Climate Change Vulnerability Assessment
Phu My Species and Habitat Conservation Area, 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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List of abbreviations

BMUB	German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety
CPC	Commune People Committee
DARD	Department of Agriculture and Rural Development
DPC	District People's Committee
Ha	Hectare
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
US $	United States Dollar (1 US $= 22,000 VND, based on long-term average)
VND	Vietnamese Dong

Executive summary

Phu My Species and Habitat Conservation Area is one of the key sites for wetland biodiversity conservation in the Mekong Delta of Vietnam. It is one of Vietnam's Important Bird Areas and is part of the Kien Giang Biosphere Reserve. Two main wetland habitat types at Phu My, lepironia grassland and a specific form of melaleuca shrubs (Tràm Gió, in Vietnamese), are now rare plant communities of the Mekong River Delta. Phu My was selected as one of the ten focal wetlands in IUCN's "Mekong WET: Building Resilience of Wetlands in the Lower Mekong Region" project. In this study, a climate vulnerability assessment was conducted as a first step in a participatory adaptation planning process for Phu My Species and Habitat Conservation Area. 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 Phu My's wetlands are severe droughts and flooding and salinity intrusion due to sea level rise. Also, the occurrence of extreme events, such as heat waves, strong typhoons, will be more frequent. For habitat vulnerability assessment, we selected the two main wetland habitats: melaleuca shrub and seasonally inundated grassland. Three wetland species were selected for species assessment, including the stunted melaleuca tree or "Tràm Gió" (*Melaleuca cajuputi*), lepironia sedge (*Lepironia articulata*) and sarus crane (*Grus antigone sharpii*). In addition, we interviewed people at three local villages – Kinh Moi, Tran The and Tra Phot – to assess the vulnerability of people's livelihoods.

Results of the vulnerability analysis showed that both melaleuca shrubs and seasonally inundated grassland are highly vulnerable to climate change. Of the three species studied, sarus crane was assessed "Very Highly" vulnerable; Tràm Gió melaleuca and lepironia sedge are "Highly" vulnerable. All wetland habitats and species are vulnerable to drought, higher air temperatures, and salinity intrusion caused by sea level rise. Droughts and higher air temperatures increase the risks of uncontrollable fires that may destroy last remnants of melaleuca shrubs and lepironia grasslands. Sea level rise and associated salt water flooding and salinity intrusion are projected to severely affect Phu My's wetlands. Most species in Phu My depend on freshwater wetland ecosystems, which functions can be fundamentally altered by high water salinity. Wetland resources, especially lepironia, are important for the livelihood of local inhabitants, whose livelihoods in general are highly vulnerable to climate adversities. In addition to droughts, local people reported significant impacts of floods and strong winds.

Phu My is a newly established protected wetland that needs a comprehensive management plan to guide the conservation of species and habitats under the anticipated climate and development changes. At the core of the wetland management plan is a peripheral dyke system that would function both as a protection boundary and a water control structure. The design of such a water control system should take into account ecological needs of key plant and animal species, fire control and the predicted impacts from sea level rise induced flooding and salinity intrusion, and changes due to Mekong River development. Besides a wetland management plan for the core zone, a buffer zone development plan is needed. Important components of the development plan include (i) a resource sharing plan that allows sustainable harvesting of key wetland resources in ways that would not impede conservation goals, (ii) development of alternative livelihood activities that contribute to improving the resiliency of local communities to climate change, and (iii) development of environmental education programs to raise awareness about potential impacts of climate and development change and the importance of wetland conservation. Sustainable implementation will require the involvement of relevant stakeholders and creative solutions.

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 Phu My Species and Habitat Conservation Area, hereafter referred to as Phu My.

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.

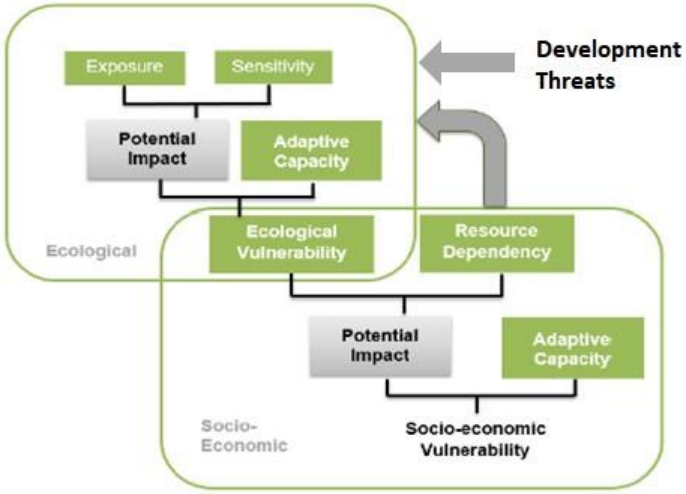
The climate change vulnerability assessment carried out in this study followed methodologies and utilized assessment tools provided by IUCN (IUCN, 2017). In the study, wetlands are considered complex socio-ecological systems; linkages between the wetland ecosystems and the communities who depend on resources 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 particular wetland species being assessed. Appendix 1 provides a list of the team members and experts.

Field data collection and interviews were carried out at Phu My in October 2017. A validation session was conducted in January 2018, when the research team revisited Phu My to present the initial results of assessment and received feedbacks and recommendations from Phu My's staff and representatives of local communities. A list of PM 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

Phu My is located in Giang Thanh District, Kien Giang Province, in the northwest of the Mekong Delta (Figure 1). Phu My was declared a protected area by Kien Giang Province in January 2016, covering a core zone of 1,070 ha and a buffer zone of 1,700 ha. Although being near the sea coast, and directly under tidal influence from the Gulf of Thailand, Phu My wetlands are predominantly freshwater. Phu My is one of a few small protected areas in Kien Giang and An Giang provinces that preserve remnants of the Long Xuyen Quadrangle floodplain wetlands. It currently protects two unique plant communities, rarely found elsewhere in the Mekong Delta: lepironia grassland and a specific form of melaleuca shrubs (Tràm Gió, in Vietnamese). Phu My is one of the important wetland sites for the eastern sarus cranes in Cambodia and Vietnam during the non-breeding season. Phu My is one of the Important Bird Areas (IBAs) of Vietnam (Tordoff, 2002) and is part of the Kien Giang Biosphere Reserve.

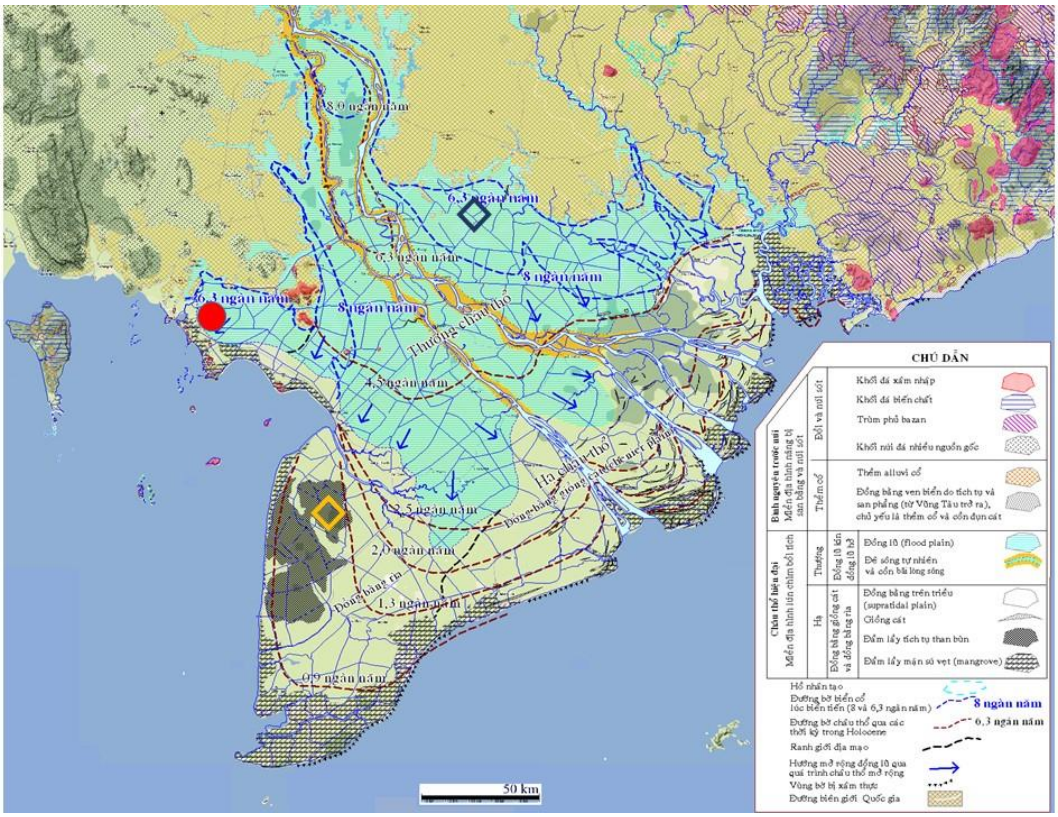


Figure 1: Location of Phu My (red circle) in the Mekong Delta. Locations of the other two wetlands included in the climate change vulnerability assessment for Vietnam, Lang Sen and U Minh Thuong, are shown in diamonds. Base map shows main geomorphological formations of the Mekong Delta (source of base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

2.2 Current and historic climate

Phu My has a typical monsoonal climate, characterized by the succession of a dry and a wet season each year. The dry season is generally from December to April and the wet season from May to November. Average temperature is 27 ^{o}C, with an average maximum temperature of 37 ^{o}C and an average minimum temperature of 15-16 ^{o}C (Duong, 2013). Phu My has an annual rainfall that is among the highest in the Mekong Delta, averaging 2,250 mm/year; about 90 % of the annual rainfall occurs in the wet season. Data and information about historic climate conditions at Phu My are very limited, therefore we refer to historic climate trends for Vietnam and selected information most relevant for Phu My 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 as recorded by monitoring stations (Tran Thuc et al., 2016). The analysis used climate 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 0.42 ^{o}C during 1985 – 2014; maximum high temperatures increased throughout the country.
- Annual rainfall decreased in the north 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 dry season.
- Stronger influence from El Nino and La Nina episodes; strong typhoons occurred more frequently.
- Sea levels in the near shore areas increased 3.3 to 3.5 (±0.7) mm/year between 1993 – 2014; sea level rise measured at Phu Quoc and Tho Chu oceanographic stations were 3.4 (±0.8) mm/year and 5.3 (±0.8) mm/year. These stations are located in the Gulf of Thailand, nearby Phu My.

Many of these past climatic trends were also observed at Phu My. Local people, who were interviewed, reported recent changes in local weather conditions, including higher air temperatures, irregular rainy seasons, more incidents of torrential rain, more droughts, and more hot days. Phu My area experienced a severe drought during 2015 – 2016 and two big floods in 2000 and 2011-12.

2.3 Hydrological characteristics

Phu My is located at the edge of the Long Xuyen Quadrangle floodplain, far from a direct river source. Phu My wetlands receive shallow floods with small loads of river sediments from the Bassac branch of the Mekong River. The floods reach Phu My mainly via Vinh Te and Ha Giang Canal. Historically, flood waters coming from Cambodia were a major source of flooding in Phy My, but recently they have become less important because of the building of extensive roads and dykes along the Cambodia-Vietnam border. With the development of an extensive canal system during the late 1990s/early 2000s, flood water in the Long Xuyen Quadrangle, including Phu My, can now be quickly drained to the Gulf of Thailand at the end of the rainy season, significantly shortening the flooding duration in wetlands and paddy fields.

Phu My is influenced by the diurnal tides of the Gulf of Thailand, which have small amplitudes of 0.5 – 1.0 meter. Small tidal amplitudes are not able to push sea water far inland, which may explain why freshwater wetlands, as those at Phu My, can be found very close to the sea. Recently, however, salt water intrusion has become more significant due to the development of canals that bring sea water inland for the booming shrimp farming industry in the region. The flow of saline water into Phu My is currently contained thanks to two water control structures built on the two main canals (Ha Giang and Nong Truong Canal), but the risk of salinity intrusion remains very high – especially considering the predicted sea level rise.

