Climate Change Vulnerability Assessment
U Minh Thuong, Viet Nam

Tran Triet, Nguyen Thi Kim Dung, Le Xuan Thuyen, Tran Thi Anh Dao

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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Table of Contents

List of abbreviations

ASEAN	Association of Southeast Asian Nations
BMUB	German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety
CPC	Commune People Committee
DPC	District People's Committee
IBA	Important Bird Area
ICF	International Crane Foundation
IKI	International Climate Initiative
IPCC	Inter-governmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
MONRE	Ministry of Natural Resources and Environment
PPC	Provincial People's Committee
PRA	Participatory Rural Appraisal
RCP	Representative Concentration Pathway
UMT	U Minh Thuong
US $	United Status Dollar (1 US $=22,000 VND, based on long-term average)
VND	Vietnamese Dong

Executive summary

U Minh Thuong (UMT) National Park is one of the key sites for wetland biodiversity conservation in the Mekong Delta, Vietnam. It is one of the two protected areas in Vietnam that preserve peat swamp ecosystems. The Park is a Ramsar Site and an Association for Southeast Asian Nations' Heritage Park. It was selected as one of the ten focal wetlands in the IUCN's "Mekong Wet: Building Resilience of Wetlands in the Lower Mekong Region" project. In this study, a climate vulnerability assessment was conducted as the first step in the participatory climate adaptation planning process for UMT National Park. The main objectives of the assessment were to assess the vulnerability of ecosystems and livelihoods to the impacts of climate change and to identify options to increase the resilience of the wetland.

Most important climate threats to UMT's wetlands are severe and prolonged droughts, higher air temperatures, flooding and salinity intrusion due to sea level rise. In addition, occurrence of extreme events, such as heat waves, strong storms, and torrential rains, will be more frequent and mostly unpredictable. For habitat vulnerability assessment, we selected three main wetland habitats: peat swamp forest, melaleuca forest on clay soils, and open swamp. Six wetland species were selected for species assessment, including melaleuca tree (*Melaleuca cajuputi*), phragmites grass (*Phragmites vallatoria*), featherback fish (*Notopterus notopterus)*, large fruit bat (*Pteropus vampyrus)*, hairy-nosed otter (*Lutra sumatrana*) and pangolin (*Manis javanica*). We interviewed local people at three villages – Cong Su, Minh Dung and Minh Thuong – to assess people's livelihood vulnerability.

Results of climate vulnerability analysis showed that peat swamps in UMT are very highly vulnerable to climate change. The other two wetland habitats, melaleuca forest and open swamp, are moderately and highly vulnerable. Of the six species studied, pangolin was assessed very highly vulnerable; fruit bat and hairy-nosed otter highly vulnerable and three species (*Melaleuca*, *Phragmites* and featherback fish) moderately vulnerable. Main vulnerabilities for all wetland habitats and species are drought, higher air temperatures and salinity intrusion that is caused by sea level rise. Droughts and higher air temperatures, especially extreme high temperatures episodes, increase the risks of uncontrollable fires that threaten the existence of the last remnants of peat swamp forests in UMT. In extreme dryness conditions, water from the outside may be pumped into the core zone to prevent forest fires. This practice increases the risks of bringing saline water, environmental contaminants – mainly agricultural chemicals used in the rice fields in the surrounding areas – and alien species into the core zone. Most species in UMT depend on freshwater wetland ecosystems, which functions can be fundamentally altered by high water salinity.

Local people's livelihoods are also highly vulnerable to climate adversities. Farming, the main source of income for the majority of people near UMT, is strongly dependent on the weather and climate changes. In addition to droughts, local people also reported significant impacts of floods, strong winds, higher air temperatures, and irregular monsoonal rain on livelihood activities, transportation infrastructure, dwellings and health. Results of our assessment suggest that climate adaptation planning for UMT National Park should prioritize on improving water control facilities and developing an effective environmental and fire monitoring system for the core zone. Since water resource is critically important for both wildlife and people, a participatory approach should be adopted that allows more active participation of local people and other relevant stakeholders in the development and implementation of water resource sharing, irrigation, and salinity control policies. An effective disaster warning system should be developed to help people prepare for climate adversities.

1. Introduction

This study was carried out under the "Mekong WET: Building Resilience of Wetlands in the Lower Mekong Region" project, led by the International Union for Conservation of Nature (IUCN). The Mekong WET Project aims to harness the resilience of wetlands in Cambodia, Lao PDR, Thailand and Vietnam. 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 their National Biodiversity Strategies and Action Plans (NBSAPs) under the Convention on Biological Diversity and pursuing their commitments on climate change adaptation and mitigation under the United Nations Framework Convention on Climate Change.

In Vietnam, the focal wetlands are Lang Sen Wetland Reserve (Long An Province), Phu My Species and Habitat Conservation Area and U Minh Thuong National Park (both in Kien Giang Province). As a first step of a participatory adaptation planning process in these sites, vulnerability assessments have been conducted. These assessments combine scientific assessments with participatory appraisals and dialogues with communities living at the sites and the authorities in charge of site management. This report presents results of the vulnerability assessment for U Minh Thuong (UMT) National Park.

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.

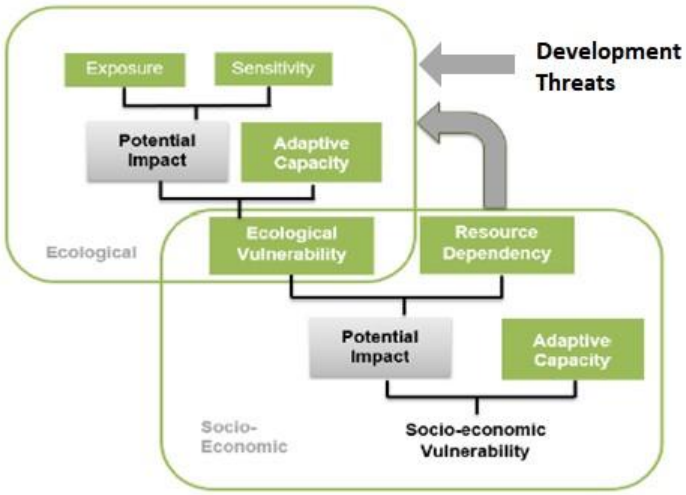
The climate change vulnerability assessment carried out in this study followed methodologies and utilized assessment tools provided by IUCN (IUCN, 2017). In the study, wetlands are considered complex socio-ecological systems; linkages between the wetland ecosystems and the communities who depend on resources provided by that wetland were evaluated in the context of climate change. A conceptual framework of the study is presented in Box 1.

The study was conducted by a team of experts from the University of Science at Ho Chi Minh City, Vietnam, and the International Crane Foundation, Wisconsin, USA. The research team also consulted with experts who are specialized on the wetland species being assessed (Appendix 1 provides a list of the team members and experts).

Field data collection and interviews were carried out at UMT in October 2017. A validation session was conducted in January 2018, when the research team revisited UMT to present the initial results of assessment and received feedbacks and recommendations from UMT's staff and representatives of local communities. A list of UMT staff that participated in the study is provided in Appendix 2.

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

According to the Inter-governmental 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. Description of the wetland

2.1 Location and site description

UMT National Park (UMT) is located in U Minh Thuong District, Kien Giang Province (Figure 1). It has a core area of 8,038 hectares and a buffer zone of 13,000 hectares. UMT is one of the two peat swamp areas of the Mekong Delta – the other is U Minh Ha located in Ca Mau Province (Tran 2016). UMT, together with U Minh Ha National Park, preserves the last remnants of peat swamp forests in the Mekong Delta. A survey conducted in 1976 by the Geological Survey Agency of Vietnam documented 12,400 ha of peatland in UMT and 20,200 ha in U Minh Ha (Le, 2010). Since then frequent fires have greatly reduced the extent of peat swamp forests and the thickness of peat layers. Agricultural development in the area also claimed much of the degraded forests, further reducing the area of peat swamps. The current area of peat swamp in UMT is estimated at approximately 4,000 ha, with peat thickness ranging from 0.4 m to 1.2 m (U Minh Thuong National Park, 2012). UMT landscape has low elevations, varying from 0.6 m to 1.8 m above the mean sea level. Almost 50 % of land area are of less than 1.0 meter of elevation; those that are 1.4 m to 1.8 m occupy only 20 % of land (U Minh Thuong National Park, 2012). UMT National Park is an Important Bird Area (IBA) of Vietnam, a Ramsar Site and one of the Association for Southeast Asian Nations (ASEAN) Heritage Parks.

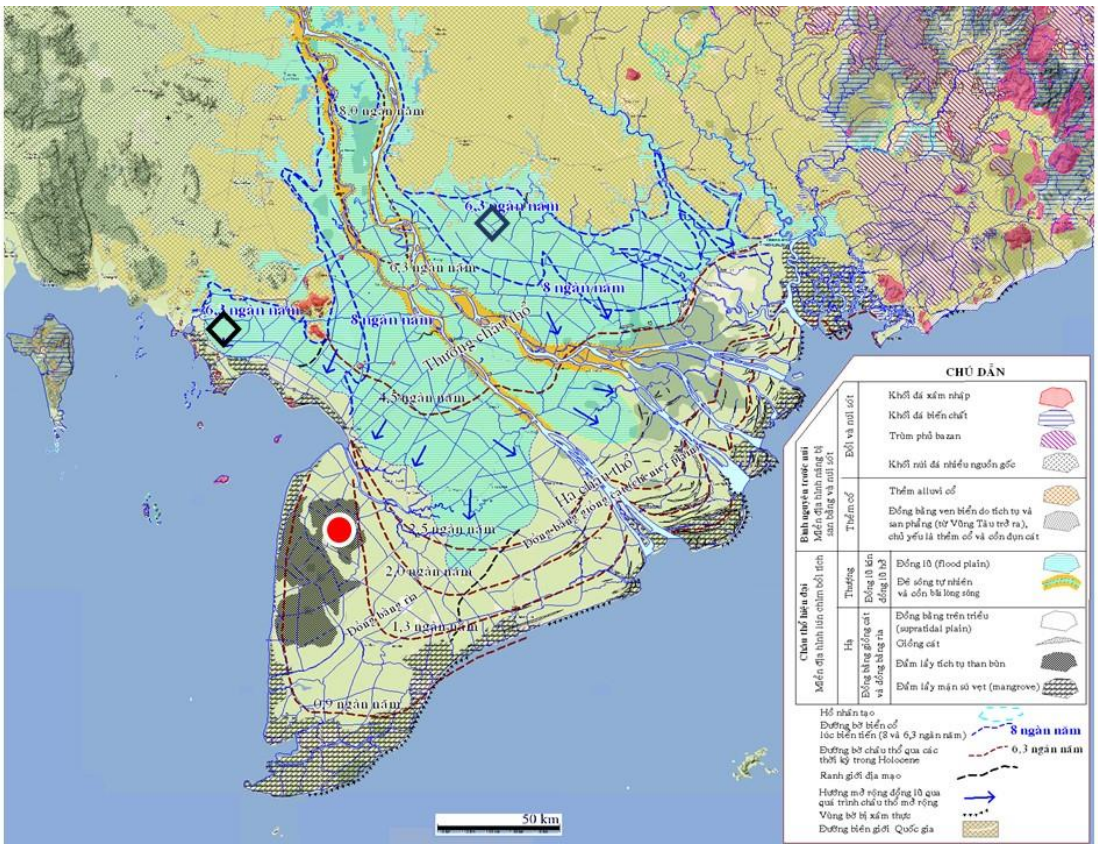


Figure 1: Location of UMT National Park (red circle) in the Mekong Delta. Locations of the other two wetlands included in this climate change vulnerability analysis for Vietnam, Lang Sen and Phu My, are shown in black diamonds. Base map shows main geomorphological formations of the Mekong Delta (source of base map: Truong, 2017).

2.2 Current and historic climate

UMT has a monsoonal climate, characterized by a December-April dry season and a May-November wet season in which 90 % of rainfall occurs. The park is located in an area that receives the highest rainfalls in the Mekong Delta. Average annual rainfall recorded at Ca Mau weather station was 2,390 mm/year, and 2,040 mm/year at Rach Gia Station (Nguyen, 1990). Annual mean, average max and average min temperatures are 27.4 ^{o}C, 38.6 ^{o}C and 16.8 ^{o}C, respectively; April is often the hottest month and January the coldest (U Minh Thuong National Park, 2012). Data and information about historic climate conditions at UMT are very limited, therefore we refer to historic climate trends for Vietnam and selected information most relevant for UMT to provide a general account for past climate conditions of the area.

In 2016, the Ministry of Natural Resources and Environment (MONRE) of Vietnam released the document "Climate change and sea level rise scenarios for Vietnam". The study included an analysis of past climate changes recorded by weather monitoring stations (Tran Thuc et al. 2016). The analysis used weather data from 150 climatological stations and sea level data from 17 oceanographic stations located throughout the country's land and sea. Historic changes in weather characteristics and sea levels for Vietnam during 1985 – 2014 are summarized below.

