Climate Change Vulnerability Assessment Boeung Prek Lapouv Protected Landscape, Cambodia

Ly Sophanna, Hour Pok, and Tomos Avent

Mekong WET: Building Resilience of Wetlands in the Lower Mekong Region

WWT

BirdLife INTERNATIONAL CAMBODIA PROGRAMME

Federal Ministry
for the Environment, Nature Conservation,
Building and Nuclear Safety

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ACRONYMS

BL	Birdlife International
BMUB	German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety
BPL	Beoung Prek Lapouv
CCK	Chamroeun Cheat Khmer
CFi	Community Fisheries
CPA	Community Protected Area
DAA	District Administrative Authority (of Takeo Province)
DoFWC	Department of Freshwater Wetlands Conservation
FiA	Fishery Administration
IBAs	Important Bird Areas
ICEM	International Centre for Environmental Management
IKI	International Climate Initiative
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
GDANCP	General Directorate of Administration for Nature Conservation and Protection
LMB	Lower Mekong Basin
MAFF	Ministry of Agriculture, Forestry, and Fisheries
MRC	Mekong River Commission
MoE	Ministry of Environment
NBSAPs	National Biodiversity Strategies and Action Plans
PDoE	Provincial Department of Environment
PRA	Participatory Rural Appraisal
RGC	Royal Government of Cambodia
TPA	Takeo Provincial Administration
USAID	United States Agency for International Development
VA	Vulnerability Assessment
WWT	Wildfowl & Wetlands Trust

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EXECUTIVE SUMMARY

Wetlands ecosystems provide various functions including regulating water flows, providing clean water, storing carbon and reducing disaster risk by acting as natural buffers against flood impacts. In the Lower Mekong Region, millions of people rely on wetlands for survival. Recently, however, infrastructure developments, deforestation, the expansion of irrigated agriculture and increasing urbanisation have led to a decline in the region's wetlands. Impacts on habitats, species and livelihoods are further intensified by climate change. Involving local stakeholders in the conservation, management, and restoration of natural ecosystems is critically important to maintain these unique environments.

"Mekong WET: Building Resilience of Wetlands in the Lower Mekong Region" (2017-2020) aims to build climate resilience by harnessing the benefits of wetlands in Cambodia, Lao PDR, Thailand, and Viet Nam. The project is funded by the International Climate Initiative (IKI) of the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB). Mekong WET will help the four countries address their commitments to the Ramsar Convention, an international treaty for the conservation and sustainable use of wetlands, and achieve the Aichi Biodiversity Targets.

Vulnerability Assessments (VAs) have been conducted at ten sites in the four countries. VAs combined scientific assessments with participatory appraisals and dialogues with local communities and authorities. In Cambodia, three sites were selected: Koh Kapik Ramsar site in Koh Kong Province, Boeung Chmar Ramsar Site in Kampong Thom Province and Boeung Prek Lapouv Protected Landscape (BPL) in Takeo Province, which is the focus of this summary.

The main objectives of the assessment were to determine the vulnerability of ecosystems and livelihoods to the impacts of climate change, and identify methods to address vulnerabilities and increase the resilience of wetlands and livelihoods to the impacts of climate change. Wildfowl & Wetlands Trust (WWT) conducted the VA in collaboration with partner NGOs and the Ministry of Environment (MoE). The assessment incorporated community workshops and expert consultations with NGOs and academic specialists, to predict the potential implications that climate change may have on habitats, biodiversity and livelihoods. The VA covered villages that rely on wetland resources for their livelihoods, and assessed how these resources are affected by climate change and non-climate threats, including those from outside the wetland boundary. In this assessment, special attention was paid to the needs, perspectives and knowledge of women, because they may use wetlands and their resources differently than men.

Boeung Prek Lapouv Protected Landscape (BPL) in Takeo Province, Cambodia, represents one of the largest remnants of seasonally-inundated grasslands in the Lower Mekong Region, at over 8,300 hectares in size. It is one of 40 globally Important Bird Areas (IBAs) identified as key sites for conservation in Cambodia and one of three sarus crane (*Grus antigone*) Conservation Areas. BPL is a flat area of land located in the western floodplain of the Bassac River, which is a distributary of the Mekong River (Figure 2). There are four main habitats within the area: seasonally inundated grasslands (24% total area), shrubs and gallery forests (<1%), open water with aquatic plants (13.7%), and rice fields (61%). Grassland habitats throughout the region are under threat from agricultural conversion, with their hydrology significantly altered to facilitate rice growing. This poses a risk to many flagship species including the sarus crane, painted stork (*Mycteria leucocephala*), Asian openbill (*Anastomus oscitans*), greater adjutant (*Leptoptilos dubius*), and spot-billed duck (*Anas poecilorhyncha)*, as they depend on grasslands as feeding grounds.

About 22 villages (~5,000 households) use the wetland for rice farming and the collection of natural resources including fish, edible plants, firewood and grass. There are tensions between the local population and transient Vietnamese farmers and fishers who come to use the land. Most people in BPL (97%) are involved in the cultivation of rice, followed by raising cattle for sale (56%) and fishing (51%) (Sophanna 2017).

An assessment in 2012 of 428 households (10 % sample size) from 19 villages in and around the reserve found that almost 68 % collected natural resources from BPL (van Zalinge *et al*. 2013). The widespread conversion to rice is therefore likely to result in a reduction in ecosystem values to local people rather than an increase. The assessment also calculated the net annual value derived from harvesting "wild goods" (fish and other wetland products) and rice cultivation. Wild goods made up 74 % (US$1,601,799) of a total net annual value of US$2,168,019 for all food provisioning services derived from BPL.

Climate change is expected to lead to an increase of maximum temperatures during both the dry and wet seasons. In addition, dry season precipitation is predicted to decrease and wet season precipitation will increase. Cambodia's floodplains may experience an increase in extreme floods with depths of 2 metres. It is likely that the duration of floods at BPL will also increase, although this may remain limited to 3 to 7 days. Climate change is likely to generate a minor increase in drought period however, coupled with large upstream dam construction projects and local irrigation systems, the area may suffer prolonged and more severe water shortages.

The assessment suggests that open water habitats containing aquatic plants are the most vulnerable ecosystems to the impacts of climate change. Pre-existing harsh conditions at the end of the dry season will be exacerbated and increase stress among aquatic species including fish, water lilies, and the flagship species that depend on them. Increased fertilizer runoff has led to invasive water hyacinth dominating native water lilies and restricting photosynthesis of other aquatic species, decreasing dissolved oxygen in the water and affecting fish in the area. Seasonally inundated grasslands were found to be more resilient to future effects of climate change. Flooding is a key characteristic of seasonally inundated grasslands and they can easily adapt to and recover from changes in precipitation and flooding. Extended drought may affect the habitat when the temperatures increase. However, during the long hot droughts in 2015 and 2016, the grasslands were able to recover quickly, while no grassland fires were recorded.

Shrubs and gallery forests were also determined to have high resilience to climate change. An increase in precipitation does not cause any threat according to historical observations from locals. This habitat may benefit from the increase in precipitation and flooding, which increases the availability of nutrients from sediment. Extreme floods in 1991 and 2001 highlighted the resilience of shrubs and gallery forests. However, higher temperatures, which may lead to forest fires and forest stunting, pose a risk. Rice paddies are moderately vulnerable to climate change, especially to long drought periods and hot temperatures, but they are less important for maintaining biodiversity.

Community members observed that non-climate impacts such as land encroachment, shrub burning, agricultural runoff, bird poaching, and illegal fishing have impacted BPL far more than severe weather events thus far. The majority of climate change coping mechanisms suggested by community groups were based on raising livestock as alternative livelihoods to rice farming and increasing water security through the restoration and creation of canals and increased water pumping for irrigation.

The protected landscape provides a range of resources for local community members. The most important are: fish (*Anabas testudineus*, *Channa striata*, *Trichogaster trichopterus*, *Trichopodus pectoralis*, *Clarias microcephalus*, *Channa micropeltes*, *Thynnichthys*

thynnoides, Cosmochilus harmandi, Puntioplites proctozysron, Kryptopterus bleekeri, Ompok eugeneiatus, Mystus albolineatus), grasses (*ryza rufipogon, sacharum, Hymenachne acutigluma*), rats (rice field rats), crabs *(Somaniathelpusa sexpunctata, Somaniathelpusa sp.)*, water lillies (*Nelumbo nucifera)*, Mazus japonicas *(Phrymaceae)*, snakes *(Xenochrophis piscator, Enhydris enhyris, Enhychis bocouti)*, firewood *(Mimosa pigra, Breynia vitis-idaea, Sesbania javanica, Gmelina Asiatic)*, frogs *(Limnonectes kuhlii, Fejervarya limnocharis)* and eels *(Ophichthus rutidoderma, Monopterus albus)*. Of these, firewood is an energy source, while grass is used as livestock feed; others are used as a food source for people or processed and sold at the market. While women and men agreed on the most important resources such as fish, grass, rat and crab, there were some notable differences. Women valued frogs and snakes much higher than water lilies for their economic value and because water lily is scarce in dry season.

The impact of climate change and human activities also affects the sarus crane, an important indicator and flagship species at BPL. Their main food source, *Eleocharis dulcis* (water chestnut) is a keystone species at BPL and relatively resilient to individual weather events, but the longer-term climatic implications of increased periods of drought and hotter dry and wet season temperatures may push the species beyond its tolerance thresholds. *Eleocharis* grassland is a key habitat for much of the important biodiversity at the site, and the individual species assessment for sarus crane suggested that habitat loss makes this species highly vulnerable to climate change. Climate change seems to have less of a direct effect on economically relevant fish species as *Channa striata*, known locally as Asian snakehead. The greatest threat to the Mekong fishery may be disruptions to the cycle of inundation, which fuels fisheries productivity, and which are strongly affected by dam construction projects, navigation channel excavation and irrigation systems.

Without active and adaptive management, it is likely that current livelihoods in BPL will become more precarious and habitats will adjust in response to the changing climate. Data from ongoing water management trials, detailed vegetation assessments, avifaunal monitoring programmes and hydrological surveys is being combined with land tenure reviews, ecosystem service assessments, and this VA to inform the MoE's new zoning scheme and associated management planning process.

The new zonation scheme, being developed as a result of the transfer of management to the MoE Protected Landscape system, is a unique opportunity to work alongside communities and experts to ensure future sustainable natural resource management. Using this assessment, managers can combine current ecosystem service data with future predictions to ensure that the local communities, habitats and species are supported to adapt to a changing future.

Local communities suggested several coping mechanisms for climate change. Diversifying rice varieties, creating improved storage mechanisms, and becoming more adaptable over rice harvesting periods are some of the more sustainable suggestions to increase resilience. Changes to water management or increasing fertilizer use in response to drought and higher temperatures are likely to have a negative impact on habitat biodiversity and ecosystem services. Increased water security for the ecosystem and local people should be a focus of future planning at the site, in order to reduce the conflict between local people and biodiversity. Rice is likely to remain the primary crop in and around BPL, with few people suggesting diversification to other crops during the community consultations.

Livestock is an important source of financial security for communities at BPL, with local people reporting that they sell livestock if crops are low-yielding because of extreme weather events. Improved shelter, vaccination and access to veterinary support should be explored to increase security in this regard. Community-based natural resource management mechanisms should be strengthened to increase people's capacity and improve yields, leading to an increase in resilience.

1 GENERAL INTRODUCTION

Wetlands, such as marshes, rivers, mangroves, coral reefs, and other coastal and inland habitats, have many important functions. They regulate water flows, provide clean water, store carbon and reduce disaster risk by acting as natural buffers against erosion and the impact of floods, tsunamis and landslides. In the Lower Mekong Region, millions of people rely on wetlands for their survival. In recent decades, however, infrastructure developments, deforestation, the expansion of irrigated agriculture and increasing urbanisation have led to dramatic declines in the region's wetlands. Impacts on habitats, species and livelihoods are further intensified by climate change. Conserving, managing and restoring natural ecosystems in collaboration with local communities and stakeholders, is increasingly recognised as critically important to maintain these unique environments.

"Mekong WET: Building Resilience of Wetlands in the Lower Mekong Region"[1] (2017-2020) aims to build climate resilience by harnessing the benefits of wetlands in Cambodia, Lao PDR, Thailand, and Vietnam. The project is funded by the International Climate Initiative (IKI) of the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB). Mekong WET will help the four countries to address their commitments to the Ramsar Convention, an international treaty for the conservation and sustainable use of wetlands, and to achieve the Aichi Biodiversity Targets. Through its focus on wetland ecosystems, the project also supports governments in implementing National Biodiversity Strategies and Action Plans (NSBSAPs) under the Convention of Biological Diversity and pursuing their commitments on climate change adaptation and mitigation under the United Nations Framework on Climate Change.

Vulnerability Assessments (VAs) were conducted in ten Ramsar sites/wetland sites in the four countries as the first step of a participatory adaptation planning process. The approach combined scientific assessments with participatory appraisals and dialogues with communities living at the sites and the authorities in charge of site management. For Cambodia, three sites were selected: Koh Kapik Ramsar site in Koh Kong Province, Boeung Chmar Ramsar Site located in Kampong Thom Province and Boeung Prek Lapouv Protected Landscape situated in Takeo Province (BPL), the focus of this report.

1.1 Objective and setup of the study

The main objectives of the assessment were:

- To assess the vulnerability of ecosystems and livelihoods to the impacts of climate change.
- To identify options to address vulnerabilities and increase the resilience of wetlands and livelihoods to the impacts of climate change.

The outcomes of the VAs should lead to actions and decisions at the local and potentially national levels. To do this, a BPL VA team was formed with representatives from different institutions at national and sub-national levels. The team included representatives of the Department of Freshwater Wetlands Conservation of the Ministry of Environment (DoFWC-MoE), commune council, Birdlife International (BL), Chamroeun Chiet Khmer (CCK), Wildfowl & Wetlands Trust (WWT), and IUCN. The assessment was led by WWT.

The assessment consisted of two parts: a description of the current situation of the wetland and a rapid assessment of its vulnerability (see IUCN, 2017). Baseline research was conducted to gather existing information on the wetland and selected villages. The Rapid Vulnerability Assessment consisted of three tools in the form of excel spreadsheets: a Habitat

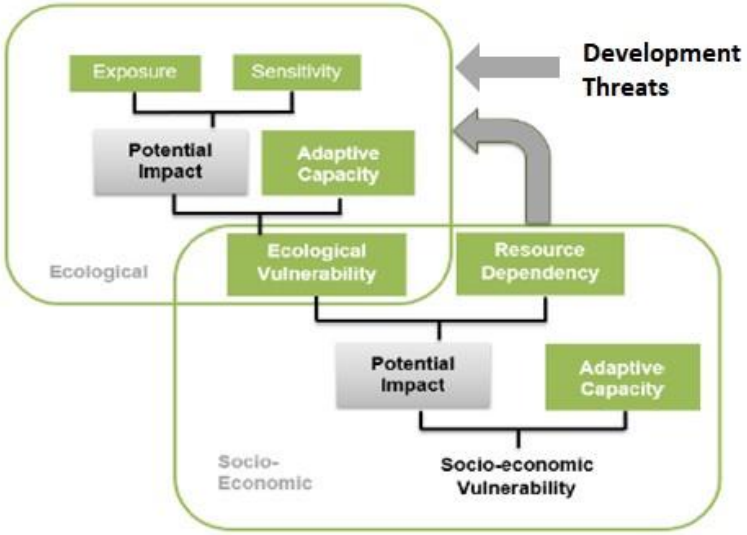
[1]See https://www.iucn.org/regions/asia/our-work/regional-projects/mekong-wet

VA tool, a Village VA tool (complemented with Participatory Rural Appraisal or PRA tools), and a Species VA tool. These tools were selected for their simplicity, clear instructions and guidance, and ecosystem-based focus; a socio-ecological framework was used to inform the design of the tools (see Box 1). Experts were consulted to complete and validate the Habitat and Species VA tools, while the Village VA tool was completed in a consultative process with the communities.

