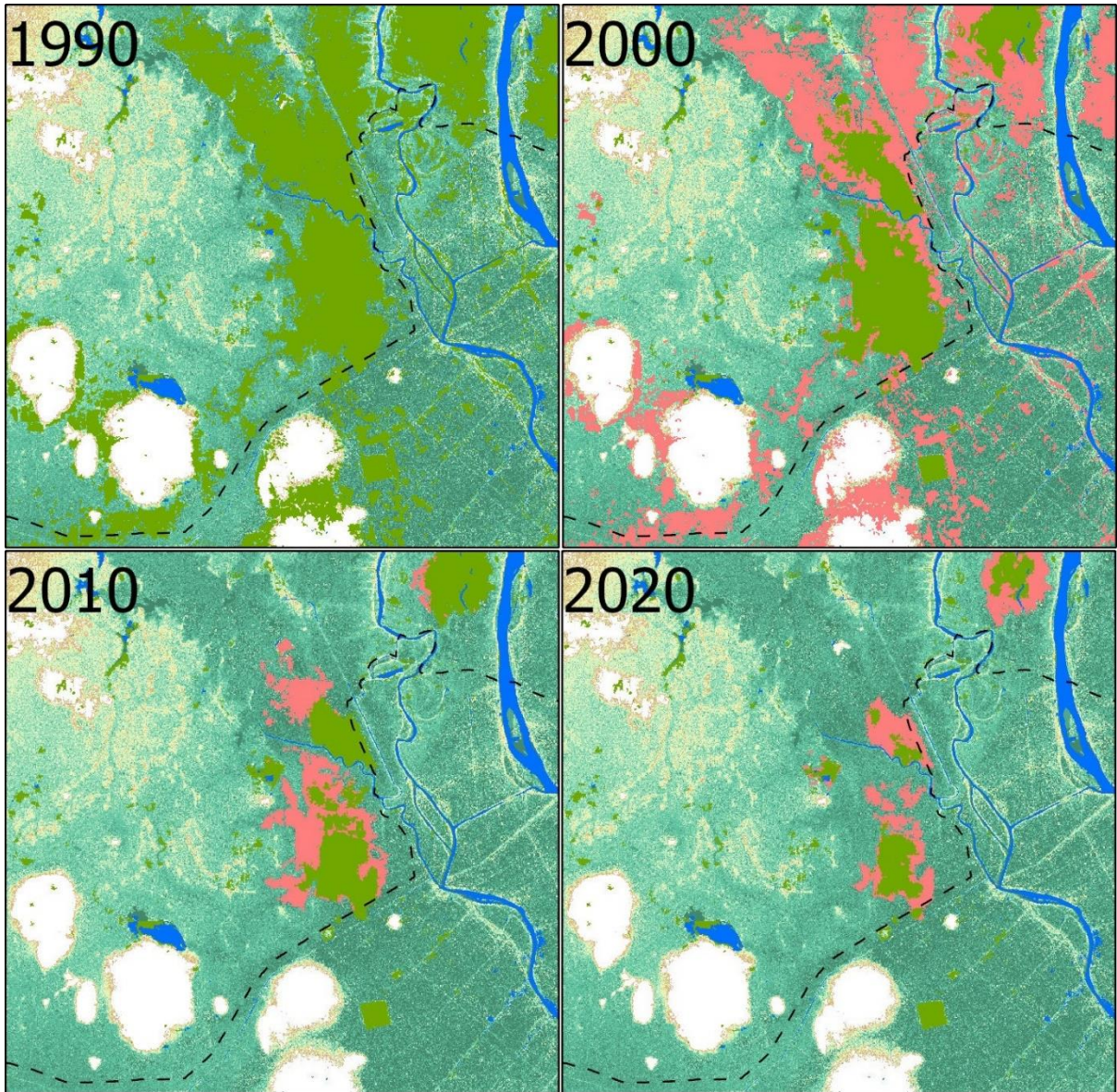
A more recent change is not reflected on these maps, which are based on satellite images from 2020 and 2021. By the start of 2022, Boeung Cheung Loung, a substantial area of natural vegetation in Kandal Province directly south of Phnom Penh and east of the Bassac channel, had been cleared for the construction of the new Phnom Penh International Airport.

Takeo-Long Xuyen Plain: This large natural depression covers approximately 200,000 hectares, of which nearly half is in Cambodia. This area has seen the most drastic clearance of vegetation in the CLMD over the past 30 years, with natural coverage reducing from 77,000 hectares in 1990 to just 7,000 hectares today, a loss of 91% (Figure 5). The majority of the remaining vegetation is within Boeung Prek Lapouv Protected Landscape. This clearance has been a gradual process, with roughly 30% of remaining vegetation cleared each decade (Figure 2.3) and is apparently set to continue, with 81 hectares of vegetation cleared from Boeung Prek Lapouv in 2020 and a further 85 hectares cleared in 2021 – in both these cases it is hoped that the vegetation can regenerate.

Figures 2.2 and 2.3 make it appear that the Vietnamese half of the plain was largely cleared of natural vegetation by 1990. In fact, the process of conversion to rice agriculture was still ongoing in that year and most of these areas had only recently been cleared. As recently as 1980, the plain was largely untouched on both sides of the border. Consequently, we can say that approximately 95% of the natural habitat of the plain has been lost in the last 40 years.

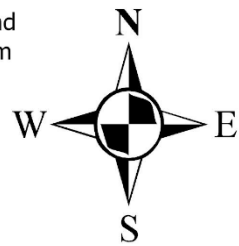
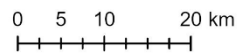
Ha Tien Plain: This plain covers approximately 240,000 hectares of low-lying coastal land. Although mostly located in Viet Nam, the northern edge of the plain crosses the border into Kampot Province. Between 1990 and 2020, natural wetland vegetation has decreased from 135,000 hectares to just 10,000, a loss of 92% in 30 years (Figure 2.4). However, nearly all of this clearance has been in Viet Nam. The Viet Nameese part of the plain was largely untouched by humans in 1990, but the Cambodian part of the plain was already largely cleared of natural vegetation.