Surface water in Phu My has high acidity levels, especially in the dry season. Results from field measurements on different wetland types of Phu My showed an average water pH of 3.4 in the dry season and a pH of 5.4 in the rainy season. Eleocharis and lepironia grassland communities were among those that had the highest water acidity in the dry season with average pH values of 2.93 and 3.07, respectively (Nguyen et al. 2007).

2.4 Wetland habitats

Phu My has two main natural wetland habitats: seasonally inundated grassland and melaleuca shrubs. In addition to these natural habitats, there are man-made habitats, i.e.: man-made canals creating permanent waterbodies, and rice fields in the buffer zone.

Seasonally inundated grasslands in Phu My consist of plant communities that are adapted to living on highly acidic soils. There are two main plant communities: *Eleocharis* and *Lepironia*. Natural lepironia grassland is now very rare in the Mekong Delta. Besides Phu My it is found only in Dong Thap Muoi Wetland Reserve in Long An Province. Seasonally inundated grasslands are flooded during the rainy season but become dry during the dry season. There exist small areas of exposed old alluvium soils in Phu My that are located on relatively higher grounds with shallower floods and shorter periods of inundation (Figure 2). This is another special feature of Phu My wetland habitats that is now rarely found elsewhere in the Mekong Delta. The plant community of old alluvium soils consists of plant species that prefer drier conditions such as *Ischaemum, Rottboellia* and *Paspalum*.

Figure 2: Aerial view of seasonally inundated grasslands. White-colour circles are areas of old alluvium soils that have sparse vegetation covers (photo credit: Nguyen Truong Sinh, March 2018)

Unlike most of planted melaleuca areas in the Mekong Delta, melaleuca shrubs in Phu My are a natural plant community, including mainly *Melaleuca* species but also others. Melaleuca trees of this community have a stunted growth form, 2 – 3 meters high, crooked stems and with thicker leaves that contain high concentrations of essential oils. Taxonomically, these trees belong to the common melaleuca (*M. cajuputi*), but sub-species level classification of this plant taxa is still poorly studied. The Vietnamese name of this type of melaleuca tree is Tràm Gió ("Gió" refers to the essential oil extracted from the plant), while the name for the common melaleuca is just Tràm, or sometimes Tràm Cừ ("Cừ" referring to the use of the stems of this melaleuca tree as a construction material to stabilize building foundations). The name Tràm Gió is also used to refer to the whole plant community or melaleuca shrubs.

Man-made canals have water all year round and can provide year-round habitats for aquatic organisms. Phu My's core zone is surrounded by canals, and there is also a canal that runs through the middle of the reserve (Canal HT6). Canals created for paddy field irrigation and local water transportation. The peripheral canals, however, can also bring salt water to Phu My and could threaten Phy My's freshwater wetlands with sea level rise.

Rice fields are the main habitat type in the buffer zone of Phu My. Rice fields in the rainy season, especially those that are not contaminated by agricultural chemicals, can provide alternative habitats for many wetland plants and animals such as freshwater fishes, frogs, snails, crabs, shrimps and aquatic insects.

2.5 Biodiversity

Previous field surveys (Nguyen et al. 2007) identified 35 species of plants, 134 phytoplanktons, 69 zooplanktons, 65 aquatic insects, 39 spiders, 23 fishes, 5 amphibians, 8 reptiles, and 96 birds.

The majority of these plant and animal species are freshwater organisms. Phu My has low plant species diversity compared to other protected wetlands in the Mekong Delta, but plants that occur at Phu My are those that are adapted to highly acidic soils. Biodiversity values are therefore reflected by uniqueness rather than species abundance. As mentioned above, natural lepironia and “Tràm Gió” melaleuca are now rare plant communities in the Mekong Delta.

Phu My is one of the most important non-breeding sites for the eastern Sarus cranes in Cambodia and Vietnam. The crane population in Cambodia and Vietnam is the smallest among the four distinct populations of the sarus crane (the other three are located in Northern India, Myanmar and Northern Australia). During the last five years, the Sarus crane population in Cambodia-Vietnam has experienced a rapid decline, going down from 850 cranes recorded in 2013 to just 358 cranes in 2017 (Tran et al. 2017). Phu My and the nearby Anlung Pring Sarus Crane Sanctuary in Kam Pot Province Cambodia now host 40 to 50 % of sarus cranes during the dry season months from January to April.

2.6 Land use

Phu My includes a core zone and a buffer zone. All areas of the buffer zone are privately-owned agricultural lands. Natural wetlands located inside the core zone of Phu My are protected. Local people are, however, allowed to harvest lepironia for handicraft production. Weaving lepironia has been a traditional livelihood activity of the Khmer ethnic minority people who live in villages around Phu My. Phu My is developing a resource sharing policy, mainly applied to harvesting lepironia, that will help balance the needs of local people for lepironia and the requirements of wetland habitat conservation.

2.7 Drivers of change

Land encroachment, shrimp farming, and changing Mekong River hydrology are three important drivers of change for Phu My wetlands, now and in the near future:

- Despite being a protected area, Phu My is under strong pressure of illegal land encroachment. Many local households claim to have private lands inside the core zone and want to farm on those lands.
- Industrial shrimp farming imposes a strong threat to Phu My wetlands, mainly from potential salinity intrusion and leaking of environmental contaminants, such as antibiotics and chemicals used in shrimp pond sanitation. The more shrimp farms being established in the area surrounding Phu My, the larger the threat (Figure 3).
- Being located on the flood zone of the Mekong River, changes in Mekong hydrology and sedimentation due to upstream development will impact Phu My wetlands.

Figure 3: Phu My core and buffer zone are surrounded by many industrial shrimp farms (Source of base map: Google Maps, accessed 24/April/2018).

2.8 Conservation and zoning

Phu My Species and Habitat Conservation Area was established only recently (January 2016). Except for a general zoning that delineates a core and a buffer zone, no detailed conservation zoning plan has been developed for Phu My. The core zone is separated into two parts by Canal HT6 (Figure 4). The larger block of the core zone, located south of Canal HT6, is surrounded by dykes, but there is no water control structure that would allow active water level management.

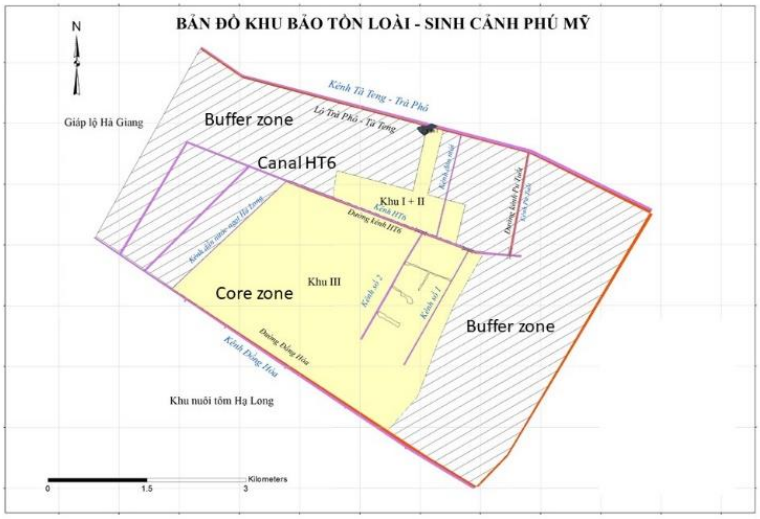


Figure 4: Phu My zoning map.

3. Communities and wetland livelihoods

3.1 Communities and population

Phu My commune was established in April 1978 and comprises 6 villages: Tra Pho, Tra Phot, Kinh Moi, Tran The, Rach Dua and Thuan An. The total area is 8,419 ha and includes 2,900 ha of Phu My Habitat and Species Conservation Zone. The commune is home to about 1,200 households with a total population of about 4,600 people (Duong, 2013); 53 % of the households are from Kinh origin, 46 % are Khmer and less than 1 % is from other ethnic groups. Women account for more than half (53 %) of the population (based on 2011 data, see Duong, 2013).

In 2011, the average income of the Phu My people was about US $1,150 per person per year, while the average income of Vietnam at the same time was about US $1,300 (Duong 2013). The educational level of the people is low, most of them are illiterate (60 %) or have had only primary education (36 %). Since the area is adjacent to Cambodia with regular exchange of goods between the two countries (Duong, 2013), many people (47 %) speak both Vietnamese and Khmer; about 40 % of the population speaks only Khmer and less than 13% speaks only Vietnamese (Le Hong Thia 2007).

The villages Tra Phot, Kinh Moi and Tran The are of particular interest for this study, since they are located within the buffer zone and rely more strongly on the wetland resources. Together they make up 43 % of the commune' population. Tra Phot Village has more Khmer people than Kinh Moi and Tran The.

3.2 Key livelihood activities

The main livelihood of people in Phu My Commune consists of rice farming and harvesting lepironia; about 25 % of the its population grows rice, 22 % harvests lepironia and weaves mats, and 9 % does both. Others work as traders, labourers, and livestock farmers (Duong, 2013). But there are substantial differences between the villages in the commune. More than 50 % of households in Tran The cultivate rice. In Kinh Moi, however, soils are too acidic and not very suitable for rice cultivation; and thus only 5 % of the households grows rice. In Tra Phot, the soil is better suited for rice crops and about a third (32 %) of the households engages in rice cultivation. However, the yield of rice paddies in Phu My villages is generally much lower than the average rice yield in the Mekong Delta because of low quality seeds, poor farming techniques and inefficient pest management (Can Tho University 2011).

According to a 2013 study, rice farming did not bring a good income to local people and most rice farmers were poor (Duong, 2013). The income from lepironia plays a crucial role in the household economy, especially for households with small rice fields and at times of low productivity. Livelihood activities related to lepironia, such as harvesting, processing and weaving, created an additional income of 5.2 million VND (US $236) per year per household (Duong, 2013). In addition to rice farming and harvesting/weaving lepironia mats, local people also raise animals (buffaloes, cows, pigs, chickens, and ducks), trade groceries and lepironia mats, and work as labourer for construction companies and others in cities. After the introduction of the project "Sustainable grassland exploitation and preservation of local handicrafts in Phu My commune" by the International Crane Foundation (ICF) in 2004, some households in the project villages of Tra Phot, Kinh Moi and Tran The, have also started services of compressing lepironia (to make the grass

flat and straight and available for mat making) by investing in their own compressors and making a living from the service.

3.3 Use of wetland resources

According to a 2004 survey, the total value of the lepironia materials collected from the wetland was between 2.3 and 2.8 billion VND (about US $105,000-127,000). On average, every hectare may provide 3.1 to 3.7 million VND (US$ 141-168) of raw materials for lepironia mats (Tran Triet et al., 2004). It is the most important resource for people in the area. Both people from Phu My commune and from outside the Conservation Area harvest lepironia, whereby most is collected during the wet (rainy) season. They exploit lepironia in two ways: by selectively pulling out matured individuals by hand or cutting by a knife a bunch of grass which may also include seedlings. Most (86 %) of the communities from outside the Conservation Area chose to cut the grass, which damages the lepironia seedlings and affects regeneration. The Phu My reserve also runs a business that produces handicraft articles from lepironia for exporting to Japan, USA, Canada, Switzerland, Hong Kong, France, Italy and Germany. Its factory is creating jobs for about 104 local people, with an average income of 3 million VND (US $136) per person per month.

The people from Phu My commune also make use of other wetland grasses. Khmer ethnic groups have a long tradition of raising buffalo and cows in the area. They may choose to cut grasses every 3-4 days to feed their cattle or graze the cattle on the wetland. The wetland also provides people with resources such as fish, frogs, and snakes that people can rely upon for food consumption or income when being sold.

Since grasslands in the Phu My are intensively used and harvested, they have become exhausted and gradually degraded. In addition, the wetland has been significantly affected by dredging of canals, land encroachment (for agriculture or melaleuca planting), and grassland burning. The dredging of canals exposes (alluvium) soils to air, leading to an increase of soil acidity and changes in plant composition on land; soil acidity may also affect water quality, making water resource toxic for people health. The encroachment of agricultural land for rice and shrimp is mainly in the area between the lepironia grassland and agricultural land, reducing the area of grasslands; land encroachment is mostly found in Tran The and Tra Phot villages. In addition, a survey conducted in 2006 showed that about 5 % of the people in Phu My often burn grassland intercalated with melaleuca forests in dry seasons in order to harvest melaleuca woods. Although lepironia recovers quickly from fires, they can affect many other plants and animals living in the grassland (Duong, 2013).