The VA covered the wetland and adjacent villages that rely on its resources for their livelihoods. It assessed how they are affected by climate change and non-climate threats including those from outside the wetland boundary. Special attention was paid to the needs and perspectives of women, because women may use wetland resources in different ways than men, and because women may have different knowledge and perspectives of wetland resources. Before finalizing the narrative report, a validation workshop was organized with the villages and site managers for feedback.

Box 1: *Conceptual framework Vulnerability Assessment (after Marshall, 2009; GIZ/ISPONRE/ICEM, 2016)*

According to the Intergovernmental Panel on Climate Change (IPCC, 2007), vulnerability is defined as the degree to which something (a species, an ecosystem or habitat, a group of people, etc.) is susceptible to, or unable to cope with, the adverse effects of climate change, including climate variability and extremes. Vulnerability is further explained as a function of the character, magnitude, and rate of climate variation to which a system/species is exposed, the system/species' sensitivity, and the system/species' adaptive capacity.



Exposure is defined as the extent to which a region, resource or community experiences changes in climate. It is characterised by the magnitude, frequency, duration and/or spatial extent of a weather event or pattern.

Sensitivity is defined as the degree to which a system is affected by climate changes.

Together, exposure and sensitivity describe the potential impact of a climate event or change.

This interaction of exposure and sensitivity is moderated by adaptive capacity, which refers to the ability of the system to change in a way that makes it better equipped to manage its exposure and/or sensitivity to a threat.

Within the context of Mekong WET, which is focused on wetlands, the ecological system consists of two elements: species and habitats. The socio-economic system refers to the socio-economic vulnerability (i.e. livelihoods) of the villages or communities that are dependent on resources derived from the wetlands. Socio-economic and ecological information collected during the assessments evaluates how the ecological and socio-economic system interact to determine the overall potential climate change impact.

2 SITUATION ANALYSIS

2.1 Description of the wetland

The vulnerability of BPL Protected Landscape to climate change is determined by various factors, of which the wetland's biophysical and ecological characteristics are critical. Through consultation and desk research, the wetland's geographical, climate and hydrological features, as well as habitats and biodiversity are described. These are followed by an overview of land

use patterns, drivers of change, and recent conservation/zoning plans to get an overview of the current state of the ecological system.

2.1.1 Location and site description

BPL is situated in Takeo Province, close to the border with Vietnam in the south of Cambodia (Figure 1). It represents one of the largest remnants of seasonally-inundated wet grasslands in the Lower Mekong Region at over 8,300 hectares in size. It is one of 40 globally Important Bird Areas (IBAs) identified as key sites for conservation in Cambodia, and one of three sarus crane Conservation Areas. The site is also critical for local people, who depend on it for their livelihood.

BPL it is a relatively flat area of land located in the western floodplain of the Bassac River, which is a distributary of the Mekong River. The grasslands are under threat from agricultural conversion throughout the region. The hydrology has been significantly altered to facilitate rice growing and BPL will require direct long-term management to conserve this valuable landscape.

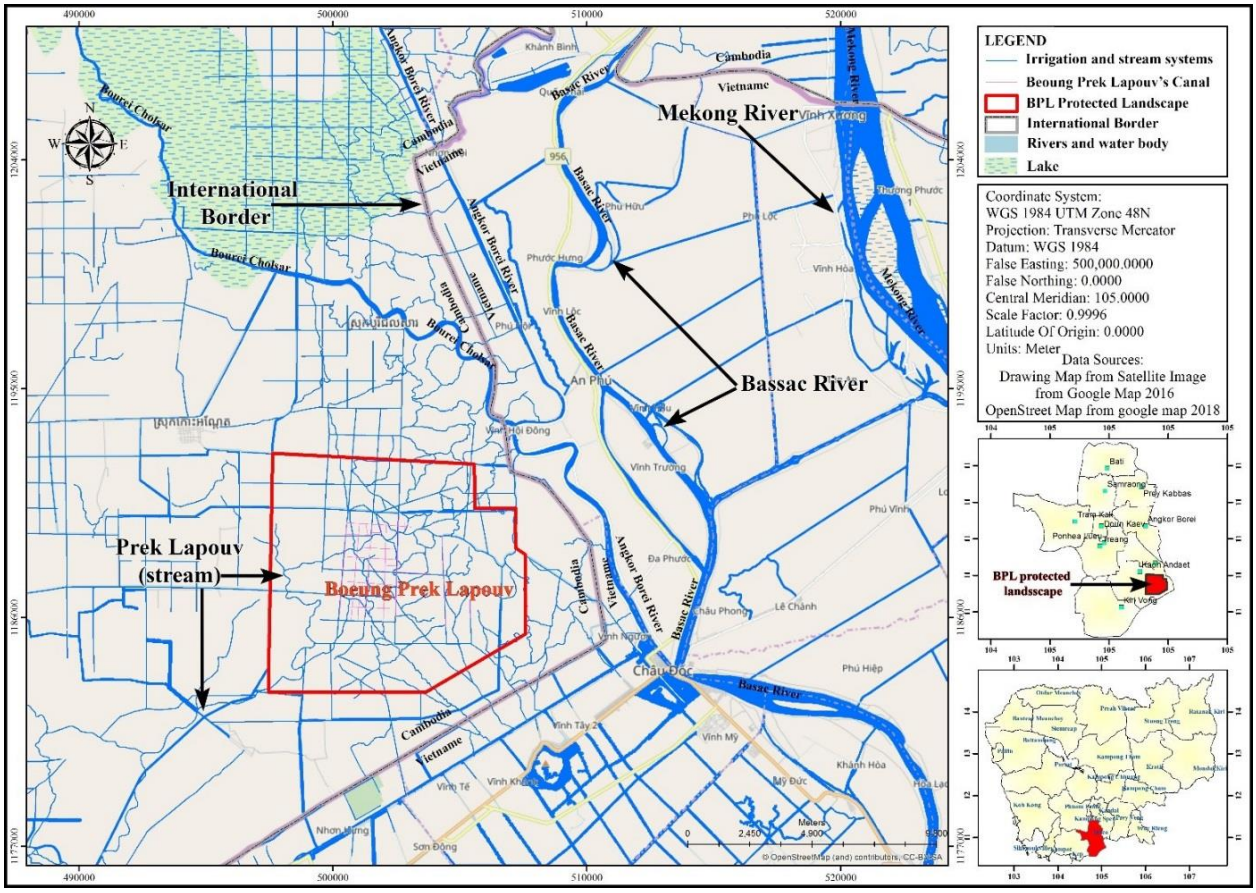


Figure 1: *Location of BPL in relation to major rivers and streams*

2.1.2 Current and historic climate

The Lower Mekong Region has tropical monsoonal climate (Table 1). The southeast monsoon usually lasts from May up to September/October, with the wettest months later in the season when tropical cyclones occur. Annual rainfall in the region ranges from 1,000 to 1,500 mm. The northeast monsoon, which starts in late October, initially brings lower temperatures, with rainfall generally confined to Vietnam due to the buffering effect of the Annamite mountain range. Annual evaporation is generally between 1,500 and 1,700 mm.

Table 1: *Generalized climate seasons in the Mekong Basin (source: Mekong River Commission 2005)*

Cool/Dry			Hot/Dry		Wet					Cool/Dry	
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
NE Monsoon			Transition		SE Monsoon					NE Monsoon	

In Takeo Province where BPL is located, the total annual rainfall over the last 10 years (2009-2017) has generally varied between 1,100 mm and 2,200 mm, with exceptions of 3,000-4,000 mm in 2009/2010 (World weather, 2017). The average temperature over the same period was 31.1°C, with an average minimum of 26.9°C and an average maximum of 33.7°C; 2015 and 2016 were the hottest years with maximum temperatures of 37-40°C in March and April.

2.1.3 Hydrological characteristics

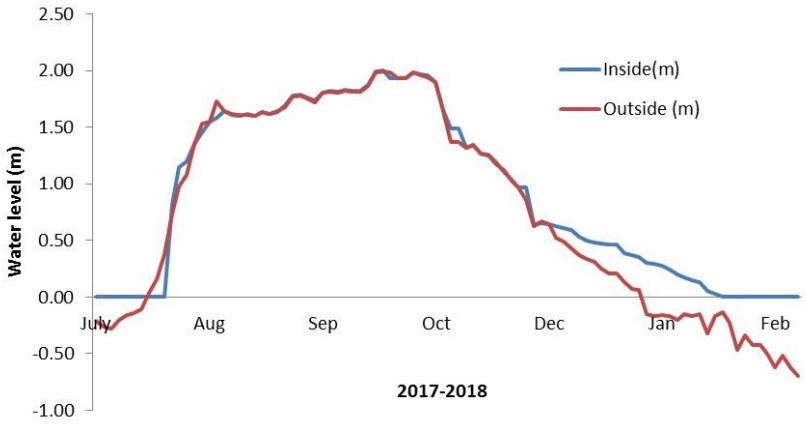
BPL is subjected to the influence of the Mekong and Bassac Rivers, with pronounced seasonal variations in flows (Quoi and Thien, 2013). In the lower section of the Mekong, water levels rise in late May with the onset of the rainy season and eventually transform the large flood plan into a sheet of sediment rich water. Water levels peak in September/October and then recede rapidly until December, gradually reaching the lowest level in April and May. In this system, the Tonle Sap – Southeast Asia's largest freshwater lake – acts as a natural flood retention area that absorbs floodwater in the wet season and adds to the main channel flow of the Mekong/Bassac Rivers during the dry season (Quoi & Thien 2013).

The natural cycle of flooding and draining is only a small component of the site's hydrology. During the dry season, main water sources include the Prek Lapouv, a large stream that meanders through BPL, and a canal linked to the Takeo River. The extensive drainage network of canals that built in and around BPL for irrigation purposes has led to rapid water loss in the dry season, with conditions typically dry enough to walk across the wetland by mid-February. The difference in water levels between wet and dry seasons is 3-4 meters, with peaks around August-October, and lows around February. The rapid drainage of the site modifies the habitat and feeding conditions for several key species, including the sarus crane, and limits water availability for agriculture. To prolong the presence of water in the wetland until the end of the dry-season, BL, WWT, and CCK established water management trials to assess the effectiveness of dykes and sluice gates in decreasing rates of water loss (see Box 2).

Box 2: *Water management trials to prolong water availability in BPL in the dry season (Yav et al., 2018)*

In 2016, BL, WWT, and CCK established water trials to prolong the existence of water in the wetland until the end of the dry-season. The plot of the water management trial was 400 m x 400 m (Yav, 2015). The main objective was to understand the effectiveness of water management, and the effects of improved water retention on plants and foraging birds.

The figure displays variations of water level between the inside and outside of the dike. Between November 2017 and February 2018, the rate of water loss was 0.015 m/day inside the experimental plot and 0.023 m/day outside the experimental plot. The lower rates of water loss inside the experimental plot resulted in the plot retaining water for 11 days longer than outside of the plot.



An analysis of infiltration rates of the silty clay soil within the experimental plot showed that the coefficient of permeability (amount of water flowing through a certain area) ranged from 3.58 x 10^{-6} cm/s to 5.13 x 10^{-4} cm/s. This suggests poor drainage of the soil, which bodes well for

similar larger-scale efforts to retain water for longer periods at BPL. Researchers are exploring ways to improve the integrity of dyke walls to further prolong water retention.

2.1.4 Wetland habitats

The wetland harbours different ecosystems based on physical and hydrological characteristics and ecological processes. There are four main habitats that can be distinguished in BPL: seasonally inundated grasslands, scrub and gallery forests, open water with aquatic plants, and rice fields (Figure 2):

- **Seasonally inundated grasslands.** These grasslands include large areas of the former core zone and stretch out to the southern part of the reserve, covering almost 2,000 hectares (24%) of the wetland. After the rainy season, the grasslands turn green, dominated by plant species such as *Panicum repens, Eleocharis dulcis* (water chestnut)*, Ischaemum rogusum, Impomea aquatic, Youngia japonica,* and *Imperata cylindrical.* The grasslands are a favourable feeding ground for bird species such as the sarus crane, painted stork, and Asian spoonbill.
- **Shrubs and gallery forests.** These forests cover only 108 hectares (less than 1%) and are densely distributed in higher parts in the south of the reserve and along river banks and canals. Common scrub and tree species include *Morinda citrifolia L., Gmelina asiatica,* and *Barringtonia acutangula,* which depend on floods for regeneration. Areas with *Barringtonia acutangula* provide a home to various wintering bird species, e.g., the painted stork, purple heron, grey heron, Asian openbill. It is also home to fish, rats, snails, snakes and turtles species that local communities use as a food source. Locals also collect firewood from the forests. In some areas, *Mimosa pigra*, an invasive species, forms mono-dominant stands on high-mid elevations where the soil has been disturbed, such as on embankments.

