Climate Change Vulnerability Assessment Koh Kapik Ramsar Site, Cambodia

Pheakdey Sorn and Sonim Veth

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

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

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Asia Regional Office
63 Sukhumvit Soi 39
Klongtan – Nua, Wattana
10110 Bangkok, Thailand
Tel +66 2 662 4029
Fax +66 2 662 4387
Email address: asia@iucn.org
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ACRONYMS

ADB	Asia Development Bank
BMUB	German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety
BSNP	Botum Sakor National Park
CBO	Community-Based Organization
CFi	Community Fisheries
CI	Conservation International
CPA	Community Protected Area
D&D	Decentralization and Deconcentration Program
DoAFF	Department of Agriculture, Forestry and Fishery
DoFWC	Department of Freshwater Wetlands Conservation
DoH	Department of Health
DoMCC	Department of Marin and Coastal Conservation
DoME	Department of Mining and Energy
DoP	Department of Planning
DoT	Department of Tourism
DoWA	Department of Women and Affairs
DoYES	Department of Youth, Education and Sport
FCA	Fish Conservation Area
FFI	Flora and Fauna International
FiA	Fisheries Administration
GDANCP	General Department of Administration for Natural Conservation and Protection
GHG	Green House Gas
ICM	Integrated Coastal Management
IKI	International Climate Initiative
IBBRI	Indo-Burma Ramsar Regional Initiative
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
KKRS	Koh Kapik Ramsar Site
MoE	Ministry of Environment
NBSAP	National Biodiversity Strategies and Action Plans
NGO	Non-Governmental Organization
NREM	Natural Resource and Environmental Management
NTFPs	Non-Timber Forest Products
PDoE	Provincial Department of Environment
PIN	People in Need
PKWS	Peam Krasop Wildlife Sanctuary
PMCR	Participatory Management of Coastal Resources
PRA	Participatory Rural Appraisal
RCP	Representative Concentration Pathway
RIS	Ramsar Information Sheet
SMART	Spatial Monitoring And Reporting Tool
VA	Vulnerability Assessment
WA	Wildlife Alliance

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The Climate Change Vulnerability Assessment (VA) was conducted within the context of the project "Mekong WET: Building Resilience of Wetlands in the Lower Mekong Region" (2017-2020). Koh Kapik Ramsar Site (KKRS) was selected as one of the wetlands sites for building climate resilience and conserving, managing and restoring natural ecosystems in collaboration with local communities and stakeholders, with the VA being a first step towards adaptation planning.

The assessment was led by the International Union for Conservation of Nature (IUCN) in Cambodia but could not have been realized without the support of others. The assignment took place in cooperation with Cambodia's national focal point of the Indo-Burma Ramsar Regional Initiative (IBRRI) based at the Department of Freshwater Wetlands Conservation (DoFWC) and the Department of Marine and Coastal Conservation (DoMCC) of the Ministry of Environment (MoE). We would like to express our gratitude to all project partners for their support, including the provincial and local authorities from Koh Kong Province and Koh Kapik Commune, and the men and women that participated in the study.

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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, the focus of this summary, Boeung Chhmar Ramsar Site in Kampong Thom Province and Boeung Prek Lapouv Protected Landscape in Takeo Province.

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. 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 report, special attention was paid to the needs, perspectives and knowledge of women, because they may use wetlands and their resources differently than men.

Koh Kapik Ramsar Site (KKRS) is one of four Ramsar sites in Cambodia, located in the southwest of the country along the coastline near the border with Thailand. The site covers a total area of 12,000 hectares and overlaps with Peam Krasop Wildlife Sanctuary (PKWS) and Botum Sakor National Park (BSNP). It is situated in the delta of three rivers – Prek Koh Pao in the north, and Prek Tatai and Prek Trapeang Roung in the southeast – and is strongly influenced by freshwater surface runoff.

The area is known to host some of the last remaining pristine mangrove forests around the Gulf of Thailand. The mangrove ecosystem is connected to the evergreen and semi-evergreen forests in the eastern part of KKRS via several waterways. Upstream illegal logging is now strictly controlled and the mangrove forest is protected. There is a 100-150 hectare seagrass bed that provides essential habitat for economically important marine species. Key species found in the Ramsar site include Irrawaddy dolphins (*Orcaella brevirostris*), humpback dolphins (*Sousa chinensis*), fishing cats (*Prionailurus viverrinus*), spoon billed sandpipers (*Calidris pygmaea*) and otters (*Lutrogale perspecillata*) and (*Lutra sumatrana*). KKRS is also home to a wide range of birds, reptiles, fish and plants, much of it still unrecorded.

There are six villages within the site, with 1,350 households and a population of slightly more than 6,000. Livelihoods in KKRS depend on the resources of the mangrove forest and open

sea; fisheries are the main source of livelihood for 85% of the people, both for income and food. Women harvest crabs, mussels and snails nearshore, while men use rowboats to fish nearshore and motorboats to fish further afield (MoE and DANIDA, 2006). Mangroves and seagrass provide essential habitat for economically important animals including fish, shrimp, mud crabs, violet vinegar crabs, swimming crabs, green mussels and blood cockles. While most seafood is consumed or sold locally, green mussels are sold and exported to Thailand. In addition, there is a rising ecotourism sector in the area, providing potential for diversified income generation.

Climate change is a serious threat to wetland habitats and may directly impact the local communities' livelihoods. Based on climate change projections, rainfall is expected to decrease in the wet season and increase in other parts of the year, while temperatures may increase by 2°C by mid-century and by 4°C by the end of the century. It is estimated that sea level in Koh Kong Province will rise by 40-60 centimetres by the end of the century. Previous studies have indicated that a sea-level rise of one meter would lead to a loss of 44 km^2 of coastline in Koh Kong Province and significantly raise the risk of severe flooding in Koh Kong City. High waves and strong winds will have significant impacts on estuaries, accelerating sedimentary deposits along channels. By 2050, the number of 'hot days' (> 35°C) in Koh Kong Province will increase by seven days per year and heat waves will extend by 10-15 days and become 3-5 times more frequent. By 2025, 6-month droughts are expected to increase in duration but decrease in frequency while 12-month droughts will increase in both duration and frequency.

Six key habitats were analysed for this vulnerability assessment: mangrove forests, beaches and swamps, open seas, freshwater bodies, catchment forests, and seagrass beds. Seagrass beds and catchment forests are the most vulnerable habitats to climate change. Seagrasses are particularly at risk from storms, freshwater inflow, sedimentation, and increases in water temperature. Catchment forests are most affected by heavy storms during the wet season with risk of erosion and landslides, alternating with longer periods of droughts and high temperatures during the dry season, raising the risk of forest fires. Mangroves and open seas, covering almost 85% of the site, are essential to maintaining biodiversity; mangroves provide important spawning and nursery grounds for fish and other marine species, while the open sea is home to many economically important fish, bivalves, and crustaceans. Freshwater bodies, beaches and swamps are at less risk from climate change, with the exception of increased beach erosion. The vulnerability assessment asked community members to draw a resource use map, demonstrating key habitats and resources, and highlighting the close association between the villagers and the wetland habitat.

Community groups were consulted on the perceived threats to wetland habitats and livelihoods. Members indicated that changes in rainfall patterns and longer droughts have already led to a lack of freshwater in the area. In addition, the condition of transportation channels has deteriorated over time, making boat navigation difficult. Beach erosion has also been affected by high waves and storms (IUCN, 2017). The use of destructive fishing gears and conflicts between fixed gear that rests on the substrate and moving gear that is towed behind boats has led to equipment damage and costly repairs.

Most flagship species are already endangered, and become even more vulnerable due to the impact of climate change. Although species such as the Irrawaddy dolphin can adapt, within limits, to changes, the availability of freshwater inputs compounded by sea level rise can have strong implications on its estuarine habitat. Similarly, other endangered species such as the fishing cat, smooth coated otter and hairy nosed otter, are expected to become more vulnerable due to loss of suitable habitats for foraging and breeding. While this report focused on flagship species, climate change is also expected to undermine keystone species with large impacts on ecosystems, as well as key economic and food resources on which people depend.

Extreme weather events, including strong winds and waves, thunderstorms, droughts and floods have increasingly affected communities around KKRS. Droughts cause strong declines in fish stocks, forest fires can be devastating for habitats and wildlife, and saltwater intrusion is particularly disastrous for agricultural land and freshwater bodies. Most villagers do not seem to have adequate coping mechanisms in place; they focus on their basic needs, such as securing shelters, water, food, and medicines and treatment when becoming ill. Community members also suggested digging wells and restoring ponds to cope with the lack of freshwater, building dams for freshwater bodies to protect against the intrusion of sea water, selecting drought tolerant crops, setting up protection systems in case of lightning, diversifying jobs, saving money, and building houses and villages on higher, more secure, locations. These are all well thought strategies and plans that could be developed further.

There needs to be a clear demarcation of the boundaries of KKRS as the first step of for future sustainable management. Relevant stakeholders must be involved in decisions being made regarding fishing gear and laws. The enforcement capacity of these laws must also increase. The Ministry of Environment (MoE) has management jurisdiction of the resources within the area, but because the Fishery Administration (FiA) controls fishing, aquaculture and management of mangrove resources, it must also be closely involved. Researching the spawning cycles and breeding areas of economically important fish, crustaceans, and bivalves can provide crucial information for ensuring the longevity of these organisms and food security for those who depend on them.

It is critical that community members are involved in awareness raising activities focused on wetlands management, mangrove restoration, and seagrass and wildlife conservation. They should be directly engaged in collaborative projects to ensure the longevity of the surrounding wetlands that they are dependent on. This education and empowerment may also increase their desire to engage in the growing community-based ecotourism market.

Strengthening the resilience of wetland ecosystems and the communities that depend on them is key to climate change adaptation. This requires awareness raising, capacity building, and a community-based conservation and development approach, which can only happen with the collaboration and support of other relevant stakeholders.

1 GENERAL INTRODUCTION

1.1 Building resilience of wetlands to climate change in the Lower Mekong Region

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 flood, 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 decline 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.

As a first step of a participatory adaptation planning process, vulnerability assessments (VAs) were conducted in ten Ramsar sites/wetland sites in the four countries. These combine 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: Boeung Chhmar Ramsar Site located in Kampong Thom province, Koh Kapik Ramsar Site in Koh Kong province, and Boeung Prek Lapouv Protected Landscape situated in Takeo province. This report presents the results of the VA for Koh Kapik Ramsar Site, hereafter referred to as KKRS.

1.2 Objective and set up 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 KKRS VA team was formed from different institutions at national and sub-national levels. The team included representatives from the Department of Freshwater Wetland Conservation of the Ministry of Environment (DoFWC-MoE), Koh Kong's Provincial Department of Environment (PDoE), Peam Krasop Wildlife Sanctuary (PKWS), Fishery Administration (FiA) Cantonment, commune council, Community Protected Area

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

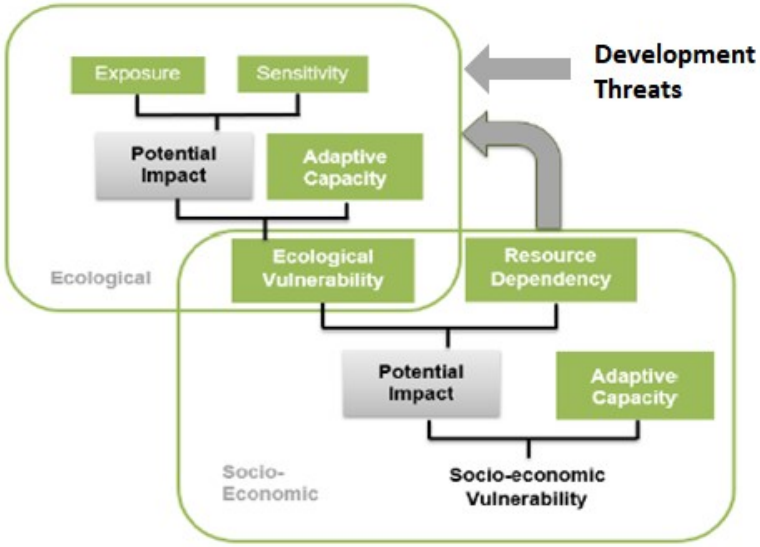
(CPA) management committee, and IUCN Cambodia. The assessment was led by IUCN Cambodia.

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 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. The report will be used as input for meetings with villagers and other relevant stakeholders to discuss the results and develop adaptation plans.

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 focuses on wetlands, the **ecological system** consists of two elements: species and habitats. The **socio-economic system** refers to the socio-economic vulnerability (e.g., livelihoods etc.) 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 SECTION II. SITUATION ANALYSIS[2]

2.1 Description of the wetland

The vulnerability of KKRS 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 and zoning plans to get an overview of the current state of the ecological system.

2.1.1 Location and site description

KKRS is in the southwest of the country along the Cambodian coastline near the border with Thailand (Figure 1). The site is 15 km southeast of Koh Kong City, the main administrative centre of Koh Kong Province; it covers 12,000 hectares, of which the largest part (60%) is located inside Peam Krasop Wildlife Sanctuary (PKWS) and a smaller part (40%) in Botum Sakor National Park (BSNP).