3.4 Land tenure and land use rights

The core zone of the conservation area (1,070 ha) is protected and managed by the government while the buffer zone (1,700 ha) is made up by private lands. Most of the land in the buffer zone is used for rice cultivation. According to a 2010 survey in Phu My Commune, the number of households with an area of less than 1 ha accounted for 42 % of total households; 25 % of households had 1-2 ha of land, 28 % had more than 2 ha and about 5 % was landless (Duong, 2013). Previously, most households did not have legal ownership of land because they reclaimed and occupied land on their own without any formal land tenue recognition from the government. Today, all of them have been granted legal certificates of land ownership. Moreover, in accordance with the approval of a new model of nature conservation in 2004 by Kien Giang People's Committee – through the project "Sustainable use and conservation of Phu My Lepironia

Wetland" – local people are allowed to continue harvesting lepironia inside the core zone of the reserve as they have done for hundreds of years (Tran, 2010).

3.5 Governance

In January 2016, Phu My Species and Habitat Conservation Area was established under the auspice of Vietnam Laws on Biodiversity. A few months later, the management board of the conservation area was approved by the People's Committee of Kien Giang Province (PPC). Phu My management focuses on securing lands, protecting biodiversity and restoring lepironia wetlands. Directly administrated under Department of Natural Resource and Environment of Kien Giang (DONRE) the reserve receives professional guidance from the Department in biodiversity management, land use planning and management. The Department of Science and Technology (DOST) coordinates and works together with other research institutes to support the conservation area in scientific research projects. The District People's Committee of Giang Thanh (DPC) and the Commune People's Committee of Phu My (CPC) support the management board in land use management, forest fire prevention and fighting. Additionally, the CPC supports conservation area in terms of livelihood development, environmental education, awareness raising of sustainable grassland extraction, and biodiversity conservation. Currently, Phu My's management board consists of one director, one deputy director and five staff in charge of community development, fire precaution and fire-fighting, and business operation (see Figure 5).

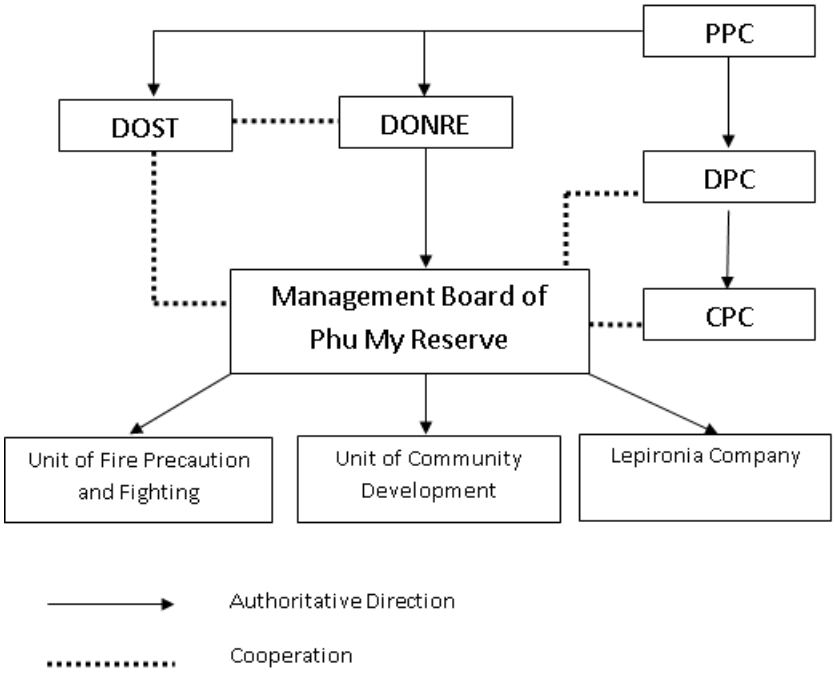


Figure 5: Governance framework for Phu My Species and Habitat Conservation Area

3.6 Stakeholder analysis

Although the conservation area was only established in 2016, it already had a long history of wetland conservation with support of various stakeholders. The Phu My Lepironia Wetland Conservation Project was established in 2004, managed by the ICF. It promoted a new model of

nature conservation whereby local people were allowed to continue harvesting lepironia inside the wetland. During the implementation of the project, provincial and district agencies, local communities, donors such as World Bank, Holcim Vietnam, ICF and research institutes such as Can Tho University and University of Science, Ho Chi Minh City (HCMC) regularly interacted to improve the effectiveness of community-based wetland management and protection.

Since January 2016, when Phu My became a government-run protected area, the "open" protected area approach is still being applied. Further refinement of the model is needed to accommodate governmental regulations regarding protected area management while allowing the access of local people to natural resources provided by Phu My wetlands. Table 1 provides an overview of some of the main stakeholders that are currently active in Phu My, including their interests and (potential) role in the management of the conservation area.

Table 1: Main actors, interests and their (potential) role in the management of Phu My conservation area.

Type of actor	Actor	Interest and (potential) role
Government	PPC	Approved establishment of Phu My reserve as "open conservation area" and directs provincial Departments and Giang Thanh DPC to cooperate with activities/projects for Phu My reserve establishment and development
	DOST	Directs and coordinates process of Phu My reserve establishment Provides financial supports for scientific research
	DONRE	Directs and coordinates in setting up land use plans and determining land boundaries of the reserve and provides professional guidelines on biodiversity and land use management
	Department of Agriculture and Rural Development (DARD)	Provides support to farming and could help to develop more effective livelihood models
	DPC	Cooperated in the process of Phu My reserve establishment and provides supports to land use management and fire control
	CPC	Cooperates with Phu My conservation area to prevent land encroachment; it also issues regulations on methods to actors for sustainable lepironia exploitation and provides support on livelihood development, environmental dissemination and awareness raising
	Management board of Phu My reserve	Directly manages the reserve
Universities and Institutes	University of Science, HCMC	Conducts basic research on the wetland and nature conservation
	Can Tho University	Conducts basic and applied research on the wetland and socio-economic issues
	An Giang University	Conducts basic research on the wetland
NGOs	ICF	Provides financial and technical support and monitors the crane population in the wetland
	IUCN	Provides financial support
	Catalyst Foundation	Implements charity activities in villages
International donor	World Bank	Provided financial supports

Private/ enterprise	Vinh Long Handicraft Company	Consuming and marketing Phu My Lepironia handicraft products
	Holcim Vietnam	Provided financial support in the past (2008 - 2012) and might be able to continue this support
Other	Buddhist temples	Consulted with the operation of the Phu My “open reserve”; helps with environmental education programs
	Media	Informed people about the establishment of the conservation area; helps to inform public about the wetland and what it wants to achieve
	Local community	Report violations of law and land encroachment; practice/ cooperate in sustainable wetland use and biodiversity conservation

3.7 Gender and vulnerable groups

Most people in Phu My Commune are relatively poor. Their average income is lower than the average Vietnamese income. Rice production is the main food and income source for most people, but the yield is very low. To make a living, households diversify their livelihood activities through wetland resource extraction, for example by collecting and harvesting lepironia and other grasses, through catching and hunting for fishes, frogs, snakes, and field rats, and through fruit tree plantation, livestock development, small-scale trade and working as hired labourer. Those with very small areas of land and those who are landless are most vulnerable and dependant on wetland resources.

Women are also vulnerable. Illiteracy rate among women in the commune is very high (83%) (Le Hong Thia 2007); girls are not encouraged to go to school and marry at a very early age (17 years old on average). They are responsible for most housework, cultivating crops, harvesting lepironia and weaving mats. They are family decision makers in issues relating to selling rice, raising poultry, keeping and borrowing money. In contrast, men perform the role of connecting the family with society such as participating in meetings and parties. In comparison to Kinh people, people with Khmer ethnicity may have more difficulties in accessing support and technology for livelihood development due to their low education and language barriers (Le Hong Thia 2007). To improve their conditions, Khmer women have been given the opportunity to participate in projects of the ICF, with income generating activities such as weaving lepironia mats and sewing bags from 2004 to the present.

3.8 Perceived threats to wetland habitats and livelihoods

Lepironia grasslands can help people in the area to ensure an income in case of difficult times. These grasslands are, however, under pressure of various developments:

- Overexploitation – The promotion of lepironia grassland extraction and production faces the challenge of sustainable management. There are warnings that the grasslands are currently overexploited, using unsuitable harvesting methods, resulting in slow natural regeneration and affecting the quantity and quality of the grass. Estimation of the appropriate level of exploitation will help the reserve to manage sustainable wetland in the future (Duong, 2013).
- Land use change – Socio-economic development has led to a shift to intensive agriculture, reducing the area of grasslands.

Other perceived threats are:

- Droughts and fires – Local people consider droughts as serious threats to the wetlands because they can cause fires to melaleuca forests and lepironia grasslands and lead to saltwater intrusion.
- Canal excavation – The building of dams by the government to prevent salinity intrusion and the dredging of canals by enterprises to lead freshwater into shrimp farms, are also perceived as threats because they disturb water flows and degrade water quality.

4. Climate projections for the site

As mentioned before, MONRE published a report in 2016 on "Climate change and sea level rise scenarios for Vietnam" (Tran Thuc et al. 2016). It is the most up-to-date and comprehensive analysis of climate 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 the MONRE's analysis followed those introduced in the IPCC Fifth Assessment Report (IPCC 2013). These scenarios are based on concentrations of greenhouse gasses. In this study, we have focused on two scenarios: RCP8.5, an extreme scenario without policy action, leading to 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.

MONRE's study provides detailed projections for all geographical regions and provinces of Vietnam; we present a summary of climate change and sea level rise projections for Vietnam, with selected information most relevant to Phu My.

4.1 General trends

Temperatures throughout Vietnam are expected to rise in the coming century, with increases in the north of the country slightly higher than in the south. For Kien Giang Province, mean air temperature is projected to increase by 1.8 ^{o}C under RCP4.5 and 3.2 ^{o}C under RCP8.5 by the end of the 21st Century. At the same time, the monsoon season is projected to arrive sooner and end later, resulting in longer monsoon seasons. Total **rainfall** during summer months and the occurrence of intensive rain events are projected to increase. At the end of the century, rainfall in or Kien Giang Province is projected to increase by 17 % under RCP4.5 and by 15.4 % under RCP8.5. Table 2 shows temperature and rainfall projections under RCP4.5 and RCP8.5 for Kien Giang Province. Since Phu My is located north of Kien Giang Province near Chau Doc weather station in An Giang Province, we also provide projections for An Giang Province.

Table 2: Temperature and rainfall projections under RCP4.5 and RCP8.5 scenarios for Kien Giang Province and An Giang 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
	An Giang	0.7	1.4	1.9	0.9	1.9	3.5
Rainfall change (%)	**Kien Giang**	4.9	9.2	17.0	6.5	14.4	15.4
	An Giang	4.7	13.1	14.1	8.2	11.1	14.7

Under RCP4.5, frequencies of **typhoons and tropical depressions** in the East Sea are projected to be of little change throughout the 21st century, whereas storm intensity would increase by 2 – 11 % and precipitations within a 100 km radius from storm eyes by 20 %. Under RCP8.5, storm frequencies would even decrease. Under both scenarios, numbers of typhoons and tropical depressions would decrease during 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, the number of **high temperature days** (days with max temperatures ≥ 35 ^{o}C) would increase by 25 – 35 days around mid-century and by more than 50 days by the end of the

century. Under RCP8.5, the projected increases are 35 – 45 days around mid-century to more than 100 days by the end of the century. **Droughts** are projected to be more severe in southern provinces during 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, covering the estuary of Ha Giang River that would most strongly affect Phu My, are 55 cm (with a 90 % confidence interval of 33-78 cm) under RCP 4.5, and 75 cm (52-106 cm) under RCP8.5 (see Table 3). 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 3: 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)

With a sea level rise of 100 cm by the end of the century – an extreme, but potential outcome – 39 % of the Mekong Delta would be inundated (Figure 6). Kien Giang has the second highest inundated area (77 %) among all provinces of Vietnam (Figure 7), only after Hau Giang Province (81 %).