- Mean temperature increased by 0.42 ^{o}C during 1985 – 2014; maximum high temperatures increased throughout the country.
- Annual rainfall decreased in the north of the country and increased in the south; extreme rain incidents decreased in the northern lowland but increased in the central highland and southern provinces.
- More droughts occurred during the dry season.
- Stronger influence from El Nino and La Nina episodes; strong typhoons occurred more frequently.
- Sea levels in the near shore areas rose by 3.3 to 3.5 (±0.7) mm/year on average during 1993 – 2014). Sea level rise measured at Phu Quoc and Tho Chu (near UMT) were 3.4 (±0.8) mm/year and 5.3 (±0.8) mm/year, respectively.

Many of these past climatic trends were also observed at UMT. Local people, who were interviewed, reported recent changes in local weather conditions, including higher air temperatures, irregular rainy seasons, strong winds and heavy storms were more common, more droughts, and more hot days. In recent years, UMT area experienced two severe droughts in 2013 and 2015 and a big flood in 2017, which caused substantial losses to local livelihoods.

2.3 Hydrological characteristics

The UMT area is influenced by diurnal tides of the Gulf of Thailand. Tidal water reaches UMT via two main pathways: Cai Lon – Cai Be River from the north and Ong Doc River from the south. Although being located close to the sea, the UMT peat swamps are a freshwater wetland ecosystem. Historically, high rainfall and poor drainage through river channels created prolonged inundation, allowing peat to accumulate. Peat layers act like water sponges, absorbing rain water during wet seasons and gradually releasing it during the dry seasons. Extensive canal systems – developed recently for transportation, rice and shrimp farming – altered the hydrology of the peat system and allowed saltwater intrusion in some parts of UMT, especially during dry seasons. Canals drained peat swamps, lowered water inundation and shortened water retention time, resulting in excessive dryness of the peat mass and making it susceptible to fires. The hydrology

of peat swamps in UMT is now managed manually by a system of dykes and sluice gates, aiming mainly at storing water inside the core zone at the end of the rainy season for forest fire prevention.

2.4 Wetland habitats

Wetland habitats in UMT's core zone consist of four main types: peat swamp forest, melaleuca forest on non-peat clay soils, phragmites grassland and open swamp (Figure 2). *Melaleuca cajuputi* (Myrtaceae) is the dominant tree species in both peat swamp forests and melaleuca forests.

On the floor of peat swamp forests, the luxurious growth of ferns, mostly *Asplenium* sp. (Aspleniaceae) and *Stenochlaena palustris* (Blechnaceae), creates dense thickets that are often difficult to penetrate. The climax forest vegetation for peat swamps is a type of mixed forest where several tree species co-dominate, most importantly *Alstonia spathulata* (Apocynaceae), *Ilex cymosa* (Aquifoliaceae), *Syzygium cumini* (Myrtaceae), *Acronychia pedunculata* and *Euodia lepta* (both Rutaceae) (Tran 2001). *Alstonia spathulata* trees can reach more than 30 m in height, forming an above-canopy stratum in the forest (Safford et al. 1998). This mixed forest type used to occur in UMT on peat domes which were 2-4 m higher than the surrounding area and were often not flooded even at the peak of the rainy season.

A big fire in 2002 destroyed the last area of mixed peat swamp forest in UMT. When peat layers were greatly reduced or disappeared because of fires, melaleuca became the only tree species in the forest and ferns also largely disappeared from the forest floor, replaced by *Phragmites vallatoria* (Poaceae) and *Eleocharis dulcis* (Cyperaceae). Severe fires could eradicate melaleuca forests entirely, giving way to phragmites and *Eleocharis* grasslands and eventually open water bodies covered by floating plants such as *Pistia stratiotes* (Araceae), *Salvinia cucullata* (Salviniaceae), and *Eichhornia stratiotes* (Pontederiaceae) where water levels are artificially maintained to prevent further fire.

Figure 2: Aerial view of UMT National Park showing a mosaic of melaleuca forests and open swamps (photo credit: Nguyen Truong Sinh, March 2018).

2.5 Biodiversity

UMT is listed as an Important Bird Area (IBA) in Vietnam (Buckton et al.1999; Tordoff 2002), with 185 bird species recorded. It currently hosts some of the largest waterbird colonies in the Mekong Delta (U Minh Thuong National Park, 2012). Birds of conservation importance are greater spotted eagle (*Aquila clanga*), spot-billed pelican (*Pelecanus philippensis*), lesser adjutant stork (*Leptoptilos javanicus*), gray-headed fish eagle (*Ichthyophaga icthyaetus*), Oriental darter (*Anhinga melanogaster*), black-headed ibis (*Threskiornis melanocephalus*), painted stork (*Mycteria leucocephala*), and Asian golden weaver (*Ploceus hypoxanthus*) (Safford et al. 1998; Buckton et al. 1999; Tordoff 2002).

Mammal species of special conservation concerns are the critically endangered pangolin (*Manis javanica*), the endangered hairy-nosed otter (*Lutra sumatrana*), the near-threatened fruit bat (*Pteropus vampyrus*), and the vulnerable fishing cat (*Prionailurus viverinus*).

Field surveys carried out in 2000-2001 recorded 243 species of vascular plants (Tran 2001). Even though none of the plant species are considered endemic, some plants are rarely found elsewhere in the Mekong Delta such as *Alstonia spathulata, Lemna tenera, Nepenthes mirabilis, Asplenium confusum, Licuala spinosa, Hydnophytum formicarum*, and two orchids *Eulophia graminea* and *Spiranthes sinensis* (Tran 2001).

Open waterbodies (canals and open swamps) in UMT are invaded by alien plants such as water hyacinth (*Eichhornia crassipes*) and water lettuce (*Pistia stratiotes*). The native aquatic plant *Salvinia cucullata* also behaves as a weedy species, growing densely together with water hyacinth and water lettuce.

2.6 Land use

Wetlands located within the core zone are strictly protected. About 50 % of area of the core zone are covered by forests, the other 50 % are open swamps, seasonal grasslands and canals. The buffer zone consists of privately-owed farm lands, mostly rice fields, sugar cane plantations, fruit orchards and a small area of shrimp farms (U Minh Thuong National Park, 2012).

2.7 Drivers of change

Forest fire and saltwater intrusion are the two most important drivers of change in UMT wetlands.

- A catastrophic fire in March - April 2002, burned some 90 % of the peat area of UMT, reducing 60 cm to 120 cm of peat thickness. In some areas, the entire peat layer was burned to the ground. Water stocking – the practice of maintaining high water level all year round – applied after the 2002 fire, turned most areas of UMT's core zone into permanent waterbodies and suppressed natural regeneration and growth of melaleuca forests.
- UMT is a freshwater wetland system. However, the many canals dug recently in the buffer zone and adjacent areas have brought salt water up to the core zone of the park, particularly during the dry season. Currently, the peripheral dykes are still able to protect the core zone from saltwater intrusion, but the risk is high. Given high sea level rise projections for the UMT area, the risk of saltwater intrusion will even be higher in the future.

2.8 Conservation and zoning

As mentioned before, UMT includes a core zone (8,038 ha) and a buffer zone (13,000 ha). The peripheral dyke and water gate system of UMT's core zone holds freshwater and prevents saline water intrusion (Figure 3). Variation in the thickness of the peat mass makes water management more complicated. If water is managed for thicker peat areas, the shallow peat or non-peat areas will be deeply flooded for long periods of time. On the other hand, if water is managed for shallow peat areas, the higher part of the peat dome will be too dry at the peak of the dry season and prone to destructive fires. Recently, UMT has tried to maintain different water levels corresponding to areas with different peat thicknesses. The practice needs to be supported by an accurate water level monitoring system and effective water control structures that allow timely water level manipulations for large areas.

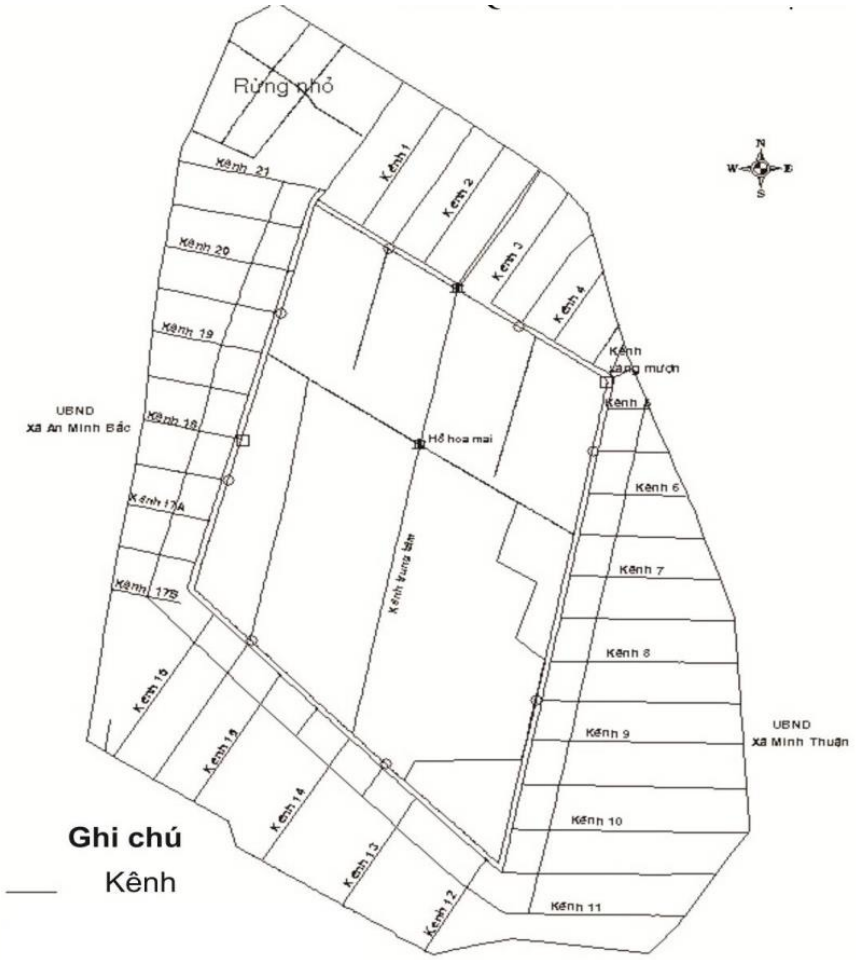


Figure 3: Core and buffer zones of UMT National Park with canal system (source: U Minh Thuong National Park, 2012)

3. Communities and wetland livelihoods

3.1 Communities and population

Within the UMT's core zone, there are no people living. Local people live in the buffer zone and around the National Park in An Minh Bac Commune (11 villages, of which 9 in the buffer zone) and Minh Thuan Commune (17 villages, of which 11 in the buffer zone). There is a total of 7,366 households (29,825 people) in these communes, of which 3,267 households (19,602 people) in the buffer zone. Most people are Kinh (90 %), but there is also a minority of Khmer origin (about 10 %) and a few Chinese families (U Minh Thuong National Park, 2012) (Table 1).

Table 1. Distribution of population by ethnicity (source: U Minh Thuong National Park, 2012).

Commune	Households				Inhabitants			
	Total	Kinh	Khmer	Chinese	Total	Kinh	Khmer	Chinese
An Minh Bac	2,696	2,520	175	1	10,977	10,336	637	4
Minh Thuan	4,670	4,235	434	1	18,848	16,941	1,904	3
Total	7,366	6,755	609	2	29,825	27,277	2,541	7

In the coming sections, we will pay specific attention to the three villages that were selected for the vulnerability assessment, i.e. Cong Su, Minh Dung and Minh Thuong villages.

3.2 Key livelihood activities

Farming is the main livelihood of people living in and around UMT. Major crops are vegetables, such as cucumber, bitter melon, onion, chives, and fruit trees, such as longan, rambutan, orange, and mandarin. However, these vegetable crops only account for a small proportion of total farming income compared to income from perennial crops such as sugarcane, coconut and melaleuca. In addition, people also farm fish for income, generating 5 to 20 million VND (US $227 – 909) per household per year. Besides, many households in the buffer zone are engaged in government programs of forest protection and receive (small amounts of) cash support from the State for protecting allocated forests.

As part of a government program to promote local livelihoods in the buffer zone, 3,500 poor households were provided with land and loans to plant melaleuca trees in the 1990s. After 7 years, each hectare of melaleuca generated about 3 million VND (US $136). But due to high capital requirements and labour investments for planting and caring, and long maturation time, melaleuca production is not ideal for poor households. In recent years, some villages have started to switch to sugarcane. Sugarcane only takes 9 months to produce and yields about 53 million VND (US $2,409) per hectare per year, not including investment costs for seedlings, fertilizers and labour (U Minh Thuong National Park, 2012). The local price of sugar cane is unstable, though, as people live far from the factory and depend on traders for collecting and buying their goods. The village location of Cong Su, and to some extent Minh Dung, facilitates convenient transportation for trading sugarcane after harvest, while the soils – intruded with salt water – also seem to support high quality sugarcane (national park staff, pers. comm.). Other areas of the buffer zones, however, such as Minh Thuong village, are less suitable for sugarcane cultivation and trading; therefore, most of their people focus on vegetable production, rice, fruits and farmed fish.