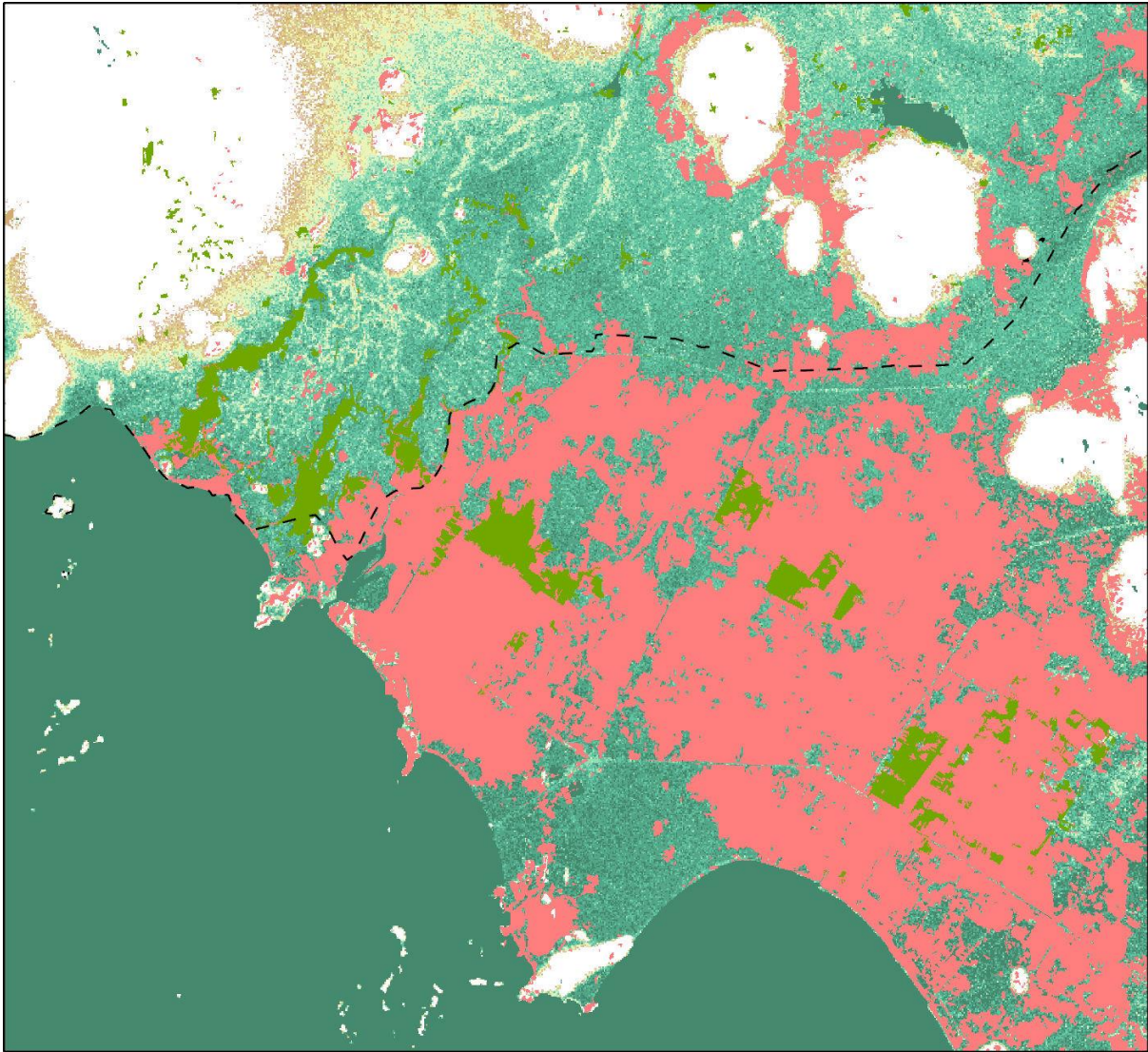
Approximately 1,100 hectares of natural vegetation remains on the Cambodian side of the border, mostly in Anlung Pring and Phnom Tuek. The largest protected area in Ha Tien is the 3,000 hectare Phú Mỹ reserve in Viet Nam.



- [- -] International border
- ▭ Boeung Prek Lapouv
- Wetland vegetation
- Wetland vegetation lost in previous decade

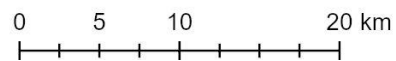
Figure 2.3. Wetland vegetation loss around Boeung Prek Lapouv for each decade from 1990 to 2020





- [- -] International border
- Wetland vegetation in 2020
- Wetland vegetation lost since 1990

Figure 2.4. Wetland vegetation loss in the Ha Tien Plain from 1990 to 2020.



3. Biodiversity

3.1. Summary

The Mekong Delta is noted for its rich and diverse biodiversity. Bird diversity is particularly well catalogued, with 247 species recorded across Cambodia and Viet Nam. There is also a substantial diversity of fish species, with as many as 360 species regularly occurring (plus transient species). Other animal groups are less well documented, however, and there is almost no published information on plant species.

The well-documented loss of habitat in the delta over the past decades means that declines in wildlife are almost inevitable, but despite the biodiversity richness of the region there has been little monitoring of wildlife within the Mekong Delta on either side of the border. The only long-term and ongoing monitoring in the CLMD are the bird counts taken at two sites where conservation is supported by NatureLife Cambodia and WWT, Boeung Prek Lapouv in Takeo Province and Anlung Pring in Kampot Province.

Boeung Prek Lapouv and Anlung Pring are known to support 101 and 58 species of bird respectively, most notably large populations of the sarus crane *Grus antigone*. One-off surveys of fish at both sites recorded 19 species at Anlung Pring and 42 at Boeung Prek Lapouv, including the national fish of Cambodia, the Critically Endangered giant barb *Catlocarpio siamensis*. For this report, other key sites (see section 1.3) were surveyed between December 2021 and February 2022. The aim of these surveys was to see how the biodiversity at lesser-known sites compares with the better-documented sites. Point counts were used to rapidly assess numbers of bird species, and eDNA surveys used for fish species.

