Climate Change Vulnerability Assessment Bang Pakong River Wetland, Thailand

Bampen Chaiyarak, Gun Tattiyakul, Naruemol Karnsunthad

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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ACRONYMS

BMUB	German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety
EEC	Eastern Economic Corridor
EIA	Environmental Impact Assessment
GAP	Good Agricultural Practice
GPP	Gross Provincial Product
ha	Hectare
HAII	Hydro and Agri Informatics Institute
IBBRI	Indo-Burma Ramsar Regional Initiative
ICEM	International Centre for Environmental Management
IKI	International Climate Initiative
IPCC	International Panel on Climate Change
IUCN	International Union for Conservation of Nature
km	Kilometre
m	Metre
NSBSAP	National Biodiversity Strategies and Action Plan
ONEP	Office of Natural Resources and Environmental Policy and Planning
PBS	Public Broadcasting Service
TDRI	Thailand Science Development and Research Institute
THB	Thai Baht
UNFCC	United Nations Framework on Climate Change
VA	Vulnerability Assessment

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EXECUTIVE SUMMARY

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

Vulnerability Assessments (VAs) were conducted at ten sites in the four countries. VAs combined scientific assessments with participatory appraisals and dialogues with local communities and authorities including the Office of Natural Resources and Environmental Policy and Planning (ONEP). In Thailand, two sites were selected: Kaper Estuary- Laemson Marine National Park Kraburi Estuary Wetlands in southern Thailand, and Bang Pakong River Wetland, in Central Thailand which is the focus of this summary.

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

The Bang Pakong River Wetland is part of the larger Bang Pakong River Basin, southeast of the Bangkok metropolitan area and connected to the Gulf of Thailand (**Figure 2**). The area represents a unique ecosystem with high biodiversity as result of freshwater, brackish water and saltwater habitats. Despite strong expansion of urban areas and industrial devleopment, 70% of local people still depend on the wetland for their livelihood. Intensive land and water use and environmental pollution, however, have put the wetland ecosystem under pressure. Climate change is expected to further exacerbate these problems.

The Bang Pakong River Basin includes 7 provinces, 31 districts, and 217 sub-districts. The Bang Pakong River flows through 4 provinces (Prachinburi, Nakhon Nayok, Chachoengsao, Chonburi) and 36 sub districts with a total distance of 122 km. In terms of population, Nah Muang Subdistrict of Chachoengsao Province has the highest population with 39,570 residents, followed by Bang Khla Subdistrict of Chachoengsao Province with 9,307 residents. The total population along the riverbanks is 201,858 (48.2% men; 51.8% women; 83,875 households). Most people are Buddhist, with small groups of Catholics and Muslims.

Climate change projections for Bang Prakong River Wetland include:

- Increased rainfall during the rainy season coupled with the diversion of water from Thailand's central region and the Bangkok metropolitan area increasing flood-risks and erosion of riverbanks;
- Decreased rainfall during the dry season and higher temperatures leading to droughts and high levels of water salinity;
- An increase in sea level due to climate change and high tides exacerbating saltwater intrusion, especially during the dry season; and
- Storms and harsh winds increasing coastal erosion in the central plains

The Bang Pakong Dam was built in the centre of the basin to protect against seawater intrusion and to store freshwater for dry season usage, but dam operations have exacerbated environmental problems including pollution, eutrophication, and erosion of riverbanks.

All habitats in the wetland face increased risks due to climate change. The main ecosystems evaluated under the vulnerability assessment include:

- *Estuary:* highest vulnerability of all habitats assessed due to land use changes, infrastructure development, pollution, wastewater discharge and increased exposure and sensitivity to droughts, floods, high sea levels and storms.
- *Mangrove and Nypoidideae forests*: affected by land use changes and increased development. Expected to be impacted by climate change, but mangrove forests are more resilient and adaptive, partly due to protection and restoration programmes. The Dam has been constructed near the centre of the basin to control saltwater, but it also decreases the amount of sedimentation at the estuaries and causes river banks to collapse.
- *Mainstream river*: affected by the Bang Pakong Dam and the water gates in the canals, built to reduce saltwater intrusion. Expansion of the industrial development has increased water utility requirements and led to waste management discharge and heavy metal contamination. Changes in rainfall will affect the river water levels, but these will be mitigated by the Dam.
- *Islands/oxbows*: threats from droughts, especially in dry season when there is less rainfall and the water in the river is low; some parts may have low water levels or be dry for longer periods, causing high salinity. Threatened by flooding and the collapse of riverbanks.
- *Cultivated systems*: both ditches orchards and the unique Na Kha Wang rice system are at risk from floods, droughts, salinity and rising temperature, which affect rice production and aquatic species. Impacts can be mitigated through management practices. Bigger threat for salt farms, which are an important ecosystem for migratory birds.
- *Tributary/canal system and flood plains:* currently moderately vulnerable. Increased floods, saltwater intrusion and deteriorating water quality could increase the vulnerability.

The deteriorating state of habitats also threatens flagship species, keystone species, and economically important species. The conditions are especially precarious for fish, including the rare and critically endangered Somphong's rasbora (*Trigonostigma somphongsi*), which can be affected by droughts, increased temperatures and salinity changes. The endangered giant freshwater stingray (*Himantura chaophraya*) and Irrawaddy dolphin (*Orcaella brevirostris* are also at risk from human impacts, water pollution, sedimentation, and water temperature and salinity increase. Populations of economically important species such as giant freshwater prawns (*Macrobrachium rosenbergii*) may decrease due to weather fluctuations and higher temperatures.

The spoon-billed sandpiper (*Calidris pygmaea*) is a migratory critically endangered bird that feeds in the salt farms. Changes in temperature can influence migration patterns, posing a threat to the dwindling population. Seasonal fluctuations and abnormal rain patterns are expected to influence flowering, affecting the food source of the Lyle's flying fox (*Pteropus lylei*).

The impact on the ecosystem and its species directly affects the people that depend on the wetland for their livelihood. People most vulnerable to changes and the impact of climate change include elderly people who cannot work in the industrial or service sectors. Elderly people and local fishermen will be affected when wetland resources decline and water quality deteriorates. Smallholder farmers that depend on the production of rice, fruits and farmed fish are also at risk from high tides, saline water levels, drought and higher temperatures. The effect of climate change at the community level is reflected in economic impacts such as damage to crops, food sources and capital. Most farmers have no ownership of the land they have been using and therefore lack stability in terms of land rights and title deeds.

The implementation of Thailand's wetland conservation measures is complex and often does not include local communities in participatory decision-making. Chachoengsao Province has been designated as part of the special Eastern Economic Corridor (EEC), which is politically and economically driven, benefitting the interests of business and industry at the expense of small-scale farmers, fishermen, and other community members. Although there are several policy measures to protect the area, the wetlands conservation approach is lagging.

Plans for adaptation to future climate change scenarios can be envisioned at three levels:

- *Household Level*: strengthening and raising houses, selection of climate tolerant plant species, sustainable and organic pest control methods, proper land use zoning, digging storage ponds, creating reservoirs and a water circulation system, installing secondary water storage systems, developing alternative livelihood activities, increased aquaculture competency and co-culturing methods. Eco-tourism can also be promoted as an alternative livelihood.
- *Community and local level:* developing local management plans, such as emergency disaster prevention and a relief centre, agreements on rehabilitation of aquatic species, increasing conservation areas, rehabilitating and dredging the canal system, developing public water ways and water sources; urban planning for sustainable land use, regulations on effluent discharge, and disposal of wastewater, including penalty clauses.
- *River basin level*: land use zoning and urban planning to ensure sustainability and environmental protection in the basin; developing legislation and policies to protect the wetlands; developing water management structures and mechanisms in a participatory manner to allocate water for specific sectors and purposes. Research should be conducted for identify ways to prevent fires in the fields during the dry season.

The community, local and national government, relevant NGOs and the private sector should be involved in developing a coordinated and sustainable wetland management plan for the area. In addition, important habitats such as estuary areas, mangrove forests and floodplains (Thung Pak Phlii), should be protected and conserved under law. Special attention must be given to the critically endangered species that use the Bang Prakong River Wetland.

1 INTRODUCTION

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

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

As a first step of a participatory adaptation planning process, vulnerability assessments (VAs) were conducted in ten Ramsar/wetland sites in the four countries. These combine scientific assessments with participatory appraisals and dialogues with communities living at the sites and the authorities in charge of site management. For Thailand, two sites were selected: Bang Pakong River Wetland and Kaper Estuary - Laemson Marine National Park - Kraburi Estuary Ramsar Site. This report presents the results of the VA for the Bang Pakong River Wetland, which was recently nominated as Ramsar Site, and which is part of the larger Bang Pakong River Basin.

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.

Since outcomes of the VAs should lead to actions and decisions at the local and potentially national levels, VA teams included representatives from government agencies, village heads, and community representatives, supported by academia or a local or international organization with experience on climate change adaptation. The composition of these teams slightly differed depending on the location, but a core team of members was maintained throughout the assessment (see Annex 1 for the main members involved).