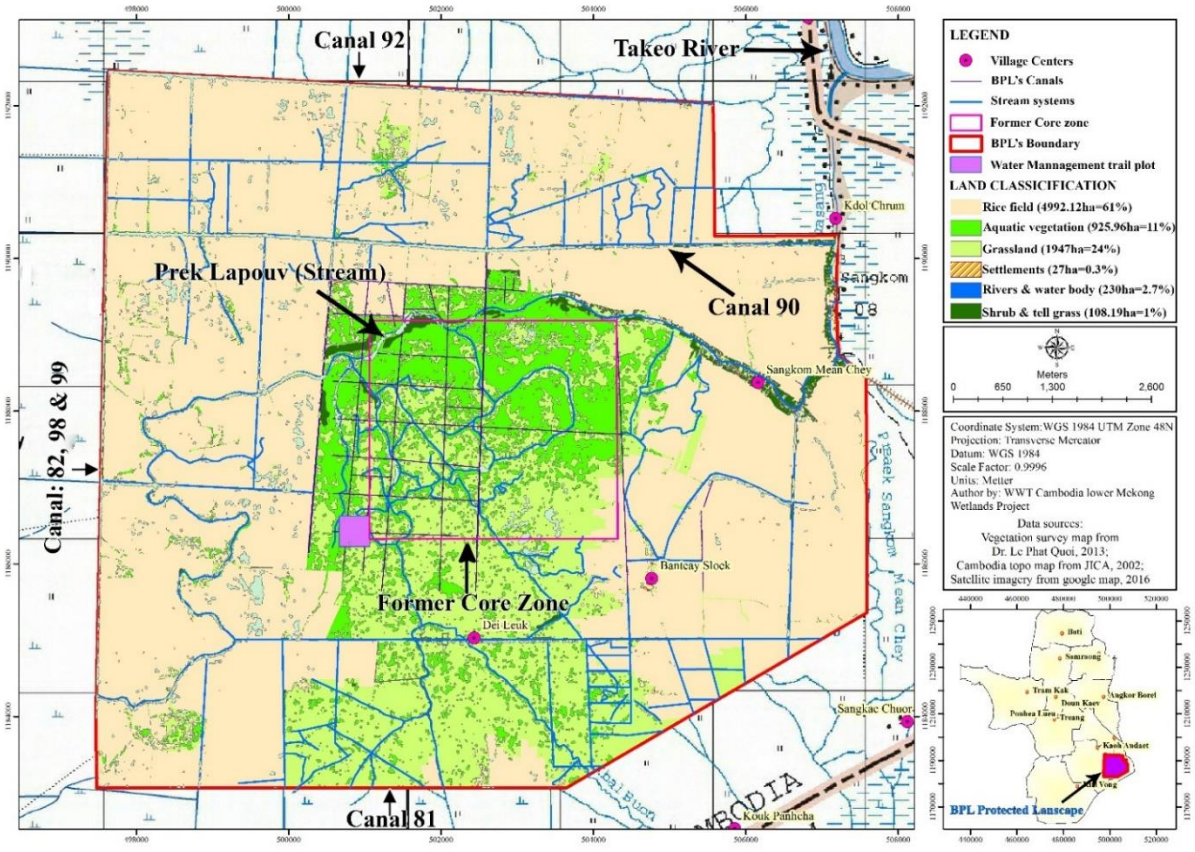


Figure 2: *Land classification areas in BPL (Source: Quoi and Thien, 2013 and Google satellite imagery, 2016)*

- **Open water with aquatic plants.** This is the general habitat of the Prek Lapouv canals and water bodies. This habitat type is mainly located in the north and west of the former core zone. The total area covers around 1,150 hectares (13.7%), of which 926 hectares is aquatic vegetation and 230 hectares is canals and streams. Dominant species are *Nelumbo nucifera* (lotus), *Nymphaea sp.* (water lily) and *Eichhornia crassipes* (water hyacinth). In areas where lotus is not dominant (e.g. in a restored fish spawning canal), the habitat provides habitat for many fish. Specifically, water lilies are an important food source for many species.
- **Rice fields**. Large areas in BPL are in use as rice fields, except the former core zone and the southernmost part of BPL where agricultural activities are not favourable. The total rice area covers almost 5,000 hectares (61%). Rice farming is the main livelihood of people in the area. Rice is cultivated 1-2 times per year depending on field conditions and access to water. Some near threatened bird species have been recorded in this habitat, such as the painted stork.

2.1.5 Biodiversity

Flora. A rapid assessment of BPL flora in February 2013 identified 65 species (Quoi and Thien, 2013). The largest family of plants were grasses (*Poaceae*) with 21 species identified, followed by sedges (*Cyperaceae*) with 13 species. Water chestnut (*Eleocharis dulcis*) and water lily (*Nymphaea sp.)* are important food items for sarus cranes. Water chestnut grows on acid sulphate soils while water lily is found along waterways and depressions in fields, with the latter being areas where sarus cranes can access the plants and feed on the soft stems. A study which compared different types of key grasses and flooded forest species between January 2015 (Quoi, 2015) and May 2017 did not show significant changes, although there are some shifts in the distribution of the invasive species, *Mimosa pigra* (Sophanna, 2017). Another confirmed non-native invasive species is the water hyacinth (*Eichhornia crassipes*).

Fauna. Information on fauna is limited to fish and bird species. Thus far, no work has been conducted on assessing the status of reptiles, amphibians, mammals, aquatic and terrestrial invertebrates or soil organisms. WWT assessed fish species in March 2015. Some typical species in the site were: *Channa striata* (snakehead murrel), *Notopterus notopterus* (Bronze featherback), *Trichohodus pectorallis* (snakeskin gourami), and *Trichohodus microlepis* (moonlight gourami). Of the 85 species that previously existed in BPL, 55 were no longer seen or caught (Somony et al., 2015). Possible explanations are the use of electro-fishing during the spawning season, dam construction upstream restricting fish migration to the lower Mekong, a lack of spawning habitat and damage to the gallery forest from illegal land encroachment. A total of 78 bird species have been recorded to date, but the actual number is likely higher due to limitations in staff capacity to identify species and a focus on threatened and keystone species (Samphors, 2017). Table 2 gives an overview of some characteristic bird species found in BPL, with further details on endangered species in Box 3.

***Table 2.2**: Recordings of characteristic bird species in BPL in recent years*

	Sarus crane	Black head ibis	Asian golden weaver	Oriental darter	Painted stork	Bengal florican	Black faced spoon -bill*	Greater adjutant	Lesser adjutant	Yellow breasted bunting	Spot-bill pelican
2014	203	58	17	34	680	-	-	-	11	-	-
2015	234	110	20	32	1200	2	-	-	2	13	8
2016	185	6	18	11	16	-	-		-	-	-
2017	152	6	-	15	128	-	-	7	1	15	4

*Black faced spoonbill was reported in 2010 and 2011, but not since then

Box 3: *Endangered bird species in BPL (based on IUCN Red List)*

Sarus crane (*Grus antigone*), 'Vulnerable'. BPL is one of the key feeding sites for cranes in the non-breeding season, which overlaps with the Cambodian dry season. The site is especially popular from December to February with a maximum count of 152 cranes in January 2017. During this period sarus cranes flock in large numbers to a small number of wetlands. At the time of their peak influx to BPL, the site supports, on average, a third of the total regional population (van Zalinge, 2011).

Bengal florican (*Houbaropsis bengalensis*), a 'Critically Endangered' bustard. Due to high water levels, its occurrence is restricted to the dry season. Records are few (six sightings between 2003 and 2013) and sporadic (spotted in only five of eleven years). The last record was a successful breeding pair in 2015. This is a highly cryptic species and is usually only seen when flushed. Based on the lack of suitable habitat, it is expected that there are fewer than ten individuals in BPL. The main conservation area of the species is the floodplain grasslands of the Tonle Sap Lake in Kampong Thom province.

Black-faced spoonbill (*Platalea minor*), an 'Endangered' winter migrant. In the winter of 2010/11 four birds were recorded. The same group plus one additional bird were found a month later in the floodplain along the Takeo River, 20 km north of BPL (van Zalinge *et al*. 2013a). The following winter two birds were reported. Although no spoonbills have been confirmed since then, they are likely to be regular visitors in low numbers. Their presence is strongly influenced by water levels as they forage in shallow waters.

Greater adjutant (*Leptoptilos dubius*), an 'Endangered' stork, resides in Cambodia but only visits BPL during the wet season. Greater adjutants were recorded annually from June to August. In July 2017, seven individuals were recorded. These were the first recordings at BPL for the last four years.

Lesser adjutant (*Leptoptilos javanicus*), listed as 'Vulnerable'. Mostly occurring in BPL in the wet season with counts from June to August, but it is also occasionally present in very low numbers in November. It was absent in BPL in 2016 but one was recorded in 2017.

2.1.6 Land use

There are two main forms of land use in BPL: floodplain wetland used for natural resource collection and biodiversity conservation, and rice cultivation. In 2004, the boundaries of BPL encompassed an area of 10,787 hectares, composed of 7,059 hectares of floodplain wetland (65%) and 3,728 hectares of rice fields (35%) (Seng Kim Hout, 2004). In 2011, the size of all floodplain wetlands in BPL was reduced to 4,568 hectares (55% of BPL; and 42% of the original 2004 area). Local people have continued cultivating rice within BPL, under support from the government of Cambodia. The government encouraged people to settle down and use the land in the 1980-1990s, following the rule of the Khmer Rouge.

2.1.7 Drivers of change

Several developments in BPL are directly affecting habitats and species:

- **Rapid drainage**: The extensive network of canals built in and around BPL between 1975-79 and 1991-98 (WWT, 2014) has led to increased runoff in the dry season and is the main cause of increasingly rapid water loss from the wetland. The rapid drainage of the site modifies the habitat and feeding conditions for several key species, including the sarus crane, and limits water availability for agriculture.
- **Land encroachment**: Since BPL was designated as Protected Landscape, people have encroached up to the former core conservation area (see Figure 2).

A potential future issue is the effect that upstream dam construction on the Mekong and its tributaries will have on BPL.[2] The ICEM (2010) predicted the following changes due to the construction of proposed mainstream dams: rapid onset of flooding may affect fish migration and plant growth; greater fluctuation in daily and hourly water levels; decrease in (fertile) sediment load; reduction in primary (plant) productivity of aquatic systems in the Mekong due

[2]Within the Lower Mekong Basin (LMB) most of the larger Mekong River tributaries have cascades of dams in place or planned with some 71 projects expected to be operational by 2030 (ICEM, 2010). A further eleven dams are being considered on the Mekong mainstream within the Lower Mekong Basin (LMB) and a twelfth is already being developed.

to habitat loss, with implications for overall river productivity; and isolation of aquatic populations leading to substantial loss in fish resources.

2.1.8 Conservation and zoning

BPL was established as a Management and Conservation Area for sarus cranes in 2007 (Prime Ministerial Decree 149, RGC 2007). The wetland covered 8,305 hectares, of which 919 hectares was a core conservation zone within an inundated forest protection area; the core conservation zone also included two Community Fisheries (CFi).[3] The reserve was officially authorized under the Ministry of Agriculture, Forestry, and Fisheries (MAFF).

The site was officially transferred to MoE and re-designated as Protected Landscape on 9 May 2016 (Prime Ministerial Decree 90, RGC 2016) (see Annex 1 for a historical timeline). The objectives are to ensure the conservation and protection of the natural landscape, ecosystems, culture, and biodiversity; provide products and nature's services for sustainable use; and encourage local communities as well as the public to participate in the management, protection, and conservation of biodiversity and natural resources in the region.

Despite its establishment as a Conservation Area since 2007, BPL has yet to be clearly demarcated. Uncertainty around land tenure and zonation status has persisted since its transfer to MoE in 2016. This has been seized upon by some people to further encroach into the protected area. In March 2017, MoE established a committee to review land claims and implement a fair and equitable zonation system after detailed consultation with experts and local community groups. The classification of the reserve into different zones (see Annex 2), will depend on the land tenure review and high value biodiversity habitat maps which are currently being produced with the support of WWT.

2.2 Communities and wetland livelihoods

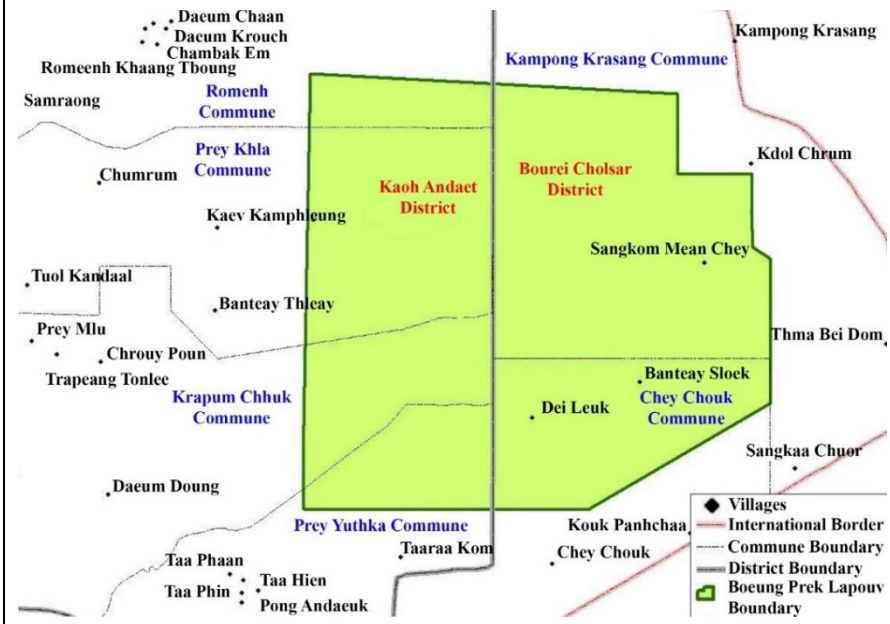
Baseline information on the the people in and near BPL was collected to better understand the current state of people's interaction with the wetland ecosystem and its components including livelihoods and reliance on wetland resources, data on tenure and resource rights, governance structures and stakeholders, and vulnerable groups and perceived threats.

2.2.1 Communities and population

The larger part of BPL is located in the eastern Borei Chulsa District, which includes two communes: Chey Chouk and Kampong Krasang. The remaining part is in western Koh Andet District, which comprises four communes: Prey Khla, Rominh, Kropum Chouk and Prey Yuthka. Figure 3 highlights the districts and communes, as well as the main villages in and near the PBL wetland.

About 22 villages (~5,000 households) make use of the wetland for the collection of natural resources and rice farming. Village size varies from 15 to 600 households, with most of the smaller villages in the southeast (Chey Chouk Commune). The larger villages are in the northwest (Prey Khhla and Romenh Commune). Three villages are located within the boundaries of the reserve: Sangkum Meanchey (296 households), Banteay Sloek (44 households) and Dei Leuk (30 households).

[3]The principle behind CFi is that it gives a community the opportunity to ensure fish stocks are used sustainably and managed in a way that allows for equal distribution of fishing benefits within the community, while also respecting the wetland ecosystem and other wetland biodiversity.



Village per commune (households)
1. Rominh Khang Cheung (599)
2. Chambok Em (508)*
3. Rominh Khang Tboung (302)
4. Daem Chan (245)
5. Daem Kroch (206)*
6. Prolay Meas (262)*
7. Samraong (197)
8. Banteay Thleay (467)*
9. Keo Kampleung (332)*
10. Tuol Kandal (315)
11. Daem Doung (178)
12. Trapeang Tonle (120)*
13. Chroy Poan (111)*
14. Tara Kum (238)[4]
14. Chey Chouk (107)
15. Sangke Chuor (73)
16. Banteay Sloek (44)*
17. Dei Leuk (30)*
18. Kouk Panhcha (15)
19. Sangkum Meanchey (296)
20. Kdol Chrum (267)
21. Thma Bei Dom (167)
22. Kampong Krasang (77)*

Figure 3: *Map of communes and main villages in and near BPL (villages clustered per commune – Romenh, Prey Khhla, Krapum Chhluk, Prey Yuthka, Chey Chouk, Kampong Krasang – and ranked based on number of households) (*selected for VA, see section 3.2)*

In addition to local villagers, BPL is also frequented by people from across the border in Vietnam. There are tensions between the local population and transient Vietnamese farmers and fishers; the border between the countries is porous and the differing levels of economic development and opportunity between the countries causes some xenophobia and resentment.

2.2.2 Key livelihood activities

The majority of people in BPL (97%) are involved in the cultivation of rice (outside and inside the Protected Landscape), followed by cattle raising for selling (56%) and fishing (51%) (Figure 4) (Sophanna 2017). Hunting and collection of other food sources may also contribute to people's livelihoods, however, it was not mentioned among people's main livelihood activities.