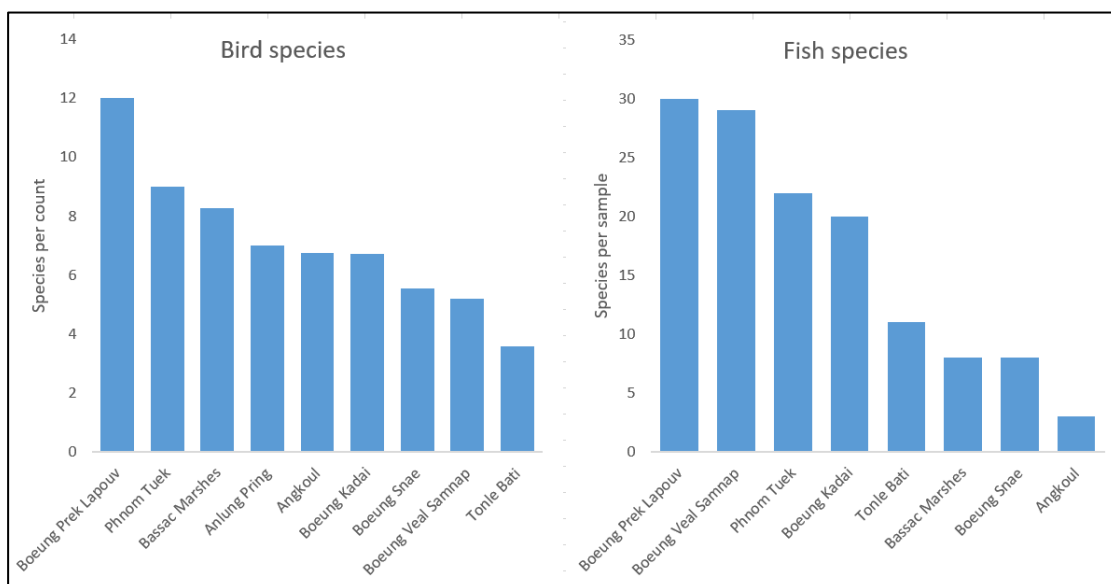


Figure 3.1. Numbers of species of bird and fish recorded at key sites in the Cambodian Mekong Delta. Number of species is shown per sample, to correct for sampling effort.

The survey results show that for both birds and fish, Boeung Prek Lapouv is the most biodiverse site in the CLMD (Figure 3.1). Of the unprotected sites, Boeung Veal Samnapp appears to have a diverse fish fauna and Phnom Tuek appears to host a surprising diversity of both groups given its small size.

Boeung Snae did not host many species, but had by far the most abundant avifauna, with over 16,000 birds recorded in our surveys, and over 20,000 recorded in other counts. The huge Bassac Marshes notably has a sparse fauna for both groups. From a conservation point of view it is notable that in all of these surveys, few species of conservation concern were recorded (Table 3.1). In addition to the species listed in table 3.2, other endangered species have been recorded at Boeung Prek Lapouv – yellow-breasted bunting *Emberiza aureola*, greater adjutant *Leptoptilos dubius* and Bengal florican *Houbaropsis bengalensis* – but the latter two only in very small numbers and not in the last few years. There is also reason to think that the endangered species that are present in the delta are in decline. Both Boeung Prek Lapouv and Anlung Pring are protected based on their populations of sarus crane, but this species is declining at both sites (Figure 3.2).

In conclusion, the Cambodia Lower Mekong Delta is home to a diverse avifauna and piscifauna. Boeung Snae qualifies as a wetland of international importance based on the number of waterbirds seen there, and was given protected status in 2021 to recognise this. Protection and management for biodiversity could well increase the species found at these sites. Likewise, the ecosystem services provided by these sites, and livelihoods that are dependent on them, makes a strong argument for their importance (see section 5).

Table 3.1. Species of conservation concern recorded in the Cambodian Mekong Delta in 2021 and 2022.

Group	Species	IUCN status	Sites
Birds	Sarus crane <i>Grus antigone</i>	VU	Boeung Prek Lapouv, Anlung Pring, Phnom Tuek – decreasing at all sites.
	Yellow-breasted bunting <i>Emberiza aureola</i>	CR	Boeung Prek Lapouv
	Lesser adjutant <i>Leptoptilos javanicus</i>	VU	Bassac Marshes. Previously recorded at Boeung Prek Lapouv, but not seen there since 2015.
Fish	Giant barb <i>Catlocarpio siamensis</i>	CR	Boeung Prek Lapouv
	<i>Mystus bocourti</i>	VU	Boeung Prek Lapouv
	<i>Hypsibarbus lagleri</i>	VU	Boeung Prek Lapouv
	<i>Wallago attu</i>	VU	Boeung Prek Lapouv
	Small-scale mud carp <i>Cirrhinus microlepis</i>	VU	Boeung Kadai

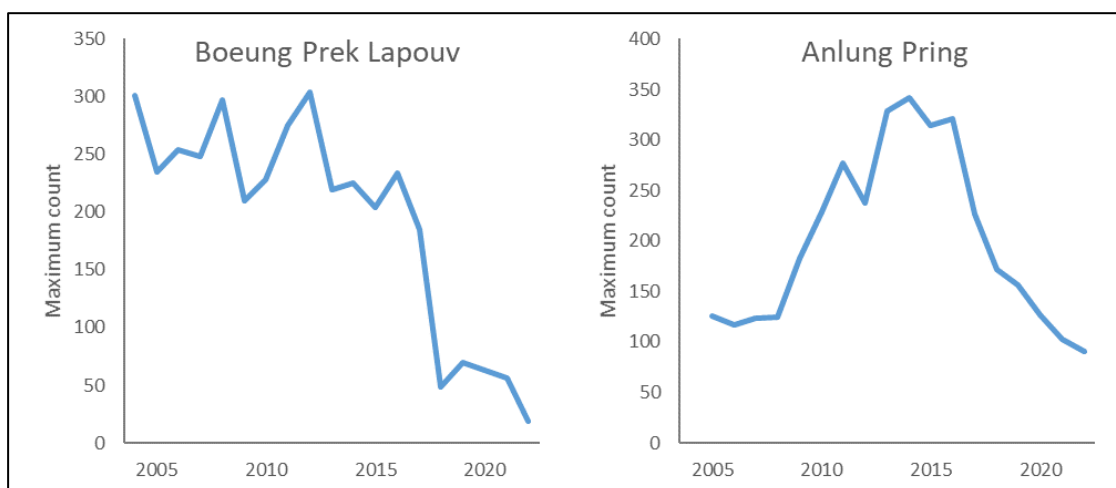


Figure 3.2. Counts of Sarus crane at Boeung Prek Lapouv and Anlung Pring since 2005.

3.2. Bird surveys and monitoring

Point counts were carried out at key sites between December 2021 and February 2022. These will not reveal the full diversity of avian species, as the ongoing detailed monitoring at Boeung Prek Lapouv and Anlung Pring will, but allows for a comparison of diversity at sites and establishes a baseline for comparisons over time. Total numbers of species recorded are shown in table 3.2.

Table 3.2. Bird species diversity shown by point count surveys at key sites in the Cambodian Mekong Delta.

Site	Species richness
Boeung Prek Lapouv	49
Bassac Marshes	35
Boeung Kadai	28
Boeung Snae	19
Boeung Veal Samnap	13
Tonle Bati	12
Anlung Pring	26
Phnom Tuek	9
Angkoul	16

3.2.1. Takeo Plain

The monitoring data collected at Boeung Prek Lapouv consists of maximum monthly counts, which have been collected since 2003. There are 101 species that have been recorded at Boeung Prek Lapouv in this period, with five of these being of conservation concern. Of those species, sarus crane and yellow-breasted bunting are recorded in large numbers. The others are lesser adjutant, greater adjutant and Bengal florican. For many species there is substantial inter-annual variation in numbers recorded, making trends difficult to discern. However, it is apparent that the sarus crane is in decline, as is the Near Threatened spot-billed pelican (Figure 3.3). Sarus crane have become so rare at the site that our point-count survey, conducted in January while peak numbers are present, did not detect them. The only species showing obvious increases are common ones such as open-bill storks, although the Near Threatened painted stork may be increasing.