Non-timber forest products (NTFPs) and other plant products can be also used in the home or sold for food and are an important resource for poor households living in the buffer zone to bridge periods of food shortage (see section 3.7). Additionally, ecotourism provides opportunities but is still at an early stage of development. At present, tourism activities in the National Park are spontaneous, with very few tourism products and target markets, and limited investment in infrastructure or promotion (U Minh Thuong National Park, 2012). Thus, so far this hasn't brought about benefits to the local livelihood.

3.3 Use of wetland resources

In the past, local communities lived in the forests and were part of the wetland environment. Their daily life included cultivating vegetables, harvesting honey, and fishing. Currently, people are no longer allowed to live in the core zone of the National Park. They now live mainly in the buffer zone around the Park in An Minh Bac and Minh Thuan communes. Their exploitation and use of the biodiversity resources must comply with the Vietnamese legal provisions on the national park management and protection, which clearly stipulates that biodiversity resources are not allowed to be exploited and used. There are tensions between law enforcement and the dependency on forest resources by the poor local inhabitants. Illegal activities such as fishing, honey harvesting and wildlife hunting in the core zone of UMT are still happening.

Authorities consider the balance between local livelihood and the park protection management and biodiversity conservation, one of the major challenges (U Minh Thuong National Park, 2012). In the current land use and development plans, the buffer zone is meant to support agro-forestry-fishery products to sufficiently meet the local living needs and reduce the socio-economic pressure on the core zone resources (U Minh Thuong National Park, 2012).

3.4 Land tenure and land use rights

The core zone of 8,038 ha is owned by the state and managed by the management board of the National Park. The buffer zone area of 13,000 ha is owned by individuals and households and managed by People's Committees of An Minh Bac Commune and Minh Thuan Commune. By law, people are not allowed to access the core zone and exploit natural resources. They can visit the park as tourists, buying tickets for fishing in certain areas of the park and being guided by the management board. Land use planning of the national park until 2020 is oriented towards forest cover protection and stable and sustainable household economic development. It provides the following guidelines:

- For each household with 5 ha of land, land is divided into: 2 ha melaleuca forest, 2 ha agricultural production (including residential areas) and 1 ha of water surface for aquaculture development.
- For each household with 4 ha of land, land is divided into: 2 ha melaleuca forest, 1 ha agricultural production, 0.2 ha of boundaries and residential gardens, and 0.8 ha of water surface.

Based on the agricultural-forestry-fishery economic development till 2020 of the park management board (U Minh Thuong National Park, 2012), UMT will invest in developing household economic models that maximize the internal strength of each household with state support. The Park will enhance the management role of local authorities and communities in economic development and natural resources protection (U Minh Thuong National Park, 2012).

3.5 Governance

After the fire disaster in March 2002, the Central Government issued Official Letter No.73/TB-VPCP announcing the direction of the Prime Minister on the handling of fire consequences. The Ministry of Agriculture and Rural Development (MARD) was assigned to help UMT restore the melaleuca forest. To do this, MARD assigned the Institute for Forest Inventory and Planning to work with the Provincial People's Committee (PPC) of Kien Giang, the Department of Agriculture and Rural Development (DARD) of Kien Giang Province, and research organizations, to propose measures to restore ecosystems of melaleuca forest on peat soil. According to the Decision No.11/2002/QD-TTg of the Prime Minister in 2002 on the establishment of UMT National Park, the Park is an administrative unit under the PPC (Figure 4). It has the function of preserving and restoring natural resources, developing and protecting the park ecosystems, and organizing scientific research and ecotourism development to benefit the communities and society.

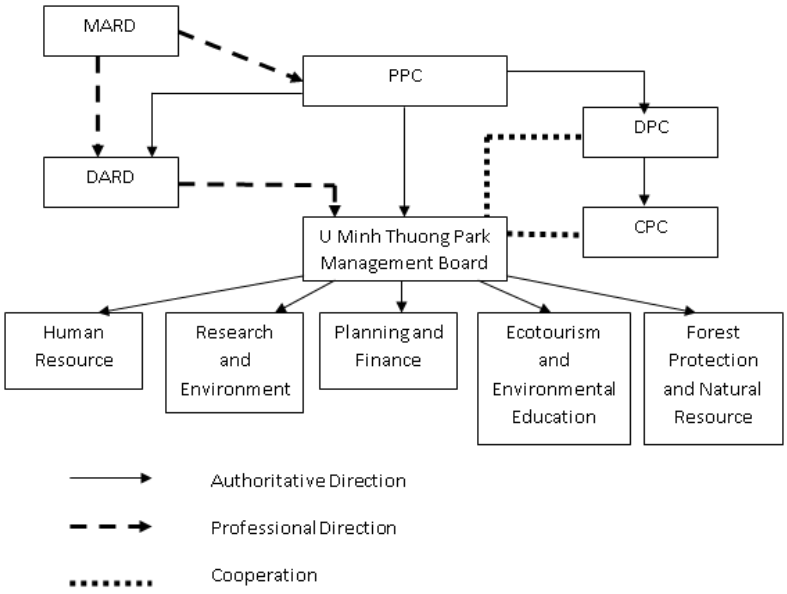


Figure 4: Governance framework for UMT National Park

The total staff of UMT National Park is 65 people; a self-assessment indicated that employees' current qualifications and capacities can fulfil responsibilities in the short term but in the long term they need more skills and knowledge on tourism management and conservation of natural resources and biodiversity (U Minh Thuong National Park, 2012). An Ecotourism and Environmental Education Centre and a Wildlife Rescue Centre were established recently to strengthen biodiversity conservation and ecotourism development. UMT Park administrators proposed the establishment of a Forest Protection Unit within the park to enhance the enforcement of forest protection laws in the park area. By cooperating with Vinh Thuan District Forest Protection Unit, the establishment of this unit are supposed to strengthen the holistic (inside and outside) forest protection of the park.

Forest protection is a priority of the park management. UMT National Park cooperates with the U Minh Thuong - Vinh Thuan District Forest Protection Unit and the local authorities of An Minh Bac and Vinh Thuan Communes (CPCs) to implement forest protection activities, especially in dry seasons. The Park also coordinates with local authorities and mass organizations to implement campaigns and education programs on forest fire prevention and fighting, while the people are asked to sign commitments to implement regulations. Besides, the Park attempts to restore forest

ecosystems that have been lost by forest fire since 2002; many activities and research projects are carried out to support forest restoration and development. In addition, the it has established a Department of Ecotourism Development and Environmental Education to run tourism activities. Currently, investment in infrastructure for ecotourism development is extracted from the revenue of gate tickets, visitor services and recreational fishing. However, this source of revenue is not enough to invest in ecotourism facilities of the Park.

3.6 Stakeholder analysis

The protection and management of UMT National Park is a complex process in which different players and interests play a role. Various type of actors can be distinguished such as government departments who are responsible for park management and enforcement of the law, local authorities who are responsible for the approval of management plans, coordination and implementation, NGOs who may provide technical and financial support on landscape protection and biodiversity conservation, and local communities who depend on the wetland for their livelihood; in addition, there are several knowledge institutes and research centres that provide technical expertise and support. These actors provide different perspectives and have different roles to play in the management of UMT; their involvement could possibly be strengthened, both formally and informally (see Table 2).

Table 2: Main stakeholders of UMT National Park.

Actor	Name	Role
Government	MARD	Provides technical and financial support for projects on forest protection and biodiversity research
	Provincial PC	Approves park management/development; provides financial support
	Commune PCs	Cooperates in environmental education programs and wildlife law enforcement; coordinates livelihood development projects
	UMT National Park Management Board	Directly manages the park
Universities/ Institutes	Forest Inventory and Planning Institute	Cooperates on project development on forest rehabilitation
	Can Tho University	Constructed a plan for buffer zone community development and cooperates on scientific research
	Southern Institute of Ecology	Conducted research on peatland ecosystem of UMT national park and cooperates for scientific research
NGOs	Vietnam Conservation Fund (VCF)	Provides financial support
	CARE	Made a plan for buffer zone community development (with Can Tho University); provides financial and technical support through projects
	GIZ	Provides financial and technical support for nature conservation and development, supporting the learning process of co-management
Communities	Local people in the buffer zone	Participate in forest plantation and protection and ecotourism development; cooperate on forest fire precaution and fighting

3.7 Gender and vulnerable groups

About 500 (16%) of the households (about 3,000 people) in the buffer zone are very poor. They are landless and illiteracy rate is very high (86%). Their income mainly relies on natural resources and is about 200,000 VND per person per month. These households live in conditions of permanent food shortage, especially from June to September. During this time, they depend on the collection of NTFPs to overcome difficulties. It is a great challenge for the state and the Park to support them in reducing poverty levels and limiting their dependence on national resources (U Minh Thuong National Park, 2012).

While women and men are likely to have different roles and responsibilities in terms of sourcing and selling of food, including natural resources, no research data were found in relation to gender for this area. This prompts further exploration, since vulnerabilities, as well as perspectives and (potential) role in natural resource management may be very different for women and men.

3.8 Perceived threats to wetland habitats and livelihoods

Specific threats and pressures on natural resources include the following:

- Melaleuca forests on peatlands burn easily in the dry season, when most people tend to go into the forest to collect honey and catch fish; fires that people use to smoke out bees and cook food are often claimed to be the main cause of forest fires.
- Hunting wildlife for food and for sale has not been effectively controlled.
- The use of destructive methods such as electro-fishing which kill all kind of fishes.
- Invasive species such as mimosa, water hyacinth, apple golden snail
- Loss of all kinds of crops because of floods and droughts

4. Climate projections for the site

As mentioned before, MONRE's published a report in 2016 on climate change and sea level rise scenarios for Vietnam (Tran Thuc et al. 2016). It provided not only an overview of historic trends, but also the most up-to-date and comprehensive analysis of trends and predictions of climate change and sea level rise in Vietnam. Some projections were downscaled to district level. The climate change scenarios used in MONRE's analysis followed those introduced in the IPCC Fifth Assessment Report (IPCC 2013). These scenarios are based on concentration of greenhouse gasses. In this study, we focused on two scenarios: RCP8.5, an extreme scenario without policy action, leading to a global temperature increase of 4.9 ^{o}C by the end of the century; and RCP4.5, a moderate scenario with policy action, whereby temperature increase is contained to 2.4 ^{o}C by the end of the century.

The study provides detailed projections for all geographical regions and provinces of Vietnam. We present here a summary of climate change and sea level rise projections for Vietnam, with selected information that are most relevant to UMT.

4.1 General trends

Temperatures throughout Vietnam are expected to rise in the coming century. Predictions of temperature change by the end of the century are slightly higher for the north of Vietnam compared to the south. By the end of the century, temperatures in Kien Giang Province will increase with 1.8 ^{o}C under RCP4.5 and 3.2 ^{o}C under RCP8.5. At the same time, the monsoon season is projected to arrive sooner and end later, resulting in a longer monsoon season. Total **rainfall** during summer months and the occurrence of intensive rainfall events are all projected to be increased. At the end of the century rainfall in Kien Giang Province will increase by 17 % under RCP4.5 and by 15.4 % under RCP8.5. Table 3 shows temperature and rainfall projections for Kien Giang Province. Since UMT is located south of Kien Giang Province, in the Ca Mau Peninsular, we also provide projections for Ca Mau Province.

Table 3: Temperature and rainfall projections under RCP4.5 and RCP8.5 scenarios for Kien Giang Province and Ca Mau Province (adapted from Tran Thuc et al., 2016).

Scenario/time period		**RCP4.5**			**RCP8.5**		
		2016 – 35	**2046 – 65**	**2080 – 99**	**2016 – 35**	**2046 – 65**	**2080 – 99**
Temperature change (^{o}C)	**Kien Giang**	0.7	1.3	1.8	0.8	1.8	3.2
	Ca Mau	0.7	1.4	1.8	0.9	1.8	3.3
Rainfall change (%)	**Kien Giang**	4.9	9.2	17.0	6.5	14.4	15.4
	Ca Mau	8.4	5.8	9.6	6.7	10.8	12.6

Under RCP4.5, frequencies of **typhoons and tropical depressions** in the East Sea are projected to change little throughout the 21st century, but storm intensity may increase by 2 – 11 % and precipitations within a 100 km radius from storm eyes increase by 20 %. Under RCP8.5, storm frequency would even decrease. Under both scenarios, numbers of typhoons and tropical depressions would decrease during the early storm season (June – August) but increase towards the end of the season (October – December). While the occurrence of weak to medium typhoons may decrease, the numbers of strong to very strong typhoons show a clear upward trend.