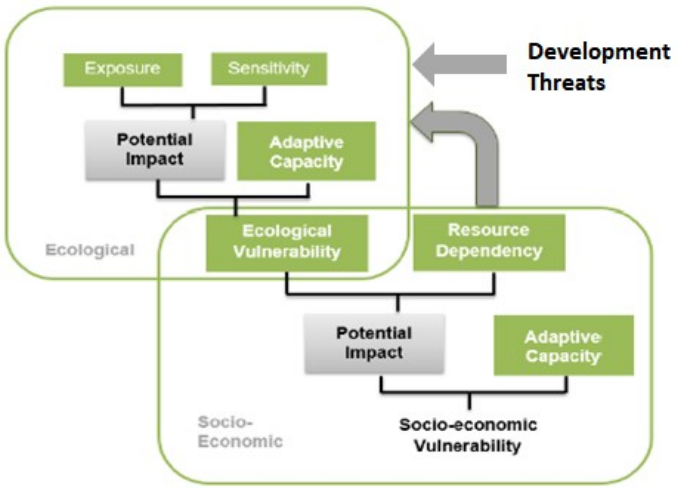
[1]See https://www.iucn.org/regions/asia/our-work/regional-projects/mekong-wet

The assessment consisted of two parts: a description of the current situation of the wetland and a rapid assessment of its vulnerability.[2] The assessment of the wetland's vulnerability consisted of three tools in the form of excel spreadsheets: a Habitat VA tool, a Village VA tool (complemented with Participatory Rural Appraisal or PRA tools), and a Species VA tool. These tools were selected for their simplicity, clear instruction and guidance, and ecosystem focus; a socio-ecological framework was used to inform the design of the tools (see Box 1). While experts were consulted to complete and/or validate the Habitat and Species VA tools, the Village VA tool was completed in a consultative process with the communities.

The VA took place in 2017-2018 and covered the wetland and the communities that rely on its resources for their livelihood. It assessed how these are affected by climate change and non-climate threats including those from outside the wetland boundary. Special attention was paid to the needs and perspectives of women, because women may use wetland resources in different way than men do, and women may have different knowledge and perspectives of wetland resources than men. The report will be used as input for meetings with villagers and other relevant stakeholders to discuss the results and develop adaptation plans.

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

According to the Intergovernmental Panel on Climate Change,[3] **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

[2]See guidelines provided by IUCN (IUCN, 2017)
[3]See IPCC, 2007

the ecological and socio-economic system interact to determine the overall potential climate change impact.

2 SITUATION ANALYSIS

2.1 Location and site description

The Bang Pakong River Basin covers a total area of 10,707 km^2 (1.07 million ha) and is connected to the Gulf of Thailand.[4] The basin catchment originates in the Sankamphaeng Mountains and Dong Phaya Yen - Khao Yai Mountains in the north, and the Chanthaburi Mountains in the east.[5] The two main rivers, Prachinburi River and Nakhon Nayok River, originate in Khao Yai National Park and come together at Yothaka Subdistrict in Chachoengsao Province to form the Bang Pakong River (see Figure 1).

The Bang Pakong River Basin includes four National Important Wetlands.[6] These are:

1. **Bang Pakong River Wetland.** These areas are formed by the main Bang Pakong River that flows through Chachoengsao, Chonburi, Prachinburi and Nakhon Nayok Provinces, with a total length of 122 km and an elevation range of 0 – 20 m above sea level.[7]
2. **Nakhon Nayok River Wetland.** This wetland originates from Khao Yai National Park, and runs through Mueang, Ban Na and Ongkharak Districts of Nakhon Nayok, before it flows into the Bang Pakong River. The water level in the river has a maximum depth of 4.7 m.
3. **The Central Plains of Thailand Wetland**. Parts of this wetland is in Nakhon Nayok and Chachoengsao. The area is a very large lowland area with scattered small lakes and swamps, and includes tree stands, small rivers, rice paddies, lotus ponds, papyrus ponds, fish ponds, irrigation canals and fruit plantations. The area is under the influence of the tropical monsoon and receives water and sediments from the Bang Pakong River.
4. **Upper Gulf of Thailand Wetland**. This wetland includes areas of the Bang Pakong Estuary (at the Gulf of Thailand), which has an average depth of 45 m. It includes mud beach, silt beach, sand beach and there are mangroves and small islands around the estuary.

The basin is ecologically diverse with fresh water, brackish water and salt-water habitats. There are more than 100 species of aquatic plants and 400 species of fish, from stingrays that weigh 150 kg to small saltwater fishes, which include over 100 economically relevant fish species.[8] The wetlands are also home to a large diversity of local bird species and provide critical resting areas and food sources for migratory birds. The estuary is a hotspot of biodiversity including different types of dolphins (e.g. Irrawaddy dolphin). The intrusion of seawater deep into the Bang Pakong River during high tides and the dry season is an important ecological characteristic, but it also affects farming activities in the basin. To protect the area against saltwater intrusion and to store fresh water for dry season usage, a dam was constructed near Ban Phai Saweang (Bang Kaew Subdistrict of Chachoengsao). The dam became operational on 6 January 2000 but has since caused several problems which will be discussed in subsequent chapters.

[4]See HAII, 2013
[5]Dong Phaya Yen - Khao Yai is also a World Heritage Site
[6]According to Cabinet Resolution November 2009 (http://www.cabinet.soc.go.th/soc/Program2-3.jsp?top_serl=99221842&key_word=&owner_dep=&meet_date_dd=3&meet_date_mm=11&meet_date_yyyy=2552&doc_id1=&doc_id2=&meet_date_dd2=&meet_date_mm2=&meet_date_yyyy2=)
[7]http://wetland.onep.go.th/Bangpakong_river.html
[8] Pers. comm. with Dr. Chawalit Witthanon, a specialist in fishery resources

As can be seen in Figure 1, the four main wetland areas of the basin partly overlap. Although the VA focussed on the Bang Pakong River Wetland as a potential new Ramsar Site (see Annex 2 for registered Ramsar sites in Thailand), its relationship with the larger basin will be discussed throughout the report.