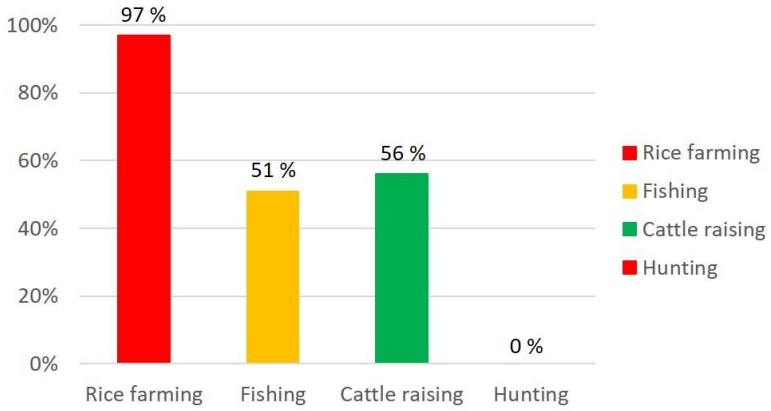


Figure 4: *Main livelihood activities in and near BPL (Sophanna, 2017)*

[4]According to the map, Tara Kum is located within Prey Yuthka Commune, but it officially belongs to Chey Chouk Commune

While rice cultivation is common among all communes, there are clear differences between communes. Communes in the western part of BPL (the upper areas) rely more strongly on cattle raising, while people in Chey Chouk and Kampong Krasang in the eastern part of PBL (the lower areas) rely more strongly on fishing. Only about 20% of the people in the lower communes raise cattle, most likely because the terrain is too close to water bodies, making it difficult to raise livestock in the rainy season.

Table 3 highlights livelihood activities and the relation to seasonal variations.

Table 3: *Seasonal calendar of livelihood activities of communities in and around BPL*

Livelihood activities/Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rain fall													
Rice farming	Upper areas												
	Lower areas												
Fishing													
Labor outside village	Upper areas												
	Lower areas												
Income	Upper areas												
	Lower areas												
Getting loan	Upper areas												
	Lower areas												
Expenses	Upper areas												
	Lower areas												
Wedding and festivals													
Disease													
Food insecurity													

Note: In July there is not as much rain as in other months of the wet season

Most villagers in lower areas cultivate rice twice a year, starting in December/January up to early July; however, most of them are not able to get a good income from the second crop because of early rains during the wet season. People in the upper areas grow rice once a year or twice (using short-term varieties), starting late July – when the rains are less – up to December. People complement their income through fishing and by working outside the village in the non-rice farming season. Income is often less at the start of the wet season when early rains make it difficult to grow and harvest rice, while storms prevent people from fishing. In preparation for the rice season, most villagers obtain small loans for petroleum, tractor rental, and seeds; people in the lower areas may also borrow money for buying rice when they run out of food; expenses for religious festivals[5] and weddings, which take place from November to May put additional pressure on finances during this time of year. The end of the dry season is usually associated with various diseases due to the hot weather and lack of fresh drinking water, while food insecurity, mainly in the lower areas, is a problem during the late wet season.

2.2.3 Use of wetland resources

BPL is essential to the livelihoods of local people who depend upon wetland resources, including fish, edible plants, firewood, and grass and water for farming. An assessment in

[5]Buddhism is the largest religion practiced by people living in and around BPL.

2012 of 428 households (10% sample size) from 19 villages in and around the reserve found that almost 68% collected natural resources from BPL (van Zalinge *et al*. 2013b). The widespread conversion to rice is therefore likely to result in a reduction in ecosystem values to local people.

The assessment also calculated the net annual value derived from harvesting "wild goods" (fish and other wetland products) and rice cultivation (see Figure 5). Wild goods made up 74% (US$1,601,799) of a total net annual value of US$2,168,019 for all food provisioning services derived from BPL. Fish alone represented half the value of all provisioning values at US$1,096,107 per year. This calculation is based on the surveyed villages and did not include value derived by people of Vietnamese origin or other villages surrounding BPL.[6]

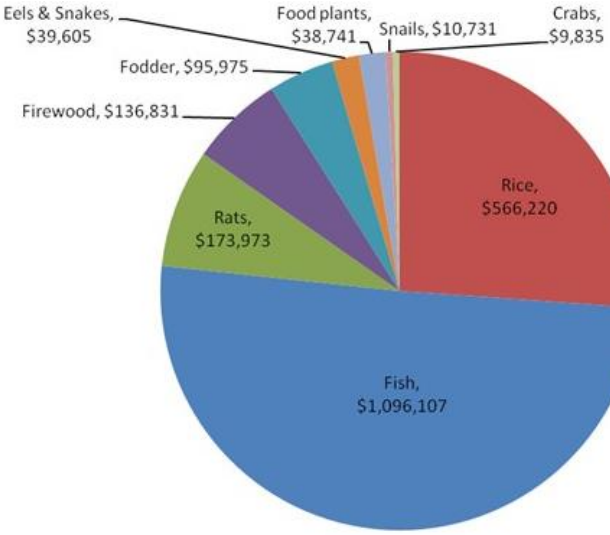


Figure 5: *Total net annual value of different products harvested from BPL (van Zalinge et al. 2013b)*

2.2.4 Land tenure and rights

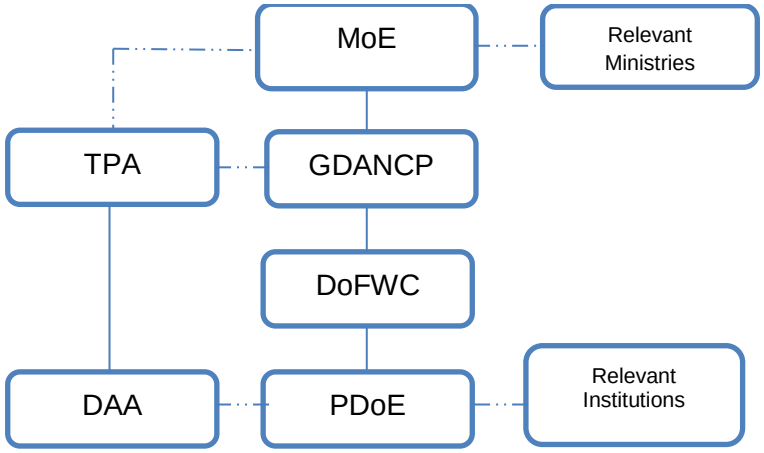
According to interviews with commune chiefs, most land in BPL is presumed to be owned by local people, although few hold official land titles.[7] The exception is land within Chey Chouk Commune where some people were granted land tenure certificates by Takeo Provincial Department of Cadastre (Kimhout 2004). According to the land law, private property and settling of land claims is based on the situation in 2001; land that was not under cultivation or settlement at that time is considered state property. Under the law, some of the land currently farmed in BPL would be considered private property after it has been used for at least five years without conflict; other land belongs to the state (RGC, 2001). Since people have been converting land to agriculture after 2001, and even after the area was designated as a Conservation Area, a full land tenure review is now underway.

2.2.5 Governance

The governance structure is displayed in Figure 2.6. Within MoE, the institution responsible for taking the lead management role is the Department of Freshwater Wetlands Conservation (DoFWC) of the General Directorate of Administration for Nature Conservation and Protection (GDANCP) and the Provincial Department of Environment (PDoE). The DoFWC and PDoE

[6]The fishing lot was just suspended, and local communities did not have access to the fishing lot in the dry season. Therefore, the total fish harvested by local people during the time of survey is likely to be less than it is now.
[7]In the 1980s the government encouraged people to live in BPL and allowed them to use and 'own' land without having certain legal documents.

cooperate with relevant authorities and institutions to conserve BPL. International NGO partners are WWT and BL.



MoE: Ministry of Environment
TPA: Takeo provincial administration
GDANCP: General Directorate of Administration for Nature Conservation and Protection
DoFWC: Department of Freshwater Wetlands Conservation
DAA: District Administrative Authority of Takeo province
PDoE: Department of Environment of Takeo province

Figure 6: *Diagram of governance and management structure of BPL*

2.2.6 Stakeholder analysis

There are various relevant stakeholders in and near BPL. Table 4 provides an overview of different types of actors, their main interests, and (potential) roles in the conservation and sustainable management of the wetland.

Table 4: *Actors, interests and (potential) roles in BPL*

Actor/interest	Organization and (potential) role
Government (implementation of government policy)	• *DoFWC (of GDANCP, MoE)*: Leads implementation. Oversees daily management together with PDoE and handles legal issues that require resolution and law enforcement. • *Rangers (led by PDoE)*: They are authorized to patrol against illegal activities within BPL to ensure sustainable management of the reserve. Currently, rangers, district policemen, the district fishery administration, and community fisheries are involved in collaborative law enforcement teams. • *Takeo administrative authorities (provincial, district, commune, village)*: Critical for implementation and need to be regularly involved in meetings, including the unified boards at provincial and district levels.[8]
Local community (depends on the wetland for their livelihood)	• *Community Protected Area (CPA)*: Does not yet exist, but based on the protected area law it is likely that a CPA will be established. Communities play an important role in the protection and sustainable use of natural resources and are encouraged to engage in law enforcement for conservation and livelihood improvement. • *Community fisheries (CFi)*: Until a CPA is established, community fisheries are invited to BPL management meetings and are involved in preventing illegal activities.
NGOs (biodiversity and wildlife conservation, natural resource management)	• *Wildfowl & Wetlands Trust (WWT)*: UK based conservation organisation specialised in wetland management and species recovery programmes. WWT has worked in BPL since 2000 and provides expertise/capacity building on biodiversity/hydrology, and wetland management. • *BirdLife International (BL)*: UK based conservation organisation specialised in birds. Started work in BPL in 2003. BL has a regional office in Hanoi and a Cambodia programme office in Phnom Penh working on bird species conservation and providing advice/support on the overall management of BPL. • *Chamroen Chiet Khmer (CCK*): Cambodian NGO based in Koh Andet district. Focuses on rural development, including natural resource management. CCK has worked in BPL since 2009 and collaborates with BL and WWT. • *NatureLife Cambodia*: Cambodian NGO that has previously partnered with BL will begin working in BPL on environmental awareness raising.

[8]Provincial/district boards include the governor, head of military and police, and departments/offices representing ministries

Other relevant actors	• E.g., agricultural NGOs, universities; Fishery Administration (FiA) of Borei Chulsar district and Koh Andeth district, Sustainable Rice Groups (groups of farmers formed by WWT to stop land encroachment and minimize use of chemicals)

2.2.7 Gender and vulnerable groups

Women and men may have different views based on their role in the community and the household. A flood-risk adaptation pilot project by Key Consultant Cambodia in 2015, identified the following general gender trends in the area. Men generally conduct land preparation, the application of fertilizers and pesticides, and field water management. Women are responsible for rice seeding, weeding, and the sale of crops and fish, and they are the main caretakers in the household, responsible for cooking, firewood collection, feeding animals, and financial management. Both men and women collect fish from local fixed fishing nets, and both groups work to collect other resources, such as rats, crabs, frogs and snails. Men are more likely to manage the boats, which includes wider and larger-scale collection of natural resources, e.g. commercial collection of water lilies (although women are often involved). Since, women and men have equal voting and membership rights in community institutions, there are opportunities to involve both groups in management decisions and activities.

In terms of vulnerability, people in the lower area in the eastern part of BPL are more likely to be negatively affected by the impact of floods and food insecurity than those in upper northwest area. Those in lower areas are generally poorer and mainly dependent on rice cultivation and fishing whereas the people in the upper western area have additional livelihoods, such as cattle raising. People from both sites of BPL may have different views and ideas on how to mitigate local problems.

2.2.8 Perceived threats to wetland habitats and livelihoods

The main perceived threats according to the communities are land encroachment, other illegal activities, and invasive non-native flora:

- **Land encroachment.** The agricultural encroachment on the land area of BPL has increased over the last 10 years, impacting biodiversity, destabilizing ecosystems, and altering habitats, especially those of the sarus crane. Although local people are involved in land encroachment, many farmers stated that the encroachment may be driven by some rich people from outside the area who are looking for extra agricultural land and benefits; these outsiders support local people to encroach land and once it is given to local people, they buy the land from them at a relatively low price.
- **Other Illegal activities.** Unsustainable fishing, bird and wildlife hunting, burning for rat catching, livestock grazing, inundated forest clearance and excessive use of agricultural chemical inputs are direct threats to BPL. Increased drainage of the site through hydrological interventions (e.g. canal building and pumping water for agriculture) is altering the hydrological state of the area.
- **Invasive non-native flora.** The invasive species *Mimosa pigra* is a major threat and has already been the subject of a control programme.[9] It out-competes native plant species that are vital for grassland habitats for the sarus crane. The spread of *M. pigra* also poses a threat for fish populations due to its sharp thorns that can damage non-scaled fish species. Water hyacinth is another invasive species. Its prolific growth and expansion on the water surface replaces native aquatic plants and reduces oxygen

[9] *Mimosa pigra* control depends on water levels and includes pre-flood control (June-August) and post-flood control (December-February). People are hired to remove the invasive species at a cost of US$95 per hectare. This method has been very successful in the short-term, but the species recovers after several years. Therefore, ongoing intervention is necessary (Yav, et al., 2014).

levels in already small and shallow waterways. It also blocks boat traffic along stretches of canals, streams and rivers in BPL.[10]

2.3 Climate projections for the site

The interaction between the social and ecological characteristics of the site are increasingly impacted by the effects of climate change. This section presents an overview of climate projections up to 2050 for BPL and is informed by ADB and ICEM's Final Inception report of the project '*TA-8179 CAM Mainstreaming Climate Resilience into Development Planning*' (ICEM, 2015).[11] It provides an indication of the type of changes that are expected and how this will affect the wetland.

Table 5 *Predicted changes to dry and wet season temperature and precipitation at BPL (ICEM, 2018)*

Variable (unit)	Season	Baseline	2050	Change
Max. Temperature (°C)	Dry	31.8	34.2	2.4 °C
	Wet	31.1	34.1	3.0 °C
Precipitation (mm)	Dry	271	259	-4.2 %
	Wet	999	1093	9.1 %

According to ICEM's online Climate Change Toolbox,[12] dry and wet season maximum temperatures at BPL will increase by 2.4°C and 3°C respectively; dry season precipitation will decrease by 4.2%, and wet season precipitation will increase by 9.1% (Table 5).

Site-based data provides useful direct information for BPL, but a more comprehensive understanding of climatic changes in the Lower Mekong Delta and the impact on the site requires a catchment and region-wide review of hydro-climatic and temperature changes.

Predictions for the wider region suggest that average maximum daily temperatures are likely to rise throughout Cambodia and the entire Lower Mekong Basin with an increase in seasonal variability in rainfall patterns (ICEM, 2015). Further up the Mekong River and around the Tonle Sap area, wet season precipitation is expected to increase substantially (see Figure 7) (USAID 2014; ICEM's (2015). This has implications for the extent, depth and duration of flooding throughout the country (ICEM 2015). Cambodia's floodplains may experience an increase in extreme floods with depths of 2.0 m. Fitting the national trend, it is likely that the duration of floods at BPL will also increase, although this may remain limited to 3-7 days (see Figure 9).

The northeastern part of the country will experience an increase in dry season rainfall, but around the Tonle Sap area and BPL there will be a decrease in precipitation during the dry season (Figure 8). The period of annual drought in the Mekong floodplain is likely to increase because of the changing climate, although BPL is in one of the few areas in the region for which a relatively stable drought duration over the next 30 years is predicted (see Figure 10). However, combined with large upstream dam construction projects and local irrigation systems, the area may still suffer prolonged and more severe water shortages.

[10]Water hyacinth can be used to make compost and when dried, the long stems can also be used as raw material for making furniture, mats and hammocks.

[11]This project was initiated to support infrastructure and development agencies with information on climate change and associated hydrological effects for understanding future vulnerabilities and planning resilience mechanisms.