Giang Thanh District (where Phu My is located) would be completely submerged (99 %) when the sea would rise with 100 cm (Table 4); this is the highest projected inundation risk among all districts of the Mekong Delta and of Vietnam. 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 hydrological state of the wetland, especially for Giang Thanh District.

Table 4: Inundated land (%) at different levels of sea level rise for Kien Giang Province and Giang Thanh District (adapted from Tran Thuc et al. 2016).

		Sea level rise					
	Area (ha)	**50cm**	**60cm**	**70cm**	**80cm**	**90cm**	**100cm**
Mekong Delta	3,969,550	5 %	9 %	15 %	21 %	28 %	39 %
Kien Giang Province	573,690	8 %	20 %	36 %	51 %	66 %	77 %
Giang Thanh District	42,358	18 %	54 %	77 %	86 %	98 %	99 %

4.3 Implications for Phu My

Climate projections applicable to Phu My are: higher temperature with more hot days/heat waves and frequent droughts; irregular monsoon season with higher rainfall and frequent torrential rains; typhoons and tropical depressions may be less frequent, but strong to very strong typhoons may occur more frequently. The sea level of the Gulf of Thailand could increase with 106 cm by the

end of the century under the worst scenario; inundation risk is projected to be severe. Giang Thanh District, where Phu My is located, would be submerged entirely if sea level rises by 100 cm. Although, expected sea level rise by mid-century is expected to be less extreme, impacts will be substantial.

Most important threats to Phu My are severe and prolonged droughts, flooding and sea level rise. Higher temperatures with droughts increase the risks of uncontrollable fires in grasslands and melaleuca shrubs. Phu My will be severely affected by sea-level-rise induced flooding; sea level rise would also increase salinity intrusion into the freshwater environment of Phu My. Decreasing flood pulse of the Mekong River due to upstream hydropower development would further compound impacts of climate change.

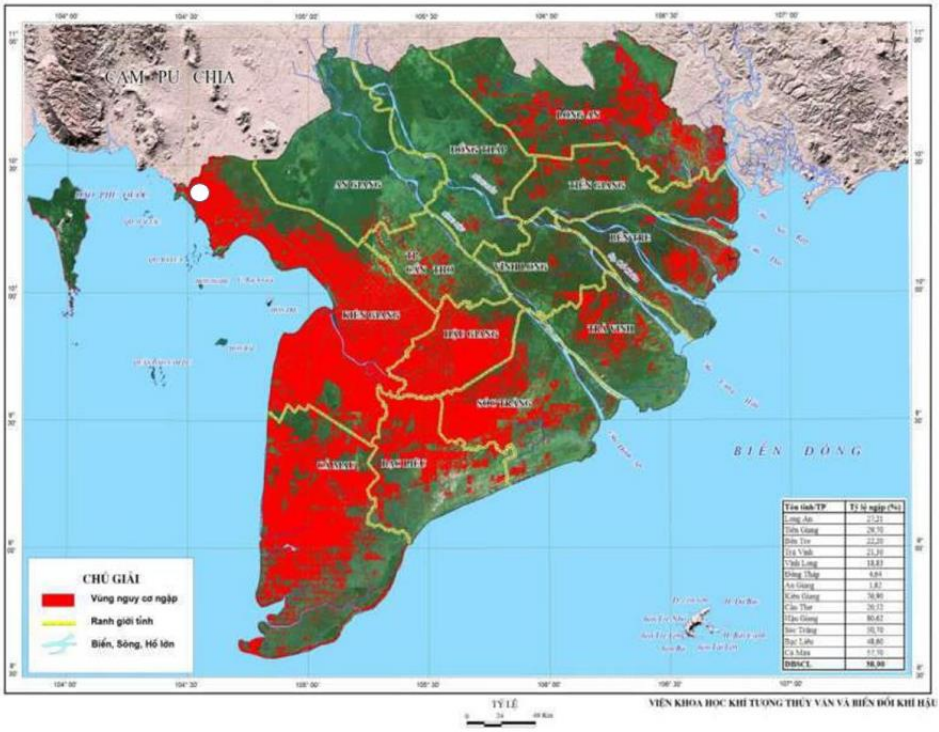


Figure 6: Map of inundation risk for the Mekong Delta when sea level rises with 100 cm; the white circle shows the location of Phu My Species and Habitat Conservation Area (source: Tran Thuc et al. 2016).

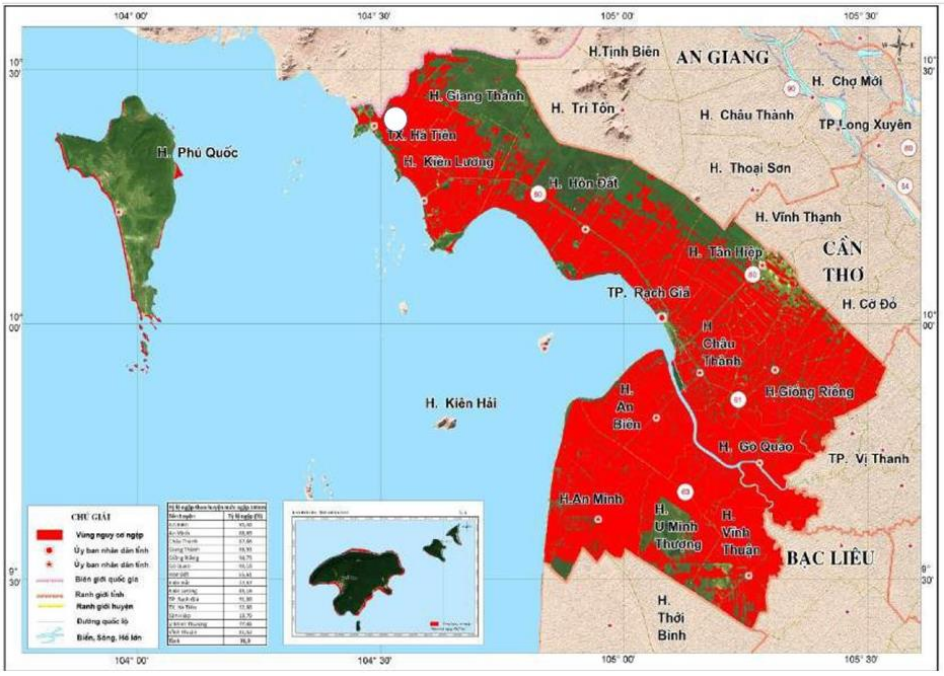


Figure 7: Map of inundation risk for Kien Giang Province when sea level rises with 100 cm; the white circle shows the location of Phu My Species and Habitat Conservation Area (source: Tran Thuc et al. 2016).

5. Results of vulnerability assessment

5.1 Habitat vulnerability

The team selected melaleuca shrubs and seasonally inundated grassland as the two main natural wetland habitats for climate change vulnerability assessment. While man-made canals and rice fields may also provide important habitats or refuges for some species, they are less critical for assessing the impact of climate change on the natural environment and its species composition.

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 under impacts of extreme weather events. Baseline conservation status reflects the importance of protection and was assessed using expert opinions, including those of the assessment team and Phu My's managers; scores range from 1 to 3, with score of 3 being high and 1 being low.

Melaleuca shrubs of the type found in Phu My are generally referred to as "Tràm Gió", a stunted form of *Melaleuca cajuputi*, the single dominant tree species of this habitat. It is becoming a rare type of plant community in the Mekong Delta. Its geographical distribution has been greatly reduced the last few decades, when reclamations of the Plain of Reeds and the Long Xuyen Quadrangle – the two floodplains of the Mekong Delta – took place. Besides Phu My, natural Tràm Gió stands can be found perhaps only at Dong Thap Muoi Wetland Reserve in Long An Province. Its area within Phu My has also been reduced due to frequent forest fires and because local people use it as fuel wood. In the Plain of Reeds, people harvest Tràm Gió leaves for essential oil extraction, but this type of harvest is not practiced at Phu My. The Tram Gió community does not have a high plant species diversity but consists of plants that adapt to high soil acidity and seasonal flooding. Besides *M. cajuputi*, which can be considered a keystone species, this community also includes *M. affine* and other common plant species such as *Xyris indica, Scleria poaeformis, Eleocharis ochrostachys and Ischaemum barbatum.* Melaleuca shrubs are strictly protected inside Phu My's core zone, but trees are still being cut by local people for fuel wood. Our analysis yielded a baseline conservation status score of 2.1. Despite being a unique plant community, this is not high; this is mainly because melaleuca shrubs still occur in other parts of the Mekong Delta (Plain of Reeds) and is an indication that "Tram Gió" melaleuca has not been recognized yet as being a unique plant community by itself.

Seasonally inundated grasslands are a typical wetland habitat of the original Long Xuyen Quadrangle floodplain, which can now only be found in a few small protected wetlands. Seasonally inundated grasslands in Phu My consist of several plant communities that adapt to different levels of soil acidity and flooding conditions. Three most common plant communities are (named after the dominant plant species in the community) *Lepironia articulata, Eleocharis dulcis,* and *Ischaemum rugosum*. Especially lepironia grasslands are unique and economically important. Local people have been harvesting lepironia for a long time, but the recent increase in lepironia demand for handicraft production has severely threatened this community. Phu My's grasslands (especially eleocharis) also provide dry season foraging habitats for the eastern sarus cranes in Cambodia and Vietnam, which population is rapidly declining in recent years (Tran et al. 2017). Seasonally inundated grassland communities depend on a wet-dry hydrology and do

not tolerate permanent flooding; moreover, they are freshwater communities and cannot survive saline water intrusion. They can tolerate a moderate fire regime, but strong and frequent fires would greatly impact their growth and regeneration. The invasive alien plant *Mimosa pigra* is another threat to the seasonal grasslands at Phu My. Our analysis yielded a baseline conservation status score of 2.0 for seasonally inundated grassland. This is a moderate score, since seasonally inundated grasslands still occur in other places in the Plain of Reeds and the Long Xuyen Quadrangle.

5.1.2 Climate change vulnerability

Table 5 presents a summary of major climate issues, exposure, sensitivity and adaptive capacity of the habitat types being assessed for Phu My.

Table 5: Summary of climate vulnerability characteristics of two wetland habitat types of Phu My Species and Habitat Conservation Area.

	Major climate issues	**Exposure**	**Sensitivity**	**Adaptive capacity**
Melaleuca shrubs	Drought; hydrological change; inundation due to sea level rise	All areas exposed to hydrological change and sea level rise	Sea level rise; droughts; high air temperature	Low
Seasonally inundated grassland	Drought; hydrological change; inundation due to sea level rise	All areas exposed to hydrological change and sea level rise	Drought; soil erosion; sea level rise*	Low

Note: seasonally inundated grassland is also highly sensitive to changes in river flooding regime and sedimentation as result of Mekong River development and which interact with impacts due to climate change.

Melaleuca shrubs and seasonally inundated grasslands of Phu My are most vulnerable to saltwater flooding and salinity intrusion caused by sea level rise. As discussed in Section 4.2 on sea level rise projections, Phu My will be severely affected, resulting in large areas being submerged. Both habitat types are freshwater wetlands and will not be able to withstand permanent flooding and high-water salinity. But the situation of Phu My's wetlands will also depend on changes in seasonal (freshwater) flooding by the Mekong River. Both the flooding regime and sedimentation of the Mekong River are projected to be strongly altered by upstream hydro-power development, most notably the reduction of river flood pulse and sediment loads coming to the Delta area (see Beilfuss & Tran 2014). Being located at the edge of the Mekong Delta floodplain, Phu My's wetlands would be under the compound impacts of climate change and Mekong River development. The interaction between them is complex and poorly understood.