The wetland is made up of alluvial islands immediately off the mainland of Koh Kong Province; most of the land lies less than 2 meters above sea level and much is inundated during spring tides only. The area is characterised by substantial tracts of intact mangrove forest, which is vitally important as a feeding, breeding, and nursery grounds for fish and shellfish species. The estuary-mangrove system plays a critical role as a nursery ground and nutrient source for coastal fish populations, supporting valuable fisheries that provides the main income for coastal fishermen communities in Cambodia (RIS, 2012)

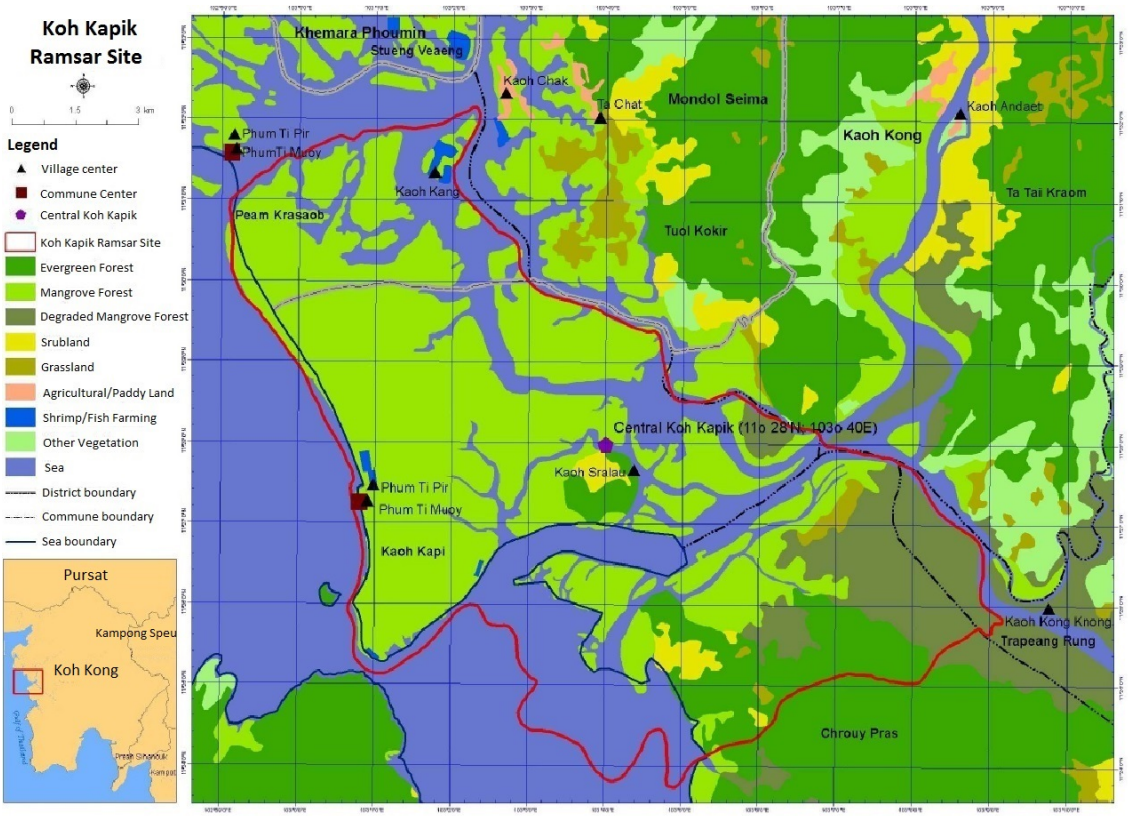


Figure 1: *Map of KKRS*

[2]This Section relies strongly on the PKWS management plan (MOE, 2018), co-developed with IUCN, and the Ramsar Information Sheet (RIS, 2012) to which IUCN provided substantial information.

2.1.2 Current and historic climate

Cambodia has a tropical monsoon climate and is influenced by various factors, including its location within the Inter-Tropical Convergence Zone and the monsoon. KKRS has two distinct seasons:

- The dry season from November to March associated with the northeast monsoon, which sends drier and cooler air, with February being the driest month;
- The wet season from June to September, in which rainfall is largely derived from the southwest monsoon drawn inland from the Indian Ocean.

April and October are transition periods between the two monsoons (MoE and DANIDA, 2006).

The mean minimum and maximum temperature in Koh Kong Province is 22°C and 32°C, respectively. April is the warmest month and January is the coldest month of the year. The annual rainfall ranges from 17 mm to 927 mm. Rain falls throughout the year, with a short semi-dry season lasting from December to February (RIS, 2012).

2.1.3 Hydrological characteristics

KKRS lies in the delta of three rivers (Prek Koh Pao in the north, and Prek Tatai and Prek Trapeang Roung in the southeast) and is strongly influenced by freshwater surface runoff. Islands have been formed from deposition of mud and sand eroded in the sandstone catchments of the three rivers. The catchment comprises part of the southern slope of the Cardamom Mountains in the southwest of Cambodia. The catchment, composed of forests and with at least 4,000-5,000 mm of rainfall per year, is the source of some of the country's largest rivers and safeguards a vital watershed (RIS, 2012).

The majority of the material deposited by the rivers is sandy. The sandy substrate of the islands is covered by humus or organic mud 10-30 cm deep. The only well-developed mudflats are found along the western side of the main island of Koh Kapik. Given the presence of relatively intact mangroves, the area contributes significantly to the stabilization of the coast against erosion from storm and tidal bore. Most sediment runoff from the rivers is trapped and settles in the mangrove stands, forming sand and mud aggregations alongside many small creek systems (RIS, 2012).

Tidal fluctuation occurs twice daily with an average variation of about one metre.[3] The site lies in the intertidal area and is mostly dry at low tide. Water remains permanently in some depressions and in one-meter deep water channels. The freshwater inflow from the three rivers is important for the maintenance of the brackish-water character of the site and essential for the existence of an assemblage of brackish-water plankton and fish populations, which are the food source for most of the birds at the site, and for supporting the fisheries activities of coastal communities (RIS, 2012).[4]

2.1.4 Wetland habitats

The area is known to host some of the last remaining areas of pristine mangroves to be found around the Gulf of Thailand and the Indochina Mangroves ecoregion (RIS, 2012).[5] The mangrove ecosystem is connected to the evergreen forest in the eastern part of KKRS via several waterways. This connectivity from reef-to-ridge is an important characteristic

[3] There is no meteorological station in Koh Kong province to record sea tides. However, it appears that tides are low during the rainy (wet) season and fluctuate by about 0.70 m; during December and January tides reach their highest peak around 2 m.

[4] Salinity significantly changes between the wet and dry season, ranging from 10 ppt to 35 ppt. Oxygen concentration only changes a little averaging 4.8 mg /l (PMMR, 2000).

[5] Indochina Mangroves Ecoregion includes coasts of Thailand, Cambodia, Vietnam and Malaysia in Southeast Asia.

contributing to the ecosystem' ability to support a diverse range of terrestrial wildlife and marine creatures.

In consultation with local stakeholders, six types of habitats were identified: (see MOE, 2018; RIS, 2012)

1) **Mangrove forests:** a majority of the site (60%) supports mangrove forests interspersed with other habitat types (Dara et al., 2009). These are areas of brackish water that are inundated by saltwater at high tides. The site represents a mangrove ecosystem of *Rhizophora* spp. backed by *Melaleuca*, both of which are rapidly being decimated in the Indochina Mangrove Ecoregion. Mangroves are important as nursery grounds for fish populations and as shoreline protection against storm surges and strong waves, but they also provide charcoal and firewood for cooking, timber for construction, and tourism and recreation opportunities.
2) **Beaches and swamps**: small areas of typical beach strand and vegetation are present on the southwest side of Koh Kapik and the sandy areas of some of the islands. This habitat is important as it provides a feeding, spawning and nursery ground for a large variety of commercially important fish and shellfish. It is influenced by sedimentary deposits, intertidal activities and the mangrove community (Bobenrieth, et al., 2012).
3) **Open seawater**: The open water covers about 25-30% of the area. In the dry season the water is salty but in the wet season the water is brackish because of the volume of rainwater. It is an important habitat for various species, including Irrawaddy dolphins, finless porpoises and Indo-pacific humpback dolphins. The open water is very important for local communities who live in and around the site and use it for traveling and fishing.
4) **Freshwater bodies**: there are four freshwater bodies in the site: Boeung Takamtachet, Boeung Praek Chring, Boeung Koh Sleukrey, and Boeung Praek Chak (two of which are located within Koh Kapik Commune). It is a habitat for species such as otters, but fishing cats have also been observed. The water cannot be used for drinking due to regular inflow from seawater. People mainly use this habitat for fishing and collecting other food sources such as wild vegetables.
5) **Catchment forests:** The southeastern part of the site is dominated by rainforest and accounts for 10-15% of the total area. It includes semi-evergreen forests, cardamom forests, and other mangrove forests; trees are locally known in Khmer as *sme* (*Aegialites rotundifolia*), *brong* (*Acrostichumaureum*), *kranhep* (*Combretaceae*), *brasac* (*Rhizophoraceae*), and *sngav* – a type of pine tree. The forest is the main source of fresh (drinking) water. There is only one place on Koh Sralao Island that provides the water on which Koh Kapik Commune depends in the dry season. Despite the protection of the rainforest, small areas are encroached by outsiders.
6) **Seagrass beds**: about 100-150 hectares of seagrass beds can be found south of Koh Sralao village[6] and a smaller area near Chrouy Bros. These areas are known for crabs, fishes, and sea turtles. Currently, the seagrass beds in the site is declining due to the shallow water and the impacts of climate change.

In 2000, local experts identified 56 types of hard and soft corals in PKWS (PMMR, 2000)**;** most coral reefs, however, have suffered varying degrees of degradation (Beasley and Davidson, 2007). Local fishermen reported 2 hectares of coral reefs around Koh Moul island, but the site is not officially recognized.

2.1.5 Biodiversity

Flora. There are three major vegetation types: mangrove, beach strand vegetation and seagrass (MOE, 2018; RIS, 2012).

[6]Based on estimate from FiA Cantonment in Koh Kong Province

- **Mangroves**. At least 64 species of mangroves are found in the area, with *Rhizophora mucronata* being the most dominant (Dara et al., 2009). The islands and creeks within the site are typically fronted by *Rhizophora apiculata*; further inland, an interesting mixture of other mangrove species exists. A combination of *Nypa fruticans* and other species can be found in the transitional zones between true mangroves at the seaward edge and inland forest (rear mangroves) which are dominated by *Melaleuca* trees (Bann, 2003; PMMR, 2000).
- **Beach strand vegetation**: At the southwest side of Koh Kapik and on sandy areas of some of the islands there are small areas of typical beach strand vegetation dominated by *Casuarina equisitifolia* with some *Terminalia catappa*.
- **Seagrass beds.** In the waters off Kampot and Kep, small seagrass beds occur intermingled with corals, but this is not the case for PKWS/KKRS. No research has been conducted on seagrass in Koh Kong Province.

Fauna: Mammals and bird species are the most thoroughly studied and catalogued species in Cambodia, as they are in the rest of the world (USAID, 2011); most molluscs, arthropods, and other invertebrates, have not yet been assessed in Cambodia, much less for their conservation status.

- **Mammals:** Based on local ecological knowledge, the area is home to 25 globally threatened mammal species. Historically, the area is known to support tigers (*Panthera tigris*), but their presence is rather unlikely. Along with tigers, a variety of mammals have been reported in decline since 1980. These include otter spp., hog badgers (*Arctonyx collaris*), jungle cats (*Felis chaus*), fishing cats (*Prionailurus viverrinus*), dhole (*Cuona plinus*), pileated gibbons, pig-tailed macaques (*Macaca nemestrina*), silvered langurs (*Trachypithecus cristatus*), bear sp., and sunda pangolins (*Manis javanica*).
- **Bird species:** The observed trends of bird species depend mainly upon observations by local villagers. Threatened species include spoon-billed sandpiper, Nordmann's greenshank (*Tringa guttifer*), bar-tailed godwit, adjutant sp., stork sp. (*Mycteria sp*.), imperial eagle (*Aquila heliaca*), green peafowl (*Pavo muticus*), broad-billed sandpiper (*Limicola facinellus*), Eurasian curlew (*Numenius arguaa*), eastern curlew (*Numenius madagasariensis*), white-bellied sea eagle (*Haliaeetus leucogaster*) and spot-billed pelican (*Pelecanus philippensis*). Most of these species experienced a population decrease during the 1980-2000s, with an exception of spot-billed pelican whose populations seemed to have increased between 1998 and 2008 (Dara et al., 2009).
- **Reptiles and amphibians.** Although no survey has been conducted on reptiles or amphibians in the area, some reptile species are recorded by local communities, such as the Bengal monitor (*Varanus bengalensis),* water monitor (*Varanus salvator),* black-masked turtle (*Siebenrockiella crassicollis)*, yellow-headed temple turtle (*Hieremys annandalii*), Asian leaf turtle (*Cyclemys dentate*), and the Malayan snail-eating turtle *(Malaymys subtrijuga)* (Dara et al., 2009). Based on the Cambodia tropical forestry and biodiversity assessment (USAID, 2011), there are 88 reptile species and 63 amphibian species in the country. Endemic reptiles include the cardamom gecko (*Cyrtodactylus intermedius*) and the Tonle Sap water snake (*Enhydris longicauda*).
- **Marine mammals.** Species found in the sanctuary and adjacent area are the dugong (*Dugong dugong*), Irrawaddy dolphin (*Orcaella brevirostris*), finless porpoise (*Neophocaena phocaenoides*) and Indo-Pacific humpback dolphin (*Sousa chinensis*) (Beasley and Davidson, 2007; Smith et al., 2014). Main threats to dolphins include by-catch (particularly from bag nets) and entanglements from the use of unsustainable fishing gears (particularly from monofilament gillnets used to catch shrimp), and disturbance from trawlers in nearshore waters.
- **Fish**. Despite the significant role of fishery resources, comprehensive surveys on fish species are lacking. Given the geographical features of KKRS, aquatic fauna can be divided into freshwater, brackish, and saltwater. The 2009 UNEP Global Environment

Fund (GEF) Project suggests there are 525 marine fish species classified in 202 genera and 97 families in the Gulf of Thailand; snapper, seabass, grouper, mackerel are important economic marine fish species. Concerning freshwater fish, Fish Base, a database developed by World Fish Center and FAO lists 484 species in Cambodia, 13 of which are introduced (e.g., various carp, catfish, and tilapia) (Froese and Pauly, 2010 cited in USAID, 2011). Some of the species change habitats according to the seasons and their live stages.

2.1.6 Land use

There is not enough arable farmland for agricultural expansion. Most people within the area depend on coastal products, especially fish and mangroves. The village areas inside KKRS have been declared a community and sustainable-use zone which can be used by local communities under Protected Area Law (see Section 2.1.8); mangroves in these areas are relatively intact and local people collect them for fuel wood, family-scale use of charcoal, and construction material for housing.

2.1.7 Drivers of change

An increasing number of people that live and depend on resources in the area are causing stress in the coastal zones. Key environmental challenges in KKRS are:

- **Land encroachment:** The wetland is protected under the 1993 Royal Decree and designated into different management zones under the 2008 Protected Area Law, restricting land utilization in the site (MoE, 2008). Land speculation has resulted in a dramatic increase of land prices in recent years causing illegal encroachment into the area. With limited enforcement by the rangers, land encroachment for economic development is a serious threat, which could affect the ecological character of the site (MOE, 2018).
- **Exploitation of mangroves**: The area has a history of mangrove depletion and degradation due to charcoal production, commercial logging and shrimp farming (PMMR, 2000).[7] Mangrove loss has resulted in land erosion and a decline in marine resources. Mangrove exploitation for charcoal production and shrimp pond installation have been stopped through donor-supported projects and programmes (RIS, 2012). The mangrove forest is currently under restoration; almost all degraded mangrove areas have been replanted and protected.
- **Sand mining:** Sand mining only began in the past few years. Sand and mud are mined from river bottoms as well as sandy sea floors, exacerbating beach and river erosion (MOE, 2018). Insufficient sediment from upstream rivers due to sand mining has multiplied adverse impacts. Mangrove trees are smothered by sand and left dead in the ocean. Mud-crab and clam populations, once abundant in mineral-rich mud of the mangroves, are losing their habitats. Fishermen have reported catch reductions of fish and swimming crab species. Despite the impact, there are no environmental impact assessment or monitoring systems in place.
- **Illegal and destructive fishing**: Illegal fishing is still occuring and is highly destructive to habitats and fish stocks (MOE, 2018). The use of dynamite fishing and gears such as push netting and trawling destroy marine habitats, while the use of coastal back nets (locally known as *Pong Phang*) leads to a dangerous reduction of fish stocks through heavy overfishing of juveniles.
- **Climate change**: In the past few years, climate change related phenomena such as abnormal high tides and extreme storms have been observed. Strong winds and wave

[7]Charcoal production was banned in 1994 and activities declined from 1996 to 2000 (Rizvi and Singer, 2011), although production in some areas remained rampant long after that with support of people with political power (PMMR, 2000).

action have damaged roofs, houses and agricultural land, and accelerated coastal erosion and mangrove loss.