Under RCP4.5, number of **high temperature days** (days with max temperatures ≥35^{o}C) increases by 25 – 35 days in mid-century and more than 50 days by the end of the century. Under

RCP8.5, the projected increases are 35 – 45 days in mid-century to more than 100 days by the end of the century. **Droughts** are projected to be more severe in southern provinces during months of March to May.

4.2 Sea level rise

Sea level rise as result of climate change is expected to have a huge impact in Vietnam, whereby sea level rise in the southern provinces are projected to be higher than in the northern provinces. By 2100, sea level rise projections for the near-shore area between Ca Mau Cape and Kien Giang Province are 55 cm (with a 90 % confidence interval of 33-78 cm) under RCP 4.5 and 75 cm (with a 90 % confidence interval of 52-106 cm) under RCP8.5 (see Table 4). Even when taking the most optimistic IPCC scenario (RCP2.6), sea level rise by the end of the century would be 45 cm (with a 90 % confidence interval of 27-68 cm).

Table 4: Sea level rise projections (in cm with 90% confidence intervals) for the near shore sea area between Ca Mau Cape and Kien Giang Province under two climate scenarios (adapted from Tran Thuc et al., 2016).

	2030	**2040**	**2050**	**2060**	**2070**	**2080**	**2090**	**2100**
RCP4.5	12 (7 ÷ 18)	17 (10 ÷ 25)	23 (14 ÷ 32)	28 (17 ÷ 40)	34 (21 ÷ 49)	41 (25 ÷ 58)	48 (29 ÷ 68)	55 (33 ÷ 78)
RCP8.5	12 (9 ÷ 17)	18 (13 ÷ 26)	25 (17 ÷ 35)	33 (23 ÷ 47)	42 (29 ÷ 59)	52 (36 ÷ 73)	63 (44 ÷ 89)	75 (52 ÷ 106)

If sea level would rise with 100 cm by the end of the 21st century (extreme but potential increase in case of RCP8.5), 39 % of the Mekong Delta would be inundated (Figure 5). Kien Giang has the second highest inundated area (77 %) among all provinces of Vietnam (Figure 6), only after Hau Giang Province (81%).

Within Kien Giang Province, U Minh Thuong District (where UMT is located), would be severely inundated, with 77 % of land being submerged with a 100 cm sea level rise (Table 5). Even though sea level rise projections and resulting inundation risks for the intermediate term (2030-2050) are considerably lower, they are expected to have severe implications in terms of salt-water intrusion and changed hydrological state of the wetland.

Table 5: Inundated land (%) at different levels of sea level rise for Kien Giang Province and U Minh Thuong District (adapted from Tran Thuc et al. 2016).

		Sea level rise					
	Area (ha)	**50 cm**	**60 cm**	**70 cm**	**80 cm**	**90 cm**	**100 cm**
Mekong Delta	3,969,550	5 %	9 %	15 %	21 %	28 %	39 %
Kien Giang Province	573,690	8 %	20 %	36 %	51 %	66 %	77 %
U Minh Thuong District	43,218	8 %	18 %	33 %	47 %	62 %	77 %

4.3 Implications for U Minh Thuong National Park

Important climate threats to UMT's wetlands are severe and prolonged droughts, higher air temperatures, flooding and salinity intrusion due to sea level rise. In addition, occurrence of extreme events, such as heat waves, strong storms, and torrential rains, will be more frequent and mostly unpredictable.

Wetlands are most seriously threatened by severe droughts, especially those that last a few consecutive years. Higher temperatures in combination with droughts will increase the risks of uncontrollable fires and threaten the last remnants of peat swamp forests in UMT. Rainfall is expected to increase and be more variable. Large variations in the timing and duration of wet and dry seasons are expected, resulting in high fluctuations of soil water availability. Variation in annual rainfall has significant implications on wetland management at UMT because it strongly affects water availability in peat swamps. Less rains in the early wet season may further increase risks of forest fires and saline water intrusion. Since the UMT area will be strongly affected by sea-level-rise, induced flooding would also contribute to salinity intrusion into the freshwater wetland environment of UMT.

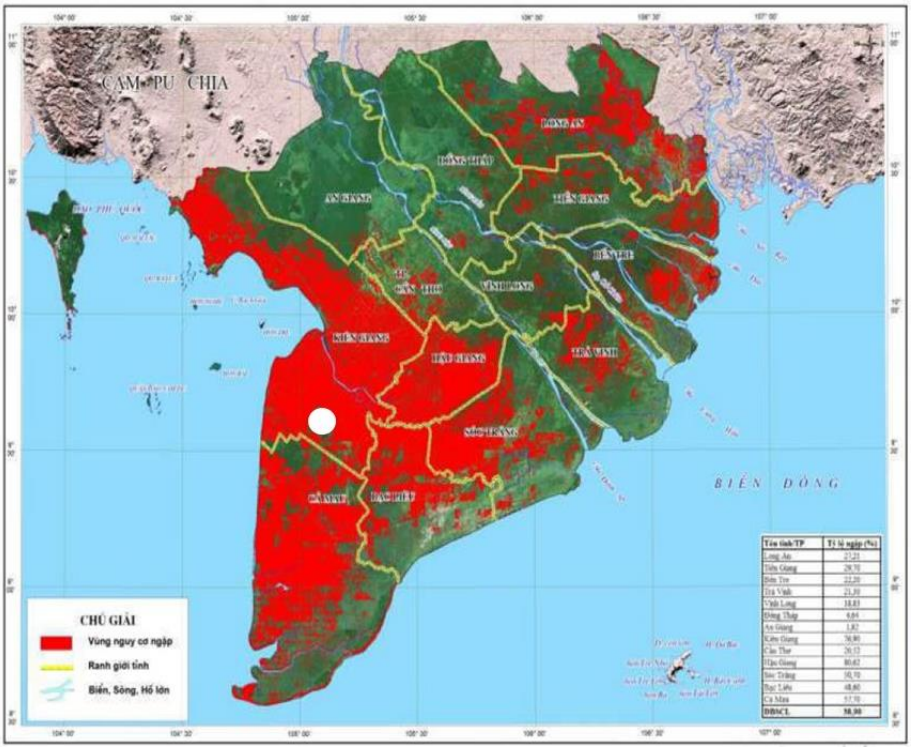


Figure 5: Map of inundation risk for the Mekong Delta when sea level rises with 100 cm; white circle shows location of UMT (source: Tran Thuc et al. 2016).

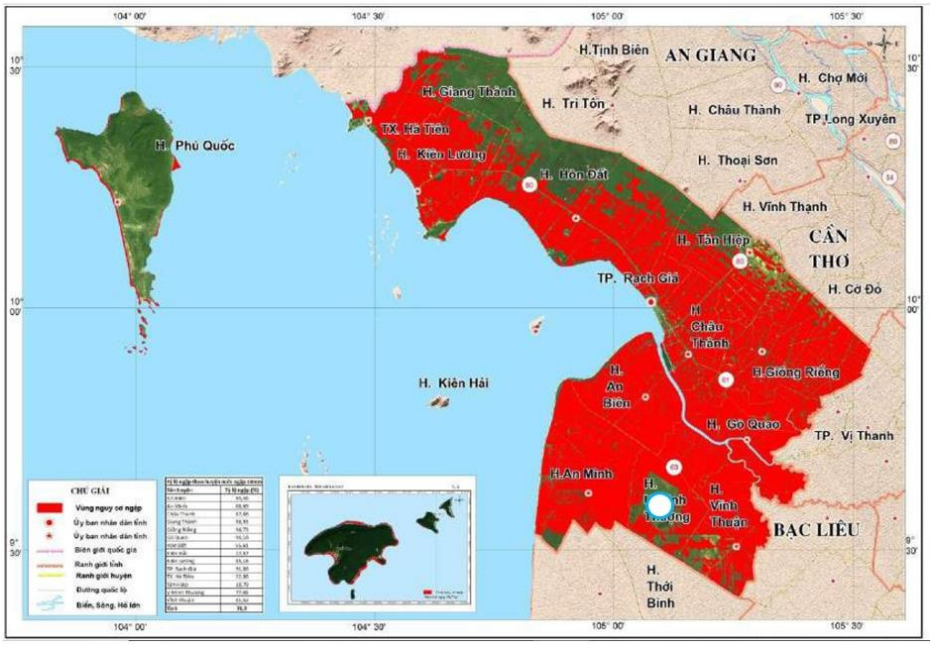


Figure 6: Map of inundation risk for Kien Giang Province when sea level rises with 100 cm; white circle shows location of UMT (source: Tran Thuc et al. 2016).

5. Results of vulnerability assessment

5.1 Habitat vulnerability

The assessment team selected 3 wetland habitat types of UMT for climate vulnerability assessment, namely peat swamp forest, melaleuca forest on clay soils (non-peat), and open swamp. These are the three main habitat types of UMT.

5.1.1. Baseline conservation status

Baseline conservation status of habitats was assessed based on their regional and local representation and trends (increasing or decreasing), biodiversity conservation values (presence of flagship, keystone species), protection status, national or international recognitions, and their ability to recover from extreme weather events. Baseline conservation status reflects the importance of protection and was assessed using expert opinions, including those of the assessment team and UMT's managers; scores range from 1 to 3, with score of 3 being high and 1 being low.

Peat swamp forest is a rare wetland habitat type of the Mekong Delta, now only exists in UMT and U Minh Ha national parks. Its geographical extent has been reduced significantly due to fires and conversion to farmlands. The current area of peat swamps in both UMT and U Minh Ha is around 13,000 ha, of which 4,000 ha are in UMT, as compared to 32,600 ha recorded in the early 1970s (Tran 2016). Peat swamp forests of UMT are home to many plant and animal species that are of special conservation concerns in Vietnam and internationally, such as pangolin (IUCN's Critically Endangered category), hairy-nosed otter (Endangered), large fruit bat (Near Threatened), and fishing cat (Vulnerable). UMT peat swamp forest vegetation is dominated by *Melaleuca cajuputi*, which can be considered a keystone species of this type of wetland habitat. It is also an economically valuable tree species. Peat swamp forest is strictly protected in the core zone of UMT. Our analysis yielded a baseline conservation status score of 2.2 for UMT peat swamp forests, which is still considered to be moderate but close to high.

Melaleuca forest on clay soils in UMT is a secondary form of peat swamp forest, whereby the peat layer is completely removed – often by fires. Melaleuca forest on clay soils is a common wetland habitat type in the Mekong Delta. The water stocking practice applied at UMT following the 2002 catastrophic forest fire, has put almost all areas of melaleuca forest in permanently inundated condition and has resulted in poor growth of melaleuca trees. Our analysis yielded a baseline conservation status score of 1.7 for UMT melaleuca forests, reflecting a low baseline conservation status.

Open swamps in UMT were created in 2002 when high intensity fires burned the entire peat layer and formed permanent waterbodies. Open swamps are covered by an aquatic vegetation that is co-dominated by several floating aquatic plants. Open swamps in UMT are heavily affected by invasive alien species such as water hyacinth, water lettuce and golden apple snail. Open swamps are important habitats for water birds and many species of fishes which are economically important for UMT. Fishing permits, sold to recreational fishermen coming from large cities such as Ho Chi Minh City, bring in considerable incomes for the Park. The fish stock maintained in UMT's core zone also supplies local communities in the buffer zone with ample fish resources. Our analysis yielded a baseline conservation status score of 1.9 for UMT open swamps, which is considered moderate.

5.1.2. Climate change vulnerability

Table 6 presents a summary of major climate issues, exposure, sensitivity and adaptive capacity of the habitat types being assessed for UMT.

Table 6: Summary of climate vulnerability characteristics of three wetland habitat types of UMT National Park.

	Major climate issues	**Exposure**	**Sensitivity**	**Adaptive capacity**
Peat swamp forest	Drought; high temperature; sea level rise, salinity intrusion	All areas being exposed	Heat; drought; sea level rise; soil erosion	Low
Melaleuca forest (non-peat)	Drought; high temperature; sea level rise, salinity intrusion	All areas being exposed	Drought; sea level rise	High
Open swamp	Drought; sea level rise, salinity intrusion	All areas being exposed	Drought; sea level rise; soil erosion.	Intermediate

Main climate issues for all three wetland habitat types assessed for UMT are drought, higher air temperatures and sea-level-rise induced salinity intrusion.

Droughts and higher air temperatures, especially extreme high temperatures episodes, increase the risks of uncontrollable fires. This is especially a problematic for peat swamp forests at UMT, threatening the existence of their last remnants. Droughts also create drier condition in the peat mass, expose peat to air, resulting in oxidation of peat materials. Peats would be compacted and acidified under aerobic conditions. With current water management policy, when the water level inside UMT's core zone reaches a certain low level, water from the outside will be pumped into the core zone to prevent forest fires. This practice increases the risks of bringing saline water, environmental contaminants and alien species into the core zone.