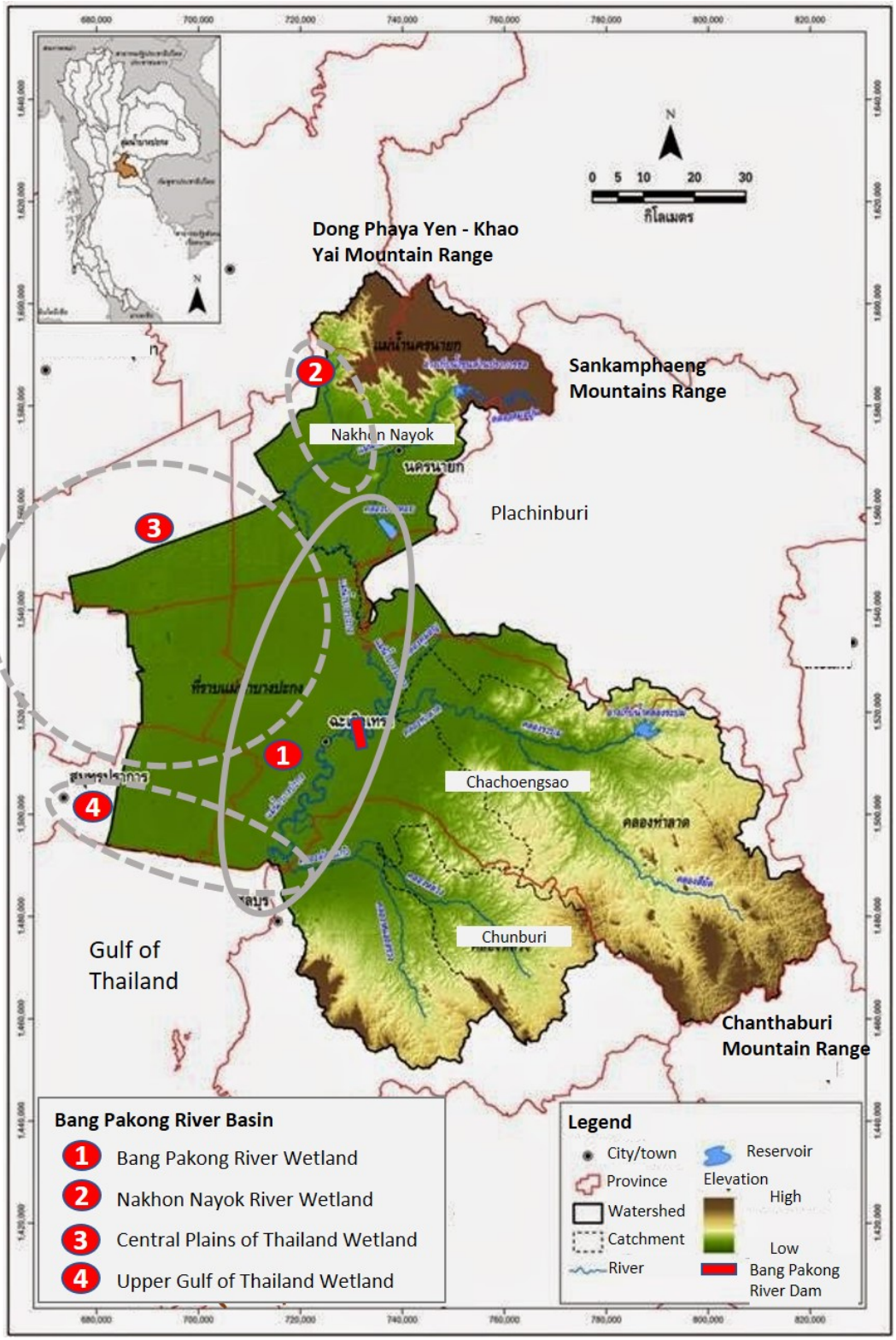


Figure 1: *Map of Bang Pakong River Basin (source: adapted from HaII, 2012)*

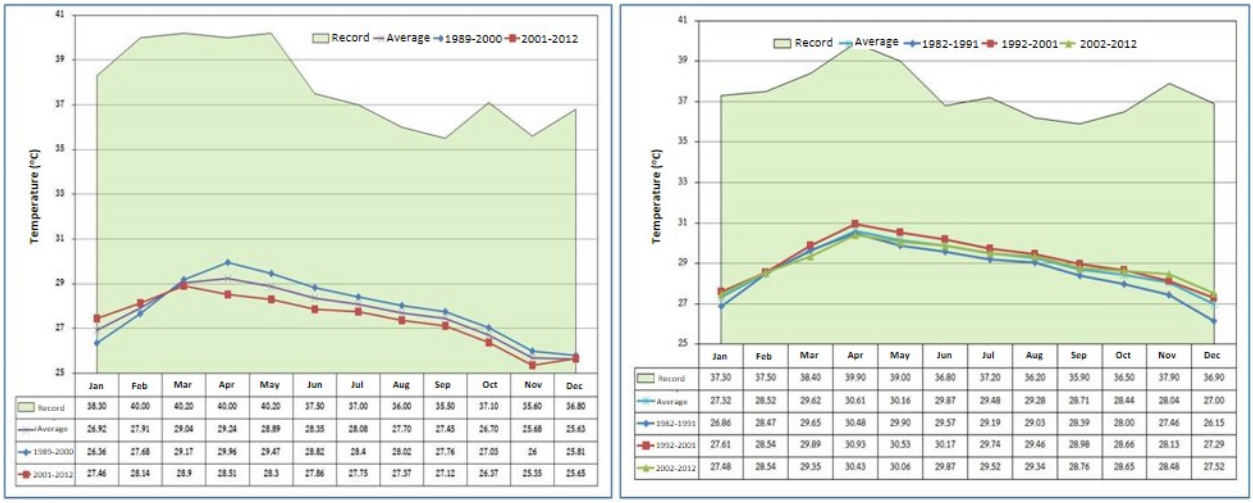
2.2 Current and historic climate

Thailand's climate is influenced by monsoon winds that have a seasonal character. Generally, three seasons can be distinguished:[9]

- **Rainy season** (May until October), when the southwest monsoon brings warm, moist air from the Indian Ocean to Thailand, causing abundant rain over most of the country (with very heavy rains in September).
- **Winter** (October until February), when the northeast monsoon brings cold and dry air from China over most of Thailand.
- **Summer** (mid-February till end May), when there are low pressure cells due to a heat layer, which make it hot and dry with April the hottest month of the year.

The following paragraphs present current/historic data on temperature, rainfall and storms in the basin, with a focus on Chonburi and Chachoengsao, the most relevant provinces for the Bang Pakong River Wetland.

Temperature. Figure 2 presents the average temperatures for Chachoengsao between 1989 and 2012 and for Chonburi between 1982 and 2012, based on provincial weather statistics. The average temperature for Chachoengsao ranged from 25.7ºC in November to 29.2ºC in April, with a record high of 40.2ºC in March/April; for Chonburi, the average temperature ranged from 27.0ºC in December and 30.6ºC in April, with a record high of 39.9 ºC in April.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Record	38.30	40.00	40.20	40.00	40.20	37.50	37.00	36.00	35.50	37.10	35.60	36.80
Average	26.92	27.91	29.04	29.24	28.89	28.35	28.08	27.70	27.45	26.70	25.68	25.63
1989-2000	26.36	27.68	29.17	29.96	29.47	28.82	28.4	28.02	27.76	27.05	26	25.81
2001-2012	27.46	28.14	28.9	28.51	28.3	27.86	27.75	27.37	27.12	26.37	25.35	25.65

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Record	37.30	37.50	38.40	39.90	39.00	36.80	37.20	36.20	35.90	36.50	37.90	36.90
Average	27.32	28.52	29.62	30.61	30.16	29.87	29.48	29.28	28.71	28.44	28.04	27.00
1982-1991	26.86	28.47	29.65	30.48	29.90	29.57	29.19	29.03	28.39	28.00	27.46	26.15
1992-2001	27.61	28.54	29.89	30.93	30.53	30.17	29.74	29.46	28.98	28.66	28.13	27.29
2002-2012	27.48	28.54	29.35	30.43	30.06	29.87	29.52	29.34	28.76	28.65	28.48	27.52

Figure 2: *Monthly temperatures for Chachoengsao (Left) between 1989-2012 and Chonburi Province (Right) between 1982-2012 (source: adapted from provincial weather statistics)*

Rainfall. Average annual rainfall in Chachoengsao Province is about 1,294 mm with an average number of 113 days with rainfall. September is the month with the highest rainfall with 256 mm (the highest amount of rain measured over 24 hours was 127 mm on the 15 June 1989). The record monthly rainfall between 1952 and 1995, shows a low of 68 mm (December) and a high of 541 mm (August) for Chachoengsao Province, and a low of 60 mm (December) and a high of 658 mm (September) for Chonburi Province. The overall trend shows a decreasing amount of rain over time for both provinces.[10]

[9] Poramet Amattayakul and Taywin Jomta, 2016

[10] Agricultural Meteorology to know for Chachoengsao, Meteorological Department, 2016

Heavy storms. For the past 62 years (1951 – 2012), the average number of heavy storms in Thailand, including depressions, tropical storms, and typhoons, was three per year (Figure 3). Between the 1960s and 2000s, the average number for each decade reduced from six to two per year; for the years 2008-2012, the average was only one heavy storm per year. Most storms occur in September, October and November.

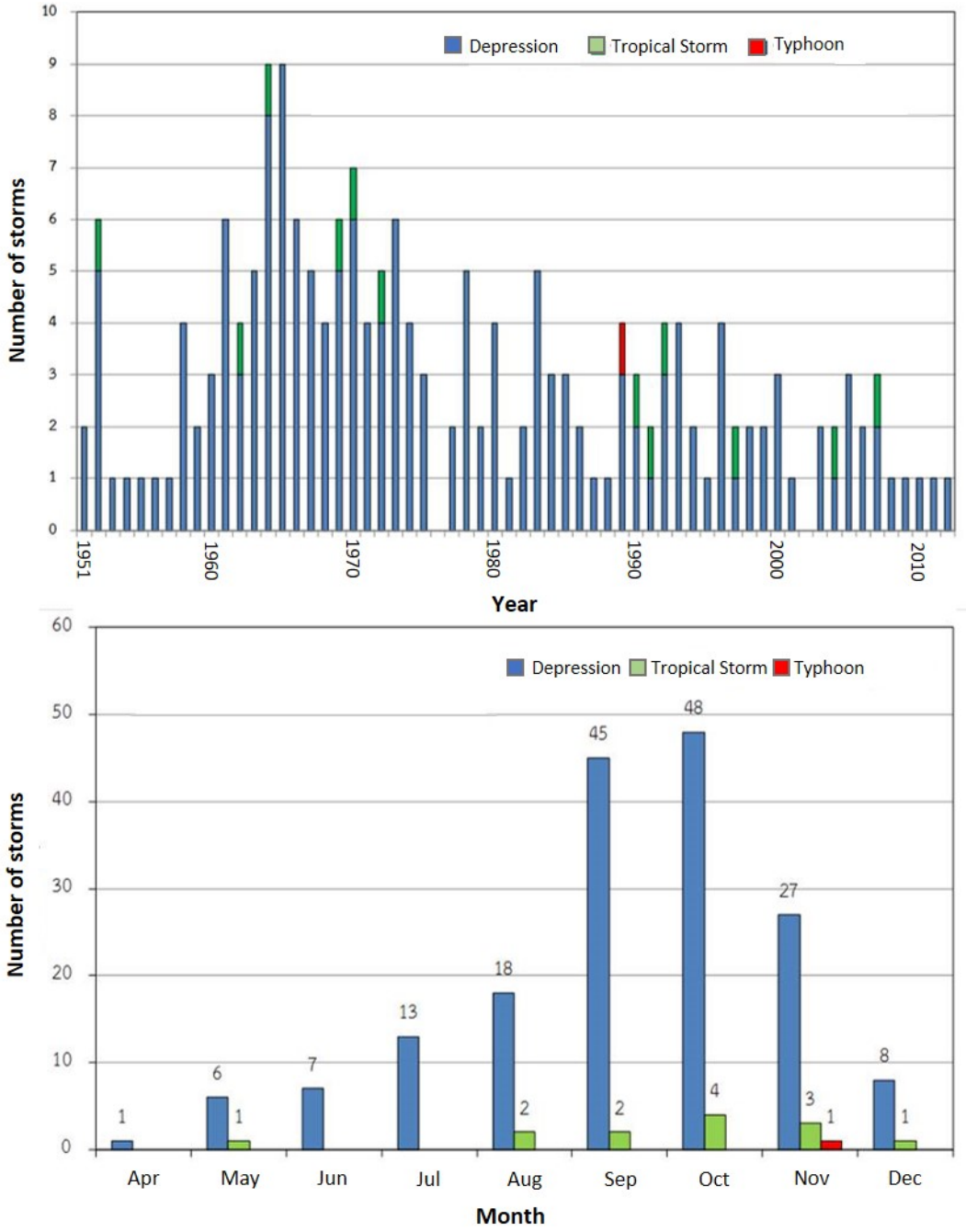


Figure 3: *Heavy storms in Thailand between 1951-2012 by year (top) and by month (bottom) (source: adapted from Meteorological Department, 2014)*

2.3 Hydrological characteristics

A hydro-geological map of Bang Pakong River Basin was constructed by the Department of Geological Resources in 2001.[11] Based on this map, the basin's geological structure consists of porous layers with gravel sediments, semi-hardened sediments, and hardened rocks; about half (3,341,072 rai or 534,572 ha) of the geological structure of the basin consists of different porous layers with sediments, which makes the soil fertile and suitable for cultivation.