[12]http://icem.com.au/CambodiaCC/

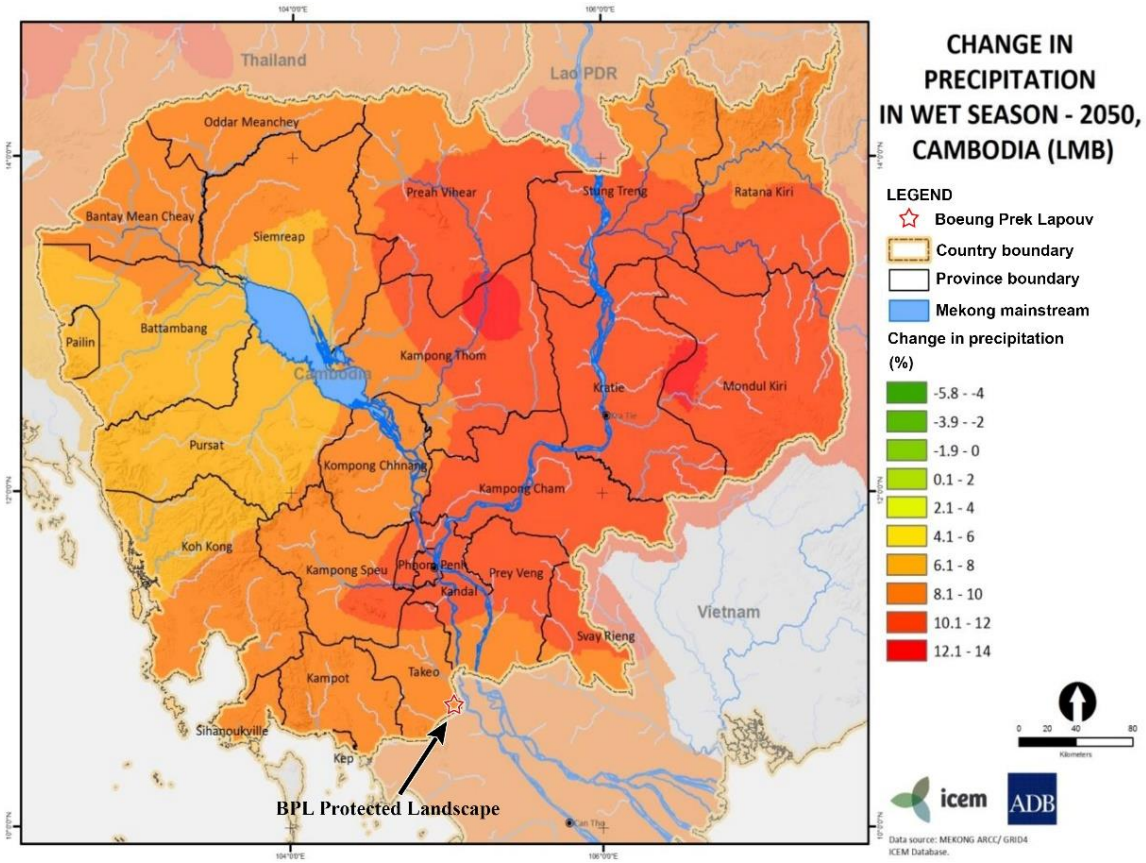


Figure 7: *Rainfall change in the wet season by 2050 (ICEM 2015; BPL indicated)*

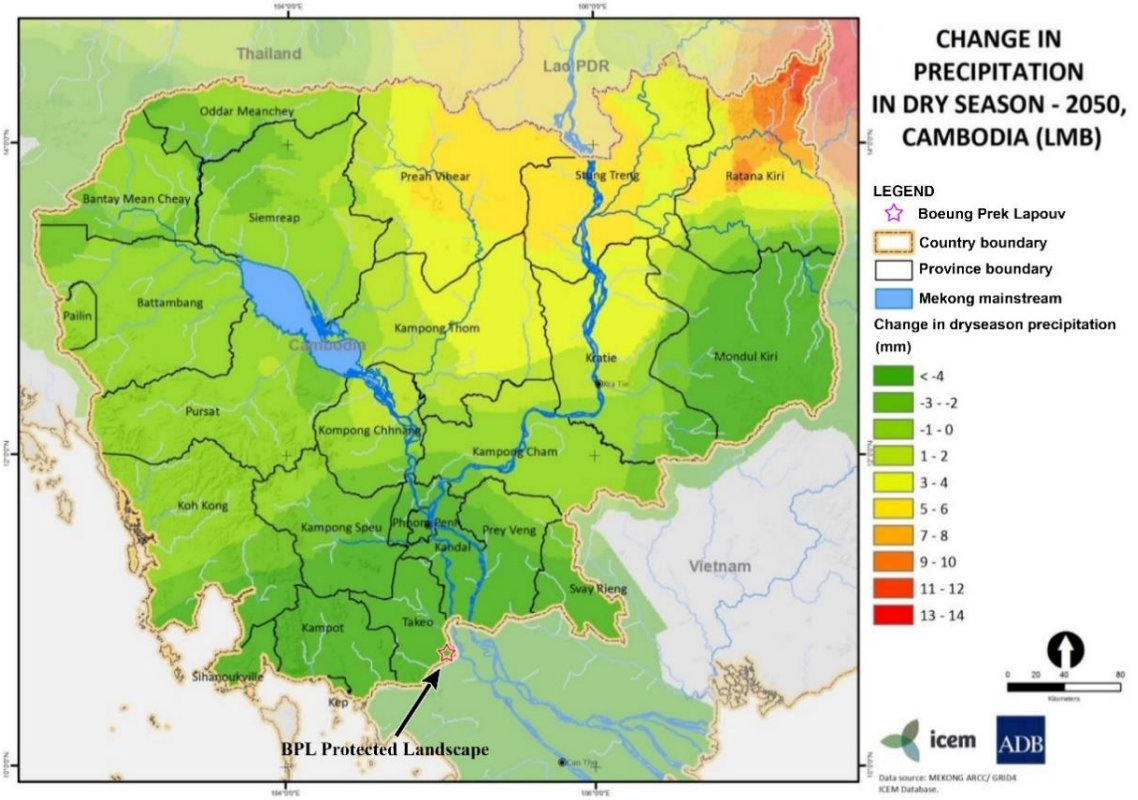


Figure 8: *Rainfall change in the dry season by 2050 (ICEM 2015; BPL indicated)*

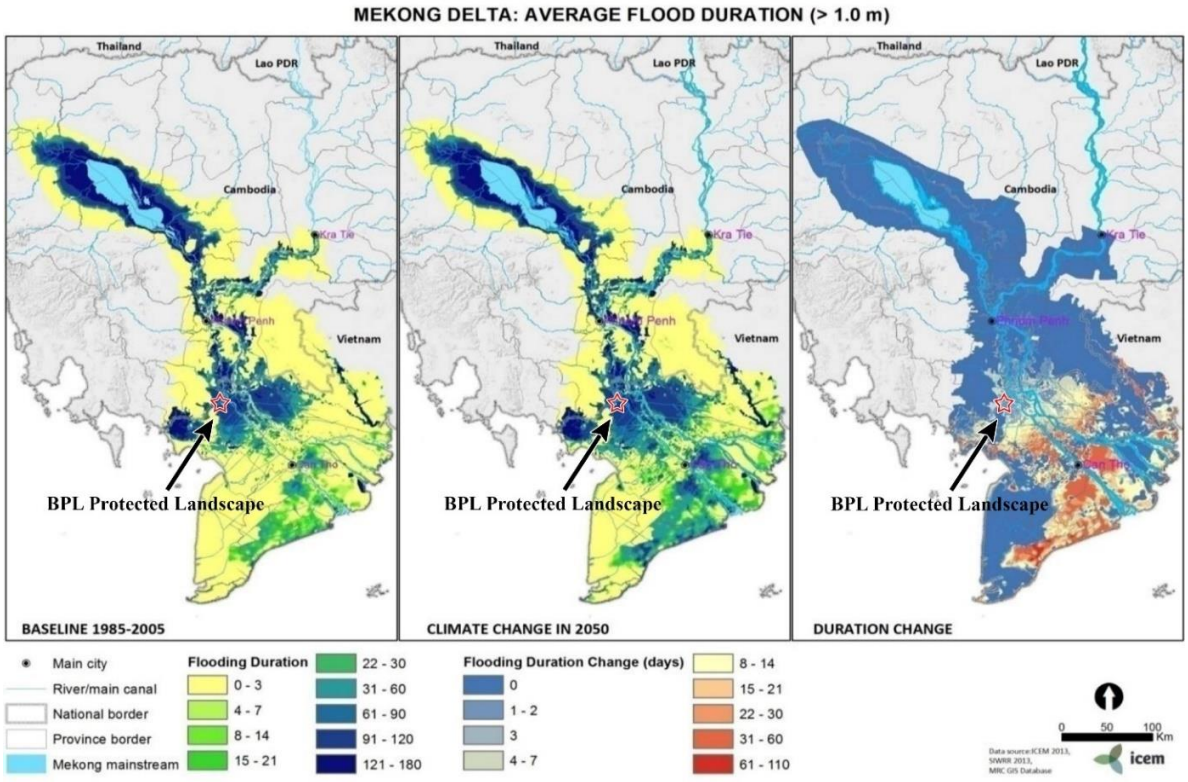


Figure 9*: Projected flooding in the Mekong delta and floodplain – 2050 (ICEM 2015; BPL indicated)*

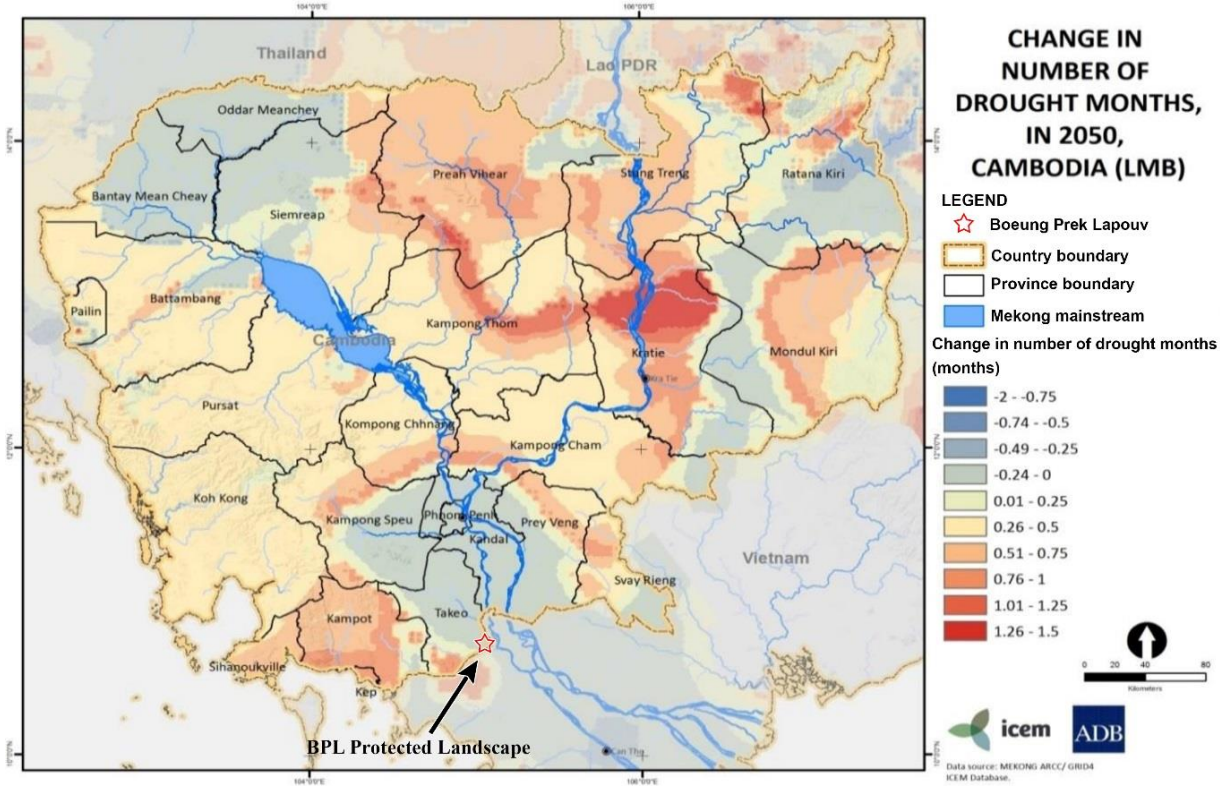


Figure 10: *Change in number of drought months per year by 2050 (ICEM 2015; PBL indicated)*

3 VULNERABILITY ASSESSMENT

3.1 Habitats

A vulnerability assessment of key habitats (see section 2.1.4) was conducted through group discussions and consultations. Each habitat was first assessed in terms of its representation in the site and the larger region, its tolerance to disturbances (e.g. land conversion, invasive species, extreme weather events), the presence of important flagship, keystone, and economically relevant species, as well as the current level of protection. These aspects provide an indication of the current risk status and importance of additional protection measures, expressed as a score for 'baseline conservation status', varying from 1 (low) to 3 (high).

These same habitats were then assessed in terms of their vulnerability to projected climate change (see section 2.3). Potential impacts on each habitat were explored by examining their exposure to specific climate changes, the sensitivity to the projected changes, and capacity to adapt to them. The overall analysis was expressed as a score for 'climate change vulnerability', also from 1 (low) to 3 (high).

The overall results of the vulnerability assessment are summarized in Figure 11.

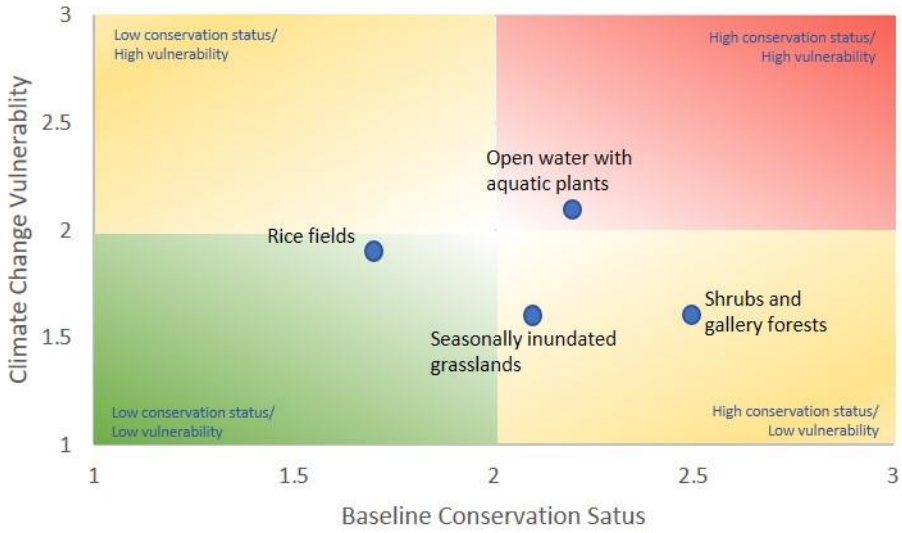


Figure 11: *Baseline conservation status and Climate change vulnerability for the main habitats at BPL.*

Overall, open water with aquatic plants was determined to be the most vulnerable habitat to the impacts of climate change. The other habitats are less at risk from climate change, but seasonally inundated grasslands and especially shrubs and gallery forest play an important role in BPL and need specific attention. Moreover, differences in assessment values were relatively small and because habitats influence each other, all habits should be considered when developing adaptation plans. The results of the assessment are discussed in detail below for each habitat.