Sea-level-rise induced inundation is expected to have a strong influence on the UMT area and the risk of salinity intrusion is, therefore, very high. All wetlands of UMT are freshwater and will not tolerate high salinity. Being located outside of the flood zone of the Mekong River, wetland habitats in UMT would not be directly affected by changes in Mekong River's hydrology and sedimentation, but by Ong Doc River and Cai Lon – Cai Be River system. Currently, a mega river control project is being planned for Cai Lon – Cai Be system, aiming to store freshwater and prevent salinity intrusion. The potential impacts of this project on UMT, both positive and negative, need to be carefully assessed.

The open swamp has a vegetation, comprising of mostly grasses, sedges and aquatic plants, that is more capable of regenerating after a climatic extreme event as compared those of peat swamp and melaleuca forest, which consist of mainly large woody trees that take longer time to regenerate. Open swamps are, however, susceptible to severe droughts that dry them up and kill most aquatic animals. Peat swamp is the least resilient among the three habitat types because the climatic and hydrological conditions needed for maintaining peat mass are projected to be strongly influenced by climate change. Melaleuca forest, on the other hand, is more resilient because of available spaces for this type of habitat in the general Mekong Delta region.

Overall, results of our analysis showed that peat swamp forests are “Very Highly Vulnerable” (score 2.7) to climate change, open swamp “Highly Vulnerable” (score 2.4), and Melaleuca forest “Moderately Vulnerable” (score 2.0).

5.1.3. A comparison between habitats

The scores for baseline conservation status and climate change vulnerability for the three main habitats in UMT are summarized in Table 7. As indicated in the previous section, peat swamp forests are “Very Highly Vulnerable” to climate change, open swamp “Highly Vulnerable”, and melaleuca forest “Moderately Vulnerable”. From these, open swamps and melaleuca forests have lower than average conservation status values, reflecting the fact that these wetland habitats are common elsewhere in the Mekong Delta. The familiarity of our assessment team to habitat conditions at UMT resulted in high confidence scores (scale 1-4) for all habitat assessments.

Table 7: Summary of habitat assessment results for UMT National Park, Kien Giang Province, Vietnam.

	Baseline conservation status		Climate change vulnerability	
	Score	**Confidence**	**Score**	**Confidence**
Peat swamp forest	2.2	3.8	2.7	3.5
Melaleuca forest (non-peat)	1.7	4.0	2.0	3.3
Open swamp	1.9	3.9	2.4	3.6

Figure 7 presents the results of the baseline conservation status and climate vulnerability assessment for the three habitats in UMT compared to other habitat types assessed for Vietnam’s wetland sites in the Mekong Delta. At Lang Sen Wetland Reserve in Long An Province, three wetland habitats – lotus swamp, seasonally inundated grassland and melaleuca forest – were assessed. At Phu My Species and Habitat Conservation Area in Kien Giang Province, two habitats – seasonally inundated grassland and melaleuca shrub – were assessed. All habitat types were ranked from moderately to highly vulnerable to climate change, except UMT’s peat swamp, which is ranked very highly vulnerable. UMT peat swamp is also among the wetland habitats that received the highest baseline conservation scores.

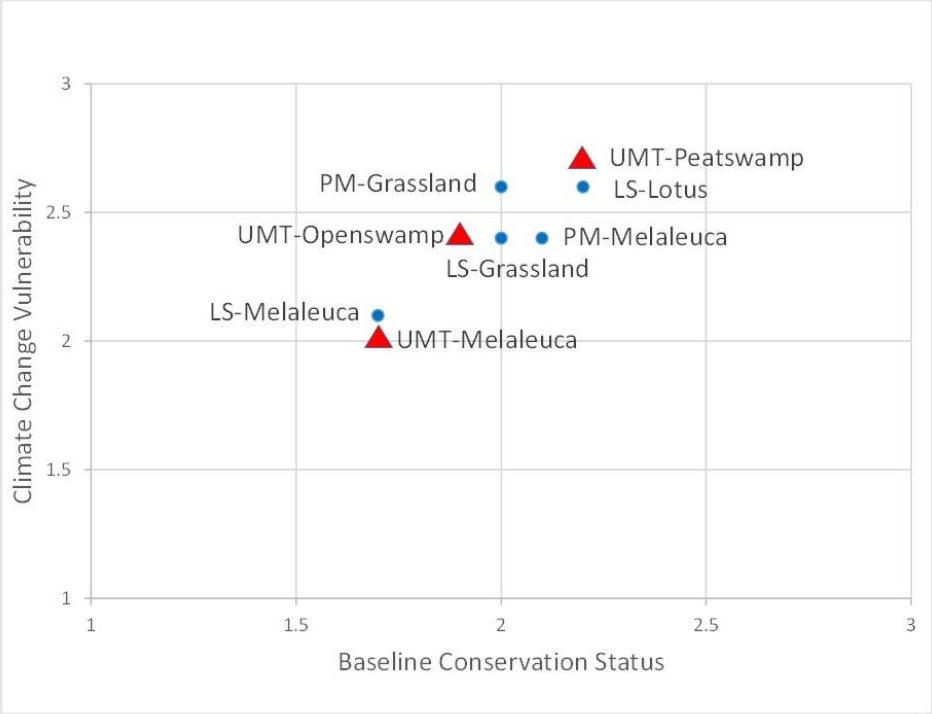


Figure 7: Conservation status/Climate vulnerability diagram for all wetland habitats assessed for Vietnam sites. LS: Lang Sen Wetland Reserve; PM: Phu My Species and Habitat Conservation Area; UMT: U Minh Thuong National Park. UMT's habitats are represented by red triangles.

5.2 Livelihood vulnerability

In consultation with UMT managers, the assessment team selected three villages for the vulnerability assessment, namely Cong Su, Minh Dung and Minh Thuong. The locations of the villages are indicated in Figure 8.

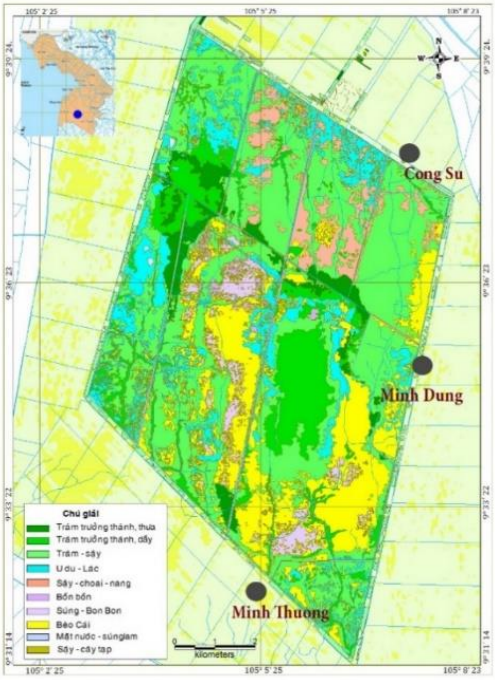


Figure 8: Village locations

At every village, the team engaged with village members and applied participatory rural appraisal (PRA) to mobilize villagers and learn from their knowledge. PRA is an appraisal process conducted in a short time and helps villagers to share, consolidate and analyse their knowledge and living conditions. PRA tools included rankings, village resource maps, seasonal calendars, historical timelines, and discussions.

In this study, PRA tools were used to collect data on resource priorities, distribution of resources, seasonal characteristics of wetland resource use and collection, historical timelines of extreme weather events and impacts, and group discussions on coping behaviour and management practices. Needs and perspectives of women and men were included through separate focus groups.

5.2.1. Dependency on wetland resources

Important resources identified by men and women included well water, river water, rice, fish, melaleuca, and wild vegetables (Table 8). In all three villages, well water is the most important resource for the people. Besides well water, people in Minh Dung use river water for transportation and irrigation. Fish and wild fish are also an important resource for people's livelihoods in all villages. Minh Thuong village focuses more strongly on growing rice and vegetable crops; while for Minh Thuong, rice plays an important role, for other villages, it does not. In Cong Su and Minh Dung village, local people cultivate sugarcane and fruit trees and collect wild vegetables for food and sell them to earn more income, while Minh Dung village has also many people raising livestock.

Insects and bats were also mentioned and valued as natural resources by people in Cong Su village. This is the only area where bats fly over from UMT and seek food in the area. They were interested in bat farming for collecting bat guano (bat droppings). As a manure, guano is a highly effective fertilizer due to its exceptionally high content of nitrogen, phosphate and potassium: nutrients essential for plant growth. When probed, they also mentioned that insects helped them increase crop productivity when compared to other villages. Due to the location nearest to UMT, people in Cong Su are also more aware of the importance of melaleuca trees for creating a fresh and cool sub-climate or environment; *Eucalyptus* was mentioned by Minh Thuong village for similar reasons. Other mentioned wetland resources included medicinal herbs, snakes and field rats.

Illegal wildlife exploitation in the core zone of UMT was not reported by the people. However, the board management mentioned cases of illegally fishing and hunting by people from the villages. There are also human-wildlife conflicts, e.g. in Cong Su – which is located near the otter habitat in the park – people complained about otters catching their fish. There were no major differences in the perceptions of men and women toward the importance of resources in the villages.

Table 8. Ranking of key wetland resources by men (M) and women (F) from Cong Su (CS), Minh Dung (MD) and Minh Thuong (MT) villages in UMT.

	Wetland resource	**CS**		**MD**		**MT**		**Resource-use**
		M	F	M	F	M	F	
1	Well water	1	1	2	1	1	1	For household consumption
2	River water	-	-	1	2	-	-	For transportation and irrigation
3	Rice	-	-	-	-	2	2	For food and sale
4	Crops & fruit trees	-	-	3	3	3	3	For food and sale, incl. sugarcane, banana, coconut, rambutan, longan
5	Insects	3	4	-	-	-	-	For helping increase crop productivity
6	Fish	4	5	4	5	5	5	For food and sale
7	Vegetable crops	-	-	-	-	4	4	For sale, incl. cucumber, bitter melon, onion, chives
8	Bats	5	3	-	-	-	-	For fertilizers
9	Pigs and poultry	-	-	5	4	-	-	For food and sale
10	Wild vegetables	-	-	6	7	7	6	For food and sale
11	Melaleuca	2	2	7	6	9	9	For fresh and cool environment and firewood
12	Eucalyptus	-	-	-	-	6	8	For fresh and cool environment and firewood
13	Medicinal herbs	-	-	-	-	8	7	For healing disease and protecting health
14	Phragmites	-	-	9	8	-	-	As seedling cover for sun protection and as truss to help plants (e.g. cucumber) to climb
15	Snake	-	-	8	9	10	10	For food and sale
16	Field rats	-	-	10	10	-	-	For food and sale

Note: People from Cong Su village only identified and rank five resources (with some probing); crops and fruit trees were not mentioned, even though banana and sugarcane did emerge as important crops in later discussions.

Resource maps and seasonal calendars were made with members of the three villages to get a better understanding of the distribution of resources over space and time (see Figure 9 and 10). Livelihood activities in Cong Su are based on banana cultivation, sugarcane cultivation, hired labour and fish farming; sugarcane cultivation and fish farming are restricted to the months of April to December (wet season). In Minh Dung, activities are more diversified, including growing vegetable crops, raising chicken, farming fishes, and growing sugarcane and pineapple; the latter two from April to December. In addition, people collect wild vegetables, hunt for snakes and rodents, and fish. In Minh Thuong, people make a living by growing rice – three times a year – and through fruit trees such as coconuts, bananas, medicinal plants and fish farming. These activities take place in the farmlands of villagers. The people also exploit natural resources such as wild fish, snakes, and wild vegetables which are common in the buffer zone canals around the core zone and in the farmlands. Some people are local traders and hired labourers. In general, cultivation, animal husbandry, and fish farming activities take place throughout the year, while exploitation of natural resources is seasonal – except for wild vegetables which are regularly harvested.