3.2.2. Central Depressions

Bassac Marshes

Surveys conducted here in the 1990s concluded that this was an important site due to its size, but also noted that the avifauna consisted of large numbers of common species. Surveys from 2022 lead to a similar conclusion, although few species are now recorded in large numbers. Very few species of conservation concern are recorded at this site, making the presence of rare species a poor argument for its protection. Comparison of surveys from the 1990s with our 2022 survey suggests that certain species, notably jacanas and some common duck species such as garganey, have disappeared from the site over the past 3 decades. See Appendix 3 for a full comparison of past and present surveys.

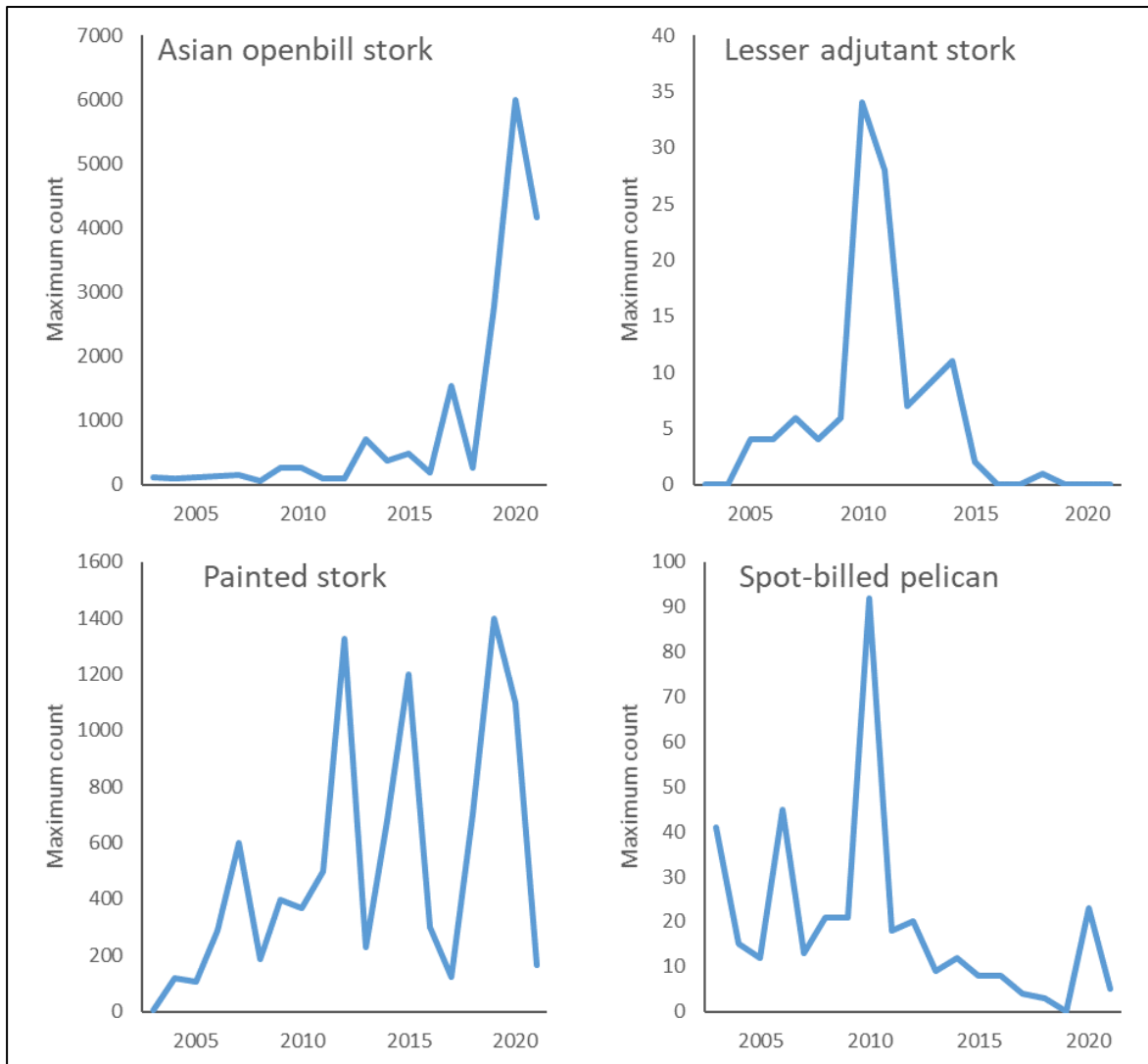


Figure 3.3. Trends in maximum counts of selected species at Boeung Prek Lapouv.

Boeung Snae

Little natural vegetation remains at this lake, but a forested peninsula in the south of the lake is home to a massive waterbird roost with around 20,000 waterbirds counted on a regular basis. Most of these birds are open-bill storks. Interestingly the one survey from the 1990s conducted here makes no mention of this species, which appears to be on the increase elsewhere in the region too, notably Boeung Prek Lapouv. The absence of common duck species in the 2022 survey as compared with the 1990s survey is similar to at Bassac (Appendix 3).

Boeung Kadai

This site has not been previously surveyed, but our results show that it has a diverse fauna compared to other unprotected sites within the CLMD, especially considering the small size of the site.

3.2.3. Ha Tien Plain

There are 57 species regularly recorded at Anlung Pring, of which two are of conservation concern. Similar to Boeung Prek Lapouv, sarus crane is in decline at this site. The two unprotected sites on the plain – Phnom Tuek and Kampong Trach River – had less diverse avifauna, although the survey effort at Phnom Tuek was very low.

3.2.4. Forested Regions

Only Tonle Bati was surveyed for this report. This is a small lake, home to few species but large numbers of waterbirds for its size. Again, there were no species of conservation concern.

3.3. Fish Diversity

There is little documentation on fish species within the CLMD. To gain an up-to-date snapshot of fish diversity in the region, surveys were undertaken for this report. Traditional capture surveys were undertaken at Boeung Prek Lapouv and eDNA surveys were conducted across the CLMD.