3.1.1 Open water with aquatic plants

Open water habitats are slowly declining as people fill in the canals for use as rice fields. This habitat covers around 13.7% of the wetland (Figure 2, section 2.1.4). Although similar areas

are found in the region, they are increasingly converted into agricultural land. This habitat is made up of many different types of plants, such as *Paspalum paspaloides*, *Nymphaea* (water lily), *Nelumbo nucifera* (lotus), and morning glory; many of which need inundation for regeneration. The habit is home to various flagship species such as the painted stork (*Mycteria leucocephala)*, cranes *(Grus Antigone)*, pelicans *(Pelecanus philippensis)*, spot billed ducks (*Anas poecilorhyncha)*, Asian open bills (*Anastomus oscitans)*, and fish species, including kontor (*Trichopodus pectoralis)*, sdor *(Channa micropeltes)*, domrey *(Oxyeleotris marmorata)*, and kol raing (giant barb) (*Catlocarpio siamensis)*. Water lilies play a critical role in the ecosystem as food source for various species. Economically important species include different types of fish, water lily, lotus, morning glory, snail, kachet, and *Sesbania sesban*. There is a growing problem with invasive species. Due to the high use of fertilizers, water hyacinth and lotus have become so dominant at certain places that they restrict the photosynthesis of other aquatic plant species. This leads to a decrease in dissolved oxygen in the water, affecting various fish species. Other threats include agriculture and land encroachment. Extreme weather events can be problematic because water lily recovers very slowly. Despite its protected status, extra measures are necessary to protect this habit, resulting in a moderate to high baseline conservation status (score 2.2).

This habitat is strongly exposed to climatic changes in the dry season: increased evaporation due to higher temperatures and extended droughts result in lower water levels and fewer ponds and streams, while canals will be smaller and shallower. Already harsh conditions at the end of the dry season will be exacerbated. These conditions will stress aquatic species such as various types of fish species and water lily, including the flagship species that depend on them. Although the annual vegetation regenerates relatively fast, there is not much space for the habitat to expand to other areas or adapt to the new conditions. Higher temperatures during the wet season with increased risk of floods should not be a major stressor. Increased precipitation during the wet season may help to restore water levels and conditions of the habitat. Overall, the habitat's vulnerability to climate change is mainly confined to the dry season (score 2.1).

3.1.2 Seasonally inundated grassland

Over the last 50 years, seasonally inundated grasslands have decreased faster than any other habitat in the region, including within BPL. Grass fields covered almost 2,000 hectares (24%) in 2016, but the area has been reduced by more than 10% over the last decade. The habitat contains a large number of plant species and is favourable as a feeding ground for many flagship species including the sarus crane, painted stork, Asian openbill, greater adjutant, and spot-billed duck; sarus cranes also use inundated grasslands for roosting. The grass is also an important economic resource; it has market value for feeding livestock, while local people hunt for rats, snakes and small turtles in the grassland. Invasive species and land encroachment are the major threats to this habitat. Grassland recovers relatively quickly from extreme weather events but needs regular flooding for regeneration. Overall, the baseline conservation status was just above average (score 2.1), reflecting both positive and negative influences on habitat characteristics.

The habitat is not highly vulnerable to climate change (score 1.6). Flooding is a key characteristic of seasonally inundated grasslands and it can easily adapt to and recover from changes in precipitation and flooding. Extended drought may affect the habitat when the temperatures increase. However, during the long hot droughts in 2015 and 2016, the grasslands were able to recover quickly, while no grassland fires were recorded.

3.1.3 Shrubs and gallery forests

This habitat has a high conservation value (score 2.5). Shrubs and gallery forests only cover a small proportion of the wetland and the area is slowly shrinking, both in BPL and regionally. The habitat is made up of many plant species that require flood for regeneration. The habitat is home to many different flagship and key stone species, including the painted stork, Asian openbill, greater adjutant, and spot-billed duck. Various economically important species are found in the wetland such as fish, rats, snails, snakes, and turtles, supporting livelihoods. This habitat plays a vital role in sustaining fish resources by providing spawning grounds for various fish species; this is especially important given that fish represents half of the total economic value provided by BPL. This habitat is sensitive to disturbance and needs careful conservation. Based on observations, people referred to the loss of typical species as raing trees *(Barringtonia acutangula Gaertn)*, snao kook (*Sesbania sesban)*, khdol trees (*Nauclea orientalis*), anh nhanh trees *(Gmelina asiatica)*, tros trees *(Combretum trifoliatum Vent)*, and nhoor prey trees (*Morinda pandurifolia*) due to firewood collection and agriculture. Invasive species are a serious problem. Bindweed covers large areas of the habitat, leading to restricted growth of flooded forests. Moreover, the habitat recovers slowly from extreme weather events, such as the long droughts in 2015 and 2016.

While shrub and gallery forests are very vulnerable to current (non-climatic) threats, they are not particularly vulnerable to the impact of climate change (score 1.6). As previously mentioned, the habitat plays a significant role in sustaining and providing habitat to different species, including birds, fish, and others. According to historical observations from local people, an increase in precipitation does not cause any threat to the ecosystem. This habitat may actually benefit from the increase in precipitation and exposure to floods through the availability of nutrients from sediments. Previous weather events showcased the resilience of shrubs and gallery forests to extreme floods in 1991 and 2001. However, higher temperatures may lead to forest fires and forest stunting. In addition, the habitat is moderately vulnerable to extreme weather events like typhoons and high winds that can fell and damage trees. Although shrubs and forests can recover quickly, this could become more problematic when the frequency and intensity of extreme weather events increases.

3.1.4 Rice fields

Baseline conservation status for this habitat was considered low (score 1.7). Rice fields have expanded regionally and by more than 10% in BPL over the last four years. The fields have a high economic value for local people but are biodiversity poor. Still, several characteristic bird species have been observed, such as the greater adjutant, sarus crane, painted stork, and Asian openbill, which use the area for feeding. Some species play critical ecological roles in the rice fields, such as the nitrogen-fixing *Sesbania sesban*, and certain frog species that predate on pests that can destroy the rice crop. Invasive species such as the golden apple snail and *Mimosa pigra* are serious problems. Rice fields recover relatively quickly from extreme weather events.

Rice fields were assessed as being moderately vulnerable to climate change (score 1.9). The local community perceived the increased risk of floods as beneficial for rice cultivation due to the enrichment of soil fertility through sediment delivery, although this could be restricted by upstream dam construction. Early precipitation or flooding can also impact late dry season rice during harvest time. The impact of a 3^{o}C increase by 2050 will have a greater impact; rice fields tend to become affected by longer droughts and exposure to the hot sun. In the long term, water supply to the rice field could become problematic, as people upstream may need more water.

3.2 Community and livelihoods

The status and vulnerability of various ecological habitats to non-climatic and climatic threats has a direct impact on local livelihoods. The habitats are home to various plant and animal species that play an important role as a resource for food, livestock feed, fuel, and construction. Therefore, a village VA was conducted to assess the impact of climate change on people's livelihoods.

Representatives from ten villages in and around BPL were invited to the village vulnerability assessment using participatory rural appraisal (PRA) tools (Figure 3).[13] The participants included villagers, the site manager and representatives from commune councils, community fisheries, and local NGOs. Many participants were previously involved in the conservation programs and have a comprehensive understanding of the current situation. Among the 35 participants, a third were women. Several participatory tools were used to evaluate the linkages between resource use and the impact of extreme weather events and climate change, and coping mechanisms used by the communities (see Box 4).

Box 4: *PRA tools used to assess the impact of climate change on people's livelihoods*

PRA tools are easy to use visual tools that help to mobilize people and reveal local knowledge. Social and economic data collection focused on resource priorities, resource mapping, the seasonal calendar of resource use, historical timeline of extreme weather events, and group discussions on coping behaviour and wetland management. The needs and perspectives of women and men were included through separate focus groups.

For example, after an initial resource priority ranking, the VA team continued with a resource map. People were asked to draw the BPL landscape and were provided pictures of the top ten wetland resources. Then villagers drew key villages, canals and streams and placed the pictures on the map. It allowed participants to locate resources they extract from the reserve. Discussions helped to identify patterns and exchange findings with outsiders, creating positive energy among participants and the VA team.

(Photos: Resource mapping activities by local people).

3.2.1 Resource dependency

Table 6 provides an overview of the 10 most important wetland resources used by people in and near BPL. The most important resources are: fishes, grasses, rats, crabs, water lilies,

[13]Villages selected were: Keo Kampleung, Banteay Thleay, Deum Kroch, Trapeang Tonle, Chroy Poan, Chambok Em, Prolay Meas, Dei Leuk, Banteay Sloek and Kampong Krasang.

bromat dei (*Mazus japonicas*), snakes, firewood, frogs and eels. Of these, firewood is an energy source, while grass is used as livestock feed; others are used as a food source for people or are processed and sold at the market. While women and men agreed on the most important resources such as fishes, grasses, rats and crabs, there were some notable differences. Women valued frogs and snakes much higher than water lilies for their economic value, because water lilies are scarce in the dry season.

Table 6: *Ten most important resources mentioned by participants from the villages (M=male; F=female)*

Nr.	Rank (M/F)	Item	Use	Local names of main species utilised
1	(1/1)	fish	Selling, making Khmer cheese, eating	*Black fish:* kranh (*Anabas testudineus)*, phtorkk *(Channa striata)*, kom phleanh *(Trichohodus trichopterus)*, konthor *(Trichohodus pectoralis),* andaeng (*Clarias microcephalus*), chhdor *(Channa micropeltes)* *White fish:* linh *(Thynnichthys thynnoides)*, chhkork *(Cosmochilus harmandi),* chro keng (*Puntioplites proctozysron)*, kes *(Kryptopterus bleekeri),* ta orn (*Ompok eugeneiatus),* kanh chos *(Mystus albolineatus)*, kok (*Zenarchopterus dunckeri*)
2	(2/2)	grass	Livestock feed, selling	kromhorm mormis, phleng phlorng, krek, chungkong kriel, derm sor, chanh cherm brovoeuk, sragner
3	(3/3)	Rat	Selling and eating	Rice field rat (*Rattus argentiventer*) (kondor bay and kondor preng)
4	(4/4)	crab	Selling, eating, used for other foods	Krorng *(Somaniathelpusa sexpunctata)*, sro gner *(Somaniathelpusa sp.)*
5	(5/8)	water lily	Selling and eating	*Nymphaea nouchali* (brolit bay, brolit krobei)
6	(7/7)	bromat dei	Selling and eating	bromat dei *(Mazus japonicus)*
7	(9/6)	snake	Selling and eating	samlab kangkep *(Xenochrophis piscator)*, brolit (*Enhydris enhyris)*, chanlmorng (*Enhychis bocouti)*
8	(6/9)	firewood	Selling, fuel	banla youn *(Mimosa pigra),* phnek preap *(Breynia vitis-idaea)*, snor *(Sesbania sesban),* anh chanh *(Gmelina asiatica)*
9	(10/5)	frog	Selling and eating	kangkep thom *(Limnonectes kuhlii)*, kangkep arch ko *(Fejervarya limnocharis)*
10	(8/10)	eel	Eating and selling	an tong tomda *(Ophichthus rutidoderma)*, an tong domnerb *(Monopterus albus)*

A resource map was development with the local community to provide deeper insight on the spatial distribution of the most important wetland resources in the community (see Box 4). Villagers drew key villages, main canals and streams and then placed pictures of the top ten resources in the areas where they are collected. Resources were not confined to specific areas but spread throughout the landscape. Most fish are caught from canals inside BPL and particularly from the restored Prek Lapouv canal. Water lilies can be found in canals and water bodies, while bromat dei is mainly found along the canal bank within the reserve. Firewood is collected from shrub and gallery forests near the canals. Grass is found in the middle of the former core zone and, just before flooding, throughout other parts of the reserve. Eels, snakes, and crabs can be found in canals and water bodies, and frogs are within canal banks.

Table 7 presents the seasonal calendar of wetland resource use and collection. It gives insight in the exploitation of the most important resources over a one year period against key environmental conditions. People start fishing after the onset of the wet season in July until the end of March when the lakes and canals are drying up. Grasses can be collected year-round. Most economically relevant species are collected during the wet season until the end

of December. Rats and frogs are hunted from May onwards, while people start to collect crabs, water lilies and eels in July. People start collecting firewood at the end of the dry season in April when they can walk into the reserve. The resource remains available until early June.

Table 7: *Seasonal calendar of wetland resource use/collection*

Resources	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rain												
Fish												
Grass												
Rat												
Crab												
Water lily												
Bromat dei												
Snake												
Fire wood												
Frog												
Eel												

3.2.2 The impact of climate change on resources

Participants were asked to recall extreme weather events from the last ten years to assess the impact of climate change on the most important wetland resources. They were also asked to consider the impact of these events on wetland habitats and important species. Seven types of extreme events were mentioned: droughts, storms, floods, extreme heat, lightning and thunder, flash floods, and storm surges (Table 8).

Table 8: *Historical timeline of extreme weather events and impacts*

Extreme event	Date	Effect on wetland habitats and important species
Drought	2010, 2015, 2016	Severe drought in 2016. Grasslands dried up and died in some areas, flooded shrub and forests lost their leaves, birds left, and fish in open water were severally affected. About 90% of rice fields in the upper area were damaged. Farmers in lower areas only lost 10% but had to increase expenses by pumping extra water in their fields. The health of both humans and livestock was affected.
Storms	Every year during Sep-Oct	No impact on grassland and open water habitats and limited impact on shrubs and flooded forest, but 50-60% of rice fields were affected. In 2016, rice fields lacked sunlight (cloudy) for 16 days, impacting rice growth and reducing rice harvests to 70-80% compared to other years.
Floods	2011	Some impact on grassland habitats (flash floods killed young grasses). No impact on shrubs, flooded forests or open water habitats. Rice field habitats gained fertility as a result of flooding.
Extreme heat	2014, 2015, 2016	Little impact on grasslands and shrub and flooded forests but affected fish in open water. Some impact on rice fields, but farmers minimized impact by pumping water into their fields.
Thunder and lightning	2014, 2015, 2016	Little impact on habitats, but people and livestock lost their lives.
Flash floods	2011, 2014, 2017	Little impact on habitats, but flash floods in July of 2017 damaged rice among 70% of the farmers.
Storm surges	2016, 2017	Little impact on habitats, although some rice fields were affected.

Storms were identified as annual phenomena with significant impacts on rice yields. Events like flooding, heat waves, thunderstorms and storm surges have been occurring more frequently in recent years, with varying degrees of impact. By far the most devastating weather

phenomena in the last decade have been droughts. Events in 2010, 2015 and 2016 caused grassland and flooded forests to wither, drove away birds, killed fish, affected the health of people and livestock, and made it economically difficult for many rice farmers in BPL.