2.1.8 Conservation and zoning

There is no specific zoning plan for KKRS,[8] but in August 2011 the Government of Cambodia issued a sub decree to zone PKWS (Figure 2; see Annex 1 for zone definitions). With most of KKRS located inside the sanctuary, 1,024 hectares were declared as core zone (no-touch-area) and 912 hectares as conservation-use zone, where people must comply with strict sustainable use management rules of the zone's natural resources. The remaining area has been declared as community zone and sustainable-use zone. With support from donor-supported projects/programmes, a Community Protected Area (CPA) has been established, in which natural resource management has been handed over to the local communities; the area overlaps several zones, including the commune zone, the conservation zone, and the sustainable-use zone.

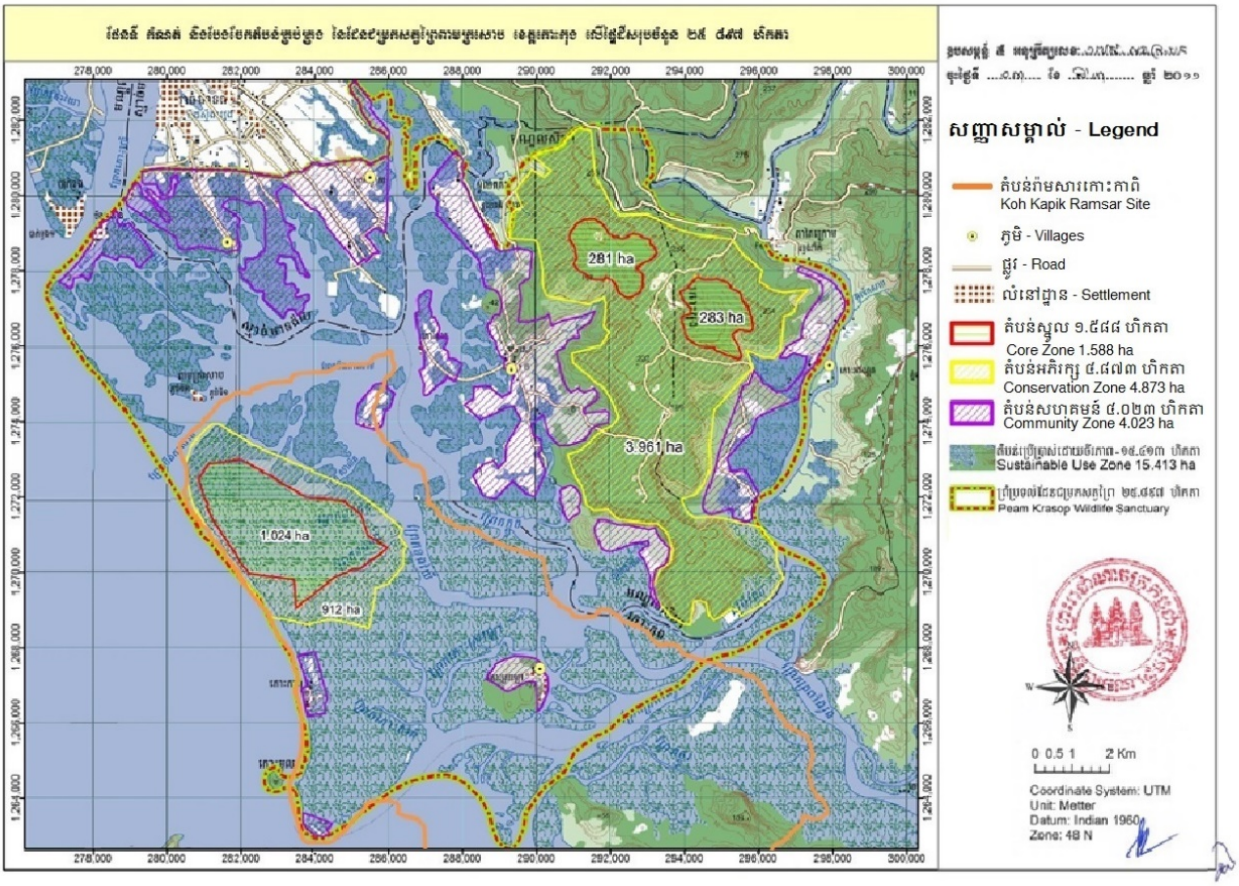


Figure 2: *Management zones in PKWS, with KKRS boundary indicated (after MOE, 2018)*

Although the human population density has increased in and around the area, it is still relatively low compared to that in many other Southeast Asian countries. The mangrove and *Melaleuca* areas could be used sustainably by local people for charcoal, poles, building materials and fishing, while maintaining the ecosystem benefits. At present there is only family-scale use of mangroves, especially *Rhizophora*, under the regulation of communities and

[8]Several coordination/integration efforts have been undertaken to provide greater clarification and strategic zonation to the site's demarcation, e.g., through DANIDA-funded Environmental Management in the Coastal Zone (phase 2 & 3, 2000-Sep 2007), IDRC-funded participatory management of coastal resources (PMCR), and the IUCN Cambodia and Natural Resource and Environmental Management (NREM) under the Decentralization and Deconcentration (D&D) Program.

monitored by park rangers. Most formerly degraded mangrove areas have been replanted and are in healthy conditions now.

Logging upstream in the Cardamom Mountains catchment area is now strictly controlled by the government in collaboration with organizations including Wildlife Alliance (WA) and Conservation International (CI). Within the wildlife sanctuary, mangrove forest is strictly protected through community based natural resource management, coordinating efforts from government institutions, and key partners' activities.

2.2 Communities and wetland livelihoods

To further comprehend the current state of people's interaction with the wetland ecosystem and its components, additional information was collected on the people in and near KKRS, their livelihoods and reliance on wetland resources; as well as data on tenure and resource rights, governance structures and stakeholders, and vulnerable groups and perceived threats.

2.2.1 Communities and population

KKRS extends across six villages in four communes (Koh Kapik, Peam Krasop, Trapeang Roung, and Chrouy Bros). In 2017, the approximate number of people living and around the site was 6,000, with slightly more men than women (Table 1). The poverty rate was 15.9% and slightly higher than the provincial average of 13.2%.[9] Prior to 1975, most people living in the area were born there, but since then many people have migrated from other provinces during the civil war and the charcoal production boom (PMMR, 2000). Low population density, livelihood opportunities and abundant natural resources in the area were important reasons for attracting people (Dara et al., 2009). Based on a socio-economic survey by IUCN in 2013,[10] most dwellers are Khmer, and some belong to the Cham ethnic group. Buddhists are in a larger proportion when compared to Muslims.

Table 1: *Population data of villages in and near KKRS in 2017 (source: Commune Data Base)*

Commune	Village	Households	Population	Men	Women	Poverty (I+II)
Koh Kapik	Koh Kapik I	332	1,448	765	683	42
	Koh Kapik II	68	352	183	169	24
	Koh Sralao	359	1,526	791	735	34
Peam Krasop	Peam Krasop 1	193	794	396	398	51
Trapeang Roung	Koh Kong Knong	145	698	377	321	28
Chrouy Bros	Chrouy Bros	249	1,351	691	660	35
Total		*1,346*	*6,169*	*3,203*	*2,966*	*214*

Note: Poverty level reflects number of households falling into category I (very poor) or II (poor) based on several criteria

The core area of KKRS is in Koh Kapik Commune (Koh Kapik I, Koh Kapik II and Koh Sralao). People's livelihoods are linked to natural aquatic resources through natural creeks on which they depend for fishing, businesses, going to school, and sending patients to the health centre and hospital. Despite the existing livelihood options, several coastal communities suffer from poverty and require improved basic infrastructure, such as proper road systems, waste management, basic health and education services.

[9]Statistics provided by the Commune Data Base managed by the Ministry of Planning showed that the national poverty rate decreased from 30.7% in 2007 to 18.8% in 2015; poverty rate for Koh Kong Province in 2015 was 14.6% (slightly lower than the national average).

[10]The survey was conducted in the context of the project Building Resilience to Climate Change Impacts: Coastal Southeast Asia, Koh Kong Province, Cambodia.

2.2.2 Key livelihood activities

Based on consultation with local stakeholders, most households (85%) in KKRS depend on fishing for their primary income, which includes shrimp fishing, mud crab fishing, green mussel farming and small shrimp fishing. Other activities that make an important contribution to people's livelihoods are: processing and trading, farming, aquaculture, and working as wage laborers or for the government. Nature-based tourism, including ecotourism, is expected to grow as Koh Kong Province attracts increasing numbers of local and international tourists. The communities are heavily dependent on the natural resources of the wetland and their lives and activities are closely interwoven with seasonal dynamics (see Box 2).

Box 2: *The close relation between people's livelihoods and seasonal dynamics*

Villagers can fish all year round, but target different species at different times of year, including fishes, shrimps, squids, and various types of crabs. From the end of May to October it is difficult to harvest certain species, such as swimming crabs, due to the heavy influence of freshwater in the estuary and heavy storms. The dry season from November to May generates more income, especially through selling and marketing fishery products, and signifies the start of the festive season. Families in the area celebrate traditional Cambodian festivals, but the fishermen around KKRS also have additional festivals to pray for their fishing boats to bring good luck and safety at sea and to be able to collect a better harvest. The end of the dry season is characterized by a lack of fresh water and increased disease.

Activities/conditions	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rain fall and storms						■	■	■	■	■		
Fishing	■	■	■	■	■	■	■	■	■	■	■	■
(Small) shrimp collection	■	■	■	■	■			■	■			
Firewood collection (mangrove)	■	■	■	■	■	■	■	■	■	■	■	■
Repairing boats				■	■							
Temporary labour							■	■	■			
Working at factory	■	■	■	■	■	■	■	■	■	■	■	■
Teaching	■	■	■	■	■	■	■	■			■	■
Ceremonies/festivals		■		■					■	■		
Weddings	■	■	■	■								
Lack of money/borrow money									■	■	■	■
More income (from selling)	■	■	■									
Expenses (wedding/ceremonies)				■	■							
Lack of food							■	■	■	■		
Lack of fresh water		■	■	■								
Diseases			■	■	■							

Key livelihood activities are presented below (see MOE, 2018).

Fisheries. Villagers fish throughout the year. They travel as far as 20 km from their residential land to fish; fisheries are partitioned into inshore (coastal) and offshore fisheries. Inshore fishery includes shallow waters across the mangrove areas, including rivers, creeks and estuaries; motored boats with low horsepower and rowboats are commonly used. Fishing activities in this area include female gatherers who harvest snails, mussels and crabs by hand (MoE and DANIDA, 2003). Offshore fishing takes place at 3-6 m depth, around 7-20 km away from the coastline; fishers use boats with larger engines and higher horsepower. Many of them are from Koh Kapik and Peam Krasop Communes. Since most coastal fishers lack the resources to procure proper fishing equipment for coastal fishing, they tend to use small-scale fishing gear more appropriate for use in the mangroves and inshore (Rizvi and Singer, 2011). For Peam Krasop and Koh Sralao, the blue swimming crab is the main target species, with gill nets and traps being the main gears used. Trawl nets are the main gear used in Koh Kapik Village I, while push nets are mainly used in Koh Kapik Village II. Shrimp, squids and fish are the main species caught in Koh Kapik Village I and II (Chaksuin, et al., 2014). Push netting and trawling in shallow waters is illegal, as is dynamite and cyanide fishing; however, these practices have persisted in the area since the early 1990s (PMMR, 2000).

Green mussel cultivation and other aquaculture. Green mussel (*Perna viridis*) farming began in 1994. Initially, they were cultured as feed for shrimp farms, but after the collapse of shrimp farming in 1998, green mussel cultivation emerged as an important alternative income

source for the communities. Due to high market price in Thailand, green mussels are exported. The number of people growing green mussels has substantially increased since 1999 (PMMR, 2000). The farming method employed in the site consists of planting wooden stakes (often *Phoenix paludosa*, *Lumnitzera sp*. or bamboo) in areas where natural settling and attachment of young bivalves to the substrate is expected. After a growing period of up to twelve months, green mussels are harvested between December and February when they have attained an average size of 5-6 cm. Other aquaculture, such as cage cultures of seabass, grouper and snapper are practiced but largely unsuccessful due to upland runoff, market constraints, wild-supply dependence, and impacts from cyanide fishing. Information on the culture methods, production and growth performance of green mussels and other fish species in the sanctuary is rather limited.

Agriculture. Agricultural activities in the area involve paddy rice and some swidden agricultural practices, locally referred to as *chamkar*. Agriculture is oriented to support household food security rather than for commercial purposes. In highland sites, where Koh Sralao village is situated, terrains are forested and water systems are in place; meaning that these communities can pursue rice farming and upland agriculture. Land ownership in this case would be an important factor to boost the household safety net, since landholders can easily diversify their livelihood portfolio, enhance their savings opportunities and ensure continuous access to food sources (Bobenrieth et al., 2012; PMMR, 2000).

Tourism and recreation. Tourism and recreation have become an increasingly important part of the economy of Koh Kong Province. There have been efforts in the past to promote ecotourism in the wildlife sanctuary, for example by creating a community-driven ecotourism site in 2002, which still exists and is successful (pers. comm., IUCN Cambodia wetland manager). The site provides picnic platforms in the mangroves, a 600 m walkway through mangrove forests, a 17-m observation tower, shops and restaurants, and boat tours. Villagers are engaged in activities and derive their income from a motorized taxi boat operation that ferries visitors across the waters. Nearly all visitors (90%) are domestic tourists, with most foreign visitors from Thailand. A new resort offering accommodation and a restaurant has been under construction near the ecotourism site. Dolphin watching is another ecotourism activity promoted in and around the sanctuary, particularly in Peam Krasop. Although there are no existing codes of conduct for tourism operations, ecotourism is regarded as one of the most successful environmental protection projects in the area.