Given their small sizes, the whole area of these two habitats would be exposed to influences of climate change and Mekong River development. There is little space available outside of the Phu My conservation area for melaleuca shrubs and seasonal grasslands to occupy in response to these impacts. Grassland communities would be more sensitive to changes in the Mekong river flooding regime and sediment loading as compared to melaleuca shrubs. Droughts and high air temperatures are also a threat. They increase the risks of catastrophic fires that may destroy large areas of both types of habitats. Melaleuca shrubs and seasonal grasslands can tolerate a moderate fire regime (low intensity and less frequent) but would be seriously affected by frequent or high intensity fires.

Our analysis yielded a climate change vulnerability score of 2.4 for melaleuca shrubs and 2.6 for seasonally inundated grasslands; hence their vulnerability to climate change is considered “High”.

5.1.3 A comparison between habitats

The scores for baseline conservation status and climate change vulnerability for the two wetland habitats in Phu My are summarized in Table 6. Whereas both habitats have a relatively moderate score for baseline conservation status, they were assessed as being highly vulnerable to climate change. The familiarity of the assessment team with the habitat conditions at Phu My resulted in high confidence scores (on a scale of 1-4) for all habitat assessments.

Table 6: Summary of habitat assessment results for Phu My Conservation Area, Kien Giang Province.

	Baseline conservation status		**Climate change Vulnerability**	
	Score	**Confidence**	**Score**	**Confidence**
Melaleuca shrubs	2.1	4.0	2.4	3.0
Seasonally inundated grassland	2.0	4.0	2.6	3.3

Figure 8 presents the results of the baseline conservation status and climate vulnerability assessment for the two habitats in Phu My 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 U Minh Thuong National Park in Kien Giang Province, three habitats – peat swamp, melaleuca forest and open swamp – were assessed. All habitat types were ranked from moderately to highly vulnerable to climate change, except peat swamp in U Minh Thuong National Park that was ranked very highly vulnerable.

The average baseline conservation status and climate change vulnerability of inundated grassland habitat in Phu My seems similar to that of grassland habitats in Lang Sen Wetland Reserve. Melaleuca habitat in Phu My, however, seems very different in terms of vulnerability compared to melaleuca habitat in U Minh Thuong National Park and Lang Sen Wetland Reserve. Melaleuca shrubs in Phu My is a less common habitat type compared to melaleuca forests of the other two wetlands; it is also projected to be under stronger influence of salinity intrusion and flooding that would be caused by sea level rise.

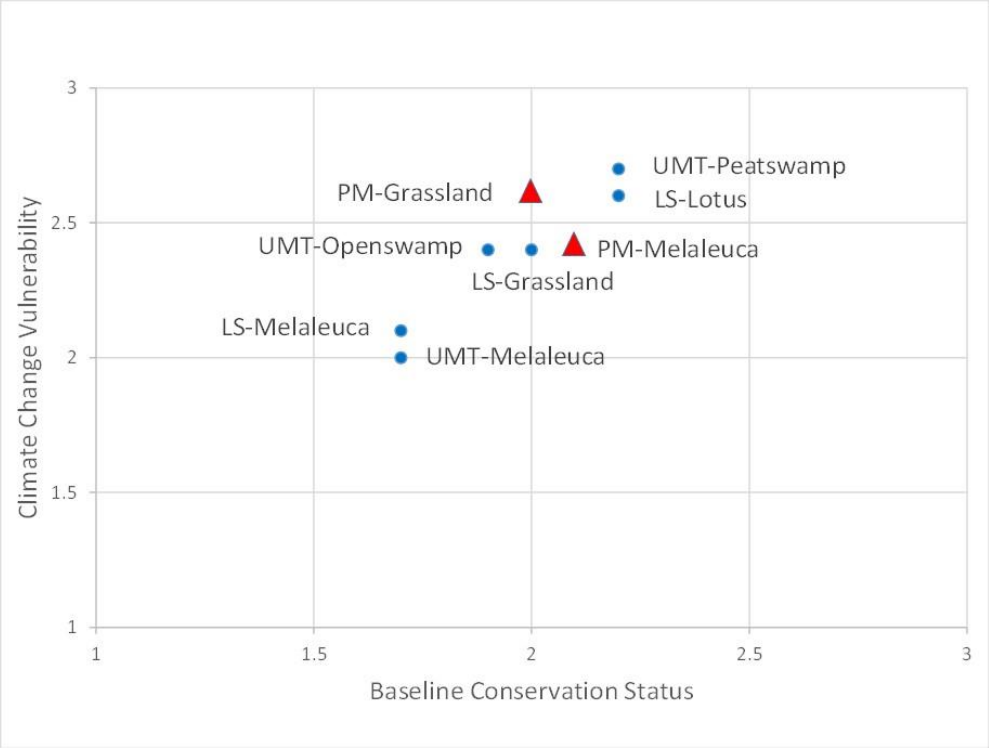


Figure 8: Conservation status/Climate vulnerability diagram for all habitats assessed for Vietnam wetland sites. LS: Lang Sen Wetland Reserve; PM: Phu My Nature Reserve; UMT: U Minh Thuong National Park. Phu My's habitats are represented by red triangles.

5.2. Livelihood vulnerability

In consultation with managers from Phu My Species and Habitat Conservation Area, the assessment team selected three villages from Phu My Commune for the climate change vulnerability assessment, namely Kinh Moi, Tra Phot and Tran The (see Figure 9). Within their commune, these villages relied most heavily on Phu My's natural resources due to their proximity to the wetland. These villages were also engaged in ICF projects since 2004.

Figure 9: Locations of villages assessed at Phu My

At every village, a PRA (Participatory Rural Appraisal; Figure 10) was applied to mobilize and engage village members and learn from their perceptions, experience and knowledge.

Figure 10: PRA Tra Phot village (photo credit: Tran Triet, 2017)

Visual tools were used to collect data on resource priorities, on resource distributions in space (resource map) and time (seasonal calendar), and on past extreme weather events and their impact (historical timeline). In addition, group discussions were held on current and future coping and wetland management strategies. Needs and perspectives of both women and men were considered by organizing separate focus groups. PRA is a learning activity conducted in a short time, whereby outsiders help villagers to share and reflect on their situation, knowledge and lived experiences.

5.2.1. Dependency on wetland resources

The ten most important natural resources in the area, listed in descending order, are lepironia, melaleuca, water, black fishes, grasses, rodents (field rats), honey, snakes, medical herbs, frogs, wild vegetables, bitter bolete, and birds (Table 7). While rice is the most important food crop for people, it was not considered for this exercise since it is cultivated on farm land. The overall pattern in resource use from the wetland is rather similar, but there are some important differences between villages. Tra Phot and Tran The are very close to the wetland and lepironia and melaleuca are the most important resources to them. While these are also important resources for Kinh Moi village, its people chose water as the most important and critical resource since their village is located furthest away from the wetland. In Tra Phot, water was not even mentioned as a resource, possibly since it is situated so close to the wetland core zone and various canals that they take the availability of water for granted.

There were some striking differences between men and women in Kinh Moi and Tra Phot. In both villages, women ranked grasses and field rats higher than men; some women even plant grass around their house for their livestock. Men in Tra Phot, however, ranked the collection of melaleuca and frogs higher than women, and men in Kinh Moi ranked medicinal herbs and vegetables higher than women. The relative importance of resources seems related to role divisions between men (collecting firewood, catching fish, frogs, using medical herbs) and women (taking care of housework, cooking and feeding livestock).

Among the less high ranked resources, snakes, frogs, birds, medicinal herbs, wild vegetables, and bitter bolete, some may play a role in one village but not in others. It is further important to note that field rat is both a food source for local people and a harmful pest in rice fields. Snakes are also a source of food, but those that are natural enemies of rats are valued and protected.

Table 7: Ranking of key wetland resources by men (M) and women (F) from Kinh Moi, Tra Phot and Tran The Village

	Wetland resource	**Kinh Moi**		**Tra Phot**		**Tran The**		**Resource-use**
		M	F	M	F	M	F	
1	Lepironia	2	2	2	1	1	1	Weaving mats
2	Melaleuca	3	3	1	5	2	2	Firewood and house construction
3	Water	1	1	-	-	5	5	Household consumption/irrigation

4	Black fishes	4	4	3	3	4	3	Food
5	Grasses	-	6	6	2	3	4	Livestock feed
6	Field rats	8	5	8	4	6	6	Food and sale
7	Bee (honey)	6	7	5	6	7	7	Sale
8	Snakes (Colubridae)	-	-	7	8	8	8	Food and sale
9	Medicinal herbs	5	-	-	-	-	-	Health care and sale
10	Frogs	9	10	4	7	-	-	Food and sale
11	Wild vegetables	7	-	-	-	-	-	Food
12	Bitter bolete	-	8	9	9	-	-	Food and sale
13	Birds	10	9	-	-	9	9	Sale

The distribution of wetland resources that are important to the people of the three villages is shown on the maps in Figure 11. Key resources seem randomly distributed throughout the wetlands at first sight, but there are also some patterns that can be distinguished. Melaleuca and lepironia are concentrated in certain areas, with most dense distributions in the area close to Tra Phot, followed by Tran The. Especially people in Kinh Moi have to travel longer distances to access melaleuca areas. Other wetland resources such as fish, frogs, snakes, and field rats are spread along the canals, in grasslands and rice fields, providing equal access to the people of the three villages.

Activities related to resource-use and collection for the three villages are presented in Figure 12. Activities include: harvesting lepironia, weaving lepironia mats, raising poultry and cows, catching fish, collecting firewood, harvesting honey, catching field rats/rodents, picking wild vegetables and herbs, and working as hired labourer. Some activities take place throughout the year, such as harvesting lepironia, weaving mats, raising livestock and collecting firewood, while others take place at certain times of the year such as rice cultivation and honey harvesting. Bitter bolete (mushrooms in melaleuca forest) only appear during some days at the beginning of the rainy season; the increase in natural resource abundance at certain times of the year goes along with an increase in activities related to the resource. Methods of resource exploitation may also change based on resource availability, such as electricity fishing in the dry season and net fishing in the wet (rainy) season. In the dry season, natural resources in the area are significantly reduced, such as fish, honey, rats, snakes and grasses for livestock. People in Tran The and Tra Phot rarely work as hired labourer or worker for companies. This is more common in Kinh Moi, where there are more job opportunities for young people offered by companies from outside the wetland zones.