Records show that the rate of the water flow from the Bang Pakong Estuary[12] into the Gulf of Thailand between May to December 1995 (overlapping with the rainy season) averaged 2,803 +- 2,824 m^3/s. While the high tide had a flowrate averaging 2,087 +- 3,168 m^3/s moving into the Bang Pakong River. This accounts for a volume of 22,605 m^3/s of fresh water flowing out to Gulf of Thailand every year and is the main factor that causes the change in water properties in the Bang Pakong Estuary. The change in salinity of water ranged from 0 – 33 parts/1000 where during the high tides the average change is 9+-12 parts/1000 and for low tides it is 8+-11 parts/1000.

The Bang Pakong Dam was built to protect against the seawater intrusion into the Bang Pakong River and to store fresh water for dry season usage. However, dam operations have caused several negative impacts. The river upstream of the dam as well as the canals flowing into the river became heavily polluted due to the discharge of wastewater from factories and slurry from pig farms as the discharge into the sea was blocked. Below the dam there were problems of erosion and collapse of river banks. The dam is said to have been poorly planned and the Irrigation Department often opens the water gates to allow natural water flow.

2.4 Wetland habitats and biodiversity

The Bang Pakong River Basin is known for its diversity in ecological characteristics and the diversity in species, especially aquatic ones. However, conditions have deteriorated over time, and are threatening the existence of several species. Based on a workshop by Mekong WET in August 2017, 9 habitats were identified that are relevant to the Bang Pakong River Wetland:[13] (1) estuary, (2) salt farms, (3) mangrove and Nypoideae forests, (4) mainstream river, (5) tributary/canal system, (6) islands/oxbows, (7) Na Kha Wang rice system, (8) ditches orchards, and (9) flood plains (Thung Pak Phlii).

(1) Estuary. The coastal area around the estuary is made up of mud, silt and sand beaches, mangrove areas and land expansion due to the accumulation of sediments. It used to have a fertile stretch of mangrove area but at present, only a narrow stretch of 10-100 m remains, with some planted forests. Shrimp and salt farms are located 2-3 km from the mangrove stands. Currently, most of the coastal area has been developed into tourism and industrial areas. In addition, there is land for agricultural purposes, residences and a fishmonger village. Land use around the estuary includes 38,393 rai (6,143 ha) of agricultural land (not very suitable for rice), 33,267 rai (5,323 ha) of aquaculture, 4,554 rai (729 ha) of salt farms and 146 rai (23 ha) of field crops. The estuary is an important breeding and nursery area for aquatic animals. There is a wide

[11]Referenced in the project report, "Increasing Area Management Efficiency for Wetlands in Thailand", by Office of Natrual Resources and Environmental Planning (ONEP) which was implemented by Thailand's Science and Technology Institute (STI) in 2015 pages 3 – 64, referencing data from HAII (2013)

[12]Pers. comm. with Luechai Darunchu, Chanthaburi Coastal Fisheries Research and Development Center and Jarun Wongsewiwattanawut, Chanthaburi Coastal Aquaculture Institute.

[13]Mekong WET workshop (29-30 August 2017) on assessing the vulnerability of habitats and living species in support of the proposal to register Bang Pakong River Wetland as a Ramsar Site.

variety of plant species,[14] and the coastal areas of the estuary are important to waterfowl and other local birds as well as migrating ones. Many local birds and water birds in the area are classified as globally threatened.[15] A biodiversity survey in 2012,[16] found that there are at least three types of dolphins in the area, including Irrawaddy dolphin (*Orcella brevirostris*), Indo-Pacific humpback dolphin (*Sousa chinensis*) and Indo-Pacific finless porpoise (*Neophocaena phocaenoides*). Many tourists come to see them, but the dolphins often forage further offshore due to the impact of deteriorating water quality on food sources near the estuary.

(2) Salt farms. These are manmade habitats in the estuary. There are about 4,554 rai (729 ha) used for salt production in the dry season, starting in October/November and ending mid-May. Sea salt production requires sunlight to evaporate salt water. If the rainy season starts early or when it rains in summer, salt yield is reduced. The salt farm ecosystem must be connected to the sea through a canal system, drawing water into the "wang" (sea water pond), before taking it to dry in the field. There are often marine animals in the "wang", therefore the salt farms act like a nursery for marine life. Mangrove forests surround the farms and provide a source of vegetables such as *Sueda maritima* and *Pluchea indica (L.) Less*. Salt farms are also home to migratory birds. The Bird Conservation Society says that there are more than 50 species of birds in the Gulf of Thailand. The spoon-billed sandpiper (*Calidris pygmaea*) uses the salt farms as feeding grounds and is a critically endangered species with less than 400 found globally.

(3) Mangrove and Nypoideae forests. These forests are scattered over the estuary and along the Bang Pakong Riverbanks. In the past, they were common from the estuary up to Bang Khla District of Chachoengsao Province, measuring 14,500 rai (2,320 ha) in 1979, but the area was reduced to less than 2,313 rai (370 ha) in 1991 due to shrimp farming, community expansion, salt farming and the establishment of industrial factories. According to a survey in 2001,[17] mangrove forests were mostly degraded. *Sonnerratia caseolaris* was the most dominant species, followed by *Avicennia alba*. *Nypa fruticans* trees were found above the Bang Pakong Dam. Dense forests of *Sonnerratia caseolaris*, with *Bruguiera sexangula*, *Hibiscus tiliaceus, Xylocarpus granatum, Heritiera littoralis Ait.* and *Excoecaria agallocha* were located around the river. In the estuary, most tree species were found on Nok Island, including *Nypa fruticans*, *Avicennia alba, Avicennia officinalis, Rhizophora apiculata and Hibiscus tiliaceus*; some *Xylocarpus granatum, Rhizophora mucronata and Sonneratia caseolaris* were found in this area as well. As results of conservation measures, mangrove forests have slightly recovered again.

(4) Mainstream river. The river flows through Prachinburi, Nakhon Nayok, Chachoengsao and Chonburi, covering 122 km, bridging an altitude difference of 20 m. The salinity of the water in the river varies greatly; the saline water spreads out in the main river stream and the river branches for up to 200 km. The river has strong economic relevance for the central region; it is utilized for

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[14]Plant species in the Gulf of Thailand are: *Indigohera unicata*, *Sesuvium portulacastrum, Ipomoea pescaprae, and Casuarina equisetifolia; in the mangrove area it is mostly: Rhizophora apiculate, R. mucronata, Bruguiera sexangula, B. cylindrica, Ceriops spp., Xylocarpus granatum, X. moluccensis, X. rumphii, Acanthus spp., Avicennia alba, A. officinalis, Sonneratia caseolaris, S. griffithii,* N*ypa fruticans, Thespesia populnea, Hibiscus tiliaceus, Excoecaria agallocha, Cycas sp.,* and *Cerbera odollam; cleared f*orest areas include several types of grass, such as: *Lumnitzera littorea, L. racemusa, and Meialeuca leucaolendra.*

[15]Bird species in the Gulf of Thailand include: *Egretta eulophotes, Pelecanus philippensis,* Platalea minor, C*haradrius peronei, Limnodromus semipalmatus and Rhinomyias brunneata;* critically endangered species include: *Egretta eulophotes, Leptoptilos javanicus, Pelecanus philippensis, Platalea minor, Anhinga melanogaster; endangered species include Phalacrocorax carbo, Ardea cinerea, Ardea purpurea, Mycteria leucocephala, Threskiornis melanocephalus, Milvus migrans, Sterna bergii*, *S. dougallii, Charadrius peronii, and Muscicapa muttui; vulnerable species include Limnodromus semipalmatus, Phalacrocarax fuscicollis and Rynchops albicollis.*

[16]The project supporting and mobilizing networks and knowledge on ecosystem management in the environment protection area at Bang Pakong estuary was implemented by ONEP in 2015.

[17]Upper Gulf of Thailand Coastal and Marine Research Center, Department and Marine and Coastal Resources, 2005

agriculture and industry and acts as an important source for fisheries. Giant freshwater prawns, a commercially important resource, are found throughout the river; the average catch of giant freshwater prawns is about 23 million tons/year (1.9 million tons/month).[18] The river water is used for tap water production for Chachoengsao, Nakhon Nayok and Prachinburi Provinces and is important for people's livelihoods on both sides of the river banks, playing an important role in local culture and practices. At least 100 fish species can be found in the river, including endangered species (*Albulichthys albuloides, Wallago leerii*) and vulnerable species (*Batrachocephalus mino*, *Clarias batrachus*, *Coilia dussumieri*, *Hemipimelodus borneensis*, *Heteropneustes fossilis*, *Ketengus typus*, *Kryptopterus apogon*, *Ompok hypophthalmus* and *Probarbus jullieni*). The distribution of species depends on the salinity of the water. Brackish and saltwater species are found from Muang District of Chachoengsao all the way to Bang Pakong District; giant freshwater prawns, which live in brackish and saltwater areas, can be found throughout the year and reproduce well. There are at least 28 species of water plants, with *Eichornia crassipes* being the most abundant species.