2.2.3 Use of wetland resources

Coastal resources provide critical support to local communities. Direct food sources provided include fish, crabs, shrimp, squid, and molluscs; whereas, non-food products are firewood, construction materials and traditional medicine for the treatment of diarrhoea, pain, and other ailments (Nong et al., 1998). With increasing prosperity, consumer preference is shifting from traditional processed products to live and fresh fish. However, many consumers still require preserved fish, particularly fermented fish (*Prahoc*) for daily consumption, because of the absence of refrigeration in many rural areas.[11]

The processing of marine fishery products is undertaken by both small-scale family style operations as well as commercial productions. Small scale processing is primarily for domestic use and comprises the manufacture of fish sauce, shrimp paste, dried salted fish and dried squids. On a larger commercial scale, high quality products include crabmeat, grouper, snapper, sea bass, Spanish mackerel, jellyfish, squid and octopus. Most fish are landed in the village and sold to the middlemen and collectors. A large proportion (> 90%) of commercial marine fishery products are exported to Thailand (Chaksuin et al., 2014; Rizvi and Singer, 2011), and small proportions are sold to Phnom Penh (< 10%). Nevertheless, there is a high

[11] http://www.fao.org/fishery/facp/KHM/enorr

demand from Phnom Penh during the New Year and other national festivals (Chaksuin et al., 2014). Middlemen play an important role in the communities by providing access to gear, supplies and cash in emergency situations, however, in turn, this has resulted in low bargaining power, price fluctuations and debt to the middlemen.

2.2.4 Land tenure and rights

The Government of Cambodia owns the land in the site because it is inside the wildlife sanctuary and the national park. Based on the Protected Area Law (RGC, 2008), however, local people have the right to use natural resources when they are in the community zone and sustainable-use zone – even when this refers to mangroves, open water and freshwater bodies (see Section 2.1.8).

2.2.5 Governance

The Wildlife Sanctuary Office is responsible for the preparation of the management plan and monitoring in the sanctuary, including KKRS (see Figure 3). This covers restoration, education and the dissemination of information related to management and conservation. Since part of KKRS falls outside the sanctuary and overlaps with BSNP, the Wildlife Sanctuary Office works together with park rangers of the National Park Office, which also falls under the authority of the Provincial Department of Environment (PDoE).

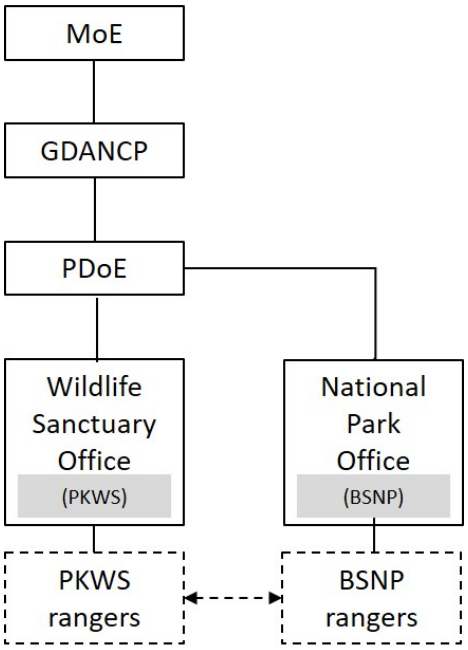


Figure 3: *Governance structure of KKRS*

The PDoE, the National Park Office and Wildlife Sanctuary Office are the authorities directly responsible at the sub-national level. The PDoE is accountable to the General Department of Administration for Nature Conservation and Protection (GDANCP) within the MoE. The GDANCP's responsibilities include monitoring, evaluation, decision-making and management of the site, as well as the management of resources of the Community Protected Area (CPA) and responding to reports of any illegal activities (Bobenrieth et al., 2012).

2.2.6 Stakeholder analysis

To effectively manage the site, it is essential to acknowledge the interests of different stakeholders, including; governmental departments, local authorities, community representatives, non-governmental and community-based organisations (NGOs/CBOs), the private sector, and knowledge institutes. Involving all relevant groups in decision making may help to capitalize on available knowledge and expertise to ensure that decisions are widely supported. Community involvement is especially critical in conservation and resource management. The VA team worked with community members to develop a stakeholder analysis and Venn-diagram to determine primary and secondary stakeholders (Figure 4).

Primary stakeholders: These are key actors who are directly affected and involved in daily management of KKRS, including: the Wildlife Sanctuary Office, MoE/PDoE (as responsible agencies), commune councils (local authorities), Fisheries Administration (FiA) Cantonment and CFis (Community Fisheries), CPAs, IUCN (environmental NGO), and schools (for awareness/environmental education). MoE/DPoE and the Wildlife Sanctuary Office are responsible for KKRS management. FiA is responsible for fisheries research and

development, laws and policies, and has inspection powers to ensure people's food security and socioeconomic development. Within this framework, CFis are voluntarily established groups of citizens living near fishing areas, who have taken the initiative to improve their own standard of living by sustainably using and processing fishery resources. Primary stakeholders have an important role in the future management of the KKRS and should be regularly informed and involved in decision making.

Secondary stakeholders: These are key actors working indirectly with the Wildlife Sanctuary Office. They include provincial/district authorities and various governmental departments, such as the Department of Agriculture, Forestry and Fishery (DoAFF), the Department of Planning (DoP), the Department of Health (DoH), the Department of Tourism (DoT), the Department of Mining and Energy (DoME), the Department of Youth, Education and Sport (DoYES), and the Department of Women and Affairs (DoWA). There are also various international organizations, private sector stakeholders, and NGOs that can be identified, such as the Asia Development Bank (ADB), the provincial Integrated Coastal Management (ICM) project (funded by ADB), BirdLife/Nature Life, Flora and Fauna International (FFI), Wildlife Alliance (WA), Kla Trey | Cambodian Fishing Cat Project, People in Need (PIN), and the Red Cross. Secondary stakeholders may not need to be continuously involved, but they should be regularly updated and drawn into the process when relevant.

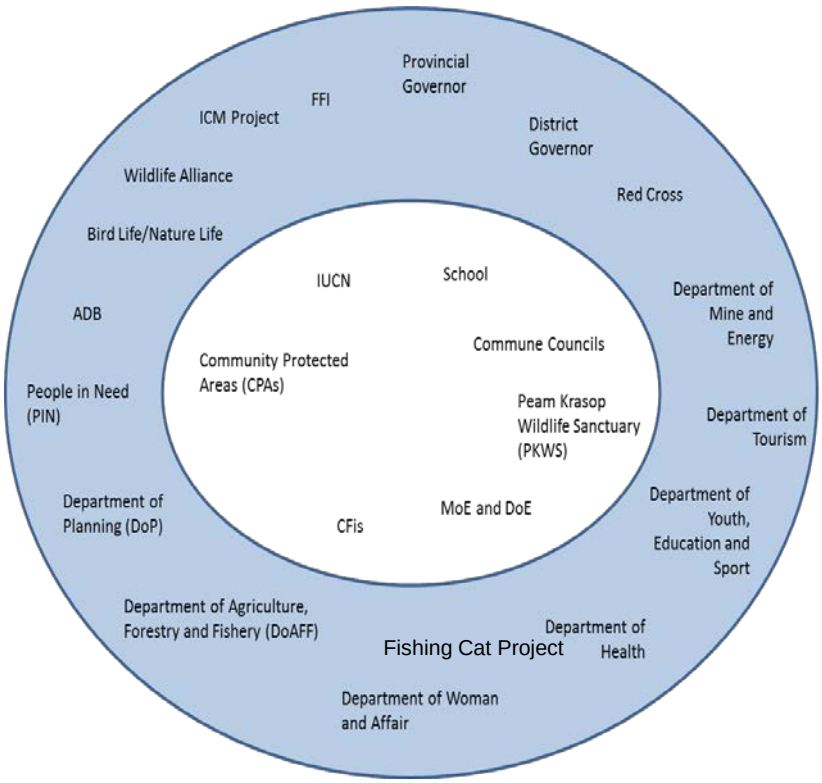


Figure 4: *Overview of primary and secondary stakeholders relevant to decision making in KKRS*

2.2.7 Gender and vulnerable groups

Fisheries are the main source of income and food for women and men in KKRS. Fishery resources decrease during the wet season, particularly affecting households with small vessels, because fresh water influx into the mangroves makes it harder to collect resources (MoE and DANIDA, 2003). Furthermore, open sea fishing generates larger catches with a better market value, making the fisher folks who fall in this category wealthier than those confined in the mangrove and shallow waters. Fishing boats and equipment are key elements in determining the adaptive capacity of fishermen and their families, particularly during periods of stress (mainly the wet season).

Men are primarily responsible for fishing in the open sea and shallow waters, while women are predominantly involved as gatherers of snails, mussels and crabs (MoE and DANIDA, 2003). In poorer families, women help their husbands by picking crabs from the net, processing fish products, repairing nets, and painting boats. While women often play an important role in family fishing businesses, and have strong influence on decision making, they are also more vulnerable. During the dry season, the most productive season for coastal people, women often work more than ten hours a day, excluding household work. For women-headed households the work is even harder, as they must also look after children, conduct small business, maintain the home, collect firewood, and cook (USAID 2001). Some women, but also men, may resort to wage labour as another alternative livelihood, mainly for fishing (men) and crabmeat processing (women), however, it mainly occurs among the poorest households.

2.2.8 Perceived threads to wetland habitats and livelihoods

The influence of socio-economic developments and global climate change have a direct impact on the wetland and its habitats; communities mentioned several specific related threats, which affect their livelihoods and lives (see also MOE, 2018):

- **Lack of freshwater.** Changes in rainfall patterns and longer droughts have led to insufficient freshwater supply. In recent years, communities have experienced dried ponds, wells and channels during the dry season. Families who do not have nearby access to a freshwater supply have to collect water or buy it from other villages. Institutional planning – meant to ensure water supply in rural and isolated villages – is poor and limits the availability of drinking water throughout the year. The availability of freshwater may be stressed further when the impact of climate change increases over time (MOE, 2018).
- **Deteriorating conditions of the channels**. Conditions of the naturally occurring creeks have deteriorated over time due to soil erosion, accumulation of rotten leaves, sedimentation, and mangrove cutting for charcoal production (now strongly reduced). The navigation of boats along the creek during the dry season is not a problem because of high tidal period, but it is very difficult to navigate during the wet season due to low tidal period. Residents of Koh Kapik Island are especially facing difficulties with boat navigation to the village along the 2 km creek during low tide. The impact of high waves and strong winds on the estuaries coupled with sand mining upstream, accelerates sedimentary deposits along the channels (IUCN, 2012). People in Koh Kapik pointed out that policy and legal restrictions exacerbate the problem as they need the authorization of MoE to dig out or dredge the creek, especially since the area has been declared as a Ramsar site.
- **Use of destructive fishing gear/illegal fishing and conflicts**. There are often conflicts between local fishermen and fishermen and poachers from outside. In many cases, problems arise in fishing grounds where both fixed gear and moving gears are used at the same time. For example, one fisher using crab traps but another using trawlers and push nets, resulting in the destruction of crab traps by the trawlers and push nets (Nasuchon and Charles, 2010).
- **Beach erosion**. The land that surrounds the island has decreased dramatically the last decades due to higher waves and storms (IUCN, 2012). Beach health has been further compromised because of inconsistent sand replenishment from upstream rivers. Beach erosion can have long-term impacts on fishery resources and mangrove stands (IUCN, 2012). Beaches protect much of the mangrove forest from wave energy and help moderate salinity levels (Kastl et al., 2013). Moreover, without the beach and mangroves barrier, some communities will be on the frontline against the ocean and become more vulnerable to coastal hazards.
- **Heavy storms, thunder and lightning, and floods.** Heavy storms have increased in frequency, increasing coastline erosion and affecting seagrass habitats, and

destroying trees, houses' roofs and wharf. Storms also prevent fishermen from going to the open sea to fish. Heavy thunderstorms with lightning are also becoming more common, leading to human fatalities, and damaged houses and mangroves. Local communities have become more cautious when there is a storm or heavy rain. Combined with increasingly higher tides, storms may lead to floods, making it impossible to move across the village (IUCN, 2012).

- **Improper solid waste management**. Waste disposal and poor management of waste is a major threat to coastal and marine biodiversity and human health. This is particularly a problem in Koh Sralao, where solids and plastic tend to accumulate on the beach. High tides and floods may further exacerbate the problem. The absence of waste management is a main issue that needs to be addressed for effective solid waste management for the coastal community.

2.3 Climate projections for the site

People's livelihoods and wetland resources are intrinsically linked. While these relations are affected by many (non-climatic) factors, global climate change is increasingly playing an important role. This section presents an overview of climate projections for Koh Kong Province, where KKRS is located. It provides an indication of the type of changes that are expected and how this will affect the wetland.

2.3.1 Climate change projections for Koh Kong Province

CSIRO conducted climate change modelling and a vulnerability assessment for Koh Kong Province for the ADB SPCR biodiversity cooridors work in Cambodia (ADB, 2013; Climate Investment Funds, 2014). The results of this modelling provide focused insights on the climate change projections for the coastal areas. The main trends and climate change projections for the coming decades are summarized in Table 2 below.

Table 2: *Main climate trends for Koh Kong Province, relative to the baseline period 1980-1999*

Type	Climatic trends
Temperature	- Increases in annual temperature, as well as maximum and minimum temperatures
Rainfall	- Slight decrease in annual mean rainfall, with decrease in rainfall during the wet season and increases in other parts of the year. - Increase in maximum one-day extreme rainfall, while maximum five-day totals tend to decrease.
Extreme events	- Increase in number of days of extreme temperatures (days > 35°C) and Heat Wave Duration Index - Decrease in short-term and medium-term droughts but increase in long-term droughts.
Sea level rise	- Increase in local sea level by approximately 10 cm above the 1986-2005 baseline by 2025, and possibly by 60 cm by the end of the century.

The climate change modelling and vulnerability assessment in Koh Kong Province found that by 2025, annual temperatures are going to increase by 0.7°C under a scenario of low GHG concentrations (RCP4.5) to 1.0 °C under a scenario of high GHG concentrations (RCP8.5), with potential effects on agriculture, forestry, biodiversity, water resources, natural disasters and human health. Under a scenario of high GHG concentrations (RCP 8.5), minimum and maximum temperatures may even increase by 1.9 and 2°C, respectively, by mid-century and by 3.6 and 4.0°C by the end of the century. These increases are uniform throughout the year.