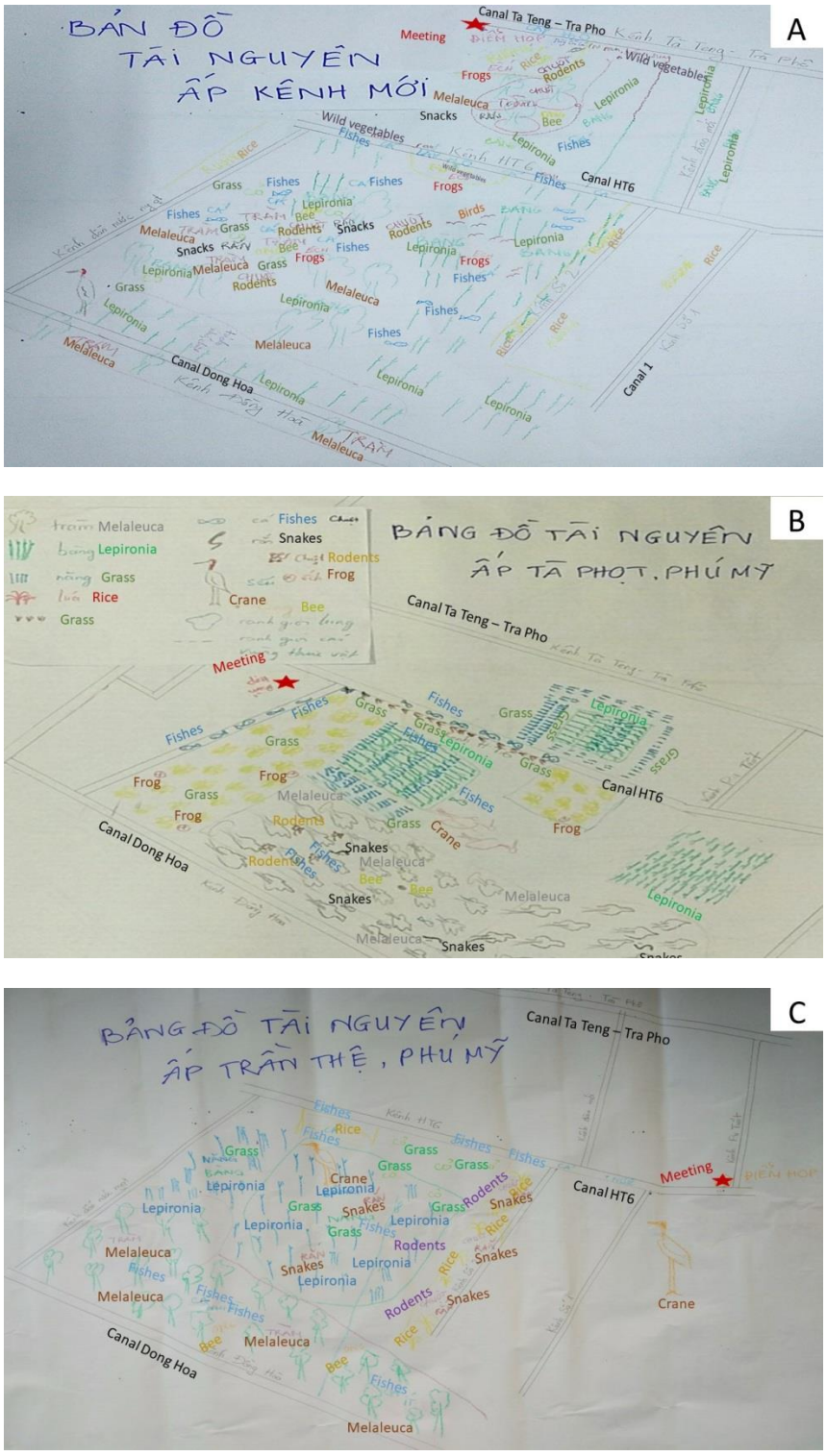
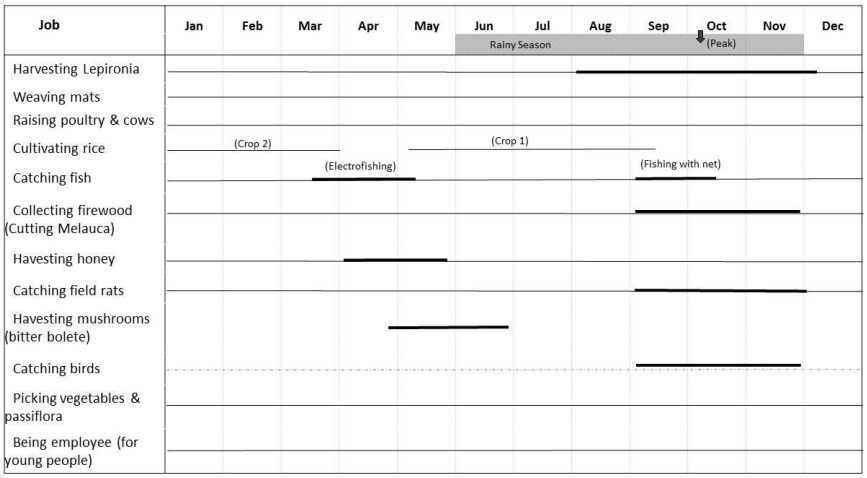
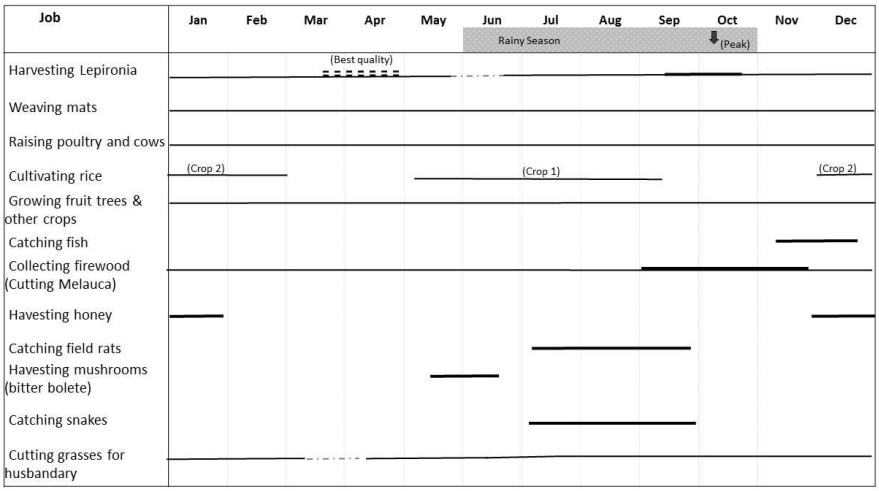


Figure 11: Resource map of Kinh Moi (A), Tra Phot (B) and Tran The (C) Village

Kenh Moi



Ta Phot



Tran The

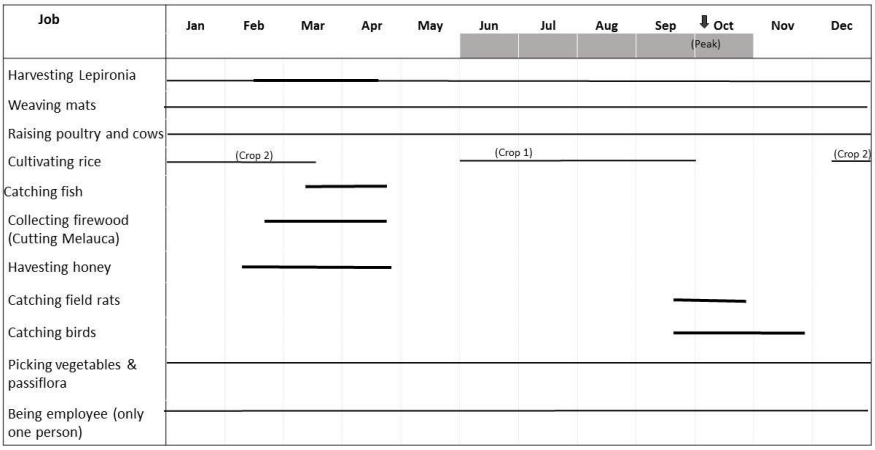


Figure 12: Seasonal calendar of resource-use/collection in Kinh Moi, Tra Phot and Tran The Village

5.2.2. Extreme weather events and impacts

People from the three selected villages reported many extreme weather events in the area over the last 10 years, including floods, storms, droughts and salinity intrusion, with severe weather impacts of crop and income losses, water shortage, and damage to houses (Table 8).

Table 8: Extreme weather events over the last 10 years and their impacts.

Extreme events	Years and villages	Impacts
Flood	2011 – Kinh Moi, Tra Phot, Tran The	Water rose to a very high levels, inundating and destroying houses and crops; disease outbreaks among children; fish and snakes could not be exploited, while it was difficult to harvest lepironia.
Storm	2014 – Kinh Moi, Tra Phot, Tran The	Heavy rain with strong winds lasted for a week; damaging and uprooting melaleuca trees; damage of rice crops.
Drought and Salinity intrusion	2016 – Kinh Moi, Tra Phot, Tran The	Droughts caused high salinity water to reach and damage the rice fields and other crops; water resource was in short supply; diseases broke out among livestock (buffalo, cow poultry).

Rains in Phu My have become unpredictable as the timing of the rainy season and intensity of rains have changed. Floods and droughts occur more frequent, with droughts often leading to salinity intrusion. Regarding the water regime, people have witnessed that the water level in the lepironia grasslands and canals has declined remarkably in recent years.

The flood in 2011 caused severe damage to people's houses. Newly cultivated rice crops and fruit trees such as mango and banana were damaged. Water resources in the area became polluted by the flood. Diseases, such as diarrhoea, broke out among children. Boats had to be used for local transportation. With the land being flooded, it was difficult to harvest lepironia – although growing conditions were better. It also affected other wetland resources, for better or worse. For example, bitter bolete ("*Nấm Tràm"* in Vietnamese), a kind of mushroom that appears in melaleuca forests, disappeared; the numbers of rats and frogs reduced, while fish became more abundant. High water level, however, hindered the exploitation of fish and snakes. People from Kinh Moi mentioned that the soil was fertilized thanks to the flood, while people in Tra Phot said that lepironia grew better than before.

In 2014, the area was hit by a storm which lasted for a week. In this extreme weather, rice and vegetable crops were inundated and damaged. Lepironia was submerged in the flood and could not be harvested. Melaleuca trees were damaged and fell because of strong winds. Eucalyptus trees planted by local people were also damaged by the strong winds. Other resources such as fish became more abundant. During the storm, local people tried to harvest and store rainwater. Right after the storm, soil fertility improved due to sediments; lepironia grew better, and people in Kinh Moi indicated that rats and frogs increased in numbers.

Drought and salinity intrusion had a serious impact on the villages in 2016. As result of the drought, water with high levels of salinity reached the rice fields and destroyed the crops. Lepironia was not affected much by the drought despite turning (slightly) yellow. There was a shortage of water for irrigation and water could not be used for bathing as usual because of its high salinity. A lot of fish also died. Buffalos, cows, and poultry suffered from disease outbreaks resulting in increased mortality among animals [Kinh Moi]. The shortage in water for irrigation led

to a 50 % decrease in rice productivity in Tra Phot village and a decrease of about 40 % in Tran The village. Impact on rice was not mentioned by Kinh Moi village, most likely because rice cultivation in Kinh Moi is less popular due to soil conditions. After the drought, rice fields could not be cultivated immediately, and people had to skip the next three crops.

5.2.3. Coping strategies and wetland management

The impact of extreme weather events and anticipated climate change pose people with enormous challenges. So far, people were often ill prepared and have tried to deal with these impacts as best as they could; more strategic responses may, however, be required – with extreme weather events expected to become more extreme and more frequent in the future. Table 9 – 11 summarize current and future coping strategies identified by people of Kinh Moi, Tra Phot, and Tran The Village in response to extreme weather events and climate change.

Most of people's responses to extreme weather events in the past have been ad-hoc and rather passive. People barely managed to find enough food and struggled to make ends meet. Most people lacked effective strategies to deal with the impacts of crop loss, damage of dwellings, water shortages and salinity intrusion. Lepironia grasslands, however, have been a great help for people to survive extreme events because they were impacted relatively little. While harvesting lepironia was carried out by both men and women, the weaving was mostly done by women. Fish, field rats/rodents, frogs, snakes have been important food sources to overcome natural disasters. In the case of floods, people often had to build temporary shelters as there was no safe place for storm and flood escapees in the area; Kinh Moi and Tra Phot also reported a lack of clean water. As judged by staff of the reserve, this was also an issue in Tran The, even though people did not mention it. In case of drought, people rely more strongly on water resources of wells and on Phu My grasslands for their daily life and production, putting increased pressure on specific natural resources such as lepironia, honey, melaleuca, and fishes. The damage of salinity can be extensive and long-lasting because salinized land cannot be cultivated for a long time afterwards; the treatment of salinized soils is highly dependent on natural conditions and requires large amounts of rains to wash away the salt. Damage and income loss have forced people to borrow money, from banks if possible, but mostly from neighbours, making households even more vulnerable; this was especially the case in Kinh Moi. People in Kinh Moi also relied more often on paid labour as alternative income source, compared to Tra Phot and Tran The.

Building on these discussions, men and women were also asked how they plan to cope with extreme weather events in the future. Future strategies proposed by the villagers include building salinity prevention facilities, clean water supply systems, developing a stable pricing system for rice, pesticides and fertilizers. In response to natural disasters, people would store rice seedlings for food and cultivation. People also want to shift to fruit cultivation in lieu of rice; it was further interesting that men in Kinh Moi would like to help their wives weaving lepironia mats. However, most people expect substantial support from the State for providing a clean water supply system, salinity prevention facilities, effective models of cultivation and policy, and financial investment. These are also the main priorities of the people, supporting them in reducing their dependency on the wetland. As employment opportunities are limited, many – especially young people – may have to move to other areas such as Ho Chi Minh City and Binh Duong Province to find jobs for more income, while the elderly wish to receive financial support from their descendants. Overall, people in Kinh Moi and Tran The seemed more thoughtful about their future coping strategies than those in Tra Phot.