In total, 70 species were recorded by the eDNA surveys whilst the traditional capture surveys caught 42 fish species. Amongst these, of particular interest are those listed as Vulnerable on the IUCN Red List of Threatened Species: the small scale mud carp (*Cirrhinus microlepis*), *Mystus bocourti*, *Hypsibarbus lagleri* and Wallago (*Wallago Attu*), as well as the Mekong giant barb (*Catlocarpio siamensis*), which is listed as Critically Endangered and is recognised as the national fish of Cambodia. The total number of species recorded at each site are shown in table 3.3. For further information on the survey methods used, see appendix 4.

Table 3.3. Total number of fish species recorded at key sites in the Cambodian Mekong Delta.

Site	Species richness
Boeung Prek Lapouv	78
Bassac Marshes	8
Boeung Kadai	20
Boeung Snae*	8*
Boeung Veal Samnap	29
Tonle Bati	11
Anlung Pring*	1
Phnom Tuek	22
Angkoul	3
* Samples from Anlung Pring and Boeung Snae produced fewer than expected target reads. Therefore samples may have been degraded by time of analysis	

The most widely detected groups were Cypriniformes (carps, barbs and minnows) and Gouramis. The most commonly detected species are shown in Table 3.4. All of these species are native to the Mekong Delta. Three of the species are frequently used for fish farming (*Barbonymus gonionotus*, *Anabas testudineus* and *Channa striata*) which in Cambodia mostly takes the form of low technology and small-scale ponds. In general, these ponds are stocked with wild caught fish, although domesticated *Barbonymus gonionotus* are sometimes introduced alongside wild caught fish. The three gourami species are caught wild and used for food, but are not farmed – they are all popular in the aquarium trade, however. Of these species, only *Puntius brevis* is not used for food.

The Critically Endangered giant barb *Catlocarpio siamensis* was caught by research teams at Boeung Prek Lapouv, but not detected by the eDNA survey. Fishermen at Boeung Kadai report catching the species there, but again it was not detected by the eDNA surveys.

Table 3.4. The most commonly detected species in the eDNA surveys, and the sites at which they occurred. No species was detected at all 9 sites.

	Boeung Prek Lapouv	Bassac Marshes	Boeung Snae	Boeung Kadai	Boeung Veal Samnap	Tonle Bati	Anlung Pring	Phnom Tuek	Kampong Trach River
Silver barb <i>Barbonymus gonionotus</i>	X		X	X	X	X			
Swamp barb <i>Puntius brevis</i>	X			X	X	X		X	
Climbing perch <i>Anabas testudineus</i>	X	X		X	X			X	
Striped snakehead <i>Channa striata</i>	X	X		X	X			X	
Three-spot gourami <i>Trichopodus trichopterus</i> / Moonlight gourami <i>T. microlepis</i> / Croaking gourami <i>Trichopsis vittata</i>	X	X		X	X	X		X	

4. Water Quality

Detailed water quality monitoring was conducted at a small number of sites to give temporal data showing seasonal changes, and in addition one-off assessments were conducted at other sites to assess spatial variation across the delta. Water quality monitoring was conducted at two sites, Anlung Pring and Boeung Prek Lapouv, monthly from Sep 2021 to Oct 2022. One-off measurements taken from other sites in Dec 2021 and Jan 2022.

Quality is generally good, falling within recommended drinking water guidelines. Some notable exceptions:

- Dissolved oxygen is a good overall measure of water quality, indicating the ability of water to support aquatic life. Fast flowing water will have high DO levels, which means in the context of the CLMD low DO levels are not necessarily bad, as they reflect areas where the original slow sheet-flow still dominates. DO decreased at both monitoring sites during Feb / Mar as the floods receded. Bassac Marshes had very low DO levels compared to other sites
- pH at Anlung Pring was generally acidic, except for Feb to Apr. The water was also found to be acidic in neighbouring Phnom Tuek, which locals report as causing it to be unsuitable for drinking during this period (see Ecosystem Service, section 5).
- Ammonia in water is the preferred form of nitrogen for plant growth, but also represents a hazard to human health in high levels. High levels of ammonia reflect organic pollution. Peaks in Ammonia at Anlung Pring and Boeung Prek Lapouv during both October 2021, October 2022 and May 2022, suggesting a regular and widespread pollution source. A large peak at Boeung Prek Lapouv in Feb suggests localised pollution source.
- Electrical Conductivity (EC) readings suggest some saltwater intrusion into the coastal sites Anlung Pring and Phnom Tuek, but not into Angkoul. Readings for other sites suggests very pure water.

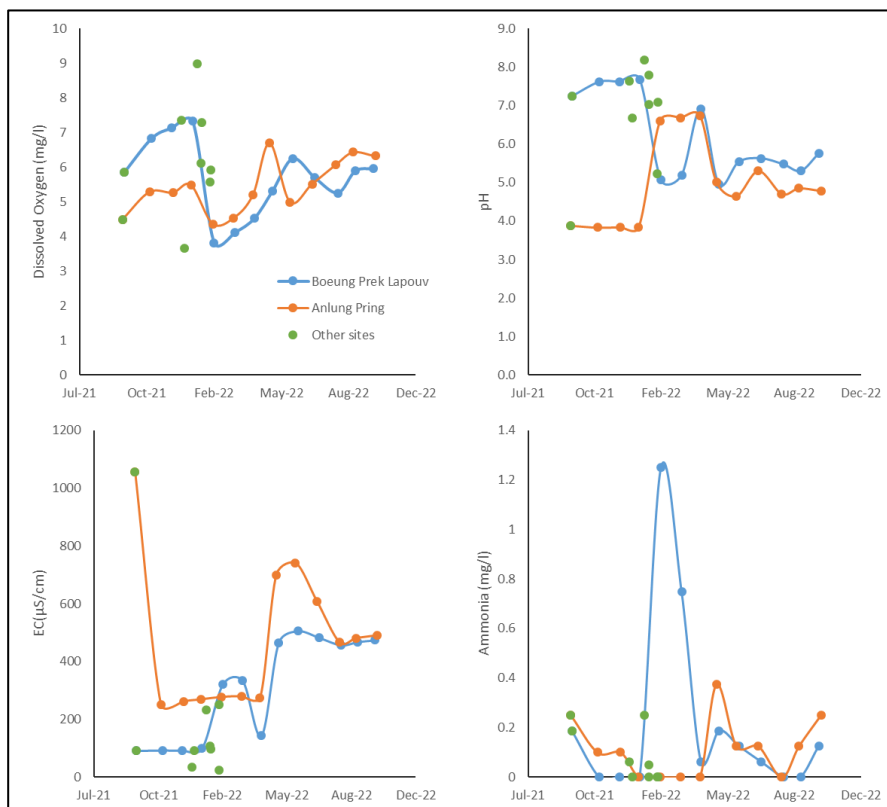


Figure 4.1. Water chemistry measurements at sites in the CLMD

5. Ecosystem Services

Rapid Assessments of the Wetland Ecosystem Services (RAWES²) workshops were conducted at Anlung Pring in July 2019 and the remaining eight key identified sites from January to March 2022. The RAWES process is designed to help communities identify important ecosystem services at their sites. This section summarises the ecosystem services identified by communities living around the nine key sites in the CLMD. Detailed appraisals of the RAWES assessments for each of the nine key sites are available in Appendix 5.