Annual rainfall in Koh Kong shows little change of -1% (range -6% to +6%) for the RCP4.5 (lower) scenario, and a change of -2% (range -4% to 0%) for the RCP8.5 (higher) scenario by 2025. However, seasonal rainfall changes do show differences, with an increase for the period from December to May and a decrease for the period from June to November, although with little changes in extreme rainfall. Observed abnormal rainfall during het dry season may

however lead to an increase in sedimentary flows from upstream, elevating water turbidity and altering the balance between fresh and salt water along estuaries.

Based on local reports, **extreme weather events**, such as storm surges, rainstorms, dry season strong wind (gusts), lightening, floods and droughts, have become more frequent. High waves and strong winds can significantly impact on estuaries by accelerating sedimentary deposits along channels and making the waterways shallower. The study seems to confirm that these changes are here to stay for the coming decades. The number of Hot Days (days above 35°C per year) in Koh Kong Province will increase by about 7 days a year, and heat waves (periods of more than five consecutive days of extreme temperatures) will increase in average length by 10-15 days and become 3-5 times more frequent. Most types of droughts show increases by 2025: 6-month droughts are expected to increase in duration but decrease in frequency, while 12-month droughts increase in frequency and duration.

The observed **mean sea level rise** shows an annual cycle with highest levels in January and lowest levels in July. A 10 cm rise has been observed already in the last 40 years. It is estimated that sea level in Koh Kong will rise by 40 to 60 cm by the end of the century. Previous studies have indicated that a one-meter sea-level rise would lead to loss of 44 km^2 of coastline in Koh Kong and significantly raise the risk of severe flooding in Koh Kong City. Even a minor rise in sea level will already increase coastal erosion and eventually lead to the inundation of economically important coastal infrastructure and low-lying agricultural land.

2.3.2 Implications of climate change for KKRS

Temperatures are projected to increase for Koh Kong Province. A large increase in the number of hot days and heat waves is projected, raising the potential for enhanced evaporation. Annual rainfall changes are more complex, with models showing both increases and decreases in the future. There is some indication of decreases in summer rainfall and increases in winter rainfall. Changes in rainfall from year to year and from decade to decade are greater than expected overall changes in the mean annual totals, so there is a need to consider inter-annual variability as well as changes due to climate change in future planning.

The trend towards greater frequency of long-term droughts (longer than 12 months) could be the feature of climate change that has the most impact in Koh Kong Province for the next 20 years. This might lead to less groundwater due to less recharge and greater extraction. In addition, more and longer droughts could further exacerbate (already existing) saltwater intrusion in Koh Kong Province (see MOE, 2018).

Sea level will continue to rise. It is likely to be more important in winter (the time of highest annual sea level), and storm surges may also be affected. The decrease in summer monsoon activity and only small changes in extreme rainfall amounts (or possibly decreases), indicate that there may be fewer storms, although this will be combined with a trend toward greater tidal and storm extremes in the coastal regions of Koh Kong.

3 SECTION III. VULNERABILITY ASSESSMENT

3.1 Habitats

A vulnerability assessment of key habitats (see section 2.1.4) was conducted through group discussion and consultation by first evaluating the current situation. Each habitat was assessed in terms of its representation in the site and the larger region, its tolerance to disturbances (e.g. conversation of land, 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 (extra) protection, which was expressed as a score for ‘baseline conservation status’, varying from 1 (low) to 3 (high).

These same habitats were then assessed in the context of projected climate change up to 2050 and the impact they may have on the wetland. Potential impacts of these changes on each habitat were explored, while examining their vulnerability through the extent of exposure to specific climate changes, their sensitivity to the projected changes, and the capacity to adapt to them. The overall analysis was again expressed as a score, in this case for ‘climate change vulnerability’, from 1 (low) to 3 (high).

The overall results of the habitat vulnerability assessment are summarized in Figure 5.

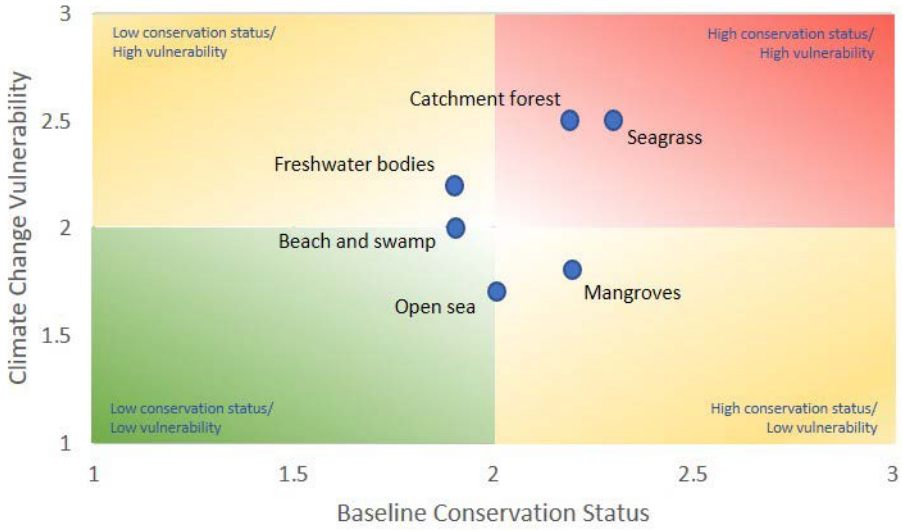


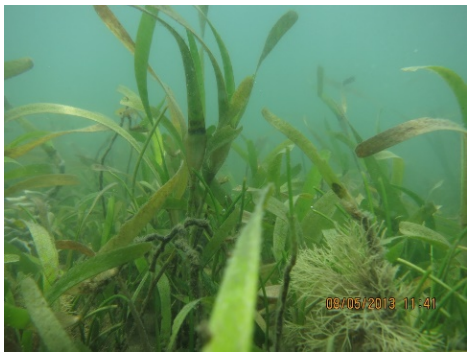
Figure 5: *Baseline conservation status and climate change vulnerability for habitats in KKRS*

The habitats ‘seagrass beds’ and the ‘catchment forest’ were most vulnerable to the impact of climate change, while they are already at risk currently. ‘Mangroves’ and ‘open sea’ are also important to protect due to their size and the important role of providing a spawning and nursery ground for fish and all kind of other species, but they seem less vulnerable to the impact of climate change itself – although this may be different for the various species that depend on them. The current risk for ‘freshwater bodies’ and ‘beach and swamp’ habitats seem slightly less urgent (except for the risk of beach erosion), but both habitats seem more sensitive to climate change compared to ‘mangroves’ and ‘open sea’. Differences in assessment-scores were, however, small, and the VA team – which did not include specific expertise in this subject area when conducting the assessment – did not always find it easy to assess the impact of climate change on each habitat. This means that regular monitoring and involvement of experts will be necessary to keep track of the status and changes in the wetland, as well as their implications for management. Results are further discussed below.

3.1.1 Seagrass and catchment forest

The habitats ‘seagrass’ and ‘catchment forest’ emerged in the top-right quadrant of the vulnerability diagram. They both have a relatively high baseline conservation status (indicating the importance of protection), as well as a high vulnerability to the impact of climate change.

Seagrass. Seagrass beds only cover a small proportion of the wetland area (100-150 ha south of Koh Sralao village and a smaller area near Chrouy Bros). While seagrass can be found in the larger region, it is threatened through coastal development, pollution and fishing activities. The habitat is dominated by a few species and is sensitive for disturbance, although it recovers relatively fast. Seagrass is home to many flagship and key stone species, including fishes, crabs, and sea turtle, and supports various fish species that are important as an economic resource for local communities. Sea grass beds are located within conservation areas and currently protected (it is not allowed to use fishing equipment/gear such as trawlers, nets, etc.), but additional measures are required to save this important habitat for various species.



Seagrass beds are highly vulnerable to climate change; especially near Chrouy Bros, seagrasses are disappearing in shallow waters. Seagrass beds are particularly at risk of storms, freshwater inflow, sedimentation, and increased water temperatures. Seagrass is sensitive to these impacts and are likely to have a big impact on the biodiversity its supports. While seagrass has rapid generation times and is likely to bounce back from extreme conditions, there is only limited suitable space for this unique habitat.

Catchment forest. About 10-15% of the wetland is covered by catchment forest, mainly near Koh Sralao and the national park. The habitat can be found be found in a few places in the region and is an important freshwater source for humans, animals and plants. The forests include a wide diversity of plant and tree species. The area in KKRS and the wider region is decreasing due to land encroachment for agriculture and settlements. Extensive forest fires and extreme rainfall, causing fast water run-off and land erosion/slides are not well tolerated. Catchment forests harbour various flagship and keystone species such as pileated gibbon (*Hylobates pileatus)*, pig-tailed macaque (*Macaca leonine)*, silvered langur (*Trachypithecus germaini)*, dhole (*Cuon alpinus)*, bear sp. *(Helarctos malayanus or Ursus thibetanus)*, and sunda pangolin (*Manis javanica)*, while it provides various Non-Timber Forest Products (NTFPs) such as honey, mushrooms, vines, rattan and medicinal plants. Overall, the catchment has a relatively high baseline conservation status.

The catchment forest is highly exposed to climatic change, most notably through heavy storms during the wet rainy season with risk of erosion and landslides, alternated with longer periods of droughts and high temperature during the dry season with risk of forest fires. Long periods of droughts may also affect fresh water supply, while abnormal rains in the dry season may increase the risk of erosion and possibly floods with sedimentation, affecting the water quality. In general, the habitat is sensitive to the impact of climate change and recovery will be slow.

3.1.2 Mangroves and open sea

'Mangroves' and to a lesser extent 'open sea' also show relatively high baseline conservation status, an indication of that they are at risk and need protection, but they seem less vulnerable to the specific impact of climate change.

Mangroves. Mangroves are still found throughout the region, but the total area is decreasing. In KKRS, mangroves are dominating the landscape; they are being supported in a large area (60%) of the wetland. Although the total area of mangrove forest in KKRS has decreased since the 1980s due to overexploitation for charcoal production and shrimp farming, restoration efforts during the last decade have stopped the decline; most mangrove forests have been replanted and are currently protected. Forest encroachment for agriculture and settlements, as well as beach erosion, are, however, ongoing threats – even in protected areas. Mangrove forests are characterized by a wide diversity of plant species that depend on regular inundation and flooding, but they are not very tolerant to forest fires and recover slowly from the impact of extreme weather events such as lightning and storms. Mangroves are an important habitat for birds and mammals and provide a breeding ground for fish and other species, many of them which are used as an economic resource by local people. Due to its critical role in the support and protection of other species, the mangrove forest ecosystem has a relatively high conservation value.

Mangrove forests are the most exposed to the impact of storms and sea level rise. They are subjected to heavy storms most years from June to October, and the intensity of storms can seriously affect mangroves located around the seaward edge. Even though mangroves – especially big ones – show strong tolerance to higher temperatures and droughts, the combination of these events with water stress periods and sea level rise during the dry-season, may result in increased levels of soil salinity, changes in vegetation structure and reduced productivity, leading to a decrease in the ecosystem services that mangrove forests provide. In general, though, they can adapt relatively well to changes and could potentially expand to new areas if there is no disruption by human activities. This makes mangrove forests less vulnerable to the impact of climate change in the short term, but the situation may change in the long term when impacts become more extreme and frequent.

Open Sea. About 25-30% of the wetland area is open sea. The sea has its own natural dynamics of water flows, tides and waves, which play an important role in maintaining water for a large diversity of plant and animal species. The open sea is home to various flagship and keystone species and is an important habitat for economically relevant fishes. The vastness and open character of the habitat make it is relatively resilient to disturbances such as extreme weather events, although the water quality is increasingly threatened by pollution as result of oil spills, garbage and plastics. It is also increasingly affected by the impact of trawlers, sand mining and overfishing. Although the open sea is not at immediate risk, it is a critically important habitat that requires attention.

In terms of climate change, the open sea seems most exposed to temperature rise and extreme storms. Increases in water temperature affect the productivity of nursery grounds if it is beyond the organisms thermal tolerance, shrinking the amount of available fish and other species; water quality may also be affected indirectly through the impact of storms on land and beach erosion, and sediment accumulation. The habitat is expected to absorb most of these changes without large impacts. The impact may be different though for specific plants an animal species it supports.

3.1.3 Fresh water bodies and beaches and swamp

‘Beaches and swamps’ and ‘freshwater bodies’ have a lower score for baseline conservation status, but both, especially ‘freshwater bodies’, are vulnerable to the impact of climate change.

Freshwater bodies. There are four freshwater bodies in KKRS; while only representing 1 % of the area, they are important sources of freshwater. The total area has remained constant over the past few decades but increases in size during the wet season and decreases during the dry season. The habitat is characterized by a high diversity of plant and animal species, including flagship and keystone species, such as otter spp. and green peafowl; there are also lots of freshwater fishes and crabs. The habitat faces regular inflow of seawater, which makes it unsuitable for drinking; preserving it as a permanent freshwater reservoir would require active intervention and investment, e.g. by building a dike. The freshwater bodies are protected by the mangrove forest and they do not seem to be at immediately risk.

Aquifers for fresh water are however vulnerable to climate change. Freshwater bodies are likely to be affected directly by higher temperature and droughts; they may also be affected by floods and sedimentation, although they are protected by surrounding mangrove forest and flora. The greatest impact, however, is expected from higher high tides (dry season) and storms (high waves and winds), both producing saltwater intrusion (although they could be positively impacted by abnormal rainfall during the dry season). Since the water in these habitats has been brackish for some time of the year, the species that live in it are to some extent tolerant and resilient to these changes. However, extreme changes in water level combined with higher water temperate and saltwater intrusion may reach a tipping point, making this habitat vulnerable to the impact of climate change.

Beach and swamps. Beaches and swamps are common throughout the region. They cover about 10-15% of KKRS, mainly at the southwest side of Koh Kapik and on sandy areas of some of the other islands. Although some beaches along the canal have been lost in the past few years due to sand mining, the habitat area has generally increased over the last 50 years due to sedimentation. The habitat consists of many plant species, some of which need regular flooding for regeneration; it also provides a spawning and nursery ground for commercially relevant fish and shellfish and is an important feeding habitat for migratory birds. Sand beaches and swamps recover relatively quickly from extreme weather events and do not need immediate action, except for the 4 km long sand beach in front of PKWS that protects the islands and its people, and which is sensitive to erosion.

Large areas of beaches and swamps will be increasingly exposed to higher temperatures, droughts, sea level rise and storms. These may make living conditions more difficult, but many of the habitat's plant and animal species are relatively tolerant to the impact of climate change. While species living in the habitat seem to be able to adapt to the new conditions, the habitat itself seems more vulnerable. Beach erosion – which is likely to be exacerbated by sea level rise and storms – is a concern, because it can have a long-term impact on fishery resources and mangrove stands. While new beaches and swamp may (slowly) return, they are unlikely to return in the same place. Overall, this make the habitat moderately vulnerably to the impact of climate change.