Table 9: Summary of current and future coping strategies as identified by representatives of people from Kinh Moi.

Extreme events	Impacts	Current coping strategies		Future coping strategies	
		Men	Women	Men	Women
Flood	Crop damage	No coping strategies; passively waiting for planting next crop	Replanting trees/crops. Using rice stored from previous crops. Catching fish for food	Catching fishes for food and sale	Storing rice seeds and replanting crops after floods
	Reduced water quality	Using flood water	Using flood water or rainwater	Having no coping strategies	Expecting government al supports for clean water
	Damage to dwellings	Making temporary shelters in flood		Having no coping strategies	Making temporary shelters at higher lands
	Income loss	Being employed and/or harvesting lepironia	Being employed. Catching fish and weaving lepironia mats	Looking for job and being employed	Looking for job and being employed. Weaving lepironia mats.
Storm	Crop damage	Catching fish and snake	Using stored rice of the previous crops	Having no coping strategies	No idea, but asking for early warning when storms hit their area
	Income loss	Getting loans from banks	Catching fish, collecting wild vegetables. weaving mats using lepironia stored before	Looking for job and being employed. Helping wives weave lepironia mats	weaving lepironia mats and expecting a better price for their products
Drought and salinity intrusion	Crop damage	Using rice stored from previous crops for daily meals	Waiting for rains to help wash out the salinity naturally	Planting coconut and mango instead of rice	Expecting government support to prevent saltwater intrusion into the canals
	Water shortage	Using water from wells and lepironia wetlands instead of canals	Using well water or ask water from neighbours. Saving water.	Using water from wells, ponds, rice fields, and lepironia wetlands	Expecting government al supports for clean water
	Income loss	Looking for jobs, getting loans from neighbours, spend more time harvesting lepironia and honey.	Being employed and getting loans from neighbours.	Planting fruit tree for more income	Expecting government support for managing market prices of rice, fertilizers, pesticides

Table 10: Summary of current and future coping strategies as identified by representatives of people from Tra Phot.

Extreme events	Impacts	Current coping strategies		Future coping strategies	
		Men	Women	Men	Women
Flood	Crop damage	Harvesting lepironia, cutting melaleuca, and catching fishes	Harvesting lepironia and weaving mats	Harvesting lepironia, catching fishes and looking for jobs.	Harvesting lepironia and weaving mats
	Reduced water quality	Having no coping strategies	Having no coping strategies	Having no coping strategies	Having no coping strategies
Storm	Crop damage	Having no coping strategies	Harvesting lepironia, weaving mats	Loan money from bank	Harvesting lepironia, weaving mats

	Income loss	Harvesting lepironia, cutting melaleuca, catch fish, rodents, and frogs	Being employed by construction companies	Having no coping strategies	Having no coping strategies
Drought and salinity intrusion	Crop damage	Cutting melaleuca, harvesting lepironia	Harvesting lepironia, weaving mats	Harvesting lepironia/ bee honey. Raise poultry	Harvesting lepironia, weaving mats
	Income loss	Looking for job and being employed.	Saving. Going to towns/ provinces for work	Harvest lepironia and bee honey	Having no coping strategies

Table 11: Summary of current and future coping strategies as identified by representatives of people from Tran The.

Extreme events	Impacts	Current coping strategies		Future coping strategies	
		Men	Women	Men	Women
Flood	Crop damage	Catching fishes for food	Weaving lepironia mats; working for the lepironia Company nearby (young females) and catching fishes for food	Keeping rice for use in flood season	Weaving lepironia mats. Young people move to other cities and look for work/job. Expect more support from government
	Damage to dwellings	Building temporary shelter in the flood		Giving no solutions to cope with this impact	Asking supports from government
	Income loss	Moving to other cities and look for job		Giving no solutions to cope with this impact	Working as employee (young people)
Storm	Crop damage	Catching fishes for food	weaving lepironia mats	Harvesting lepironia and/or working as employee	Young people work as employees. Old people get financial support from their children.
	Damage to dwellings	Building temporary shelter in the flood	Asking a loan from their neighbors	Giving no solutions to cope with this impact	
Drought and salinity intrusion	Crop damage	Harvesting lepironia and catching fishes	weaving lepironia mats	Harvesting lepironia and working for people who hire them	Weaving lepironia mats. Besides, they will need technical supports for controlling pests
	Reduced water quality	Reporting the situation to local government. Shifting to use water from wells and the lepironia wetland		Using water from wells and lepironia wetland. Waiting for river water that run into the canals and rice fields to reduce salinity and pollution.	Harvesting rainwater and store at home or asking water from nearby companies who have stored water in large tanks
	Reduced fish stocks	Harvesting lepironia and cutting melaleuca		Giving no solutions to cope with this impact	Avoiding catching fishes in their breeding season

As a follow up to the focus groups on current and future coping strategies, villagers were asked about wetland management strategies that have a direct impact on key resources used by them. In general, they do not think that resources are managed well. Table 12 provides an overview of current strategies and proposed improvements.

Lepironia and melaleuca are two key resources. Regarding the management of lepironia, people proposed to allocate plots of Lepironia to households and support these with fertilizers. They

expect a fair allocation mechanism, although they did not know how such a mechanism should look like. Currently there are no significant conflicts in the area, but there have been cases of lepironia theft in the area. Villagers also want good pricing policies for lepironia products and be able to participate as workers in the handicraft factory run by the wetlands' management board; this may point to some dissatisfaction with current policies and management practices. Regarding melaleuca, people insist on measures to prevent forest fires, but concrete proposals are lacking.

The management of water touches on several resources such as freshwater for drinking, water as a habitat for fish and other species, and water as a source of irrigation for crops. People prefer governmental support for a system of clean water supply to address shortage and quality of water resources in the area. Villagers also expect the government to construct dams for salinity control, while maintaining good water quality to protect fish species; in their view, the State knows best where saltwater comes from and how it can support people to prevent it. Furthermore, people see a role for the State to dredge canals for improving irrigation and to sustain water transportation. For other resources, such as bees, snakes, and birds, no specific recommendations were proposed. There are concerns though, since people have reported that their population numbers and diversity have been reduced in recent years.

In summary, although compromised by future Mekong River development, wetland resources play a crucial role in helping people to overcome harsh weather conditions and events. Especially lepironia seem to provide people with a valuable resource and alternative. While members of villages that are most likely to be affected by climate change made useful suggestions to improve coping strategies and/or the protection of key resources, it is also clear that their capacities are limited and that they will need strong support from government agencies and/or others. Proposed actions as irrigation and fertilizer-use raise questions about sustainability, which needs to be closely monitored and managed. There are also questions of who will benefit and who not, requiring attention for issues of inclusive development and equity. DARD needs be engaged together with private sectors and NGOs, to explore some of the proposed actions and measures and support the conservation area and local people to develop effective models of livelihood development and lepironia handicraft product consumption.

Table 12: Current/future management strategies of key resources in Kinh Moi (KM), Tra Phot (TP) and Tran The (TT)

Resource	Current management	Future management
Lepironia	Not yet managed (KM, TP, TT); zoned areas for exploitation by villagers (KM, TT); fertilized for better productivity (KM, TT)	Zoning and allocation to villagers for exploitation and protection; fertilizing and watering the grass; converting rice fields into Lepirona with technical assistance, fertilizer, and support for marketing handicraft sales; but also need loans for rice crop investment to become less dependent on lepironia (KM, TP, TT)
Melaleuca	Cutting branches for firewood (TP, TT); currently burned a lot (KM); no effective management (KM, TP)	Need for measures to prevent forest fires (KM); allowing to collect dead trees and dried branches (TT)
Water	No water management (KM, TP, TT); importance wetland for well-water quality/quantity known; use stored rainwater in tanks at Phu My (TT)	Need support to construct water tanks to collect and store rain water (TT)
Black fishes	No effective management; keep using electricity for catching fishes (KM); many people exploiting; out of management control (TT)	Banning and controlling people from electricity fishing (KM); manage and prevent water from salinity intrusion; need state support in water management (KM)

Resource	Current management	Future management
Grass	Free exploitation; *Eleocharis* grass is cultivated/ fertilized around the house for exploitation (TT)	No need to manage (TT)
Field rats/rodents	Causing damage to agricultural crops; no management (TT); wanting to kill the rats (KM)	Need control to protect crops (KM, TT)
Bee (honey)	Not yet managed; aware of need to prevent forest fire due to honey exploitation (TT); avoid killing bees (KM); honey productivity decreased recently; only Apis bees remained (KM)	Keeping melaleuca forests in good condition for bee habitats and protect them from forest fires (KM); no specific recommendations for honey exploitation management (TT)
Snakes	Not yet managed (KM); catch most snakes (TT)	No recommendations for management (KM, TT)
Medicinal herbs	No management (KM)	No need for management (KM)
Frogs	Not yet managed (KM)	No recommendations for management (KM)
Wild vegetables	No management (KM)	No need for future management (KM)
Bitter bolete	No management (KM)	Exploitation based on natural productivity (KM)
Birds	Not managed effectively (TT); outsiders come and catch birds.	No suggestions for bird exploitation management

5.3 Species vulnerability

Three species were selected for climate change vulnerability assessment, namely *Lepironia articulata*, Tràm Gió melaleuca and sarus crane. The reasons for selecting these species are presented in Table 13.

Table 13: Species selected for climate vulnerability assessment for Phu My Species and Habitat Conservation Area.

Species	Reasons for selection
Lepironia articulate	Keystone species, economically important
Melaleuca cajuputi (Tràm Gió)	Keystone species, economically important
Sarus crane (*Grus antigone sharpii*)	Flagship 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, and their ability to survive extreme weather events. Species conservation status scores range from 1 to 3, with 3 being high and 1 being low.

Lepironia articulata is now a rare plant in the Mekong Delta. It is, however, planted in some small plantations in Tien Giang Province. Lepironia provides an important livelihood base for local people at Phu My, especially for Khmer ethnic people. It can tolerate high soil acidity, which is a characteristic that helps lepironia compete well with other grassland species. With moderately deep floods (1.5 m to 2.0 m), lepironia plants will grow long stems that are favourable by local people for weaving. Shallow floods will degrade lepironia quality as a raw material for handicraft production. Lepironia is capable of long distance disperse by wind and water. It is a freshwater plant and may not tolerate high water salinity. With increasing demand for raw material for lepironia handicraft production, the current level of lepironia harvest at Phu My does not seem to be sustainable. There is an urgent need of developing a resource sharing policy and a wetland restoration plan to help manage lepironia resources in Phu My sustainably. Our analysis yielded therefore a baseline conservation score of 2.6 for *Lepironia articulata*, which is relatively high.

The stunted **melaleuca** (Tràm Gió) is another rare plant that now only grows naturally in Phu My and a few other protected wetlands in the Mekong Delta. Tràm Gió melaleuca is not harvested for essential oil extraction in Phu My, but local people do cut melaleuca stems for fuel woods. Melaleuca areas in Phu My are also susceptible to fires that happen frequently during the dry season. Melaleuca is a freshwater plant, capable of withstanding low water salinity for short periods of time but will not tolerate high salinity. As indicated before, the taxonomy of this plant species is still ambiguous. It is unclear whether this stunted form is a sub-species of *Melaleuca cajuputi* or only an eco-type. Since it is usually categorized as the much more common tree-form *M. cajuputi*, "Tràm Gió" is often given similar conservation priority. Hence, our analysis yielded a baseline conservation score of 2.2 for Phu My melaleuca.

Sarus cranes that come to Phu My in the dry season belong to the Cambodia/Vietnam eastern sarus crane population, one of the four distinct populations of the sarus crane. This is the smallest population, currently estimated at 400 individuals, and has been declining rapidly during the last five years (Tran et al. 2017). This population of sarus cranes is in great danger of being extinct. The Cambodia/Vietnam eastern sarus cranes breed on small wetlands in deciduous Dipterocarp forest of Northern Cambodia and migrate to the Mekong Delta and wetlands around the Tonle Sap Lake during the dry season. Main threats to Sarus cranes in Cambodia and Vietnam include habitat loss (both breeding and non-breeding), low productivity due to disturbances in breeding areas, and environmental contaminations (pesticides and herbicides) from agricultural practices that lead to high adult mortality. Phu My is now one of the most important non-breeding sites for sarus cranes in the Mekong Delta, providing both foraging and roosting habitats. The *Eleocharis* grasslands at Phu My are sarus crane's favourable feeding grounds. Any impact on seasonal grasslands at Phu My will directly impact Sarus cranes. Our analysis yielded a baseline conservation score of 2.9.