Assessments were carried out with varying numbers of participants, to reflect the different population sizes near each site (see Table 5.1). Participants were divided into groups of 5-10 and gave their responses in workshops.

Sites were categorised into broad habitat types (e.g. grassland, open water, flooded forest) and ecosystem services were assessed separately for each habitat type. There were 38 services assessed, grouped into four categories:

- **Provisioning** services comprise resources that can be collected or harvested from the wetland.
- **Regulating** services maintain desired environmental conditions for human society.
- **Cultural** services enrich human society.
- **Supporting** services are necessary for the maintenance of ecosystem integrity, functioning and resilience, and for the production of all other ecosystem services.

Each ecosystem service was rated by workshop participants with the following scale: -1: significant disbenefit, -0.5: dis benefit, 0: no benefit/dis benefit (or not applicable), +0.5 positive benefit, +1 significant positive benefit. The ratings show numbers that range between the categories (e.g. 0.8). This is because multiple workshops were held at each site, and so the mean rating across workshops was used for analysis. Mean scores are calculated across the workshops and habitat types to give an overall score for the site.

Out of 38 ecosystem services (ESs) discussed, 16 (42%) of all services were recorded at every field site. Three ecosystem services were not recorded at any of the sites (these being energy harvesting; clay, mineral, aggregate harvesting; and salinity regulation). Figure 5.1 shows the highest rated ecosystem services across all eight sites.

Table 5.1. Size, population and number of participants in ecosystem services assessments. The number of villages is measured within a 1km buffer of the site boundary. Both the number of villages and the population are taken from the 2008 census.

Site	Area (km ²)	Villages	Population (2008 census)	Number of participants
Boeung Kadai	15	2	7,792	10
Boeung Veal Samnap	5	4	6,124	15
Boeung Snae	35	11	12,320	20
Bassac Marshes	300	27	35,829	87
Tonle Bati	4	3	4,041	18
Boeung Prek Lapouv	80	20	13,700	46
Phnom Tuek	4	3	5,445	12
Angkoul	25	17	24,820	20

² Ramsar Regional Center, East Asia (2020) *Rapid Assessment of Wetland Ecosystem Services: A practitioners' guide*. RRC-EA, Suncheon, Republic of Korea.

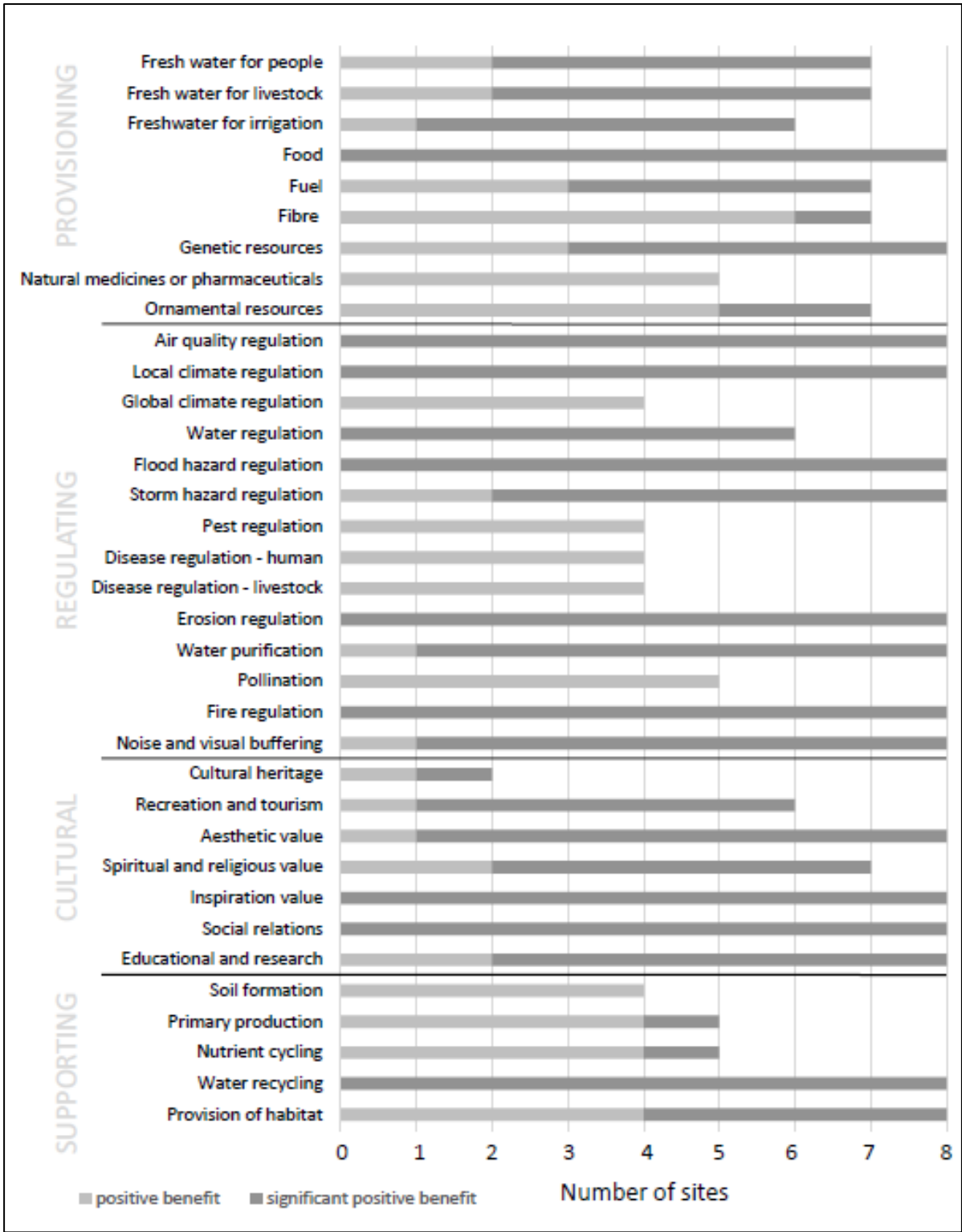


Figure 5.1. Number of sites (out of 8 total) with 'positive benefit' and 'significant positive benefit' ratings for each of the ecosystem services

5.1. Provisioning Services

One or more provisioning service was considered of significant positive benefit at every site assessed. Freshwater and food were the most consistently highly rated services in this category, and also fuel from the sites that still have large forested areas (Boeung Kadai and Bassac Marshes). Freshwater is used for people and livestock from all sites, and for irrigation from most sites (excluding Phnom Tuek, Anlung Pring and Angkoul). Food resources include fish, crab, shrimp and rats, as well as aquatic vegetation. Natural medicines were utilised at Boeung Kadai, Bassac Marshes and Angkoul but not from other sites. Other services, such as collection of mineral resources and energy collection, were not utilised at any site.