As harmful as many of these weather events were, however, community members maintained that disturbances such as land encroachment, shrub-burning, agricultural runoff, bird poaching, illegal fishing and several other activities had impacted BPL far more severely. Climate change related phenomena were perceived to have more of an impact on the livelihoods of people than on the habitats around them. Both women and men reported similar impacts:

- Droughts: rice damage, disease to humans and animals, and lack of water (1 in 5 years)
- Floods: rice damage, disease to humans and animals, and lack of food storage (1 in 10 years)
- Storms: house damage, daily livelihood restriction, and rice damage (1 in 3 years)
- Extreme heat: crop damage, disease, and lack of water source (1 in 3 years)
- Flash floods: rice damage, disease, and house damage (1 in 3 years)
- Lightning: human danger, livestock danger, and palm tree destruction (1 in 3 years)
- Storm surge: some impact on rice (1 in 3 years)

3.2.3 Coping and management

Coping mechanisms for extreme weather events and climate change provide a good indication of the people's adaptive capacity. While most community members were mainly interested in the impact on people's lives and livelihoods, their activities are also directly and indirectly linked to the environment, and the habitats and resources of the wetland.

Table 9 provides an overview of how men and women currently cope with the impact of extreme weather events. Most responses are rather passive. Both men and women provided similar answers: *'let it be', 'go to the health centre when sick', 'get a loan or ask children for money', 'repair houses'* etc. One of the more interesting strategies to cope with droughts, which may also have a positive impact on open water with aquatic plants, is canal restoration so that it can retain more water. However, its main purpose would be to use the water for domestic or even agricultural purposes, thus water use from canal should be regulated in the future. Rainwater collection can reduce stress to water sources in the canal and ponds. Rainwater might be relatively clean compared to that from the canal, thereby reducing the risk of disease.

Table 10 provides an overview of what men and women would do when the impact of climate change becomes more prominent. Through group discussions, they proposed to cultivate dry season rice earlier just after Khmer New Year in mid-April and harvest it before the floods in July. Another significant coping strategy is to grow alternative crops around their houses. The strategy can provide additional food for daily consumption and reduce the family financial burden. In addition, people are willing to raise more livestock for household use and selling if more than needed. This, together with alternative crops, can reduce the impact on wetlands.

Table 9: *Impact of extreme weather events and current coping activities of men and women.*

Events	Impact	Current coping activities (Men)	Current coping activities (Women)
Drought	Rice damage	Increase pumping water from wetland	Asking commune chief for canal digging for next year
	Disease to human and livestock	Humans: go to health centre or pharmacy and buy medicine; Livestock: call for vet	Go to health centre or refer to district health centre if serious
	Lack of water	Capture rain water; buy from vendors for daily use/drinking	Piped water for upland people; pump water from canal to pond using money from household
Flood	Rice damage	Let it be, no intervention	Do nothing
	Disease to humans and livestock	Humans: go to health centre or pharmacy and buy medicine; Livestock: build cattle shelter	Human: coughing, public health centre and private clinic; Livestock: take them to vet
	Lack of food storage	Loan and depreciation for extra food and selling labour	Lend food/rice; ask money from children who work as labourer
Storm	House damage	Repair house	Call for help from Red Cross
	Restricts daily activities	Loan and depreciation for extra food	Stay at home and do nothing
	Rice damage	Let it be, no intervention	Tie rice together or use sticks to raise up rice
Extreme heat	Crop damage	Increase pumping water from the wetland	Pump water to supply crop; put more fertilizer
	Disease	Humans: go to health centre or pharmacy and buy medicine; Livestock: Call vet for cattle	Human: diarrhoea, go to hospital, public health centre/private clinic; Livestock: diarrhoea go to Vet
	Lack of water source	Capture rain water; buy from vendors for daily use/drinking	Pump water from canal or pond
Flash Flood	Rice damage	Let it be, no intervention	Do nothing
	Disease	Humans: go to health centre or pharmacy and buy medicine; Livestock: build shelter	Human: coughing, public and private; Livestock: go to Vet
	House damage	Repair house	Repair, call for help
Lightning	Human danger	Let it be, no intervention	Stay at home; not hold metal instruments; turn off phone
	Livestock danger	Let it be, no intervention	Do nothing
	Palm tree destruction	Let it be, no intervention	Do nothing
Storm surge	Rice damage	Let it be, no intervention, loan and restore	
	House damage		

Table 10: *Impact of extreme weather events and future coping activities of men and women*.

Events	Impact	Future coping activities (Men)	Future coping activities (Women)
Drought	Rice damage	Canal restoration	Canal restoration; catching rats; move to the city or other country for work
	Disease to human and livestock	Inform relevant institution to help with treatment	Human: go to health centre; living in clean environment, drink/eat healthy water and food; Livestock: traditional medicine for animal; clean their sheds, call vet
	Lack of water	Pump water from canals, ponds, wells, rain water capture	Collect rainwater; pump water from canal to ponds (store); buy water from private vendors; pond restoration
Flood	Rice damage	Crop cultivation before flood season (before July)	Cultivate rice early (from April after Khmer new year); receding rice for all; alternative crops but just around house
	Disease to human and livestock	Listen to media/news	Human: drink boiled water, buy treated water, self-treatment; Livestock: water and wash it; keep animal at hill and in the net at night; selling chickens and ducks
	Lack of food storage	Getting loans, selling property, food preparation	Keep more rice for self-use; use traditional food from fish; raise more livestock; borrow food from others; selling cows
Storm	House damage	Fixing houses, listen to media/news, and methods to prevent damage	Save money to build stronger house; reinforce supports/walls to protect house
	Restricts daily activities	Food reservation	Stay tuned to the information through TV, radio, and stay at home
	Rice damage	Listen to media/news and grow rice by adapting to the season	Do nothing because rice field is very big
Extreme heat	Crop damage	Pump water from wetlands	Construct roof to reduce heat exposure by placing tree leaves/straw; heat tolerant rice
	Disease	Inform relevant institution to help with treatment	Human: try to stay at home rather than expose to sun; healthy food/water; clean the house; Livestock: traditional medicine for animal; clean their sheds, call vet
	Lack of water source	Restore wetlands and canals; pump water from canals, ponds, wells; capture rain water	Collect rainwater; pump water from canal/ wetland to ponds (store); buy water from private vendors; pond restoration
Flash Flood	Rice damage	Listen to media/news	Discharge water from field via small canal; use excavator to protect water entering
	Disease	Go to health centre and take medicine	Human: drink boiled water, buy treated water, self-treatment; Livestock: water and wash it; keep animal at hill and in the mesh net at night; sell chickens and ducks;
	House damage	Fixing	Repair and call for help from Red Cross
Lightning	Human danger	Turn off electronic devices and don't go out when raining	Stay at home; stay tuned to media for information
	Livestock danger	Keep cattle inside when raining	Do nothing since it is kept out side
	Palm tree destruction	Do nothing	Do nothing
Storm surge	Rice damage	Do nothing	Do nothing
	House damage	Fixing and get loan	

As a follow up, the site manager of BPL (working for the PDoE) and community representatives discussed current management measures and how these could be improved. The site manager and the ranger team conduct patrosl and educate local people about the reserve and environmental awareness. There are currently no strategies to protect key resources, except for the protection of fish and grasses (see Table 11). Restoring canals, preventing the use of chemicals to catch crabs, planting more flooded forests, encouraging the cutting of *Mimosa pigra*, and preventing forest and grass fires, are potential management options that could increase resource abundance (especially fish). The use of chemicals for rice cultivation needs immediate attention due to its impacts on water and soil quality and biodiversity, reverberating throughout the food chain and the system.

Table 11: *Wetland management during extreme weather events*

Wetland Resource	Use	Current management	Future Management
Fish	Selling, make Khmer cheese, eating	Restore canal, Remove *Mimosa pigra*	Restore all important canals, Protect and Plant more flooded forest; Remove *Mimosa pigra*; Restore the whole BPL lake since there is increase in sedimentation over years
Grasses	Selling and eating	Grass fire prevention	Grass fire prevention
Rats	Selling and eating	Do nothing	Protect flooded forest, and grass; No chemical poison for rat
Crabs	Livestock feed and selling	Do nothing	Stop crab poisoning with chemicals; Protect flooded forest, and grass; No chemical poison for rats
Water lilies	Selling, and Eating	Do nothing	Restore the canal; Educate local people not to harvest by removing its roots
Bromat dei	Eating and selling	Do nothing	Prevent chemical/pesticides used in the surrounding area
Snakes	Selling, eating, and make to other foods	Do nothing	Protect flooded forest, and grass; Prevention forest fire; Educate people to use sustainable catching;
Fire wood	Selling and Eating	Do nothing	Plant more flooded forest; encourage cutting *Mimosa pigra*
Frog	Selling; used as fuel	Do nothing	Prevent forest and grass fires; Carefully apply chemical pesticides; Restore canal
Eel	Selling and eating	Do nothing	Restore the canal; Educate local people not to catch the very small eels

The sustainable management of key resources provides a great opportunity for local people to create favourable conditions to adapt to climate change. However, for effective resource management, it is also important to look at the wider institutional and policy context. Annex 3 provides an overview of issues that are important to take into account, such as: cross border movements of people and poor awareness of wetland boundaries; illegal harvesting, limited control over levels of resource harvesting and inability to manipulate water levels; inadequate protection by existing laws and lack of land entitlement; the lack of community participation and the need to improve communication between government agencies; and the limited human and financial resources for management activities. Addressing these issues will require collective action and cooperation with management authorities.

3.3 Species

The species climate change vulnerability assessment focused on keystone, flagship and economically important species. BPL was originally granted legal protection due to its importance for the regional population of sarus crane (*Grus antigone*). Therefore, sarus cranes, and their primary food source, *Eleocharis dulcis* (water chestnut), were selected for the assessment. In addition, *Channa striata* (snakehead murrel) was selected since it is an economically important fish species for the communities. Baseline conservation status – a measure of the importance of protection – and climate change vulnerability for the three species are summarized in Figure 11; values varied from 1 (low) to 3 (high).

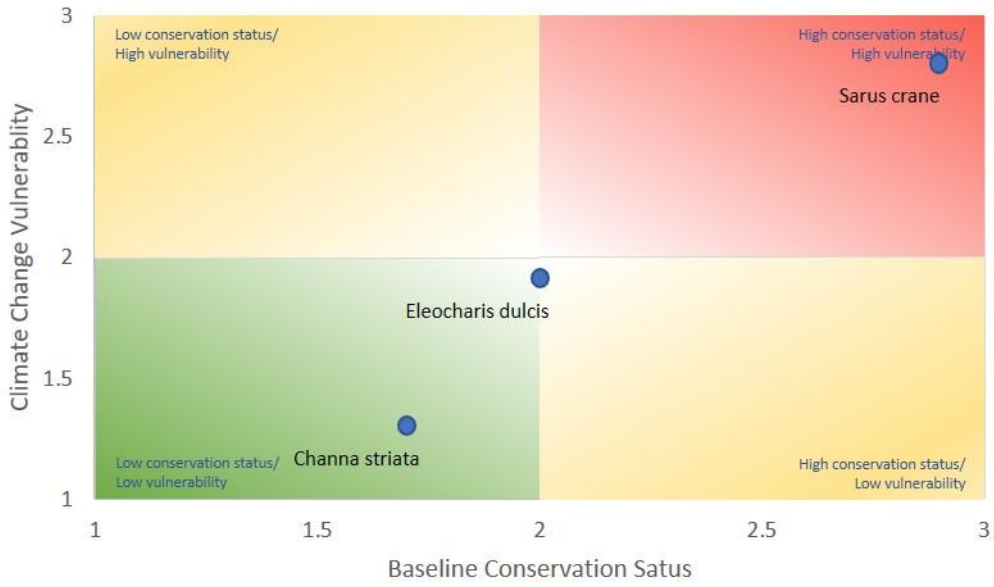


Figure 11: *Baseline conservation status and Climate change vulnerability for the sarus crane, Eleocharis dulcis, and Channa striata at BPL.*

3.3.1 Sarus crane

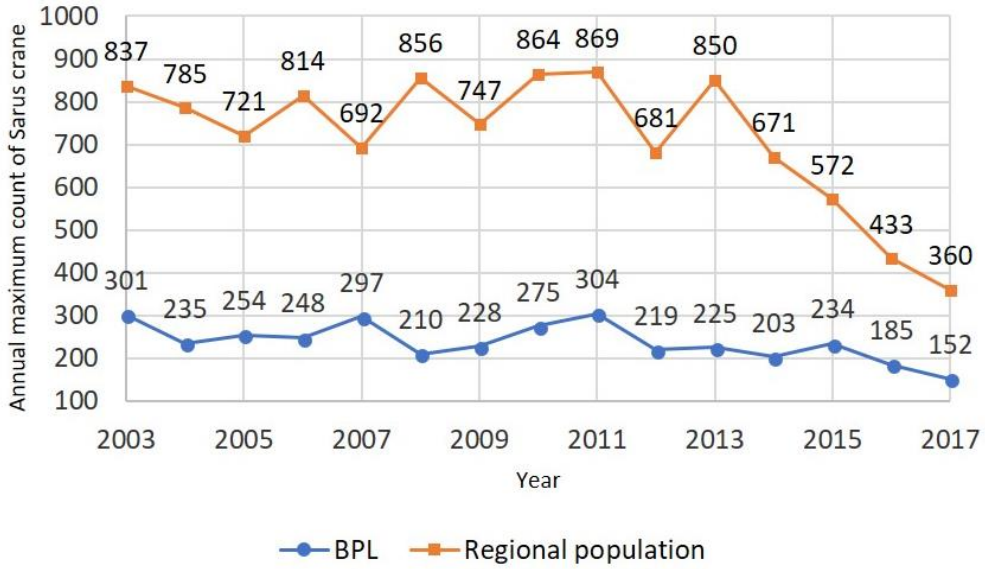
The population numbers of sarus cranes visiting BPL are well studied. Although numbers in BPL have varied dramatically over the last ten years, they seem to be consistent with population estimates for the regional population (Triet et al., 2017) (see Box 5). The dramatic downward trend of the regional population over the last four years is a major cause for concern. The reasons for this are poorly understood, but habitat loss and direct threats to cranes in their breeding grounds are likely to be the primary drivers. At BPL, it is essential that wetland conditions maximise the duration and quality of foraging for the cranes so that they are in the best possible condition when traveling to their breeding grounds.

The greatest threat to sarus cranes is the rapid drainage of water from the site once the flood starts to recede. This is most likely caused by the canals that were built in and around BPL for irrigation purposes (see 2.1.3). Once the site is too dry, sarus cranes cannot access tubers of *Eleocharis dulcis*, their primary food source, while opportunities to feed on supplementary elements of their diet (e.g. crabs and fish) are limited. The altered hydrology may also affect the growing conditions of *Eleocharis dulcis*. Sarus cranes are specialists in terms of habitat

selection and foraging and are now restricted to small pockets of seasonally inundated grasslands for winter season feeding. Their slow breeding rates mean that they are not very resilient to population crashes. Although the species itself is only listed as 'Vulnerable' by IUCN, this is the result of relatively stable populations in the Indian sub-continent and Australia. The health of the Indo-Burma regional population is precarious. Due to its biological and ecological characteristics and current threats, its protection needs are high, expressed in a very high value (2.9) for baseline conservation status.

Box 5*: Maximum number of sarus cranes per year in BPL*

BPL is one of three sarus crane Conservation Areas established by the Royal Government of Cambodia to protect sarus crane feeding areas during their non-breeding season. Between 2003 and 2017, the average annual maximum count for sarus crane in BPL was 238. The average maximum for the whole of Cambodia and Vietnam during the non-breeding season in January 2017 was 360 cranes (Triet et al., 2017).