(5) Tributary/canal system. Naturally occurring tributaries include Nakhon Nayok River and Prachinburi River which flow into the Bang Pakong River, as well as other river branches. The canal system originates from human excavations linked to the main river, and includes Tha Lad, Khlong Si Yud, and Klong Rabom. Canals such as Klong Samrong, Tha Kahi, Klong Bang Khanag (Klong Saen Saeb), Klong Lluang Peang, Long Sib-ed and Prawes Burirom, connect to canals in Bangkok. In the past, transportation by boat was a key factor in linking the local socio-economic system with the Bangkok metropolitan area. Experts mentioned that the diversity of species in the tributaries/canals is like that of the main river, depending on the salinity of water. However, urban development, water transport and the construction of the Bang Pakong Dam has interrupted the ecological link between the canals and the main river. It significantly affects the water quality and biodiversity in the canals and has increased water pollution in the canals and branches of the Bang Pakong River. Moreover, floods, water shortages and water pollution in Bangkok also affect the Bang Pakong River Basin.

(6) Islands/oxbows Islands (Koh) and oxbows (Klong Om) are formed when the "original river way" changes direction and makes a short cut, whereby the "old river" dries up with deltas of sandy soil and sediments remaining. The ecosystem remains connected to the main river causing seasonal changes dependent on the rise and fall of water levels. Water moving in from the estuary may inundate the deltas during high tides, allowing some fish to come into the area. Some birds may also inhabit the area; if the water is reduced, swamps, bogs, ponds and ditches will be formed.

(7) Na Kha Wang rice system. This is a man-made habitat in the Lower Bang Pakong River Basin for growing rice, mixed with natural aquaculture by digging canals to the river. The system depends on high and low tides. When it is the season for freshwater, the land will be used for rice farming along with freshwater aquaculture. In the saltwater season, there will be saltwater aquaculture making the agricultural practices function in harmony with the natural cycle of the river system. This type of wetland is utilized for sustainable agriculture can only be found in Khao Din Subdistrict, Bang Pakong District, Chachoengsao.

(8) Ditches orchards. These are man-made gardens that correspond to the tidal system of salt and fresh water fluctuations. They are common in the central and lower parts of Bang Khla, Khlong Khuean and Muang Districts of Chachoengsao Province, and support agricultural activities and aquaculture. The gardens are fed by hundred-year-old canals connecting them to the Bang Pakong River; they consist of dirt walls or mounds separated by wide irrigation ditches. Income-producing fruit trees, including coconut, betel nut, and mango, are cultivated on the dirt walls. The

[18]http://wetland.onep.go.th/Bangpakong_river.html

ditches serve several purposes, they not only ensure that freshwater will remain available for fruit trees during the dry season, but they also act as spawning grounds for fish from the river. The raised walls keep trees from being inundated with water and prevent tree roots from reaching the salinity found in deeper soils. The ditches must be hand dug precisely each year; if they are too shallow the ditches will run out of water during the dry season, but if they are too deep, they may become contaminated with salt water from below. The gardens highlight how communities use local ecological knowledge to adapt to seasonal rainfall patterns and climatic conditions.

(9) Flood plain (Thung Pak Phlii). The flood plain is part of the Central Plains, which are partially located in Nakhon Nayok and Chachoengsao. It is a large plain with small ponds, swamps, grove forests, canals, rice paddies, reed ponds, fishponds, agricultural areas, irrigation canals and orchards. This area provides food and nesting areas for many local and migratory bird species.[19] Many species of birds visit Thung Pak Phlii in Nakhon Nayok, including the Black Hawk (*Milvus migrans*). Thung Pak Phlii is a lowland plain connected to the World Heritage Forest of Dong Phaya Yen - Khao Yai. The area is flooded every year from August/September to November, providing space for excess river water. This plateau is a breeding area for aquatic animals. There are various species of fish, with some endemic fish species that are only found in this area, such as Somphongs's rasbora (*Trigonostigma somphongsi*).

2.5 Land use in the river basin

According to land use data from the Land Development Department from 2002 and 2012 (see Table 1),[20] most of Bang Pakong River Basin (about 70%) has been used for agricultural purposes, including the cultivation of rice, field crops, fruit trees and perennials and other farming activities. Of these, the cultivation of rice and field crops have been most dominant, although the share of rice has decreased by a quarter (from 38% to less than 28%), and that of field crops by half (from 22% to 12%). The share of fruit trees/perennials (15%) and other farming activities (10%), have more than doubled over the same period. The total forest area has been relatively stable at around 15-17%. Other areas, including urban settlements and water bodies, have increased from 12% to 18%.

Table 1: *Land use characteristics in 2002 and 2012 and trends for the Bang Pakong River Basin*

Type of land use	2002			2012		
	Area (rai)	Area (ha)	Ratio (%)	Area (rai)	Area (ha)	Ratio (%)
Rice fields	2,560,392	409,663	38.3	1,839,628	294,340	27.5
Field crops	1,496,516	239,443	22.4	834,719	133,555	12.5
Fruits trees/perennials	385,963	61,754	5.8	1,033,793	165,407	15.5
Other farming*	334,364	53,498	5.0	696,565	111,450	10.4
Vegetables	4,901	784	0.1	18,335	2,934	0.3
Forests	1,136,968	181,915	17.0	1,041,640	166,662	15.6
Other areas**	773,072	123,692	11.6	1,227,497	196,400	18.3
Total	*6,692,176*	*1,070,748*	*100*	*6,692,176*	*1,070,748*	*100*

*including livestock pasture/farms, aquatic plants/vegetables, aquaculture, integrated farming/diversified farmlands.

**including urban and built-up land, water body, and miscellaneous-use areas.

[19]The central plains are home to more than 20,000 birds, some of which are globally threatened, including: *Leptoptilos dubius, L. javanicus, Pelecanus philippensis, Aythya baeri, and Aquila clanga*. Thailand's 'critically endangered' species include: *Leptoptilos dubius, L. javanicus, Pelecanus philippensis, and Anhiaga melanogaster; many* 'endangered' species are also found, including: *Ardea cineria, A. purpurea, Mycteria leucocephala, Threskiornis melanocephalus, Haliactus albicilla*, and *Milvus migrans; 'v*ulnerable' species for Thailand include: *Aythya baeri, Anas Formosa, Phalacrocorax fuscicollis and Vanellus duvaucelii.* The *Grusantigone sharpie was last reported in 1965; it is now extinct from nature due to poaching and destruction of its habitat.*

[20]Institute of Water Resources Information and Agriculture, 2012.

Figure 4 provides an overview of land use patterns in terms of their geographical distribution between 2002 and 2012.

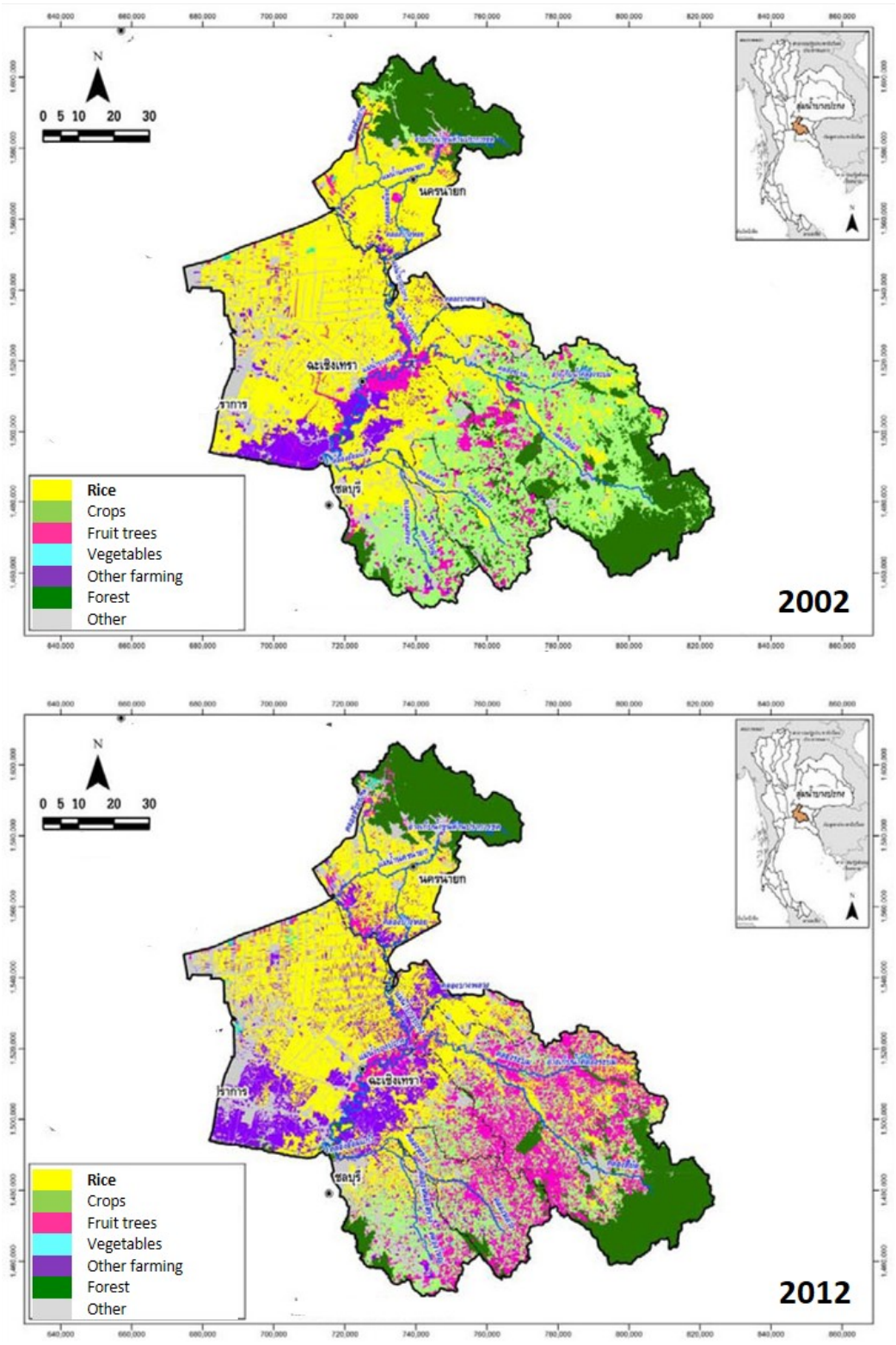


Figure 4: *Land Utilization maps of Bang Pakong River Basin in 2002 (top) and 2012 (bottom) (adapted from Institute of Water Resources Information and Agriculture, 2012)*

In 2002, the area southeast of the Bang Pakong River in Chachoengsao and Chonburi Provinces was dominated by rice and cropland. By 2012, however, large areas of cropland were replaced by fruit trees and some rice areas close to the river had been replaced by other farming activities. The rice areas west and north of the river (up to Nakhon Nayok),as well as areas along the lower Bang Pakong River and in the Upper Gulf of Thailand Wetland were replaced by other farming activities.