3.2 Community and livelihoods

In addition to exploring the impact of climate change on various habitats, a community and livelihood vulnerability assessment was also conducted. Koh Kapik I, Koh Kapik II, and Koh

Sralao – all within Koh Kapik Commune – were selected for the assessment, as most of the people living in these villages rely upon resources from the wetland. Village chiefs, CPA committee members, the Commune Council, old and respected people, and local fishermen were invited to identify the resources that they are using and collecting for their daily livelihood. Various participatory tools were used to evaluate the linkages between their resource use, climate change impact and adaptive capacity (see Box 3).

Box 3: *PRA tools used with villagers in KKRS*

PRA tools are easy to use visual and discussion tools that help to mobilize people and reveal local knowledge. Data was collected through resource ranking, resource maps, seasonal calendars, and historical timelines, and complemented with focus groups and follow-up discussions, each highlighting different aspects of people's livelihoods. Where relevant, needs and perspectives of women and men were included.

Resource ranking: Villagers identified top 10 wetland resources contributing to their livelihood. Women and men expressed their priority by number of stones allocated to each.

Resource map: By making a map of their own area, villages collaboratively recorded, tracked, and analysed the distribution of key resources.

Seasonal calendar: A calendar allowed them to visualize activities related to wetland resource use/collection and derive patterns and variation over a 12-month period.

Historical timeline: Through the recollection of extreme weather events in the past, villagers were able to identify trends and patterns in impact and frequency.

Focus groups: Men and women explored coping strategies in response to extreme weather events/climate change.

Follow up discussion: Villagers and site managers helped identify and explore resource management strategies.

These tools and discussions provide simple and effective ways for villagers to understand links between different aspects of their lives and environment, to stimulate discussions, to plan for change, and be able to monitor and evaluate it.

3.2.1 Resource dependency

Table 3 provides an overview of the top 10 most important wetland resources that people use in Koh Kapik Commune. Resources were selected based on their value as food and income and for providing other resources.

The most important resources were shrimps spp. (*Penaeus spp.*), mud-crabs (*Scylla serrata*), small shrimps (*Penaeus spp.)*, violet vinegar crab (*Galene bispinosa*), swimming crab (*Portunus pelagicus*), green mussel (*Perna viridis*) and blood cockle (*Anadara nodifera*), while mangrove forests and seagrass beds were mentioned as important habitats for several of these. Fish is also an important resource, whereby men – who are mainly responsible for (open sea) fishing – rank it much higher than women, whereas shrimp – which are processed into shrimp paste and marketed as a well-known local product from Koh Kapik island – are valued higher by women. While most species are collected for both food and income (sold fresh and processed), green mussels are mainly sold and exported to Thailand. Although the selection of key resources is biased towards food items, it is common knowledge that people also collect resources for firewood (especially mangroves) and other NTFPs (from the catchment forest and mangrove forest).

Table 3: *Ten most important wetland resources ranked by women (F) and men (M) in KKRS*

Item	Rank	Use	Local names of main species utilized

	M	F		
Mangrove	1	1	Collecting resources for eating and selling – main species mud crab, violet vinegar crab, mangrove snail, green mussel	Kdam Thmar, Kdam Pkolann, Kdam Chhor, Chak Chreng, Kchoung Champos Thea, Trey, Kang Kep, Banle Prey, Bangke, Bangkang, etc.
Shrimps	4	2	Selling and eating (raw and processed as dried shrimps)	Bangkea Sambork Roeung, Bangkea Kleung, Bangkea Bakk, Bangkea Sar, and Bangkea Kong Loeung
Mud crabs	2	5	Selling and eating – good quality sold fresh; low quality cooked before selling	Kdam Thmor
Small shrimps	7	3	Selling and eating – processed as shrimp paste	Kikrahorm, Kisvay, and Kikmao
Violet vinegar crab	5	6	Selling and eating – sold fresh to middle-men; can be kept long time by cooking	Kdam Chhor
Fish	3	8	Selling and eating – several, especially shortfin scad (*Trey Kamong*) (breeds in site; migrates to Thailand when bigger)	Trey Chhpong, Trey Kbok, Trey Toke, Trey Andeng Poy, Trey Krab Knol, Trey Pakong, Trey Kingkok, Trey Kaok, Trey Kamong
Sea grass	8	4	Collect resources for selling and eating – especially swimming crab, fish (general)	Kdam, Trey, Bangke, Bangkang etc.
Swimming crabs	6	9	Selling and eating – sold fresh or cooked for collecting meat	Kdam Ses
Green mussel	10	7	Selling and eating – sold fresh (90% to Thailand) (high price-high demand)	Kchong Dekol, Kchong Tradek, Kchong Matkrahorm, Kchong Matveach, Kchong Champos Tea
Blood cockle	9	10	Selling and eating – sold fresh	Gneav Phouk

Table 4:*Species Local Names in KKRS*

Local Name	English Name	Latin Name
Kdam Thmar	Mud crab	Scylla serrata
Kdam Pkolann	Spottedbelly rock crab	Ozisus guttatus
Kdam Chhor	Violet vinegar crab	Episesarma versicolor
Kchong Dekol	Mud creeper	Terebralia palustris
Kchong Tradek	n.a	
Kchong Matkrahorm		Neritina violacea
Kchong Matveach	Judas ear cassidula	Ellobium aurisjudae
Krum Champos Thea	Green mussel/Asian brown mussel	Perna viridis
Chak Chreng	Quadrate horn shell	Cerithidea quadrata
Trey	Fish spp.	Poisson
Kang Kep	Frog	Grenouille
Banle Prey	Wild vegetable	Légumes sauvages
Bangkea	Shrimp	Crevette
Bangkang	Lobster	Le homard
Bangkea Sambork Roeung	Western king shrimp	Penaeus latisulcatus
Bangkea Kleung	Giant tiger shrimp	Penaeus monodon
Bangkea Bakk	Shripm spp.	
Bangkea Sar	Banana shrimp	Penaeus merguiensis
Bangkea Kong Loeung	Shrimp	
Ki krahorm	Shrimp spp.	

Ki svay	Shrimp spp.	
Ki kmao	Shrimp spp.	
Trey Chhpong	Waigieu seaperch	Psammoperca vaigiensis
Trey Kbok	Bluetail mullet	Moolgarda buchanani
Trey Toke	Sixbar grouper	Epinephelus sexfasciatus
Trey Andeng poy	Gray eel-catfish	Plotosus canius
Trey Krab Knol	n.a	
Trey Pakong	n.a	
Trey Kingkok	n.a	
Trey Kaok	Spotted catfish	Arius maculatus
Trey Kamong	Shortfin scad	Decapterus macrosoma
Gneav Phouk	Common geloina	Polymesoda erosa

To get a better understanding of the distribution of key resources, villager members made a resource map of KKRS, with villages, channels, streams, habitats, and key species (see Figure 6). They identified the important habitats and locations of resources that they use.

The map shows how closely entwined and embedded the villages are in the wetland and their dependency on the resources and the environment around them. Habitat areas can be clearly distinguished, although they may be a 'home' to more resources than indicated on the map. Although there may be inconsistencies in the use of the terms habitats versus resources, the map provides a very colourful and detailed overview of where key areas/habitats and resources can be found. Mangroves are mainly found on Koh Kapik Island and are a key habitat for crabs. Catchment forests are mainly found in the southeast, in the area that belongs to the national park. Villages are connected through a dense network of canals and some roads; several freshwater bodies can be distinguished, as well as shrimp farms; mussel cultivation mainly takes place northern part of KKRS, in shallow waters near the mangrove forests. Beaches and swamps are formed along the coast, providing important feeding habitats for migratory birds, while Irrawaddy dolphins are found nearby in the open sea. The sea is also the main area for fishing for fish and shrimp. Seagrass, instead, can be found in more shallow water, closer to Koh Sralao village.

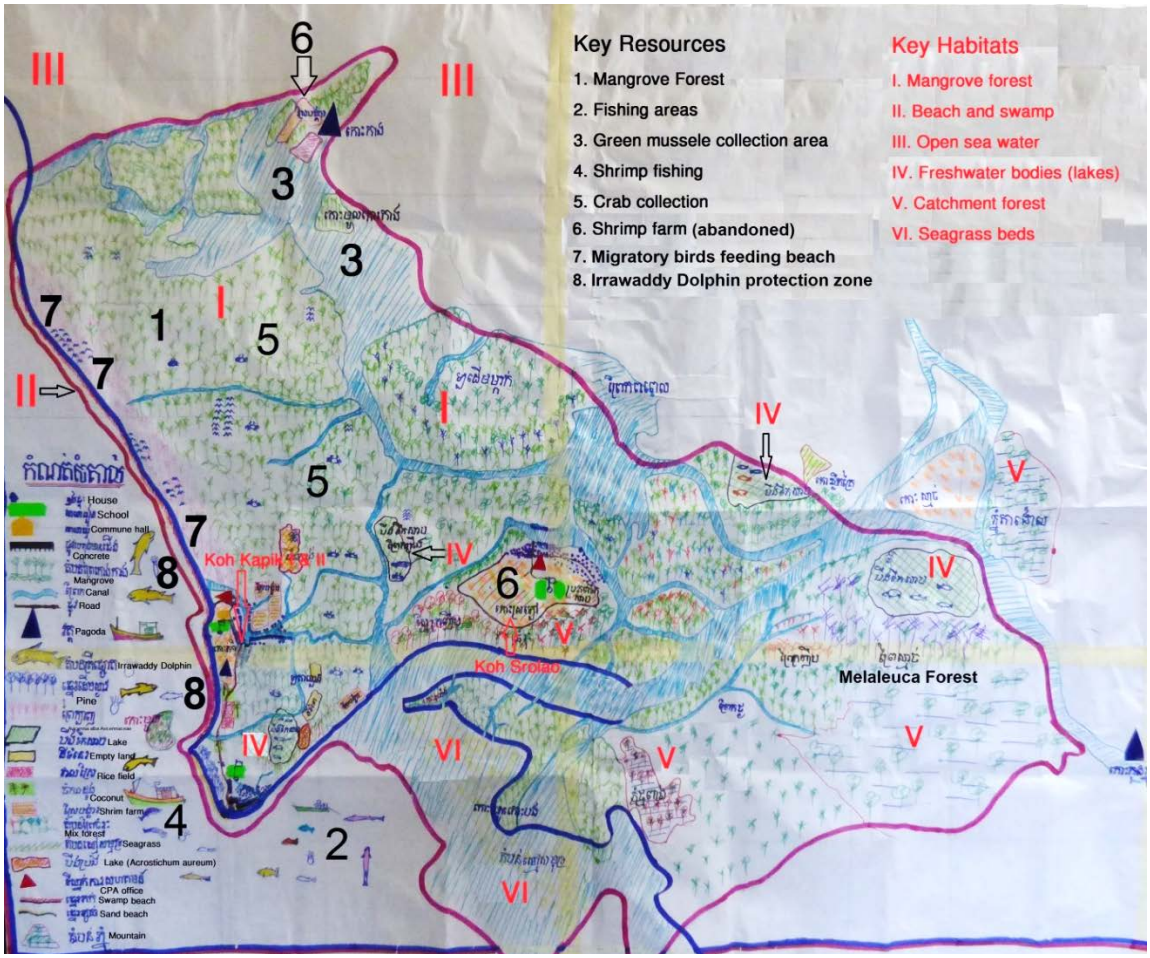


Figure 6: *Resource map of KKRS*

Villagers also made a seasonal calendar for resource use/collection over a 12-month timeframe. Various resources are used/collected year-round (see Table 5). As indicated before, villagers fish all year round, but different species at different times of the year. Shrimp-fishing takes place throughout the year, but high intensity catches are carried out from May to July and from October to December. Normal catches are encountered from January to April, whereas lower intensity catches are made in August/September. Small shrimps, instead, are mainly caught from January to May, although they can also be collected in August/September. Except for violet vinegar crab, mud-crab and swimming crab are mainly collected during the dry season, whereby mud-crab is commonly collected in areas with mangroves and blue swimming crab in deep water or open sea. From July to October it is difficult to harvest them due to the heavy influence of freshwater in the estuary and heavy storms. Green mussel farming takes place throughout the year; the late dry and wet season are mainly used for spawning and growing, with harvesting taking place from December to March.

Based on the seasonal calendar, fish, shrimp, crabs, mussels, snails and blood cockle, are the main wetland resources used and collected by local communities. Whereas mangrove forests are accessible throughout the year, seagrass dies in the dry season due to shallow and hot water but recovers in the wet season and grows very fast, providing a habitat for crab, fish, lobster, shrimps, etc. Hence, people indicated that they only access seagrass beds during the wet season, although it needs to be said that areas with seagrass are currently protected.

Table 5: *Seasonal calendar of wetland resource use/collection in KKRS*

Resources	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fish												
Shrimp												
Small shrimp												
Mud-crab/swimming crab												
Violet vinegar crab												
Green mussel												
Mangrove snail												
Blood cockle												
Mangrove (general)												
Seagrass (general)												

Note: wet season (June-Oct) characterized by rainfall and storms indicated in dark grey

Although not indicated, marketing/selling tends to become more prominent in January/February, months that correspond with the high season for international tourism. During April (Khmer New Year) and in September/October (traditional festivals), selling is also quite active.

3.2.2 The impact of climate change on resources

To gain a better understanding of how climate change affect people's resources, the VA team asked villagers to recall extreme weather events over the last 10 years (2007-2017). The main types of extreme events and impacts on wetland habitats and important species are summarized in Table 6.

Table 6: *Extreme weather events and impact over the last 10 years in KKRS*

Extreme event	Year	Effect on wetland habitats and important species
Drought	2016	Lack of freshwater, decrease of fish stocks, increase in human/wildlife diseases, seagrass and some mangrove areas died; people's livelihood affected; difficult to travel due to shallow water.
Storm	2017	Huge storm destroyed houses, seagrass, CPA center, some mangrove areas, and affected beaches; directly impacted on people's income.
Lightning and thunder	2015 to 2017	Impacts mangrove forest, local fishermen could not go out for fishing; loss of property, human and animal lives. In 2017, two people died from lightning when fishing.
Sea high tide	2012 to 2017	Impact on agriculture, settlements, freshwater bodies; pollution because of improper waste management; local people started noting it in 2012 (never experienced it before)
Flood	2000*	Destroyed and affected a small island (20m x 40m) near Koh Sralao village; loss of some areas of mangroves, beach and swamp, while sea grass died

*Happened more than ten years ago, but included due to impact and relevance

In the past few years, communities in the area have noticed various changes associated with global climate change. A drought in 2016 affected freshwater reserves and led to an increase in disease incidence; they led to shallow waters making travelling and life in general more difficult. Droughts also affected mangroves and seagrass and led to a strong decline in fish stocks. People also experienced heavy storms in 2017, which were combined with heavy thunder and lightning in 2015 and 2016. Strong winds and waves damaged roofs, houses and agricultural land; they affected mangrove forests and seagrass and led to coastline erosion and beach loss. Thunderstorms and lighting threatened humans and animals directly and increased the risk of forest fires. Since 2012, people also started noticing that sea tides have been noticeably higher; saltwater intrusion due to sea level rise is particularly disastrous for agricultural land and freshwater bodies and can lead to pollution because of improper waste management. People even recalled a flood in the year 2000 when a whole island near Koh Sralao village was lost, and which had such an impact that people considered re-building villages in safer zones. While floods happen less often (once in ten years), other events seem

to occur regularly (once in three years). These climate change impacts directly affect some of the main livelihood activities of the people in KKRS, such as shrimp and mud-crab fishing, green mussel farming, and businesses that depend on them (see Box 4).