The number of sarus cranes and the duration of their presence is highly variable between years as conditions become unsuitable towards the middle of the dry season. Cranes depart BPL when the site becomes very dry around late February/March but will sometimes return at the onset of the rainy season or when it rains consecutively for a few days. It is believed that the soils around late February become too dry and hard for the cranes to probe for food. Retaining soil moisture at suitable levels is crucial in managing BPL for sarus cranes.

At BPL, the species is highly vulnerable to drought and hydrological changes. The length of time that sarus cranes feed in BPL has decreased in the last decade, likely a consequence of increased drainage and water extraction. Severe droughts or prolonged dry seasons are likely to result in the cranes leaving to their breeding grounds in poorer condition. The main consequences of flooding are indirect, altering the period of inundation of the crane's food sources and changing foraging conditions, making their primary food source less accessible. There are very few seasonally inundated grasslands left in the Mekong Delta. Opportunities to find alternative feeding sites are therefore very limited. The small regional population, slow reproductive traits, and limited (known) adaptation behaviours, mean that it is unlikely that there will be adequate time or refugia for the population to successfully adapt to a changing climate in the region. Active conservation efforts will be essential for the survival of the species in BPL. The assessment score was 2.8, a score that indicates a high level of vulnerability of this species to climate change at BPL. Confidence in this assessment was considered strong, although the assessors acknowledge that there is limited current knowledge on heat tolerance and associated risks from other species, such as the potential impact of climate change on *Eleocharis dulcis*, the main food source of sarus cranes.

3.3.2 *Eleocharis dulcis*

Eleocharis dulcis is a fast reproducing plant species with a wide-ranging distribution in the region. Due to habitat loss, the species range has decreased over the last 50 years, but it is still likely to have a relatively high ecological connectivity. The species is resilient, recovering well from current flooding and seasonal droughts but does require specific ecological conditions, including seasonal inundation. A period of drought is required for the species to produce tubers, so constant inundation reduces the foraging value for the sarus crane, which primarily feeds on this part of the plant. It is presumed that there are few threats from current levels of direct human use or other non-human interactions, but the indirect pressures from water drainage and extraction have compromised the hydrological conditions, creating a longer period of annual drought. This appears to have exceeded the drought tolerance levels of *Eleocharis dulcis* in some parts of BPL as the area covered by this grass is decreasing. The baseline conservation status was assessed as 2.0. The species is unlikely to be of national or international concern, but given its key ecological function within BPL, it is essential that future climate change implications to the species are assessed.

Given the species' existing distribution throughout the region, *Eleocharis dulcis* is likely to be relatively resilient to the anticipated increase in temperatures at BPL based on the extreme drought events of 2015 and 2016. The predicted increased depth of floodwater during the wet season was not determined to be a factor that would affect the population or distribution of the species at BPL. Drought from a reduction in precipitation and direct threats from extreme weather were only considered to be moderate threats, but the consequences of wider long-term hydrological change were adjudged to have a more significant impact. Subjective assessments of species coverage at BPL suggest that the coverage is decreasing in some of the areas that are the earliest to dry up as the floodwater recedes. As the site is surrounded by actively managed rice paddies, it is unlikely that large wetter refuges will be available as suitable habitat for *Eleocharis dulcis* if extended periods of drought become commonplace. The fringes of agricultural habitats, villages and waterways are likely to ensure some habitat connectivity to the wider landscape. The species has a medium climate change vulnerability at BPL (score 1.9). It is likely that the species will remain in refugia in and around the site, but potentially not in the densities required by some of the key fauna that depend upon it.

Considering the commercial use of this species (commonly known as water chestnut) there is surprisingly little known about its ecology. Its precipitation, heat and hydrological tolerances are not well understood. If conditions remain within the physiological tolerance range, the species may be out-competed by more adapted species. This process has usefully highlighted the need for greater research into *Eleocharis* spp. in the Mekong Delta to enhance the understanding of a resilient optimal hydrological state to strive for in management.

3.3.3 *Channa striata*

Channa striata (snakehead murrel, but locally known as Asian snakehead) is an economically important fish species in and around BPL. It has a high market value due to high protein content, high quality flesh and health benefits (Annasari et al., 2012). An analysis conducted by Naret et al. (2002) showed snakehead to be one of the seven most common species in markets in Takeo Province. The same study showed that wild caught fish comprised 87% of fish found in Takeo markets, with Bourei Chulsar and Koh Andet among the highest contributing districts. The species is commonly caught in and around BPL, even by rice farmers who catch them directly from rice fields and trap ponds (ICEM, 2013). *Channa striata*

is common, fast reproducing and resilient, found in ponds, streams and rivers, but preferring the stagnant muddy water of plains (ICEM, 2013). Many migrate between permanent water bodies and flooded areas. They can also burrow into the mud of lakes, canals and swamps and, as long as their skin and air-breathing apparatus remains moist, they can survive through short dry periods (ICEM, 2013). They prefer stagnant water 30-100 cm deep and around 27°C for spawning (ICEM, 2013). The population is widespread throughout the region, and although optimal habitat has decreased over the last 50 years, the species' ability to inhabit rice paddies enables resilience despite agricultural encroachment into natural systems. The IUCN Red List report for *Channa striata* states that it is a widespread species with no known major threats and is currently assessed as Least Concern (Chaudhry, 2010). The VA Species Tool attributes the fish a low-medium baseline conservation status of 1.7.

The ICEM's USAID Mekong ARCC Climate Change Impact and Adaptation on Fisheries (2013) suggests that the species has a low vulnerability to increased temperatures because the projected temperature rises in the region are well within the tolerable range for this species. Their ability to tolerate low levels of dissolved oxygen makes them well adapted to challenging conditions caused by drought, providing that some refuges are available. Discussions with local community groups in BPL suggested that the species was able to bounce back quickly after a drought-induced population crash in 2015. Between 2015 and 2016 the species was not abundant, presumably a result of the extreme heat and drought leading to the drying up of perennial canals. However, in 2017 the population soared, possibly in part due to restoration of the Prek Lapouv canal, but also a sign of the species' resilience. Prolonged periods of drought may make the area unsuitable, but habitat restoration projects to retain water at the site for longer should ameliorate longer-term drought induced threats. Flooding would increase the breeding area for *Channa striata* so is unlikely to have a negative effect on the species. Flooding is also likely to increase flooded forest inundation, providing a suitable breeding habitat for the species. This assessment rated the climate change vulnerability of *Channa striata* to be relatively low, at 1.3. Given the quality of data on the species, our overall confidence for this assessment was very high.

ICEM (2013) considers the greatest threat to the Mekong Delta fishery to be disruptions to the cycle of inundation, which fuels fisheries productivity. Dam construction projects, navigation channel excavation and irrigation systems may disrupt fish movements and alter water levels. Given the low climate change vulnerability of this species, addressing other threats should be prioritised, while also considering how the impacts of those threats may be heightened by the consequences of climate change.

4 CONCLUSIONS

4.1 Summary of vulnerabilities

BPL supports some of the few remaining patches of seasonally inundated grassland in the Mekong Delta, providing livelihoods for thousands of people and precious habitats for threatened biodiversity. Under climate change, BPL is likely to experience higher temperatures, increased flash flooding, and a greater depth of flood during the wet season. Climate change is likely to generate a minor increase in drought period but combined with large upstream dam construction projects and local irrigation systems, the area may suffer prolonged and more severe water shortages.

Despite the importance of natural resource collection and other ecosystem services at BPL, the assessment highlights that there are few if any community-instigated natural resource management systems. The community had many good ideas on mechanisms to improve the productivity of natural resources, but there was clearly a perceived lack of capacity for individuals or small groups to affect change in natural resource yields under the current management system and high levels of illegal activity in BPL. When questioned on perceived livelihood vulnerabilities as result of anticipated changes in climate, the main concerns voiced were over the impacts upon rice cultivation.

Community groups thought that the impacts of climate change would have a more significant impact on local people than on biodiversity, presumably due to the resilience of seasonally inundated grasslands, tall grasses, shrubs and flood forests, and aquatic plant habitats during extreme weather events in the past. *Eleocharis dulcis* (water chestnut), a keystone species at BPL, is indeed likely to be relatively resilient to individual weather events, but in the longer-term, increased periods of drought and hotter dry and wet season temperatures may push the species beyond its tolerance thresholds. Although the species itself is unlikely to be extirpated from the area, the fauna that rely upon it, including the flagship sarus crane, are likely to abandon the site if there are not high enough concentrations of its primary food source, the tubers of *Eleocharis dulcis*. Given the lack of alternative feeding grounds for the crane and the currently decreasing population numbers, the viability of the regional population of sarus crane would be threatened without active intervention at BPL.

The majority of climate change coping mechanisms suggested by community groups were based on increased water security, and mainly involved the restoration and creation of canals, and increased water pumping. These coping mechanisms would have significant indirect consequences on biodiversity of the surround area. It is likely that natural resource security would decrease because of habitat loss, especially due to the loss of flooded forests, which provide essential habitat for fish and other economically important species. Despite this, local people deemed climate change to be an insignificant threat to habitats compared to land encroachment, burning, illegal fishing and the excessive use of pesticides and fertilizers.

4.2 Adaptation planning

Without active and adaptive management, it is likely that current livelihoods in BPL will become more precarious as habitats adjust in response to the changing climate.

There is a growing body of empirical knowledge on which to base future habitat planning at BPL. Information from ongoing water management trials, detailed vegetation assessments, avifaunal monitoring programmes and hydrological surveys are being combined with land tenure reviews, ecosystem service assessments, and this VA to inform the MoE's new zoning scheme and associated management planning process.

This new zonation scheme, developed as a result of the transfer of management to the MoE Protected Landscape system, is a unique opportunity to work alongside communities and

experts to ensure future-proofed sustainable natural resource management. With this assessment, managers can combine current ecosystem service data with future predictions to ensure that the local communities, habitats and species are supported to adapt to a changing future.

Local communities suggested several coping mechanisms for climate change. Diversifying rice varieties, creating improved storage mechanisms, and becoming more adaptable over rice harvesting periods are some of the more sustainable suggestions to increase resilience. Changes to water management or increases in fertilizers in response to drought and higher temperatures are likely to be made at the detriment of biodiversity habitats. This would have implications on ecosystem services and biodiversity. Increased water security for biodiversity habitat and local people should be a focus of future planning at the site. If systems can be created to increase water security, then the conflict between local people and biodiversity could be minimised. Rice is likely to remain the primary crop in and around BPL, with few people suggesting diversification to other crops during the community consultations.

Livestock is an important source of financial security for communities at BPL, with local people reporting that they sell livestock if crops are low yielding because of extreme weather events. Improved shelter, vaccination and access to veterinary support should be explored to increase security in this regard. Community-based natural resource mechanisms should be strengthened to increase people's capacity to improve yields which they will be able to benefit from in the future.

ANNEX I: HISTORICAL TIMELINE OF BPL PROTECTED LANDSCAPE

Period	Description
Before 1975	The site was mainly flooded forest and remained wet throughout dry season
1975 – 1979	People started to build small channels
1981 – 1991	People planted deep water rice
1986	Earliest recorded sightings of small groups of cranes
1991 – 1998	EU irrigation project created a system of canals for transport and irrigation. Increased dry season rice production in the area. BPL becomes drier earlier in the dry season (this general trend continues to present day).
2000-2001	Fishing lot #2 abolished and fish management handed to local communities in Kampong Krasang commune, eventually leading to a Kampong Krasang Community Fishery (CFi). An Inundated Forest Protection Zone of 1,500 ha is created within Fishing Lot #1.
2001 – 2003	First biodiversity (bird & mammal) surveys conducted. Site identified as one of Cambodia's forty Important Bird Areas (IBAs). Local conservation group consisting of personnel from Forestry Administration, Fisheries Administration and local authorities is established to curb illegal activities.
2007	Boeung Prek Lapouv Management and Conservation Area for sarus cranes is established, covering 8,305 ha, of which 919 ha is a core conservation zone.
2012	Fishing lot #1 abolished along with all other fishing lots in the country. Fish sanctuary (262 ha) created, eventually leading to the creation of a second CFi.
2016	Transferred management of BPL conservation area to BPL Protected Landscape managed by MoE. This covers the same total land area as the previous Conservation Area, and plans are in place to 'zone' the protected area to create core zones, conservation zones, sustainable use zones and community zones.

ANNEX II: MANAGEMENT ZONES OF PROTECTED AREAS BASED ON THE PROTECTED AREAS LAW

Type of zone	Description	Level of Protection
Core zone	Management area(s) of high conservation values containing threatened and critically endangered species, and fragile ecosystems.	Access to the zone is prohibited except to the Nature Conservation and Protection Administration's officials and researchers who, with prior permission from the Ministry of Environment, conduct nature and scientific studies for preservation and protection of biological resources and natural environment except for national security and defence sectors.
Conservation zone	Management area(s) of high conservation values containing natural resources, ecosystems, watershed areas, and natural landscape located adjacent to the core zone.	Access to the zone is allowed only with prior consent of the Nature Conservation and Protection Administration at the area except for national security and defence sectors. Small-scale community uses of non-timber forest products (NTFPs) to support local ethnic minorities' livelihood may be allowed under strict control, if they do not present serious adverse impacts on biodiversity within the zone.
Sustainable use zone	Management area(s) of high economic values for national economic development and management, and conservation of the protected area(s) itself thus contributing to the local community, and indigenous ethnic minorities' livelihood improvement.	After consulting with relevant ministries and institutions, local authorities, and local communities in accordance with relevant laws and procedures, the Royal Government of Cambodia may permit development and investment activities in this zone in accordance with the request from the Ministry of Environment.
Community zone	Management area(s) for socio-economic development of the local communities and indigenous ethnic minorities and may contain existing residential lands, paddy field and field garden or swidden (Chamkar).	Issuing land title or permission to use land in this zone shall have prior agreement from the Ministry of Environment in accordance with the Land Law.

Source: RGC, 2008

ANNEX III: MANAGEMENT ISSUES IDENTIFIED BY STAKEHOLDERS IN MARCH 2013

Issue	Description
Poor awareness of wetland boundaries	Ineffective wetland demarcation increases risk of wetland conversion and breaking of regulations
Cross-border movements of people	Large numbers of people come from Vietnam to farm and collect natural resources, leading to illegal land encroachment and unsustainable use of BPL
Illegal harvesting	On occasions, people resort to illegal hunting and gathering often because they lack other means to support themselves. This results in reduction in populations of protected species, other species
Wetland in buffer zone is inadequately protected by existing regulations	Weak protection and confusion about legal status of wetlands in buffer zone leads to wetland conversion and degradation
Limited control over levels of resource harvesting	Open, unlimited access of wetland is considered unsustainable, impacting on biodiversity, equitable distribution of ecosystem services and long-term ability of BPL to support livelihoods
Inability to manipulate water levels	Lack of infrastructure to manage water levels appropriately leading to highly variable hydrological conditions that can be unsuitable for cranes, other biodiversity
Lack of land entitlement for local people	Lack of land rights reduces possibilities for sustainable management activities to be instigated
Lack of community participation in reserve management	Limited involvement of communities in decision-making and management processes at BPL reduces likelihood of instigating successful sustainable management activities
Need to improve communication links between government agencies	Limited communication between government agencies working in BPL has the potential to result in policies and plans being initiated that are contrary to the long-term sustainable management of reserve
Limited human and financial resources to undertake management activities	Insufficient resources to undertake all necessary activities jeopardises ability to achieve aims and objectives of the management plan

Source: Pech Bunna, et al., 2013

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