Urban and built-up land are expanding throughout the area, but especially in the estuary. Figure 5 shows land use data for the estuary in 2013. The estuary area of Bang Pakong River in the four sub-districts totals 77,388 rai (12,382 ha). Most of the land (49.6%) is used for farming (aquaculture, salt farms), followed by community area, urban and building area (28.6%), forest area (11.7%), water bodies (8.4%) and miscellaneous (1.7%). Since 2002, there has been a notable change in demand and expansion of urban and industrial areas.[21]

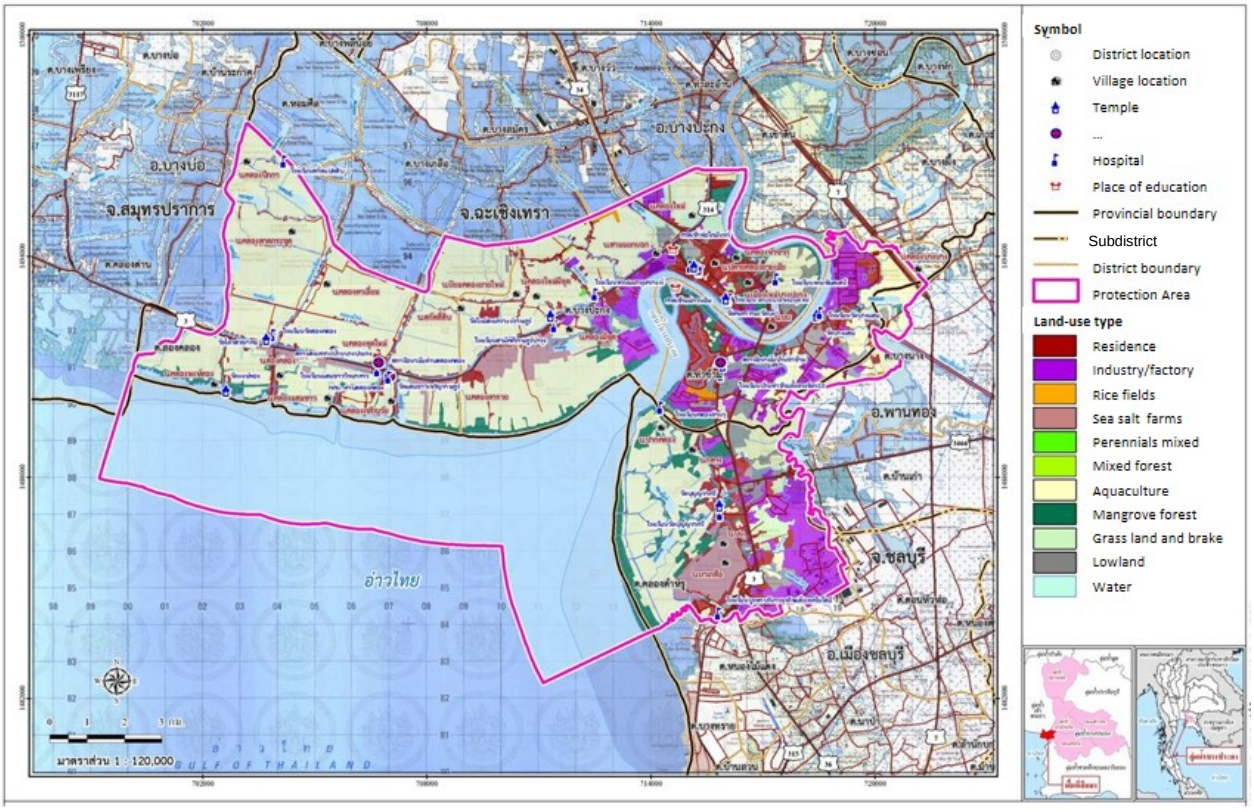


Figure 5: *Map of land use in the Bang Pakong Estuary in 2013 (adapted from ONEP, 2013)*

2.6 Drivers of change

Industrial development and economic growth are main drivers of change in the region. Since the industrial development in the Bang Pakong River Basin began 60 years ago, dramatic changes in economic, social and environmental conditions have taken place. Table 2 provides an overview

[21]Mobilization and implementation of network and knowledge on ecosystem management in environmental protection areas of Bang Pakong River estuary project by The Office of Natural Resources and Environmental Policy and Planning as accessed from http://www.onep.go.th/bangpakong-river/index.php?option=com_content&view=article&id=45&Itemid=59 on 5 March 2018

of gross provincial product per province, and the contribution by non-agricultural and agricultural sectors.

Table 2: *Gross Provincial Product for 4 provinces in Bang Pakong River Basin in 2016.*

Province	Total GPP		GPP/capita		Contribution	
	THB (million)	US$ (million)	THB	US$	Non-agriculture	Agriculture
Chonburi	912,498	28,516	548,877	17,152	98.2 %	1.8 %
Chachoengsao	340,913	10,654	433,400	13,544	94.6 %	5.4 %
Prachinburi	227,947	7,123	378,669	11,833	96.9 %	3.1 %
Nakhon Nayok	25,328	792	92,629	2,895	79.6 %	20.4 %

Source: Office of the National Economic and Social Development Boards, 2016

The economic growth is mainly the result of the growth in the non-agricultural sector. Between 1999 and 2012, the number of factories increased from 190 to 276 (+45.3%) in the Bang Pakong Estuary alone; the highest rates of increase were in Klong Tum Hru District (52.8%), Klong Song District (40.0%), Bang Pakong subdistrict (35.4%) and Ta Khaam District (34.5%). [22] Industrialization is also affecting the agricultural sector through changes in water allocation and use and land claims/investment; people from outside the area are eager to claim and buy land for industry or commercialization of agriculture. Problems with waste management, water pollution, and industrial toxic pollution are further exacerbated by urbanisation and growing number of migrant workers. The population in Chachoengsao between 1997 and 2017 increased from 627,119 to 709,889 persons (+13%), mainly in the industrial development area in Districts of Mueang, Plang Yoaw, Bang Nam Priaw, and Bang Pakong.

The Government of Thailand envisions the Eastern Region as a route for trade and investment and as national production and innovation centre for eco-industry and processed agricultural products. [23] Key policies and projects, such as the Industrial Development Policy for Eastern Thailand, the Special Eastern Region Economic Corridor Development Project (EEC), and the Development Plan for the Central Provinces of the Central Region 2018-2021, are all aligned and aim to promote investments and capacity upgrades of industries in the region under the supervision of the Special Eastern Region Economic Zone with the Prime Minister as the Chair of the Board.

2.7 Conservation and zoning

For protection, it is important to consider ecological linkages between the wetland areas and associated landscapes. There are different type of conservation areas/zones, which partly overlap.

(1) National Important Wetlands. Based on Cabinet Resolution (announced 2009),[24] the Bang Pakong River Basin represents 4 nationally important wetlands: (1) Bang Pakong River Wetland,

[22]ONEP, 2013.
[23]To link the development strategies of the Central and Eastern regions, the Eastern Region Economic Corridor Development project (EEC) is part of the strategy under the Thailand 4.0 master plan; the spatial development is an extension based on successes of the Eastern Seaboard Economic Development Plan, which has been in place for more than 30 years (Provincial Development Plan of Chachoengsao)
[24] Cabinet resolution, November 11, 2009

(2) Nakhon Nayok River Wetland; (3) The Central Plains of Thailand Wetland; and (4) The Upper Gulf of Thailand Wetland (see Section 2.1).

(2) Forest conservation areas. The basin includes various legally protected forest conservation areas, such as Khao Yai National Park 1,355,468.75 rai (216,875 ha) (announced 1962); Khao Sam Lan National Park 27,856.25 rai (4,457 ha) (announced 1981); Khao Ang Rue Nai Wildlife Sanctuary 643,750 rai (103,000 ha) (announced 1977 and 1992); and Khao Kheow Wildlife Sanctuary - Khao Chompoo with 90,438 rai (14,470 ha) (announced 1974).[25]

(3) Mangrove conservation areas. The mangrove forest conservation areas are mostly found around the estuary and along the riverbanks[26]. According to a Cabinet Resolution in 1987, an area of 24,375 rai (3,900 ha) in Chachoengsao Province was zoned for mangrove forest utilization. However, due to activities such as shrimp farming, urbanization, salt farming and increase in industrial factories, the area of mangrove forests in Chachoengsao Province decreased to only 2,313 rai (370 ha) in 1991 – compared to 14,500 rai (2,320 ha) in 1979. This led the Cabinet to issue a Resolution to strictly suspend the use of mangrove areas in 1991; in 1996, the Cabinet passed another Resolution to terminate all concessions for timber production in the mangrove area. This enabled the mangrove forests in Chachoengsao and Chonburi Provinces to recover and increase to 5,563 rai (890 ha) in 2009.