Boeung Snae is seen as a public lake, with open access fishing and no boundaries for different uses. This is perceived favourably by the local community, who feel they have freedom to fish in the lake and benefit from these ecosystem services. In contrast, perceived overfishing by migrant communities in Boeung Kadai led to local communities proposing protected area status for the site, which was granted in 2021. Fish catches in the Bassac Marshes are decreasing yearly, reportedly as there are more people fishing in the area, with some people even travelling from Viet Nam to fish. Communities near Bassac Marshes, particularly those in Saang and Koh Thom, fully rely on the wetland and its ecosystem services, and so people here are also interested in the wetland gaining protected status of some sort.

5.2. Regulating Services

The most frequently mentioned services in this category were air quality regulation and local climate regulation, along with flood regulation, erosion regulation, water purification and water flow regulation (although, curiously, this latter was not rated as a benefit in Boeung Kadai or Phnom Tuek).

Participants at most sites associated good air quality with the presence of the wetland, particularly flooded forests (at Boeung Kadai, Boeung Snae and Bassac Marshes). Flooded forests were also associated with flood control, storm control and erosion regulation. Wetlands were also credited with improving the local climate, by keeping temperatures lower than in surrounding dry regions. Mangroves at Angkoul and the large size of Bassac Marshes led to both being seen as contributing to global carbon sequestration. All of these services were recognised at Boeung Veal Samnap, meaning there is concern around an area given the scale of development, which is expected to impact the wetland and surrounding communities.

5.3. Cultural Services

Cultural services scored particularly highly at sites where tourism is an important activity (Phnom Tuek, Tonle Bati, Boeung Snae and Boeung Kadai). Tourism for viewing of Sarus Crane is important at Anlung Pring and Phnom Tuek, and there is a wish to develop this more at Boeung Prek Lapouv.

Cultural services that were considered important at all sites were social relations, due to the presence of communities that have developed around the wetland, along with aesthetic values, inspirational values and education and research. Cultural heritage was not considered important at any site, with the exception of Tonle Bati. When discussing cultural heritage people tended to link this to the old temples or other buildings of importance. As these do not exist in most of the sites assessed, cultural heritage was therefore not rated highly. Some greater interrogation around this may have opened up a greater awareness and appreciation of wider cultural heritage values.

Tourism is important at some sites, but not at Boeung Veal Samnap and Bassac Marshes. International tourists (largely from Viet Nam) visit Anlung Pring and Phnom Tuek to view the Sarus Crane, supporting the local economy through homestays and restaurants. Tourists to other sites tend to be nationals, for example visitors from Phnom Penh coming to Tonle Bati during the weekend to relax and enjoy the wetland scenery. Tourism has led to the local fishery community promoting the protection of Boeung Snae, as they benefit from tourism income from taking tourist on boat tours of the area, and selling food and providing other amenities to tourists. Communities at other sites (Boeung Kidai, Boeung Veal Samnap, Boeung Prek Lapouv and Angkoul) expressed interest in developing tourism at these sites.



Figure 5.2. Boeung Prek Lapouv wetland, showing sarus crane (top left), Asian openbill (top right), buffalo farming (bottom left) and a landscape view (bottom right)