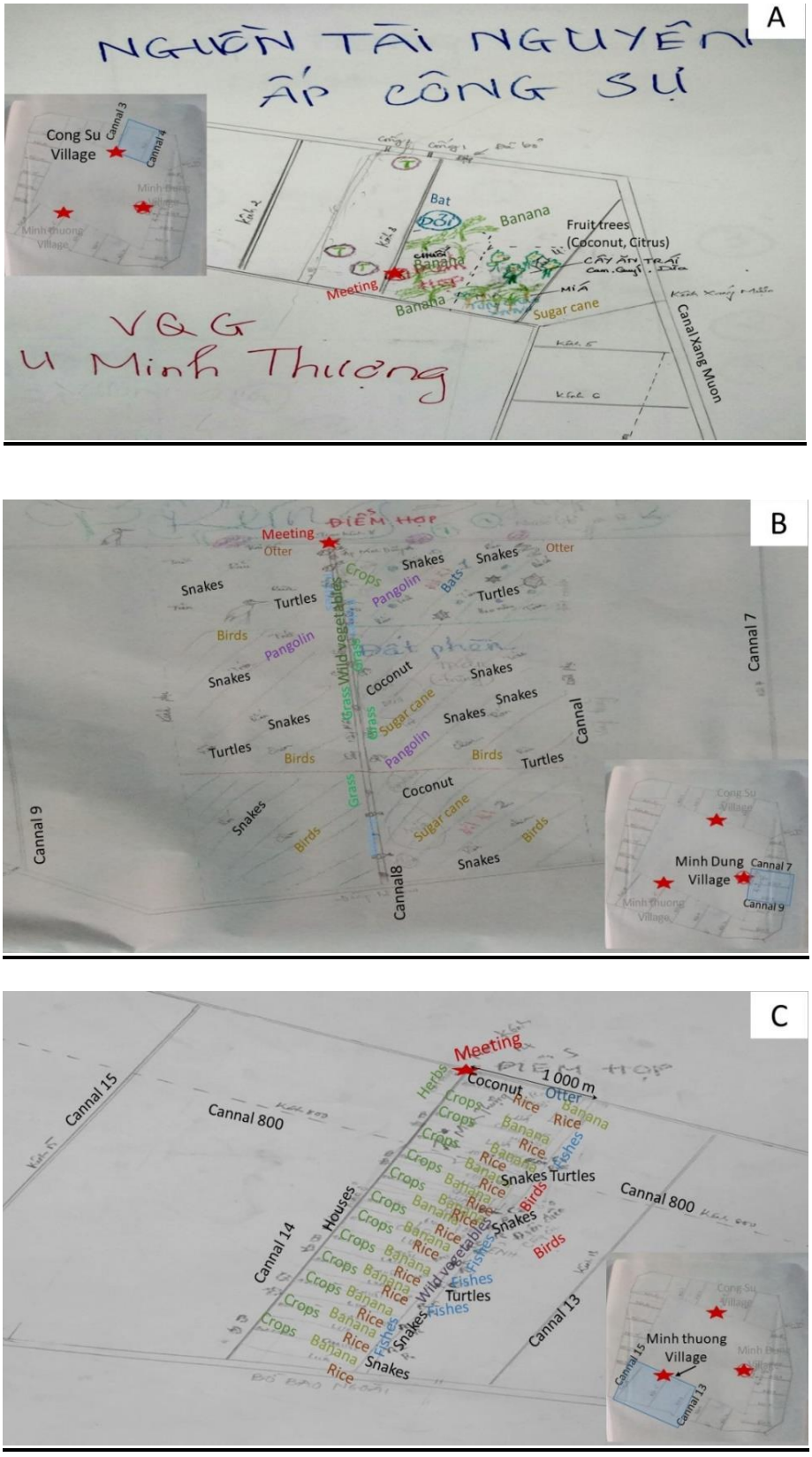
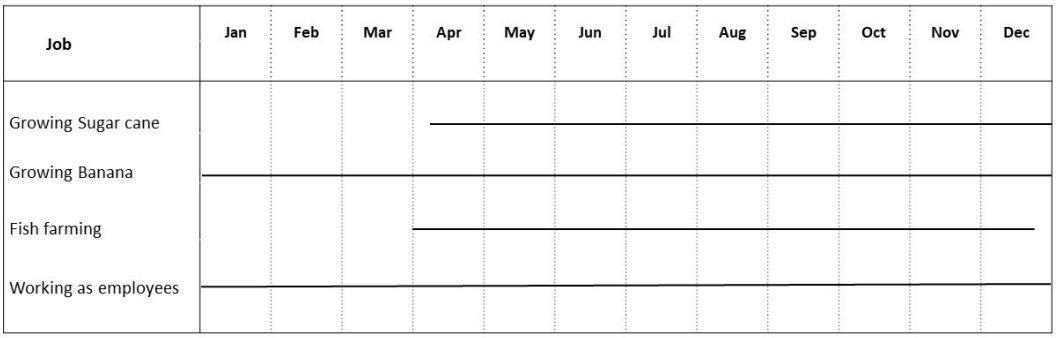
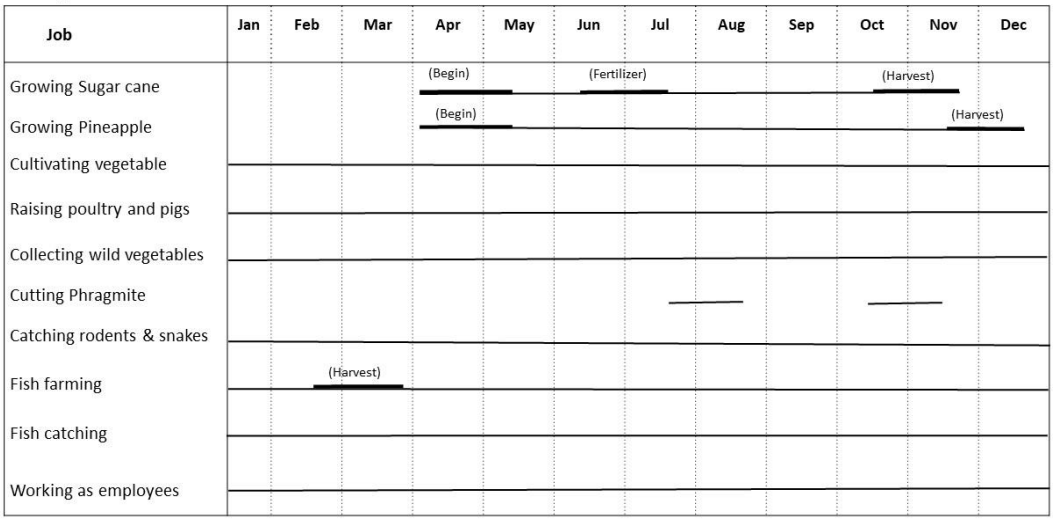


Figure 9: Resource map of Cong Su (A), Minh Dung (B) and Minh Thuong (C) Village

Cong Su



Minh Dung



Minh Thuong

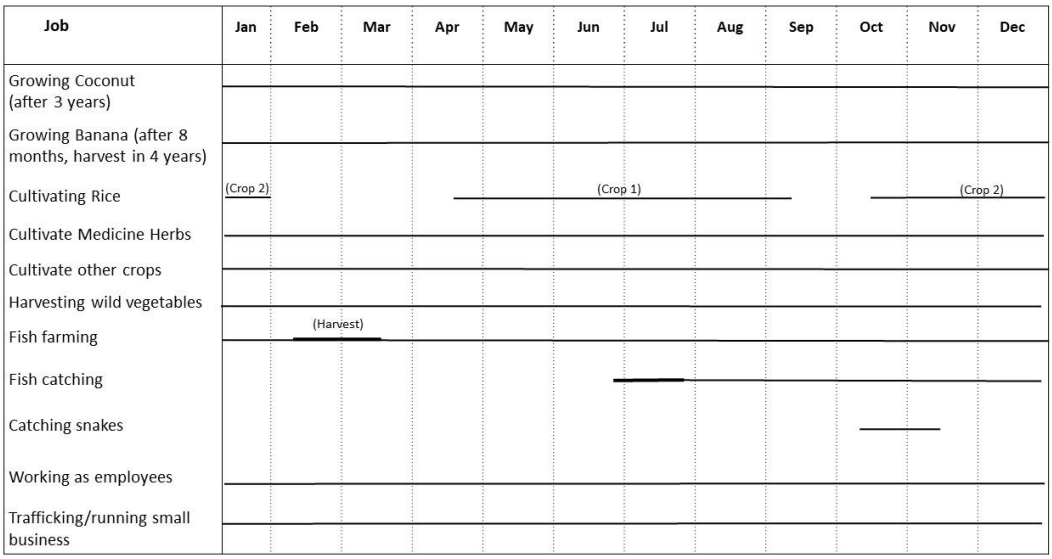


Figure 10: Seasonal calendar of Cong Su, Minh Dung and Minh Thuong Village

5.2.2. Extreme weather events and impacts

Extreme weather events over the last 10 years reported by people from the three villages include droughts, floods, strong winds and thunderstorms (Table 9). According to them, extreme weather events in the area occur every 3-5 years. Droughts tend to happen more frequently in recent time.

Table 9: Extreme weather events over the last 10 years and their impacts.

Extreme events	**Years and villages**	**Impacts**
Drought	2013 – Minh Thuong	Well water shortage and damaged crops and wild vegetables.
	2015 – Cong Su, Minh Dung, Minh Thuong	Water shortages, damages to crops, transportation interruptions, landslides, and livestock diseases.
Flood	2017 – Minh Dung	Inundated farmlands, causing losses of crops and farming fishes.
Strong wind and thunder	2013 – Minh Dung	It damaged many local dwellings and affected the electricity provision system.
Storm	2017 – Minh Thuong	The area was flooded, and all new crops were destroyed.

Over the last 10 years Minh Dung and Minh Thuong village have been affected more by extreme weather events than Cong Su village. Explaining this, villagers believe that the geographic locations make the villages differently exposed, for instance due to wind direction, the protection of UMT forests, and the intake of groundwater from the melaleuca forest and the canal system. In all cases natural disasters have severely affected people's income due to negative effects on crops, livestock and natural resources. Houses and local roads were also severely affected and required financial investment to recover.

In Minh Thuong village, droughts occurred in 2013 and 2015, causing serious damages to all crops. Wells and canals ran out of water. Rice fields dried out. Water transportation was disrupted because of low water. Transportation became very difficult because village roads were affected by soil erosion. Wild vegetables were hard to find. Many fish and poultry were exposed to disease outbreaks and deaths. When the drought happened in 2015, fish also died in Minh Dung village. Water in wells and canals also became less and transportation by boats was disrupted, while roads were damaged by soil erosion. About 90% of crops in Minh Dung were damaged. During the same drought, sugarcane was harvested in Cong Su village but could not be sold because of transport difficulties. Houses along the river in Cong Su collapsed because of soil erosion. Vegetable crops were damaged and sugarcane production decreased by 40%. Fish had to be farmed late, affecting the household's income for the following year. Well water became scarce and was contaminated with soil acids, which are speedily released from alkaline soils when they are exposed to air and oxidized. Ducks and chickens suffered from sickness and death. The villagers had to switch their working hours to night time because it was so hot during the day.

In the flood of 2017, about 50-80 % of vegetable crops in Minh Dung Village were inundated. There was a decrease in productivity of pineapple and sugarcane as well. Fish that were farmed in fish ponds were lost in the flood. There was also a decrease in natural fish stock. During the strong winds and thunderstorms of 2013, dwellings of Minh Dung village were damaged. Electricity supply was interrupted. Minh Thuong village was hit by a storm in 2017, the rice crop was not yet harvested and mostly damaged. Newly cultivated crops were also destroyed. Melaleuca forest was not affected much by the storm.

5.2.3. Coping strategies and wetland management

To understand perceptions and intentions of villagers to effectively deal with such disasters, we asked them how they coped with these extreme weather events in the past, and how they plane to cope with them in the future, when they are expected to become more frequent and intense due to climate change (see Table 10-12).

Over the last 10 years, all villages have been exposed and affected by extreme weather events. In dealing with these disasters, there was no clear difference in coping strategies between men and women. Current coping strategies are mostly unsuccessful, largely depending on state support, the anticipation of more favourable weather conditions for re-planting of post-disaster crops and the natural regeneration of resources such as wild fish. In case of droughts, water sources in the area became exhausted and well water fully exploited. Getting loans from banks or neighbours, finding jobs in other cities, finding markets for agricultural products were other strategies that people applied to cope with disasters and to remedy damages and stabilize income.

In Cong Su Village, people's future coping strategies to extreme weather focussed on making water available for transportation, fish farming, and drinking; some plan to replace fishponds with shrimp farms to increase incomes. In addition, support for the application of effective farming techniques and markets to get higher prices for agricultural products was highlighted in their strategies.

In Minh Dung village, people have come up with many measures to cope with future extreme weather events. The main measures suggested by men included: changing crops to suit the natural conditions in the region and the market demands; seeking opportunities to trade their products directly on the market without relying on traders so that they can get a higher price; applying water-saving measures and reducing water losses through dyke leaking; looking for additional jobs besides farming and raising livestock; and paying close attention to weather forecasts and public announcement systems in the area so that they are prepared in case of natural disasters. Coping strategies mentioned by Minh Dung women were less diversified and rather passive when compared to men; they hoped for more favourable weather conditions and support from the state.

Men of Minh Thuong village would like to have more jobs in the future, in addition to cultivation and husbandry to increase their incomes. They will also pay more attention to the water management in fish ponds and groundwater. Women intent to focus on issues of crop rearrangement and expect better agricultural product consumption policies. In addition, effective operations of the drainage and dyke system in the area are considered a priority by local people.

Although the links between people’s livelihoods and wetland resources have decreased over time, the wetland is an important freshwater source for irrigation and helps to maintain groundwater for local water wells. The wetland also comprises important fish habitats which help redevelop fish stocks after natural disasters. In general, the wetland plays an important role in the protection of habitats and regulatory ecosystem services. The planned diversification and rearrangement of farming and livelihood activities in response to extreme weather events may help villages to cope with climate change, but some of these activities may also put the wetland under further pressure. Increased irrigation may lead to more salt-water intrusion, while – especially in case of droughts – people will dig deeper wells to extract water for household consumption with increased risks of

(toxic) alum levels in the water source due to alkaline soils; environmental pollution maybe further exacerbated by runoff of chemicals used in crop cultivation.