(4) Environmental Protected Area. The Office of Natural Resources and Environmental Policy and Planning has proposed an area of 3,015.75 rai (483 ha) of mangrove beach and estuary ecosystem within Bang Pakong District (Chachoengsao) and Muang District (Chonburi) for protection (see Section 2.5, Figure 5). The area is currently under consideration by the Cabinet to become an Environmental Protected Area.[27]

(5) Protected Area for Good Agricultural Practice (GAP). This area in Bang Khla District covers 35,511 rai (5,682 ha) of fruit orchards and 46,562 rai (7,450 ha) of rice fields. It is a source for jasmine rice, and mango and other fruit trees. These high-quality products are being sold domestically and internationally. Chachoengsao provincial policy is to encourage farmers to conserve this land as a pilot site for GAP. The area will be nominated as good agricultural areas that need to be maintained, but until then it is defined as agricultural conservation land in accordance with the Town Planning Act. To support this strategy and promote the protection of agricultural land, legal protective measures will be developed for the area. Studies will be conducted to determine which areas are vulnerable and sensitive to ecological imbalances. There is potential that the area will be declared as an environmental protected zone in the future.

(6) Community environmental protection and rehabilitation. The Thai Constitution supports the right of community members to protect their own environment, an important and recognized element of conservation. Conservationists argue that the spirit of protection and underlying belief systems are more meaningful and sustainable than any protected law. Some examples that are rooted in this cultural tradition include:

- **Fish Home - crab bank activity.** Fishing activities in the Bang Pakong River area are legally controlled by an announcement in 1964 by the Ministry of Agriculture and Cooperation, based on the seasons when fish lay eggs and the types, regulating catch sizes and fishing methods that can be used. In practice, however, it is not very effective. The villagers of Moo 1, Bang Pakong Subdistrict work together to conserve the habitat of crabs after recognizing the impacts of coastal erosion and wastewater from industrial plants, coolant water discharge from the Bang Pakong power plant, and solid waste and

[25] ONEP, 2014
[26] ONEP, 2014
[27] ONEP and Faculty of Fisheries, Kasetsart University (n.d.)

other community waste. A conservation project was set up behind the Kongkaram Temple at Moo 1 in the estuary. The crab conservation area started in the mangrove forest area around the temple's boat dock. Later, they established the "Bang Pakong River Basin Disaster Surveillance Network" and began to create a catchment to prevent waste from entering the area using bamboo as walls. They also began mangrove planting activities such as the "Planting forests in people's hearts" activity.

- **Mangrove forest conservation group.** This is an initiative in Klong Tam Subdistrict, Muang District, Chonburi, to stop the deterioration of mangrove forests around Bang Pakong Estuary. In 1995, there were negotiations to reclaim 450 rai (72 ha) of mangrove forest area from the shrimp farming ponds. After that, people gathered to reforest and rehabilitate the mangrove forest and turned it into a nursery for aquatic species. Today, Klong Tam Hru Subdistrict Administrative Organization and the Klang Tam Hru Municipality have dug over 6,000 m of canals as a buffer to protect the area against the expansion of aquaculture, or the inappropriate use by government. They formed the "Klong Tam Hru Mangrove Conservation" group and developed the "Ecotourism, livelihoods development and mangrove rehabilitation" project.
- **Movement to register Bang Pakong River Wetland as Ramsar Site.** The People's Network for Environmental and Cultural Conservation in the watershed, operating under the name "Bang Pakong Alliances", has developed an information package to highlight the importance of the Bang Pakong River Wetland. They made a documentary called "Bang Pakong - River of Life"[28] and produced several media products[29] to create the Bang Pakong Voices Exhibition with Thai PBS held at Bangkok Art Gallery. The Alliance also collaborated with Burapa University to organize "Bang Pakong Voices" activities and produced the "Bang Pakong River – River of the Dragons" play for the conservation of the wetland. These and other activities were all prior to the official request in December 2016 to the Office of Natural Resources and Environmental Policy and Planning (ONEP) to recognize Bang Pakong River Wetland as an international important wetland site or Ramsar Site (see Figure 6). After ONEP stated on 9 March 2017 that the Bang Pakong River Wetland meets the criteria of a Ramsar Site, a consensus was made for Chachoengsao Province to be the leader in the registration process. The initial step is to identify and scope the proposed area before proceeding. The Bang Pakong Alliance coordinated with Chachoengsao Provincial Administration to produce the Ramsar Information Sheet.
- **Other initiatives**. In addition to the environmental organizations mentioned above, people also developed Farmers' Development Organizations and networks such as the Farming Practice Promotion Group. Established organizations include the Community Rice Promotion and Production Centre and Organic Farmer Network.

[28]https://www.youtube.com/watch?v=DzFIik4gUG4
[29]youtu.be/Qerdqpurb4Q

Figure 6: *Campaigning for Bang Pakong River Wetland to become a Ramsar Site: cycling campaign (left) and theatrical performance (right)*

3 COMMUNITY AND WETLAND LIVELIHOODS

3.1 Community and population

The Bang Pakong River Basin includes 7 provinces, 31 districts, and 217 sub-districts. The Bang Pakong River flows through 4 provinces (Prachinburi, Nakhon Nayok, Chachoengsao, Chonburi) and 36 subdistricts with a total distance of 122 km. Nah Muang Subdistrict (Muang District) of Chachoengsao Province has the highest population of 39,570 residents, followed by Bang Khla Subdistrict (Bang Khla District) of Chachoengsao Province with 9,307 residents. The total population along the riverbanks is 201,858 (48.2% men; 51.8% women; 83,875 households). Most people are Buddhist, with small groups of Catholics and Muslims.

3.2 Key livelihood activities

Most people in the Bang Pakong River Basin are famers. They rely on agriculture and aquaculture, but many are also involved in fisheries. Some rely on other wetland resources for their livelihoods, such as *Nypa* processing and salt farming, and others work in the industrial and service sector.

(1) Agriculture. Many people in the Bang Pakong River Basin depend on agriculture. Most of the land in the basin area (see Section 2.5, Figure 4) is fertile land for food production that feeds the people in the region and Bangkok metropolitan area. Main food produces are rice, cassava, sugarcane, mangrove and other fruits; people also grow large areas of rubber and palm oil trees (see Table 3).

Table 3: *Provincial plantation areas in the Bang Pakong River Basin between 2013-2015 (Agricultural Statistic of Thailand 2013 – 2015, Office of Agricultural Economics, 2016)*

Province	Main crops	Area (ri)			Main trees	Area (rai)		
		2013	2014	2015		2013	2014	2015
Chachoengsao	Rice paddy	713,344	728,546	409,811	Mango	30,837	30,433	32,642
	Second rice	520,913	507,862	412,499	Palm oil	19,900	22,376	29,638
	Cassava	305,787	294,273	283,848	Rubber	191,608	191,766	191,345
Prachinburi	Rice paddy	465,922	480,367	319,692	Rubber	24,236	24,241	25,939
	Second rice	168,360	165,525	143,770	Palm oil	15,148	19,452	16,288
	Cassava	159,069	156,780	154,689	Durian	2,512	2,420	3,203
	Sugarcane	21,430	17,980	17,489	Mangosteen	2,320	2,101	2,073
	Corn	12,633	11,874	22,267	Santol	4,003		3,821
	(livestock)						4,037	

Nakhon Nayok	Rice paddy Second rice	412,857 267,762	401,618 258,527	286,245 176,246	Pomelo Plumage Sweet Santol	1,421 6,783 846 856	1,970 4,263 1,301 1,022	2,737 6,878 530 1,492

- **Rice cultivation.** Chachoengsao Province has the largest area of cultivated rice with about 410,000 rai (65,600 ha) of rice paddies in 2015, both in and out of season. Famous varieties, such as jasmine rice, originate from this province. Other provinces such as Prachinburi and Nakhon Nayok also have large rice areas. The upper Bang Pakong Basin, in Ban Srang District of Prachinburi Province and the Pak Phlii District of Nakhon Nayok, uses freshwater, while receiving support from Rice Research Centres (see Figure 7). Three types of rice farming are utilized in the area:
    - **Rice paddies on water.** This type of rice farming is found in the low lands and flood prone areas, which are inundated with 1-5 m water depths in the rainy season for over a month. To survive these conditions, it uses the internode elongation, branching and rooting abilities of rice. The type of rice grown is the "light sensitive rice", i.e. those that rely on the light to produce grains. Therefore, it is seasonally produced and only once a year. This (in-season) rice will start to produce grains once daylight is shortened and the season changes into the winter.
    - **Off-season rice.** In the lower plains, where irrigation systems are available, off-season rice is commonly grown. Off-season rice is not influenced or dependent on light ("non-light-sensitive rice"). Therefore, it can be grown several times in a year.
    - **Na Kha Wang rice paddies.** This is a mixed land use method, combining rice paddies in the same area as natural aquaculture. In this method, the fields will be used for rice paddies once a year and trenches will be dug around the borders of the paddies for raising aquatic species such as shrimp, crabs and fish along with growing rice. When the rice is ready for harvest, water is released from the field and trenches and aquatic species are caught at the same time. In the dry season, brackish water is allowed into the rice paddy areas and it is used to culture shrimp and crabs. This way, the farmers can have an income year-round.