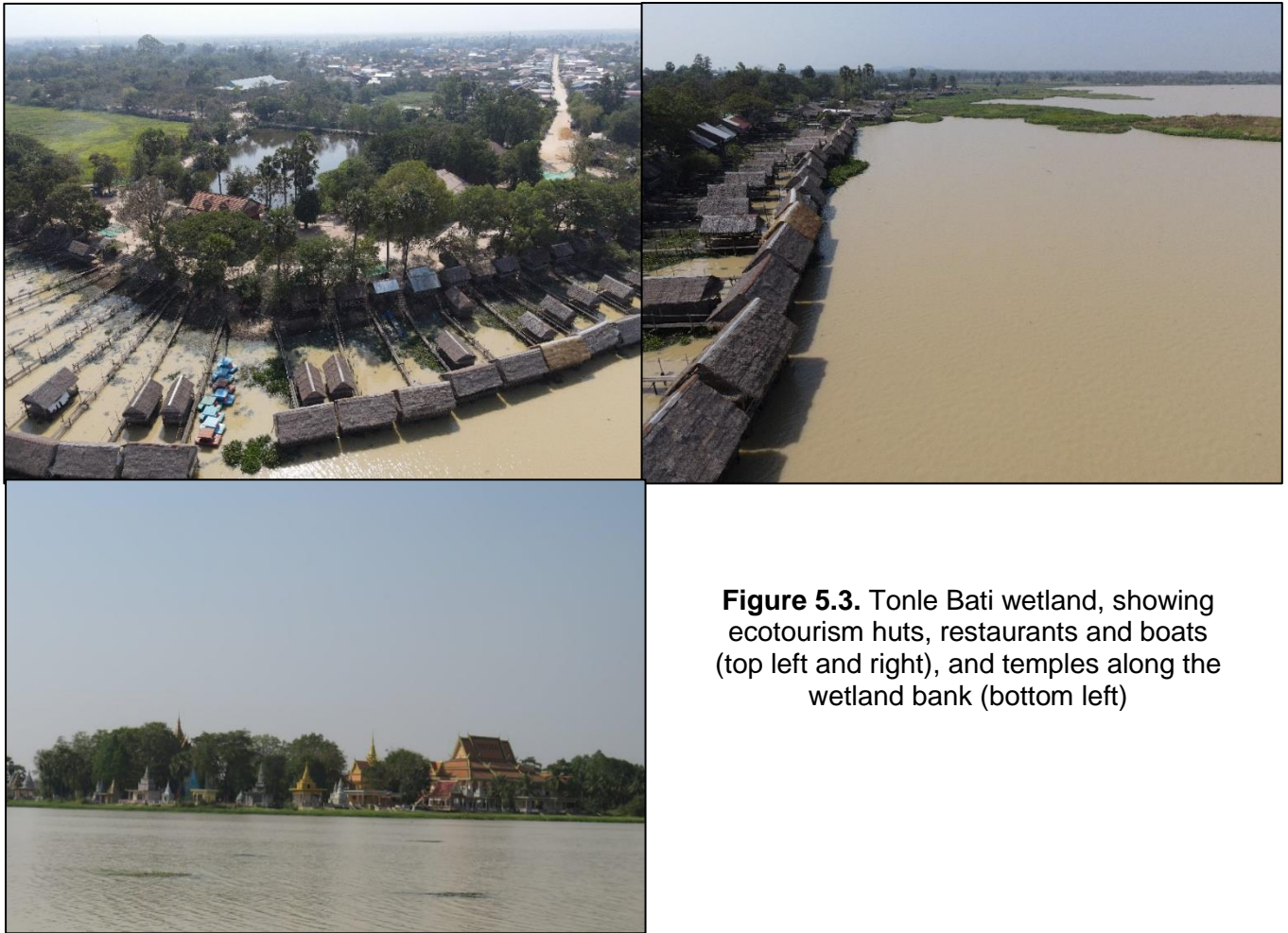


Figure 5.3. Tonle Bati wetland, showing ecotourism huts, restaurants and boats (top left and right), and temples along the wetland bank (bottom left)

5.4. Supporting Services

Water recycling and provision of habitat were the only two services considered important at nearly all sites. The other three supporting services – soil formation, primary production and nutrient cycling – were not considered important at all at Boeung Snae, Tonle Bati, Phnom Tuek and Angkoul. However, these three services are complex in nature, and may be slightly harder to communicate through local community surveys.

5.5. Scales of benefits

The benefits derived from ecosystem services are delivered across a range of scales, from locally in the immediate vicinity of a wetland (soil formation) through national benefits to those that contribute at a global scale (climate regulation) (Table 5.3). Table 5.3 illustrates how some of the ecosystem services tended to have a wider reach of beneficiaries than others: such as genetic resources, air and climate regulation, recreation and tourism, education and research and the provision of habitat. More local beneficiaries were benefiting from ecosystem services such as freshwater provision, natural medicine collection and erosion regulation. Notably, quite a few of the cultural ecosystem services seem to have a wider reach of beneficiaries, which may provide a good support for the protection of these wetland landscapes (for both wildlife and people).

Table 5.3. Ecosystem services provided by the CLMD wetlands which were rated as providing positive benefits (including 'significant positive benefits'), and their respective beneficiaries (across all workshops).

<i>Ecosystem service category</i>	<i>Ecosystem service</i>	Beneficiaries			
		Local	National	Global	
Provisioning	Freshwater – people	✓			
	Freshwater – livestock	✓			
	Freshwater – irrigation	✓	✓		
	Food	✓	✓		
	Fuel	✓	✓		
	Fibre	✓	✓		
	Genetic resources	✓	✓	✓	
	Natural medicines	✓			
	Ornamental resources	✓	✓		
	Regulating	Air quality regulation	✓	✓	✓
Climate regulation		✓	✓	✓	
Water regulation		✓	✓		
Flood hazard regulation		✓	✓		
Storm hazard regulation		✓			
Pest regulation		✓			
Disease regulation for humans		✓			
Disease regulation for livestock		✓			
Erosion regulation		✓			
Water purification		✓	✓		
Pollination		✓			
Fire regulation		✓	✓		
Noise and visual buffering		✓			
Cultural		Cultural heritage	✓	✓	
		Recreation and tourism	✓	✓	✓
	Aesthetic value	✓	✓	✓	
	Spiritual and religious value	✓	✓		
	Inspiration value	✓	✓		
	Social relations	✓	✓		

	Educational and research	✓	✓	✓
Supporting	Soil formation	✓		
	Primary production	✓		
	Nutrient cycling	✓		
	Water cycling	✓	✓	
	Provision of habitat	✓	✓	✓

6. Report Recommendations

1. Protection is needed for all the remaining natural habitat in the Cambodia Lower Mekong Delta (CLMD). The fast rate of clearance makes this a priority, but this will take different forms at the different sites.
 - a. Boeung Prek Lapouv is the most biodiverse site in the CLMD and the last remnant of a huge plain. It is still being cleared at a fast rate and requires urgent effective protection, conservation and management mechanism.
 - b. Bassac Marshes comprises the majority of the remaining natural habitat. The huge size of the site make it an important site to preserve, as it is one of the few locations remaining in the delta where natural sheetflow of water still occurs. The habitat found here is well utilised and modified by local communities, but still retains several key characteristics of more pristine habitat that would be lost if it were converted to intensive agriculture, principally relating to hydrological regulation. The ecosystem services provided by the Bassac Marshes make it a key site to protect – water regulation from a site this size is important at a regional level, as well as the livelihoods supported at a local level.
 - c. Although smaller, Boeung Snae, Boeung Veal Samnap and Boeung Kadai are all worthy of protection for their biodiversity and local provision of ecosystem services. Two of these sites have now been protected. There is proposed development at Boeung Veal Samnap (and at the wetlands within Phnom Penh).
 - d. Although both small remnants of natural habitat, Anlung Pring and Tonle Bati both appear to be well protected by their local communities for their tourism value.
2. Intensification of agriculture within the CLMD should be stopped and alternative sustainable development opportunities investigated and financed at scale. With Viet Nam moving away from intensive rice farming, an opportunity has potentially opened up for Cambodian farmers to supply low-value rice. This may bring short-term benefits but in the long-term will cause the same problems that Viet Nam is now attempting to remedy. An emphasis must be placed on mapping the drivers and impacts of unsustainable agriculture and understanding the political, socio-economic and practical pathways to transitions to sustainable practices. An agreed multi-stakeholder plan for sustainable agriculture and wetland conservation in the Cambodian Mekong Delta would help to bring together stakeholders in this endeavour.
3. Minimise unsustainable development in wetland areas close to Phnom Penh. The loss of wetlands within Phnom Penh is well documented, but this is an issue elsewhere in the CLMD too. One wetland site close to Phnom Penh (Boeung Cheung Loeung) has been cleared within the last 3 years to construct a new international airport. Proposed developments at Boeung Veal Samnap will have adverse effects on local communities there. A sustainable development approach is required.
4. An improved knowledge base on the CLMD is required to aid decision-making. Priorities include:
 - a. Improved monitoring of biodiversity. Bird counts at more sites, regular fish surveys, surveys for more groups, especially plants.
 - b. Research on the hydrological benefits provided by large areas of natural habitat such as Bassac Marshes and Boeung Prek Lapouv, including slowing of flood waters, water retention after flooding, groundwater recharge.

- c. Improved research on livelihoods, the diverse values associated with wetlands in Cambodia, and how particular forms of development and agricultural intensification may impact on communities and their livelihoods.



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