Based on the recollection of extreme weather events, villagers summarized key impacts as follows:

- *Storm*: house collapse/property damage; cannot fish on open sea; loss of income
- *Drought (heat)*: lack of fresh water; disease to human and animals; destroyed crops
- *Lightning*: damaged property; mangroves die; lost and exposed human/animal life
- *Sea level rise*: strong effect on biodiversity of freshwater body; effect to cropping, animals and other plants; effect to houses
- *Flood:* erosion along canals; impact on settlements; loss Kabong island (part Koh Sralao)

Box 4: *Impact of climate change on key resources/livelihood activities (MOE, 2018)*

Extreme weather events can affect specific resources/livelihood activities directly. Some of these impacts are outlined below. While climatic changes can have both positive and negative effects on resources, the negative impacts seem to prevail.

Shrimp fishing. High temperatures and tides between November and December can affect fishing in a positive and negative way. Huge storms occurring from June to July can also disturb shrimp fishing activities. Abnormal rainfall observed from January to February could also negatively impact fisheries during the dry season.

Small shrimp fishing. Temperature rise from February to April might positively affect populations and normal intensity fishing. Storm events between June-October, however, can shrink the positive effects of temperature rise during the dry season, compromising high intensity activities carried out in August/September.

Mud-crab fishing Heavy storms have been observed, which can compromise this fishery by damaging mangrove forest, the sheltering place of this crustacean during the wet-season. Moreover, higher tides and abnormal rainfall experienced from January to February can also affect dry-season catches.

Green Mussel Farming. Some storms events during peak period of green mussel harvesting with strong waves may cause the loss of mussels attached to stakes. High temperatures observed from November to April could also negatively affect quality of mussels harvested during the dry season. High tides from November to February can equally disturb green mussel farms, by accelerating movement in shallow waters. Abnormal rainfall in dry-season, from January to February, could alter balance between fresh and salty water across channels, impacting green mussel cultures.

Small-scale business. High temperatures and tides, both experienced during the high season, could affect this livelihood, strongly related with tourism. Storms, on the other hand, observed during wet-season would also affect selling activities during September-October.

3.2.3 Coping and management

Women and men were divided into groups and asked how they currently cope with extreme weather events (see Table 7). Despite the diversity of impacts on livelihoods, habitats and resources, most people did not have many coping mechanisms in place. They mainly resorted to meeting their basic needs, i.e. securing access to shelter, water, food, medicines and treatment. However, they also realized that they can take various actions to mitigate the impact, e.g., by building stronger houses, fish and collect resources in other habitats when there are storms and save money and time by not planting crops in case of droughts; but responses were rather ad-hoc, without a clear plan. Moreover, they may put extra pressure on certain resources and habitats, such as mangrove forests.

When asked for strategies to deal with the potential impact from climate change in the future, some responses remained rather broad and passive. There were, however, also more elaborate responses and strategies, from both women and men (see Table 8). For example, they talked about specific measures, such as digging wells and restoring ponds to cope with the lack of water, building dams to protect freshwater bodies against the intrusion of salty sea water, selecting crop seeds that are tolerant against droughts, and setting up lightning

protection systems, and building houses/villages on higher, more secure, locations; also, more general strategies were mentioned, including awareness raising, job diversification, and saving money. These are all well thought strategies and plans that could be developed further.

Table 7: *Impact of extreme events and current coping mechanisms of men and women*

Extreme event	Impact	Current coping activities (Men)	Current coping activities (Women)
Storm	House collapse / property damage	Find safe place and fix houses and buy new materials (repair or make stronger than before; support from community members)	Find safety places and fix houses and buy new materials (repair or make stronger than before; support from community members)
	Cannot fish on open sea	Fish in mangrove areas (fish/collect other resources for eating and selling)	Collect resources in mangrove forest for daily livelihood
	Loss of income	Collect resources from mangroves for eating and selling (temporary livelihood)	Collect resources in the mangrove forest for daily livelihood
Drought	Lack of fresh water	Buy freshwater (no wells/ basins; cannot use boats for taking water since they are used for fishing)	Buy freshwater from Koh Srolao village (no wells/basins; cannot use boats for taking water since they are used for fishing)
	Disease to human and animals	Go to health centre and hygiene (live far from health centre, living conditions not good; limited understanding)	Take medicines and living in clean conditions
	Destroyed crops	Reduce the planting crops (they are not tolerant to drought)	Stop planting crops during drought (spend budget and time for cropping)
Lightning /thunder	Damaged property	Repair and purchase new materials	Repair and purchase new materials
	Mangroves die	No solution	No solution
	Lost and exposed human/animal life	Emergency at the health centre	Emergency at the health centre
Sea level rise	Strong effect on biodiversity of freshwater body	N/A	No solution
	Effect to cropping, animals and other plants		Find safe places for animals
	Effect to houses		Escape to find safe place
Flood	Erosion along canals	No solution (cannot be prevented)	No solution
	Impact on settlements	Find safe place and fix houses (repair or make stronger than before)	Find safe places and fix houses
	Loss Kabong island (part Koh Sraloa)	No solution	No solution

Note: N/A means not applicable; by accident, responses to the impact of sea level rise were not discussed in male focus group

Table 8: *Impact of extreme events and future coping mechanisms of men and women*

Extreme event	Impact	Future coping activities (Men)	Future coping activities (Women)
Storm	House collapse / property damage	Build strong houses and have barriers to protect against heavy wind	Build strong houses and have barriers to protect against heavy wind
	Cannot fish on open sea	Take extra occupation and save money	Collect resources in mangrove forest for daily livelihood
	Loss of income	Take extra occupation and save money	Take extra occupation and save money
Drought	Lack of fresh water	Dig ponds and restore wells (If catchment forests lost, sources of freshwater also lost)	Dig ponds and restore wells (no wells/basins; cannot use boats for taking water since they are used for fishing)
	Disease to human and animals	Keep up good living conditions and clean the environment	Go to health centre and hygiene for eating and drinking
	Destroyed crops	Change and select crop seeds for adaptation (find crop seeds adapted to climate change for short-term benefits)	Change and select crop seeds for adaptation (find crop seeds adapted to climate change for short-term benefits)
Lightning	Damaged property	Set up lightning protection system (antenna to divert lightning)	Set up lightning protection system (antenna to divert lightning)
	Mangroves die	No solution	No solution
	Lost and exposed human/animal life	Awareness raising	Awareness raising
Sea level rice	Strong effect on biodiversity of freshwater body	Build dam to protect freshwater	Build dam to protect freshwater
	Effect to cropping, animals and other plants	Move to safe location for animals	Moving to safe location for animals
	Effect to houses	Build houses higher than before	Build houses higher than before
Floods	Erosion along canals	Plant more mangroves along the canals (mangroves can prevent erosion)	Plant more mangroves along the canals (mangroves can prevent erosion)
	Impact on settlements	Change to new location of villages (cannot move far away from fishing locations)	Find new location (cannot move far away from fishing locations)
	Loss Kabong island (part Koh Sralao)	No solution	No solution

To find out how people's coping mechanisms and strategies could be supported, current and future wetland management practices were discussed with villagers and the site manager of the Wildlife Sanctuary Office (see Table 9).

Site management includes a wide variety of activities, including awareness raising, species conservation, mangrove restoration, fisheries resource management, law enforcement, livelihood improvement, community-based ecotourism etc. While MoE, to whom the Wildlife Sanctuary Office is accountable, has management jurisdiction of the resources within the area, the FiA controls fishing, aquaculture and management of mangrove resources. Hence, both institutions have a responsibility. One of the main problems is that there are no exact area definitions for specific species/resources, even though key habitats as mangroves and

seagrass are protected. Moreover, factors obstructing sustainable management are associated with educational, regulatory and institutional aspects (see also section 2.2.8). Especially fishing zones are vulnerable due to the lack of proper fisheries management and the absence of local by-laws and platforms, reducing the adaptive capacity of fishermen.

Considering projected climate change impacts, future management plans must do more to protect specific resources. Starting with a clear demarcation of boundaries for KKRS/PKWS and the involvement of relevant stakeholders in management planning, fishing, spawning and breeding zones can be identified to further protect specific resources during certain times of the year, and fishery laws and rules can be explained and enforced better. Strengthening people's resilience is key to adapting to climate change. Community-based conservation, management and restoration of natural ecosystems are critically important elements for this, but this will require the support from other relevant stakeholders (see MOE, 2018).

Table 9: *Current and future management practices of the KKRS*

Resource	Current management	Future management	Note
Mangrove	Protected; mangroves need to be conserved and restored with participation of local people (CPAs) and other stakeholders	Conduct mangroves inventory and registration of state land to clarify boundary demarcation between local land use and conservation areas	Identify clear boundary demarcation for KKRS and conduct workshop with relevant stakeholders
Shrimps	There is no definition of shrimp fishing area	Enforcement of fisheries law	Determine fishing zone at the time of breeding
Mud-crabs	There are no exact area definitions	Disseminate how to use fishing gear properly according to guidelines of MAFF	Using of mud crab fishing gears inappropriate
Small Shrimps	There are no exact zones for small shrimp collection	Identify small shrimp fishing zone	Main income but based on season; its products can be kept for long time
Violet vinegar crab	There are no exact area definitions for violet vinegar crab	Identify the spawning zone in site	Breeding season from mid-September to November; and promote product
Fish	There are no exact area definitions	Determine fishing gear and area of fishing zone	Based on FiA Law
Seagrass	Protected and conserved by identifying the boundaries of sea grass	Protected and conserved by identifying clearly seagrass boundaries because it's a habitat for fish (general), including food and breeding	Seagrass is a place for scientific research and rare plants in Koh Kong Province
Swimming crabs	There are no exact area definitions	Disseminate how to use fishing gear properly according to guidelines of MAFF	Use of mud crab fishing gears inappropriate
Green mussel	There are no exact area definitions for green mussel	There are no exact area definitions for green mussel	
Blood cockle	There are no exact area definitions	There are no exact area definitions	

3.3 Species

For the vulnerability assessment of species, four flagship species were selected which are characteristic for KKRS: fishing cat (*Prionailurus viverrinus*), smooth-coated otter (*Lutrogale perspecillata*), hairy-nosed otter (*Lutra sumatrana*), and Irrawaddy dolphin (*Orcaella brevirostris*). Since all of them are already under severe pressure, there was not much difference in their baseline conservation status. Hence, instead of presenting them in a less

distinguishing vulnerability diagram, both baseline conservation status and climate change vulnerability scores (scale from 1 to 3) are presented below in Table 10.

Table 10: *Baseline conservation status/climate change vulnerability for selected species in KKRS*

	Baseline Conservation Status (score)	Climate Change Vulnerability (score)	Validation
Fishing cat	VH (3.0)	H (2.5)	Expert
Smooth-coated otter	VH (2.9)	M (2.2)	Expert
Hairy-nosed otter	VH (3.0)	H (2.5)	Expert
Irrawaddy dolphin	VH (2.7)	M (2.0)	Managers/field staff

Note: VH=very high (2.7-3.0), H=high (2.3-2.6), M=moderate (1.9-2.2), L=low (1.5-1.8), VL=very low (1.0-1.4)

On the IUCN Red List of Threatened Species,[12] fishing cat and smooth-coated otter are classified as vulnerable and hairy-nosed otter and Irrawaddy dolphin as endangered; however, according to the SSC Cat Specialist Group, fishing cat is highly threatened, particularly in Southeast Asia where it is facing a steep decline. The vulnerability of the four species to climate change seems to differ though, with fishing cat and hairy nosed otter being highly vulnerable, and smooth-coated otter and Irrawaddy dolphin showing moderate vulnerability. Fishing cat and otter species assessments and species descriptions were expert validated; species description for Irrawaddy dolphin was also expert validated, but the assessment itself was conducted by field staff/managers and later slightly corrected after expert consultation.

3.3.1 Fishing cat

The rare and little-known fishing cat (*Prionailurus viverrinus*) is associated with wetlands, and primarily preys upon fish, giving it its name. A fishing cat weighs about 5-16 kg, with a body length of 57-78 cm, and tail length of 20-30 cm; it is the largest of the *Prionailurus* genus. The muscular, heavyset build and short legs, together with an unusually short tail, help to distinguish it from the leopard cat (Burnie and Wilson, 2001).

The fishing cat typically displays six to eight black lines from forehead to neck, disbanding into shorter lines and longitudinal spots on the shoulders; its spots are brown-black on a grey-olive coat. The fishing cat is locally known as *Kla Trey*, which literally translates as “tiger fish”. This association with the feared tiger makes some rural Cambodians afraid of the fishing cat, which may have contributed to their persecution and rapid decline of the species in the region (Thaung and Herranz Muñoz, 2016).

Fishing cats are found in suitable areas of marshlands, mangroves, streams and rivers (Nowell and Jackson, 1996). Being a specialist that requires relatively large habitats in search of food, makes them are highly vulnerable. Land encroachment and settlements reduce their living environment, while they face increased interactions with domestic dogs and cats, leading to fights and/or the contraction of diseases. While they are protected in Cambodia, illegal hunting does take place (Thaung et al., 2017).

Fishing cats are highly exposed to climate threats. When mangrove forests are affected, fishing cats lose their main refugia. Droughts and floods have a big impact on the cat’s survival, since it needs freshwater for survival and dry areas for breeding. The capacity of fishing cat populations to recover from climate change impacts is limited due to the species’ long reproductive cycle and with the current population being small, there is little genetic diversity. If they are protected from direct (human) threats, however, their adaptive behaviour may allow

[12]http://www.iucnredlist.org/

them to cope. Climate induced changes to current mangrove habitats could have significant impact, however there are appropriate habitat refugia available on the southern (Botum Sakor) area of KKRS. Connectivity in the area is very low, unless direct interventions are carried out to improve it (risks from human activities are, however, also higher in this area). Therefore, although the species is long lived and generally adaptable, survival is highly connected to persistence of mangrove refugia and management of human activities, including illegal trade.