Table 10: Summary of current and future coping strategies as identified by representatives of people from Cong Su village

Extreme weather events	Impacts	Current coping strategies		Future coping strategies	
		Men	Women	Men	Women
Drought	Disrupted transport	Switching to using smaller boats instead of large ones. Making temporary roads for transportation.	Making temporary roads for transportation and waiting for governmental supports to fix the roads.	Keeping water enough in channels for transportation.	Irrigation canals should support transportation by boats which is much more convenient than other means.
	Damage to dwellings	Fixing and rebuilding dwellings	Fixing and rebuilding dwellings.	Rebuilding dwellings	Rebuilding dwellings
	Reduced water quality	Using well water and industrial bottled water. Treating alum water for use.	Using well water and treating alum water for living uses.	Keeping enough water in fishponds and harvesting rainwater.	Using well water
	Sick livestock	They didn't mention this impact in their response.	Burying dead poultry and husbandry.	Not mentioned	Having no solutions
	Income loss	Working as employees. Waiting for rainfalls to replant the crops.	Pumping river water to irrigate sugarcane crop. Selling sugarcane with cheap rice. Working as laborers. Getting loans from banks.	Harvesting crops sooner. Expecting technical support for cultivation. Finding better markets for aquaculture products.	Roads should be convenient for sugarcane trading. The government should coordinate drainage system timely and accordingly to weather changes. The government should also help farmers protect sugarcane from diseases. They might switch their fish farm to shrimp farm if they have enough budget.

Table 11: Summary of current and future coping strategies as identified by representatives of people from Minh Dung village

Extreme weather events	Impacts	Current coping strategies		Future coping strategies	
		Men	Women	Men	Women
Drought	Disrupted transport	No solutions to this impact. Waiting for rains and expecting supports from government to fix the roads.	Switching to using motorbike or walking instead of boats for transportation. Waiting for government al supports to reconstruct the roads.	Waiting for government support to fix the roads.	Dredging and deepening the canals.
	Water shortage	Waiting for rainfalls. Digging wells deeper for water source.	Having no solutions but waiting for rainfalls.	Deepening wells	Having no solutions
	Reduced fish stock	Having no solutions to this impact. Only waiting for rainfalls and expecting governmental supports with fish fingerlings.	Waiting for suitable weather and redeveloping fish stocks.	Having no solutions	Having no solutions
	Crop damage	Preparing soil and seeds for the next crop after the drought. The new crop starts when it rains again.	Trying to harvest the remains of the crop. Waiting for rainfalls to replant other crops.	Re-selecting the plant varieties for crops in accordance with the area condition and market. Using agricultural films and leaves of sugar cane and other plants to cover the ground and help reduce water evaporation. Using machine for direct irrigation on vegetable beds and drip irrigation to save water.	Working as laborers
	Income loss	Working as laborers. Selling cultivating products to commune markets.	Calculating daily expense carefully. Working as laborers. Getting loans from neighbours or banks.	Working as laborers. Selling cultivated products directly to market to avoid middlemen.	Working as laborers
Flood	Crop damage	Trying to harvest crops earlier to reduce damage. Waiting for floodwater drainage and replanting crops.	Trying to harvest the remainder of the crop and waiting for rainfalls to replant the next crop.	Considering suitable time to seed and harvest crops for better avoiding crop damages caused by floods. Following weather reports on TVs and local loudspeakers. Expecting the state to effectively and timely coordinate the drainage system according to weather changes.	Waiting for floodwater drainage and replanting the crop.
	Reduced fish stock	Dam building. Raised the levels of net for keeping fish stock. Fish catching. Redeveloped fish stock.	Natural fish catching	No solution	No solution
Strong wind and thunder	Damage to dwellings	Reporting the situation to local government and waiting for financial supports. Rebuilding dwellings.	Cleaning up dwellings and roads after the storm and waiting for financial supports from government.	Shielding and strengthening the dwellings before the rainy season. Thinning tree branches around the dwellings. Mobilizing people to prepare for bad weather that may hit the place.	Building more solid dwellings

Table 12: Summary of current and future coping strategies as identified by representatives of people from Minh Thuong village

Extreme weather events	Impacts	Current coping strategies		Future coping strategies	
		Men	Women	Men	Women
Drought	Disrupted transport	Switching to other means of transportation such as motorbike or walk.	Trying to handle the situation by themselves. Waiting for the state to help fix the road.	Expecting governmental supports to construct better roads in the village.	Expecting the Park to allow villagers to use canals and roads within the Park in emergency cases.
	Water shortage	Using well water or asking water from neighbours.	Using deepened well water exploited by strong pumps.	Keeping water inside the fishponds by higher dykes. Pumping water from river or canal to fishponds. Deepening wells to get groundwater.	Using water from wells and canals. Expecting local government to coordinate the irrigation system effectively.
	Reduced fish stock	Waiting for natural regeneration of fish stock in the next rainy season.	Waiting for natural regeneration of fish stock in the next rainy season.	Having no solutions	Having no solutions
	Human disease	Going to hospital	Going to hospital and getting loans from neighbours	Not mentioned in their responses	Impregnating mosquito nets with repellent.
	Crop damage	Most rice were damaged. The villagers attempted to harvest the remains. They had no coping strategies and just waited for rainfalls to replant crops.	Trying to harvest the remain of the rice crop.	Not mentioned in their responses	
	Income loss	Catching fish and vole for food or moving to other cities to look for jobs and being employed.	Catching fish, vole, and snail for food. Asking money from neighbours. Calculating daily expenses carefully. Looking for jobs within the village or other cities.	Looking for job and being employed.	Switching to vegetable crops for more income. Expecting government al supports for better policies on agriculture product consumption.
Storm	Crop damage	Not mentioned in their responses	Pumping water out of inundated rice fields. Cultivating new crops after the storm.	Not mentioned in their responses	Having no solutions
	Reduced fish stock	Not mentioned in their responses	Keeping farmed fish inside the fishponds with high dams.	Not mentioned in their responses	Having no solutions

At present, natural resources in the UMT national park are managed by the management board in accordance with the legal system for special-use forests in Vietnam. Farming practices in the buffer zone, however, are not strongly regulated. Especially in case of chemical use, people reported a complete lack of State check or control. Current management practices and suggestions for improvement were discussed with park managers and village representatives. Results are presented in Table 13.

Discussions mainly focused on key resources such as water, rice, fish and crops. Important natural resources such as river and canal water are managed by the State. However, for well water, it has not been managed and exploited properly. Therefore, proposals on water management and better policies on agricultural products are of great importance to the people. Besides, effective farm techniques and good prices of fish and crops are also of great concern. People are asking for stronger engagement of the State on these issues to help them generate more income from farming. However, this may have to go along with stronger regulation of farming practices with support of MARD, to create an environment that does not only help farmers in the short term but provides a long-term and sustainable alternative.

Table 13: Current and future wetland management strategies of key resources in Cong Su (CS), Minh Dung (MD), and Minh Thuong (MT) Villages

Resource	Current management	Future management
Canal and well water	Canal water managed by government through drainage and irrigation system (CS). Well water has not been managed (MD, MT)	Operating drainage and irrigation system effectively in accordance with weather changes (CS, MT). Drilling up to 95 - 105 m in depth to get groundwater. Treating alum water for household use (MD)
River water	Managed by the government (MD)	Monitoring and regulating the flooded status in the canals (MD)
Rice	Cultivating rice on their own (MT)	Need to control and protect rice crops (MT)
Crops & fruit trees	MD are practicing seasonal cultivation and intensive farming on their own. Their incomes depend largely on market prices. In MD, people tried to control the golden apple snail because of damages to crops.	Prices of agricultural products should be made stable by the government. The government is also expected to support the product consumption (MD). In MD, there is also a need for effectively controlling golden apple snail.
Insects	Not yet managed (CS)	No suggestions for future management (CS)
Fish	Within the park, managed by the park based on Vietnam laws on special-use forests. All villages are farming fishes in their farmlands. Otters, living in the park and protected based on Vietnam laws on rare and endangered species, have been blamed for damaging farming fish stocks (CS).	Farm all year round; may build higher dams to keep fish inside ponds during floods. Expect that fishing by electricity will be banned and strictly monitored (MT & MD). Park's melaleuca forests are habitats for wild fish breeding and recover fish stocks after disasters (MD). To avoid disturbance of otters (CS), plastic bags can be hung around fishponds to create reflecting lights and scare them of (MD). In MT, otters rarely harm farms due to location, thus no need for control.
Vegetable crops	Not yet managed (MT)	No suggestions
Bats	Managed by the Park. CS built 3 bat houses and caught natural bats for raising and collecting bat fertilizer	CS want to raise bats for fertilizers but have no technique and finance. Need outside supports. About 800 USD to build a bat house.
Pigs and poultry	Raising the animals on their own (MD)	No suggestion for future management (MD)
Wild vegetables	Not yet managed.	No suggestions
Melaleuca	Within the park, managed by the park based on Vietnam laws of special-use forests. Not yet managed those outside of the park (MT)	No suggestions for future management (CS). Managing and conserving to help protect the villagers and crops from strong winds and storms (MD, MT)
Eucalyptus	Not yet managed (MT)	No suggestions

Medicinal Herbs	Not yet managed (MT)	Managing enough water for irrigating herb crops (MT)
Phragmites	Growing naturally on banks of canals	No need for management (MD)
Snake	In farmlands, not yet managed (MD)	Letting it be natural
Field rat	Trying to control the species to protect crops (MD)	Need for effective control (MD)

5.3 Species vulnerability

Six species were selected for the climate vulnerability assessment, including two plants (melaleuca and phragmites), one fish (featherback fish), and three mammals (large fruit bat, hairy-nosed otter and pangolin). Reasons for selecting these species are presented in Table 14.

Table 14: Species selected for climate vulnerability assessment for UMT National Park.

Species	**Reasons for selection**
Melaleuca cajuputi	Keystone species, economically important
Phragmites vallatoria	Economically important
Featherback fish (*Notopterus notopterus*)	Economically important, representing resident fish community
Fruit bat (*Pteropus vampyrus)*	Near-threatened species
Hairy-nosed otter (*Lutra sumatrana*)	Endangered species; flagship (displayed on UMT National Park logo)
Pangolin (*Manis javanica*)	Critically Endangered species

5.3.1. Baseline conservation status

Species conservation status was assessed based on population size and trend, habitat preference, ability to disperse, current threats, protection status, national or international priorities, their ability to survive recent extreme weather events. Species conservation status scores range from 1 to 3, with 3 being high and 1 being low.

Melaleuca cajuputi, the dominant plant species of UMT's peat swamps, is a common plant in the Mekong Delta. Most areas of melaleuca in UMT are, however, naturally grown, not plantations as commonly found elsewhere in the Mekong Delta. Melaleuca trees can reproduce fast and disperse long distances thanks to their massive annual seed production. Melaleuca can withstand flooding, but not permanent inundation. It is a freshwater plant species, but able to tolerate low salinity for short period of time. Our analysis yielded a baseline conservation score of 1.7 for melaleuca at UMT, which is relatively low.

Phragmites is a giant grass species, can grow to 4 – 5 meters tall, occupying dyke surfaces and higher grounds in UMT that are not flooded for long periods. Phragmites can be used to make paper pulps and was harvested in UMT for that purpose before the area became a protected area. Phragmites is also used by local people to make fish traps, baskets, fences, or as fuel woods. It is a freshwater plant and won't tolerate high salinity. Phragmites is also not tolerant to prolonged flooding. It is susceptible to fires but able to regenerate quickly after being burned, both from seeds and from underground rhizomes. Phragmites seeds are capable of long distance disperse by wind and water. Our analysis yielded a moderate baseline conservation score of 1.9 for *Phragmites vallatoria*.

Featherback is a common fish species living in UMT wetlands and economically important for people living in UMT's buffer zone. The fish has high commercial value, being abundant in UMT and U Minh Ha, but not as abundant elsewhere in the Mekong Delta. It is a freshwater fish, able to withstand brackish but not salt water. Again, the analysis yielded a moderate baseline conservation score of 1.9 for featherback fish.

Fruit bat, also known as large flying fox, lives in relatively large colonies in UMT. Both UMT and U Minh Ha National Park in Ca Mau Province are home to some of the biggest populations of fruit bats in the Mekong Delta. Outside of UMT and U Minh Ha, the fruit bat populations in the Mekong Delta are in a declining trend. The species is classified Near-threatened in the 2017 IUCN's Red List. The hunting pressure on fruit bats for food is high in the buffer zone of UMT. There is perhaps

illegal hunting of fruit bats inside the core zone. Our analysis yielded a slightly higher baseline conservation score of 2.1 for fruit bat at UMT.