5.3.2 Climate change vulnerability

Climate issues, exposure, sensitivity and adaptive capacity of selected species are shown in Table 14.

Table 14: Summaries of climate change vulnerability characteristics of 3 species assessed for Phu My Species and Habitat Conservation Area.

	Major climate issues	**Exposure**	**Sensitivity**	**Adaptive capacity**
Lepironia articulata	Drought; hydrological change; salinity intrusion and flooding due to sea level rise	Little refugia available	Hydrological change	Intermediate
Melaleuca cajuputi (Tràm Gió)	Drought; hydrological change; salinity intrusion and flooding due to sea level change	Little refugia available	Hydrological change	Intermediate
Sarus crane	Temperature; drought; hydrological change; extreme events (typhoons)	Little refugia available	Heat; precipitation; hydrology	Low

All three species, which depend on freshwater wetlands, are most vulnerable to sea level rise that would cause large scale inundation and strong salinity intrusion in the Phu My area. Even though *Lepironia articulata* and Tràm Gió melaleuca can tolerate light to moderate fires, droughts and higher air temperatures may increase the risks of intensive, uncontrollable fires that can destroy lepironia grasslands and melaleuca shrubs. Droughts and fires will also severely affect sarus cranes because the dry season, when droughts and fires are more likely to happen, is also the time when cranes come to Phu My to feed and regain energy before they fly off to their breeding grounds in Northern Cambodia. The small area of Phu My provides little refuge for species to respond to the impacts of climate change; there is also limited habitat available for them outside the conservation area, as most of land areas have been used for farming and human settlements. *Lepironia articulata* and Tràm Gió melaleuca, however, may be more resilient to other climate change impacts such as high rainfall, freshwater flooding, irregular monsoon seasons, and strong typhoons.

The climate change vulnerability assessment placed *Lepironia articulata* and Tràm Gió melaleuca in the "Highly" vulnerable category (score 2.4) and the sarus crane in the "Very Highly" vulnerable category (score 2.9). The crane's very high vulnerability to climate change comes from the fact that the species population is already very small and in rapid decline. Any additional impact on its main breeding and feeding habitats will certainly drive the species closer to extinction.

5.3.3 A comparison between species

Results of the vulnerability analysis are combined in Table 15. Overall, baseline conservation status scores are above average for all species – with very high scores for *Lepironia articulata* and sarus crane; all species show high to very high vulnerability to climate change. Sarus crane is particularly vulnerable to the impact of climate change, while its population is already in a precarious situation. The confidence scores for the assessment (on a scale of 1-4) are high as a result of the familiarity of the assessment team with the ecology and conservation status of these species in Phu My.

Table 15: Baseline conservation status and Climate change vulnerability scores of species assessed for Phu My Species and Habitat Conservation Area.

	Baseline conservation status		**Climate change vulnerability**	
	Score	**Confidence**	**Score**	**Confidence**
Lepironia articulata	2.6	3.9	2.4	3.3
Melaleuca cajuputi (Tràm Gió)	2.2	3.8	2.4	3.0
Sarus crane	2.9	3.9	2.9	3.7

Figure 13 provides a "conservation status – climate change vulnerability" diagram for species assessed for Phu My as well as all other species assessed for Vietnam wetland sites. Sarus crane in Phu My and pangolin in U Minh Thuong National Park are the two species that have both the highest baseline conservation scores and climate change vulnerability among all species assessed for Vietnam's wetland sites. However, also *Lepironia articulata* shows a high baseline conservation status and high climate change vulnerability when compared to other species; it is also interesting that among the melaleuca species assessed, those in Phu My are more vulnerable in terms of both its current conservation status and climate change, reflecting both the unique melaleuca (Tràm Gió) plant community in Phu My and the expected impact due to flooding and salinity intrusion caused by sea level rise.

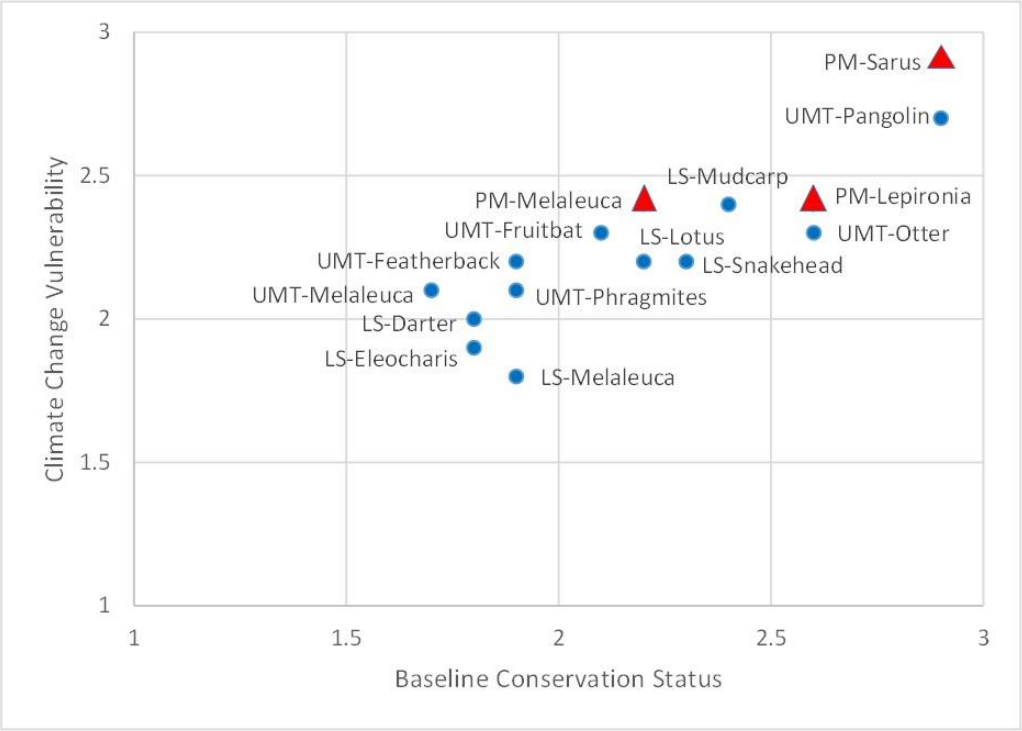


Figure 13: Conservation status/Climate vulnerability diagram for all species assessed for Vietnam wetland sites. LS: Lang Sen Wetland Reserve; PM: Phu My Species and Habitat Conservation Area; UMT: U Minh Thuong National Park. Species assessed for Phu My Species and Habitat Conservation Area are shown in red triangles.

6. Conclusions

6.1 Summary of vulnerabilities

Phu My wetlands are home to many rare and unique species and communities that are of high conservation significance. Lepironia and melaleuca shrubs are rare plant communities and the eastern sarus cranes of Cambodia/Vietnam, which depend on wetlands such as those available at Phu My for feeding, are on the verge of extinction. Main habitats and key species of Phu My wetlands are most vulnerable to droughts and salinity intrusion that would be caused by sea level rise. In Vietnam, the area in and around Phu My, faces the highest inundation risk from sea level rise as result of climate change. In addition, droughts and higher air temperatures would increase the risk of forest fires that may destroy wetland vegetation, while high levels of water salinity are detrimental to many freshwater species of Phu My wetlands. Phu My is a very small protected area; the whole system would be exposed to climate forces with almost no buffering capacity. Species of concerns, such as sarus crane, *Lepironia articulata* and Tràm Gió melaleuca, have little options for refuge outside of Phu My. Even though Phu My is located far from the Mekong River, Phu My wetlands are still influenced by Mekong floods and sediments. Changes in Mekong River hydrology and sedimentation may further complicate the impacts of climate change. The cumulative impacts of climate change and Mekong River development are still poorly understood.

Local people's livelihoods are highly vulnerable to droughts and salinity intrusion. These two climate adversities caused great losses in people's income and properties in the past. Local people also reported hardships that were caused by strong storms and floods. Their capacity to cope with climate adversities are limited. They rely heavily on rice as their main food crop and gain additional income from lepironia harvesting and related handicraft businesses; many poor inhabitants depend further on other wetland resources such as fish, honey, snakes, rats, wild medicines and vegetables There is, thus, a strong link between the ecological vulnerability of Phu My wetlands and the socio-economic vulnerability of local communities. Although people reported that lepironia helped them to overcome difficult times, the expected impact of climate change may cause people to put more pressure on already precarious wetland resources, and especially on lepironia as their main income source.

6.2 Adaptation planning

Phu My is a very small protected wetland with a core zone of 1,070 hectare. The entire wetland would not only be exposed to the impact of climate change but also to economic development pressures and other human disturbances. Since Phu My Species and Habitat Conservation Area has just been established recently, no specific management plan has been developed yet to address these issues. A comprehensive management plan is urgently needed to guide conservation efforts of species and habitats under anticipated climate and development challenges.

Based on the findings of this vulnerability assessment, the following ecological/hydrological issues should be considered for the core zone in the development of the wetland management plan:

- The design of a peripheral dyke system that would function both as a protection boundary and a water control structure. Such a system needs to be carefully designed, considering ecological needs of key plant and animal species, fire control and the predicted impacts

from sea-level-rise induced flooding and salinity intrusion, as well as changes in the Mekong River hydrology and sedimentation.

- Other impacts, largely not climate-related, also need to be considered in the development of the wetland management plan, including potential seepage of saline water and environmental contaminants from shrimp farms located in the surrounding of Phu My into the core zone.

Wetland resources are also important for a significant number of people who live in the buffer zone. Past experiences have shown that at times of difficulties, such as floods or typhoons that damaged rice crop, wetland resources such as lepironia became critical for local people to get through the hardships. Besides a wetland management plan, a buffer zone development plan is needed. The main goal of a development plan is to help improve the livelihoods of people who live in the buffer zone and reduce human impacts on the core zone. It may include:

- A resource sharing plan that would allow sustainable harvesting of key wetland resources; components of the resource sharing plan would include lepironia harvesting, fishing, buffalo grazing, and harvesting of grasses and other plant resources.
- Development of alternative livelihood activities that would contribute to improving the resiliency of local communities to climate change; the lepironia handicraft business is an example of such alternative livelihood activities.
- Development of an environmental education program to raise awareness about potential impacts of climate and development change and the importance of wetland conservation.

To successfully implement the wetland management and development plan, relevant stakeholders within and near Phu My will need to be more strongly involved as active participants, so that joint problem analyses and understanding of key issues can lead to more creative and sustainable solutions. Training should be provided for Phu My staff to enhance their capacity in climate change adaptation management and in wetland protected area management in general.

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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 and 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 Phu My staff who participated in the assessment study

Name	Organization/administrative unit	Role in the project
Nguyễn Phong Vân (Director)	Phu My Species and Habitat Conservation Area	Advisor general park management
Lâm Hoàng Tuấn	Phu My Species and Habitat Conservation Area	Advisor general park management
Lê Hồng Tuấn	Phu My Species and Habitat Conservation Area	Field guide
Mr. Liên	Phu My Species and Habitat Conservation Area	Field guide
Tiên Khom	Phu My Species and Habitat Conservation Area	Field guide
Lê Văn Toàn	Phu My Species and Habitat Conservation Area	Field guide
Tiên Danh	Tà Phọt Village	Field guide, community liaison
Tăng Văn Bài	Trần Thê Village	Field guide, community liaison
Tiên Tình	Kinh Mới Village	Field guide, community liaison
Thị Nhol	Ấp Trần Thê, Phú Mỹ	Field guide, community liaison
Trân Van Duyên	Ấp Kinh Mới, Phú Mỹ	Field guide, community liaison
Thị Hạnh	Ấp Kinh Mới, Phú Mỹ	Field guide, community liaison