Since February 2017, Kla Trey | Cambodian Fishing Cat Project has been working in PKWS (see Herranz Muñoz, 2018).[13] Kla Trey has been conducting camera trapping, habitat and threat research, and stakeholder engagement activities. Results indicate there is a breeding fishing cat population in the largest island of PKWS, where poaching and retaliation killings are now rare. However, fishing cats dispersing to smaller islands and mainland areas face severe threats due to lack of resources for effective law enforcement, which allows for high levels of snaring (using trap wire). Kla Trey | Cambodian Fishing Cat Project works together with PKWS rangers and managers, who have asked for training on wildlife research methods and technology to improve their effectiveness. Kla Trey has recently started to provide training and equipment to implement SMART (Spatial Monitoring And Reporting Tool)[14] patrolling to gather ecological and illegal activities data. Through close collaboration and adaptive management, data can be used to develop and implement a wildlife conservation plan. Concurrently, Kla Trey will continue to investigate fishing cat population ecology and distribution, raising awareness, fostering participation and finding alternatives to curb habitat destruction within the local communities.

3.3.2 Smooth-coated otter and hairy-nosed otter

The smooth-coated otter (*Lutrogale perspecillata*) is found in most of the Indian subcontinent and eastwards to Southeast Asia, with a disjunct population in Iraq (da Silva et al., 2015). The hairy-nosed otter (*Lutra sumatrana*) is endemic to Southeast Asia and one of the rarest and least known otter species (Wright et al., 2008; Aadrean et al., 2015). Despite being a hotspot for these species, populations in the region, including PKWS/KKRS, are further decreasing. The hairy-nosed otter was only camera trapped once in PKWS in 2017 (49 sites; Herranz Muñoz, 2018). Their main habitats are in decline, forcing them into ever smaller geographical ranges.

The smooth-coated otter is relatively large for otters**,** weighing 7-11 kg and measuring 59-64 cm in head-body length with a 37-43 cm tail *(Hwang and Larivière, 2005).* Compared to other otters they have a more rounded head and a hairless nose in the shape of a distorted diamond; the tail is flattened, in contrast to the more rounded tails of other species. As their name suggests, they have unusually short and sleek fur; this is dark to reddish brown along the back, while the underside is light brown to almost grey in colour. The hairy-nosed otter has a short brown fur that becomes paler on the belly, with long body (58-83 cm), slender tail (35-51 cm) and about 5-8 kg in weight (*Wright, et al., 2008).* Its skull is flatter than that of the smooth-coated otter and it has smaller teeth. The hairy-nosed otter is the least known of the Asian otters and is also the most difficult to identify in the field.

Both species occur in areas where fresh water is plentiful, such as wetlands, seasonal swamps, rivers, lakes, and rice paddies. The estuaries in Koh Kong Province are a prime habitat for smooth-coated and hairy-nosed otters. Where smooth-coated otter is the only otter-species, it can live in almost any suitable habitat; where it is lives with other otter species it avoids smaller streams and canals in favour of larger water bodies. Although it is also often found in saltwater near the coast, especially on smaller islands, it requires a nearby source of fresh water (*Kruuk et al., 1994)*. Smooth-coated otters form family groups of a mated pair with

[13]http://www.fishingcatcambodia.org/looking-back-on-2017/

[14]SMART is a software tool for conservation that allows gathering data to improve the effectiveness of patrolling efforts and management practices (see detail http://smartconservationtools.org/)

offspring from previous seasons; groups of 4 to 11 individuals have been recorded (V. Herranz Muñoz, pers. comm, 2018). The hairy-nosed otter occurs in coastal areas and on larger inland rivers, solitary or in groups of up to four.

Both species have been found before along the Tropeang Roung River in KKRS (Dong et al., 2010). More recently, the smooth-coated otter (see picture) has been recorded in over 40% of the 49 locations surveyed by the Kla Trey | Cambodian Fishing Cat Project during 2017 (V. Herranz Muñoz pers. comm, 2018). Records of hairy-nosed otter along Tropeang Roung River and PKWS/KKRS between 2006 and 2012, include 5 camera-trap pictures, 5 skins and one live individual (Heng et al., 2016). Their main habitat appears to be both small and big estuary surrounded by melaleuca, mangrove and evergreen forest with shoreline vegetation.

Smooth-coated otters are social and hunt in groups. Fish comprise over 70% of their diet, but they also eat reptiles, frogs, insects, crustaceans, and small mammals. Especially in areas where other species of otter are also found, they prefer larger fish, typically between 5 and 30 cm in length. A group of otters can have a feeding range of 7 to 12 km^2 (Kruuk et al., 1994). Hairy-nosed otters mainly eat fish, such as catfish, snakeheads, perch and water snakes, molluscs, and crustaceans. During the dry season, individuals forage in drainage canals and ponds (Nguyen et al., 2001). Both are specialist feeders who need average to large areas of suitable habitat. Smooth-coated otter groups have been recorded at locations more than 5 km apart in PKWS (V. Herranz Muñoz pers. comm, 2018).

As long as food supplies are sufficient, smooth-coated otters breed throughout the year, but where they are dependent on monsoons for precipitation, breeding occurs between October and February. A litter of up to five pups is born after a gestation period of 60 to 63 days *(*Hwang and Larivière, 2005*).* The mothers give birth to and raise their young in a burrow near water. At birth, the pups are blind and helpless, but after 10 days, their eyes open, and they are weaned at about three to five months. They reach adult size at about a year of age, and sexual maturity at two or three years. Pups have been recorded in PKWS between March and May (V. Herranz Muñoz, pers. comm, 2018). Not much is known about the breeding habits of the hairy nosed otter. Pairing of a male and a female may be limited to the breeding period. Populations in Tonle Sap breed between November and March, with a gestation period of around two months (Aadrean et al., 2015)

Major threats to Asian otter populations are loss of wetland habitats due to construction of large-scale hydropower projects, reclamation of wetlands for settlements and agriculture, reduction in prey biomass, poaching, and contamination of waterways by pesticides. In the entire region, severe conflict exists between otters and humans, because of poverty and recent increases in aquaculture leading to indiscriminate killing of otters. Poaching poses a direct threat to both otter species in PKWS/KKRS; evidence of snares (Herranz Muñoz, 2018) and camera-trap pictures of a smooth-coated otter injured by a snare have been recorded during 2017 (V. Herranz Muñoz, pers. comm, 2018). The hairy-nosed otter is the rarest otter in Asia, most likely on the verge of extinction. Only a few viable populations remain, widely scattered in region.

Climate change may further limit the survival chances of both otter species. Since they need both terrestrial and aquatic habitats, climate induced changes to mangrove habitats would

have significant impacts; droughts may seriously affect their feeding habitats, while flooding reduces the availability of key habitats for reproduction. Moreover, both species have long reproductive cycles, and it would take them long to recover from impacts – although populations of smooth-coated otters may be large enough to reflect sufficient genetic diversity to withstand the impact of climate change on populations, this may not be the case for hairy nosed otter. Generally, smooth coated otters seem better able to cope with changes than hairy-nosed otters. Smooth-coated otters have been observed in all areas of PKWS/KKRS, allowing them to reach appropriate habitat/climate space/refugia; hairy-nosed otters, instead, have only been observed in a fresh water stream over 2017 (V. Herranz Muñoz, pers. comm., 2018). Even though hairy-nosed otters are long-lived, they do not seem to be very adaptive. For smooth-coated otter, their behaviour will allow them to adapt as long as they are protected from direct (human) threats.

3.3.3 Irrawaddy Dolphin

The Irrawaddy dolphin (*Orcaella brevirostris*) is found in subpopulations near coasts and in estuaries and three large rivers in parts of the Bay of Bengal and Southeast Asia. Although sometimes called the Irrawaddy river dolphin, it is not a true river dolphin, but a marine dolphin that lives in brackish water near coasts, river mouths and in estuaries as well as in the Mekong, Ayeyarwady and Mahakam rivers.

Distinctive characteristics are their high and rounded forehead. The front of its snout is blunt. Their dorsal fin is small with a rounded tip and located behind the middle of the back. The flippers are broad and rounded. Irrawaddy dolphins can range from 90-200 kg and have average length at full maturity is 2.3 m. The dolphin's colour is grey to dark slate blue, paler underneath, with no distinctive pattern (Long, 2014).

Irrawaddy dolphins are normally found in small groups of less than 6 animals but occasionally as many 15 or more (*Culik, B., 2000).* The dolphins are not particularly active, but they do make low leaps when disturbed. There feed on fish, crustaceans, and cephalopods. During foraging, groups of dolphins sometimes circle around prey (*Ponnampalam et al.,2013).* In inland channels, they tend to be found in deep pools downstream of channel confluences and meanders, and upstream and downstream of islands. Recent surveys in PKWS found that a significant number of Irrawaddy dolphins inhabit open waters just outside the mouths of waterways leading in and out of the mangrove forest, indicating a favourable habitat for this species (Smith et al., 2014) (picture on the right).

Anecdotal reports from KKRS/PKWS suggest a population decline inside the mangrove forest due to intensive sand mining and extensive mussel aquaculture. Irrawaddy dolphins are more susceptible to human conflict than most other dolphins that live farther out in the ocean. Drowning by entanglement in fishnets and degradation of habitats are the main threats to Irrawaddy dolphins. Inside the wildlife sanctuary, dolphins are strictly protected, but most of dolphins are living outside in the open sea. Tourism activities also increasingly put a strain on dolphins.

Bycatch is the most immediate threat for Irrawaddy dolphins, but climate change could have strong implications for their freshwater and estuarine habitat in KKRS/PKWS due to changes in the availability of freshwater and sea-level rise (Smith et al., 2009; Smith and Fahrni Mansur, 2012). The dolphin's slow reproduction makes them extra vulnerable; after reaching sexual maturity at seven to nine years, cows give birth to a single calf (about 1 m in length and 10 kg

at birth) every two to three years. Although the assessment indicated a moderate score for climate change vulnerability, more research on this topic is required.

4 CONCLUSIONS

4.1 Summary of vulnerabilities

KKRS is one of four Ramsar sites in Cambodia. Its complex social-ecological system, dominated by mangrove forests, supports both the lives of thousands of marine/coastal fishermen and key habitats for global endangered species such as Irrawaddy dolphin, humpback dolphin, fishing cat, otter spp., and other migratory bird species such as spoon-billed sandpipers.

Climate-related exposures in the KKRS include higher temperatures, extreme and erratic weather events (especially droughts), and saline intrusion due to sea level rise. According to people in the area, impacts are already felt. Seagrass and catchment forest habitats are highly vulnerable and declining due to the impact of higher temperature, droughts, forest fires, and erosion. Mangrove forests and open sea are important habitats for a wide diversity of species, including many economically relevant ones, but are currently most at risk of non-climatic developments, such land encroachment, sand mining, and illegal fishing. Due to their vast sizes and capacity to absorb changes these habitats are currently less at risk of climate change, but this may change when climatic change events increase in intensity and frequency. Freshwater bodies and beaches and swamps seem less critical to protect in the short term, but they play an important role in freshwater supply and island protection, and both are vulnerable to the impact of sea level rise and storms.

Most flagship species that are already endangered, become even more vulnerable due to the impact of climate change. Although species as Irrawaddy dolphins can adapt (within limits) to changes, the availability of freshwater inputs compounded by sea level rise can have strong implications for estuarine habitats. Similarly, other endangered species such as fishing cats, smooth coated otters and hairy nosed otters, are expected to become more vulnerable due to loss of suitable habitats for foraging and breeding. While this report focused on certain flagship species, climate change is also expected to undermine keystone species with large impacts on ecosystems, and key economic resources on which people depend.

Local people depend heavily on the natural resources of the surrounding mangrove forests, seagrass beds and open sea, although freshwater bodies and catchment forests also play an important role in terms of freshwater supply. The close interaction of people's lives with the natural resources and seasonal dynamics of the wetland and its resources, makes them vulnerable to the impact of climate change. While some changes may positively affect fish populations and other resources, most impacts are expected to be negative due the effect on underlying ecological processes. Moreover, since people depend on fisheries and other natural resources, they are likely to resort to more intense fishing techniques and/or use of natural resources, increasing pressure on them.

The interaction between the wetland and the people who live in it is complex. There is a dynamic interplay between climate and non-climatic factors, affecting diverse habitats and species and the larger ecosystems. These are further embedded in and challenged by the institutional context. Although the report provides an indication of which habitats and species are at risk and how that affects communities and vice versa, it requires adaptive management and active involvement of relevant stakeholders to deal with these challenges.

4.2 Adaptation planning

Based on the VA, the following recommendations are made for adaptation planning:

- *Demarcation and zoning*: Clear demarcation and boundaries are essential for the development of management plans. Fishing, spawning and breeding zones need to be identified to further protect specific resources and mangrove inventory needs to be made to protect it against land encroachment.
- *Awareness raising*: Conducting awareness raising among local communities and relevant stakeholders on wetland and natural resources management, species conservation, mangrove restoration, fisheries rescue areas protection, seagrass bed conservation, fishery laws and rules regarding fishing gear, and law enforcement patrolling to protect the wetlands and natural resources.
- *Livelihoods improvement*: To prevent further pressure on wetland resources due to climate change and other factors, local livelihoods should be supported through training on seafood processing, aquaculture (fish, green mussel, and crab) and other income generating activities, such as ecotourism. Attention needs to be paid to those who are poor and to the role of women. However, this should go along with the provision of basic services such as good quality drinking water through digging wells or building water basins.
- *Community involvement in protection*: Due to close relation between people and the wetlands, community participation is critical for protection. Specific projects should be developed in collaboration with local people and relevant stakeholders for the protection and conservation of certain areas. Examples include the conservation of catchment forests by planting more trees on Koh Sralao island, as it is the main source of freshwater supply; promoting small-scale Fish Conservation Areas (FCAs) as a tool to strengthen marine community fisheries management and build climate change resilience; and protecting and conserving mangroves and seagrass, which are home to many species that are collected for food and income.
- *Governance and management structure*: Since local people and stakeholders closely interact and depend on the wetland ecosystem, there should be more attention to the way local people and relevant stakeholders are consulted and involved in decision-making. Joint problem analysis and development of solutions should be integral to the development of the management plan.

ANNEX 1: MANAGEMENT ZONES OF PROTECTED AREAS BASED ON 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 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

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INTERNATIONAL UNION
FOR CONSERVATION OF NATURE

ASIA REGIONAL OFFICE
63 Sukhumvit Soi 39
Klongtan - Nua, Wattana
10110 Bangkok, Thailand
Tel +66 (2) 662 4029
Fax +66 (2) 662 4387
www.iucn.org/asia