Hairy-nosed otter is extremely rare in Vietnam, only found in UMT and U Minh Ha. Internationally, it is listed as an Endangered species in the 2017 IUCN's Red List. The population of hairy-nosed otters at UMT is estimated at 150 to 200 individuals (U Minh Thuong National Park, 2012). Otters live in peat swamps, but local people also reported seeing otters in their fish ponds in the buffer zone. Hairy-nosed otters are strictly protected in UMT and seem not being hunted by local people. Our analysis yielded a baseline conservation score of 2.6 for hairy-nosed otter at UMT, which is high.

Pangolin is listed Critically Endangered in the 2017 IUCN's Red List. Hunting pressure on pangolin at UMT is very high due to its high value in wildlife markets in Vietnam. At UMT, pangolins live in peat areas. The loss of peats has therefore been an important factor contributing to the decline of pangolin's population at UMT. Our analysis yielded a baseline conservation score of 2.9 for pangolin at UMT, reflecting a very high score.

5.3.2. Climate change vulnerabilities

Climate issues, exposure, sensitivity and adaptive capacity of selected species are presented in Table 15.

Table 15: Summaries of climate change vulnerability characteristics of 6 species assessed for UMT National Park.

Species	Major climate issues	Exposure	Sensitivity	Adaptive capacity
Melaleuca	Drought; Forest fire	Refugia available	Hydrology	High
Phragmites	Drought; Forest fire	Refugia available	Moderate sensitivity to many factors	High
Featherback fish	Drought; Forest fire; Salinity intrusion	Refugia available	Heat; Drought; Hydrology	Intermediate
Fruit bat	Drought; Forest fire;	Refugia available	Moderate sensitivity to many factors	Intermediate
Hairy-nosed Otter	Drought; Forest fire; Salinity intrusion	Little chance to find refugia	Drought	Low
Pangolin	Drought; Forest fire; Salinity intrusion	Little chance to find refugia	Heat; Drought	Low

All species assessed for UMT are vulnerable to drought and salinity intrusion caused by sea level rise. Droughts, coupled with higher air temperatures, increase the risks of uncontrollable fires that may destroy habitats these species depend on. Hairy-nosed otter and pangolin are especially vulnerable because there is little chance for them to find refuge outside of UMT. All species, except fruit bat, depend directly on freshwater aquatic habitats, which may be fundamentally altered by high water salinity. The UMT area is projected to be significantly affected by inundation due to sea level rise. The associated risk of salinity intrusion is therefore very high. Drought, high temperature and sea level rise can potentially act together to amplify their impacts on UMT wetland habitats. As described in the habitat vulnerability section, when faced with extreme

dryness, UMT managers may decide to pump water from the outside into the core zone to prevent fires. In that situation, the water they pump in would very likely be salt water. That scenario happened in 2002 when the catastrophic fire occurred. Field surveys carried out one year after the fire found seedlings of mangrove plants growing in UMT's core zone (Tran Triet, pers. obs. 2003).

In summary, the climate change vulnerability analysis assessed pangolin as "Very Highly Vulnerable" (score 2.7) to climate change, fruit bat and hairy-nosed otter as "Highly Vulnerable" (both a score of 2.3), and Melaleuca, phragmites and featherback fish as "Moderately Vulnerable" (score 2.2, 2.1 and 2.1).

5.3.3. A comparison between species

Results of the vulnerability analysis are combined in Table 16. Pangolin is "Very Highly Vulnerable" to climate change, fruit bat and hairy-nosed otter "Highly Vulnerable", and melaleuca, phragmites and featherback fish "Moderately Vulnerable". Only hairy-nosed otter and pangolin have a high to very high baseline conservation status score, reflecting their endangered status. Pangolins and hairy-nosed otters have very small populations. In the Mekong Delta, pangolins and otters depend on peat swamp habitats, which are very highly vulnerable to climate change. Melaleuca, phragmites and featherback fish are all common species with large populations. There are habitats available for these common species to find refuge outside of UMT. All species were assessed with relatively high confidence (scale 1-4), because of the quality of data being collected at UMT regarding population sizes, trends, and threats to these species.

Table 16: Baseline conservation status and Climate change vulnerability scores of species assessed for UMT

Species	**Baseline conservation status**		**Climate change vulnerability**	
	Score	**Confidence**	**Score**	**Confidence**
Melaleuca	1.7	4.0	2.1	3.4
Phragmites	1.9	4.0	2.1	3.0
Featherback fish	1.9	3.5	2.2	2.8
Fruit bat	2.1	3.4	2.3	2.4
Hairy-nosed otter	2.6	3.2	2.3	2.5
Pangolin	2.9	3.7	2.7	2.6

In Figure 11, a conservation status – climate change vulnerability diagram is provided for species assessed for UMT as well as all other species assessed for Vietnam wetland sites. Pangolin and otter belong to the group of species that both have high conservation status and highly vulnerable to climate change. Pangolin and sarus crane are the two species that have the highest baseline conservation scores and climate change vulnerability among all species assessed for Vietnam's wetland sites.

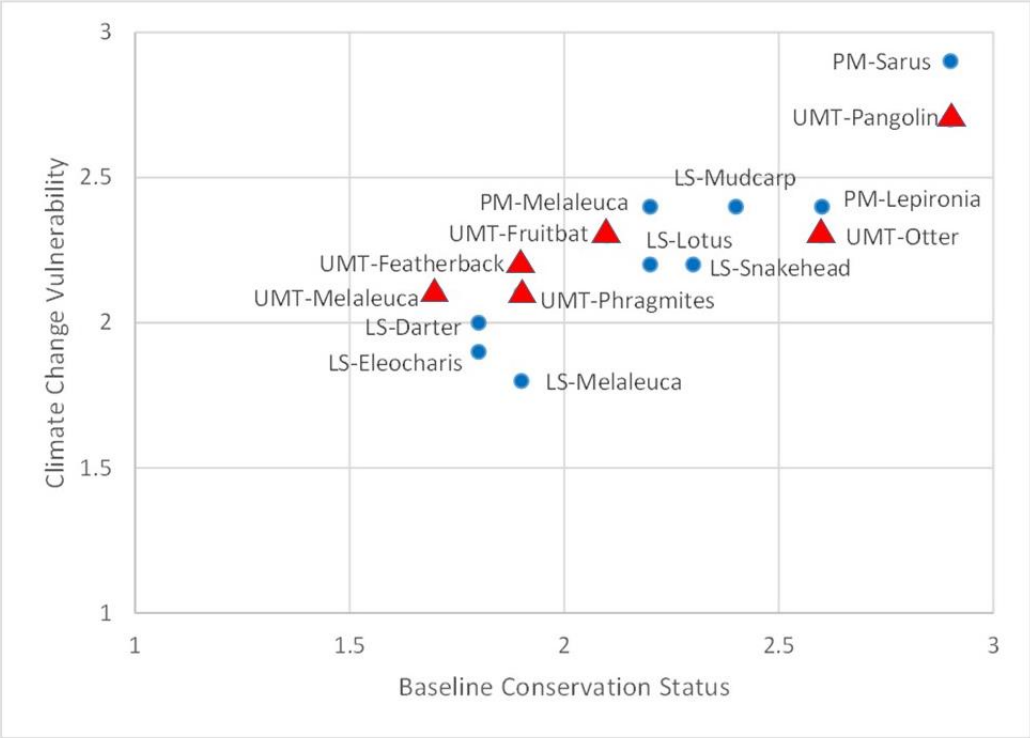


Figure 11: Conservation status/Climate vulnerability diagram for all species assessed for Vietnam wetland sites. LS: Lang Sen Wetland Reserve; PM: Phu My Species and Habitat Conservation Area; UMT: UMT National Park. Species assessed for UMT National Park are shown in red triangles.

6. Conclusions

6.1 Summary of vulnerabilities

Main wetland habitats and key species in UMT are most vulnerable to drought, higher air temperatures and salinity intrusion that results from sea level rise. Droughts and high temperatures increase the risks of uncontrollable fires that may destroy forests and species. Among the main wetland habitat types of UMT, peat swamp forest is most vulnerable to climate change because of its diminishing size and its high sensitivity to factors such as droughts, fires, salinity and artificial water level management. Most species in UMT depend on freshwater wetland ecosystems, which functions can be fundamentally altered by high water salinity. For some rare and endangered species such as otters and pangolins, there are few options to take refuge outside of UMT as habitats are either not available or very limited.

Local people's livelihoods are also vulnerable. Farming, the main source of income for most local people, is strongly dependent on the weather and climate changes. The severe drought of 2015 caused hefty losses in rice, sugarcane, fruit, and farmed fish productions in the region. People also reported significant impacts of strong winds, high temperatures, irregular monsoonal rains and floods on livelihood activities, transportation infrastructure, dwellings and health. The direct link between local livelihoods and UMT's wetland resources is however weak. Most people in the buffer zone obtain their income from farming activities while UMT is enforcing strict rules that effectively prevent the exploitation of wetland resources in the core zone. Illegal harvests of wetland resources in the Park may still happen but are limited to a small group of local inhabitants. Nevertheless, local people still depend on wetlands of UMT to some extent, at least indirectly. People reported having benefited from wild fish, which stock is maintained by wetlands of the core zone, and from forests that helped shelter them from impacts of strong winds. Freshwater stored in the core zone of UMT is also a precious resource for local people for farming and domestic uses, especially during dry seasons and droughts. During these periods of time, however, keeping freshwater is critical for the Park to prevent fires, and could become a source of conflict in the future. Wildlife in UMT, such as otters, may also increasingly embark on rich food sources in the buffer zone, which may further increase tensions between conservation management and people's livelihoods.

6.2 Adaptation planning

For UMT, the following climate adaptation activities are deemed necessary:

- Improve the water control facility, including dykes and water sluice gates, so that it can effectively manage water corresponding to different wetland habitats in the core zone. In addition, it should be explored whether water storage capacity in the core zone can be increased by deepening the open swamp areas, without negatively affecting the open swamp ecosystem.
- Develop an environmental monitoring system that will monitor air, soil (including peat), water (including surface and ground water), and vegetation in the core zone. The system should pay special attention to the peat areas, monitoring for signs of peat degradation such as lowering of water table, compaction, acidification and salt water intrusion.
- An effective forest fire detection and warning system needs to be developed.
- Since water resources are critical for both wildlife and people, a participatory approach should be promoted regarding water and forest fire management in UMT, involving Park management, local communities, authorities and with support of scientists; this may

include activities to promote water-saving technologies, salinity control, and better management of ground water extraction.

- Effective livelihood models suited for the buffer zones need to be developed and promoted with support of relevant agencies; this may include policy support on pricing and agricultural product trading for specific climate resilient farming practices as well as ecotourism activities in UMT that involve local people.
- An effective disaster warning system should be developed to help people prepare for climate adversities.
- Provide training for UMT staff to improve their knowledge and management capacity related to climate change adaptation, as well as skills to work in a participatory and collaborative way with local communities and other relevant stakeholders on common issues of interest.

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Appendix 1: List of members of the assessment team and experts

Name	Organization	Expertise
Tran Triet (VA team leader)	International Crane Foundation; University of Science – Ho Chi Minh City	Wetland ecology; aquatic plants
Nguyen Thi Kim Dung (VA-team)	University of Science – Ho Chi Minh City	Social science
Le Xuan Thuyen (VA-team)	University of Science – Ho Chi Minh City	Delta morphology, geology
Tran Thi Anh Dao (VA-team)	University of Science – Ho Chi Minh City	Zoology (amphibian, reptile)
Truong Anh Tho (VA-team)	University of Science – Ho Chi Minh City	Project assistant
Le Bach Mai (VA-team)	University of Science – Ho Chi Minh City	Project assistant
Nguyen Hoang Vu (VA-team)	University of Science – Ho Chi Minh City	Project assistant
Hoang Duc Huy (expert)	University of Science – Ho Chi Minh City	Zoology (fish)
Nguyen Hoai Bao (expert)	University of Science – Ho Chi Minh City	Zoology (bird)
Vu Long (expert)	University of Science – Ho Chi Minh City	Zoology (mammal)

Appendix 2: List of UMT staff who participated in the assessment study

Name	Organization/administrative unit	Role in the project
Pham Quoc Dan (Park's director)	U Minh Thuong National Park	Advisor general park management
Le Hong Tuyen	U Minh Thuong National Park	Advisor general park management
Nguyen Van Cuong	U Minh Thuong National Park	Advisor hydrological management
Tran Van Thang	U Minh Thuong National Park	Advisor habitat management
Nguyen Ngoc Linh	U Minh Thuong National Park	Vegetation expert, field guide
Nguyen Thanh Tuan	U Minh Thuong National Park	Field guide
Le Van Thong	U Minh Thuong National Park	Field guide
Tran Thi Anh Thu	U Minh Thuong National Park	Field guide
Ho Thanh Nhan	U Minh Thuong National Park	Field guide
Nguyen Van Dien	Minh Thuan Village	Field guide, community liaison
Ta Thi Dieu	Cong Su Village	Field guide, community liaison
Vo Quoc Vinh	Minh Dung Village	Field guide, community liaison