Figure 7: *Rice cultivation in Bang Pakong River Basin: plots for over 100 varieties (mainly native) at Prachinburi Rice Research Centre (left); rice paddies with height variation according to flood levels (1-5 m) in Pak Phli District, Nakhon Nayok (right)*

- **Ditches orchards.** This agricultural system is found in the lowland areas along the river, with salt marshes and brackish water with branched canals flowing through. Ditches are dug around the orchards to trap freshwater for use during the high tides of saltwater. Water gates are installed to let freshwater in (low tide/rainy season) and keep saltwater out (during high tide/dry season), so that fruits, vegetables freshwater species can be grown and raised. During high tides, the gates will be closed to protect the orchard from saline

conditions. These orchards usually grow areca, coconuts, mangoes and betel. Vegetables will be grown in the middle of the ditches and thus products can be harvested throughout the year.

- **Livestock farming**. Besides crops, livestock is kept for selling and consumption. These include cattle, buffaloes, ducks, chickens, pigs, goats, and sheep. The major animal industry in Chachoengsao Province is hens for egg production; it is the country's number one egg producer and the second producer of pigs and chickens.

(2) Fisheries and aquaculture. Fisheries include both fresh and saltwater species. Saltwater fishing takes place along the coastal areas of the estuary, while freshwater fishing takes place along the Bang Pakong River and natural canals. In addition, Bang Pakong River Basin has high potential for aquaculture.[30]

- **Catching small shrimp (to make shrimp paste or "kapi").** This takes place during the dry season (January to May) when water in the Bang Pakong River is brackish to salty. This is the time when small shrimps or "*khei*" come into the river area. Villagers catch them to make shrimp paste or dry them to sell. In the past, nets ("Oun Ror Khei") were used for fishing. Nowadays, fishing nets are illegal, so villagers need to take their boats out and use a "swing" to catch the shrimps.
- **Giant freshwater prawn fishing.** Giant freshwater prawn fishing is a well-paid occupation; the prawns can be sold to restaurants or regular customers or traders. The prawns can be found near the river banks where there are trees and densely knitted roots.
- **Fishing from the river.** Fishing for species such as sea bass, catfish, mongong fish (*Mystus multiradiatus*), and mullet, depending on the season. Many communities still practice traditional techniques, a study of people's way of life in Ban Pho district, Chachoengsao Province found that a total of 28 fishing tools and methods were used by communities living on the riverbanks of Bang Pakong River.[31]
- **Catching fish in flood plains** Fishermen also catch fish in the flood plains such as in Tung Yai Pak Phlii or Tung Rab Nai area in Pak Phlii Subdistict (Nakhon Nayok) and Bang Khanak Subdistrict (Chanchoengsao). A variety of fishing tools are used to trap different fish in water run-off areas. In addition, small ponds are dug in the rice paddies, so that when the water dries up they can catch fish in the ponds.

[30]ONEP, 2013.
[31]Somnuk Maythawasin et al. 2017

Figure 8: *Fisheries in Bang Bakong River Basin: sun-dried shrimp for shrimp paste (Saeng Phu Daz Sub-district, Baan Pho District, Chachoengsao) (left, top); use of cans to catch crabs (Klong Ban Pho Sub-district, Ban Pho District, Chachoengsao) (left, bottom); freshwater prawn fishing (Hua Sai Sub-district, Bang Khla District, Chachoengsao) (centre); sun-dried freshwater fish (Tung Pak Phlii, Ta Rua Sub-district, Nakhon Nayok) (right top/bottom)*

- **Aquaculture.** This includes raising giant freshwater prawns, white shrimp, freshwater fish, and brackish water fish. In 2012, there were 3,971 saltwater and 4,172 freshwater shrimp/prawn farms registered in Chachoengsao Province – the main production area within the country– with a total area of 37,828 rai (6,052 ha); these farms produced 608,052 tons of black tiger prawns and 11,427,974 tons of white shrimp.

(3) Other livelihood activities. There several other livelihood activities that can be distinguished, such as *Nypa* processing and salt farming (see Figure 9) and working in industrial or service sectors.

- **Jak processing**. Different parts of the *Nypa fruticans* plant, locally known as '*jak',* are used to make edible and non-edible products for sale. In Ban Pho District, 100 households make a living from jak products. The processing includes: cutting jak leaves for "Tapjak" (roof thatching), rolling the leaves, selling jak leaves for making sweets, selling the plants fruit or flowers, weaving it into toys, using it to make food or using the stems from the fruit baring branch as whips for keeping mosquitos away. A women's group is directly associated with the processing of jak products.

- **Salt farming**. Salt farming is done near the estuary. There is a group of people living in Baan Klong Pii Khud, Bang Pakong District (Chachoengsao), who continue salt farming as part of their family tradition. They still maintain the salt farms in the area, which is about 4,554 rai (729 ha). The salt farms are connected to the sea by man made canals, so that seawater can be brought into the areas surrounding the salt fields. There are trenches around the salt farms that can also be used for aquaculture of shrimp and fish.


Figure 9: *Other livelihood activities: woman processing Jak (Nypa fruticans) leaves for thatching roofs (left); salt farm in Baan Klong Pii Khud (right)*

- **Occupations in industrial and service sectors**. Industrial areas and factories are expanding in the area. The main sectors are metal, agriculture and transport. In 2014, 1,700 manufacturing plants were licensed in Chachoengsao, employing 127,631 people. This has made Chachoengsao Province the leading province in profits from the manufacturing industry sector. This is also a result of its location, close to large industrial sites, the government's Eastern Sea Board Development project, Laem Chabang Port, industrial estates and the current EEC development project. The economic growth of the area and its other values, such as tourism, has made the area also attractive for a growing service sector and additional jobs.

3.3 Use of wetland resources

Wetland resources play an important role in the lives and livelihoods of people that live in the Bang Pakong River Basin. These resources include water, the main resource of the river basin, and the fishes, shrimp, crabs, prawns, and plants, crops and livestock that depend on water and fertile soils. The main resources, use and importance for populations across the basin are:

- **Water**. Water is an important resource for energy, irrigation, as well as consumption. Several projects are under construction by the Department of Water Resources, the Royal Irrigation Department, and the Electrical Generation Authority of Thailand. In total, there are 291 existing projects with a capacity of 622.82 million cubic meters of water, benefiting an area of 1,531,456 rai (245,033 ha).[32]
- **Fishery resources and aquatic species.** The Bang Pakong River Basin is an important wetland resource for all kind of fish species and aquatic life forms; a survey during the dry season identified about 300 fish species (76 saltwater, 95 brackish water, and 128 freshwater species) in the estuary alone.[33] Aquaculture is practiced throughout the basin, while fishing takes place along river.
- **Agriculture**. The river basin is an agricultural area, used for the commercial production of rice, fruit and vegetables, with fruit being more common in the central plains.

[32]SDCon Corperation Ltd., 2012.
[33]Bang Pakong River Basin Database Information System as accessed from http://bangpakong.onep.go.th//ggm/BPK.html on 1 April 2017

- **Forestry.** Most of the forests are protected, but there are some areas that are used for production purposes (pulp and paper industry).

3.4 Land tenure and land-use rights

Table 4 gives an overview of land utilization in the four provinces through which the Bang Pakong River flows. The total land area of the four provinces is 10,373,976 rai (1,659,836 ha), which is about 1.5 times the total land area in the river basin. Land use patterns for Chachoengsao and Chonburi are similar, with 58-63% used for agriculture, 25-28% for non-agricultural use and 12-15 % for forests. Nakhon Nayok, the smallest province, has about 47% agricultural land, 23% non-agriculture land, and 30% forest. Prachinburi has the smallest share of agricultural land with 37%, 33% non-agricultural land, and 30 % forest.

Table 4: *Land utilization in four provinces of the Bang Pakong River Basin in 2015 (Source: Agricultural Statistics of Thailand 2016, Office of Agricultural Economics)*

Province	Total land		Agriculture		Non-agriculture		Forest	
	Rai	(ha)	rai	(ha)	Rai	(ha)	Rai	(ha)
Nakhon Nayok	1,326,250	(212,200)	616,768	(98,683)	308,846	(49,415)	400,636	(64,102)
Prachinburi	2,976,476	(476,236)	1,113,560	(178,170)	975,139	(156,022)	887,777	(142,044)
Chachoengso	3,344,375	(535,100)	1,923,681	(307,789)	926,728	(148,276)	493,966	(79,035)
Chonburi	2,726,875	(436,300)	1,719,457	(275,113)	668,983	(107,037)	338,435	(54,150)
Total	*10,373,976*	*(1,659,836)*	*5,373,466*	*(859,755)*	*2,879,696*	*(460,750)*	*2,120,814*	*(339,331)*

While Chachoengsao is the largest province with a total agricultural land area of 1,923,681 rai (307,789 ha), only 5.7% of the land is owned by farmers (see Table 5). Most (94%) of the agricultural land is leased or are lands that have been mortgaged or put up for sale or requested for use for other purposes. In Chonburi, the percentage of farm-owned land is higher (but still relatively low) with 21%; in Nakhon Nayok and Prachinburi, respectively 40 and 52% of the land that is used by farmers is theirs. The average farm size in Chonburi (75.6 rai or 12.1 ha) is more than twice as large as those in other provinces, which suggests that the land is concentrated among a smaller group of people, possibly for commercial aquaculture.

Table 5: *Type of agricultural landholding in four provinces of Bang Pakong River Basin in 2015 (Source: Agricultural Statistics of Thailand 2016, Office of Agricultural Economics)*

Province	Agriculture		Farms	Farm size		Ownership		
	Rai	(ha)	No.	Rai	(ha)	Farmer (self)	Rented	Free use/ mortgage
Nakhon Nayok	616,768	(98,683)	19,455	31.7	5.1	40 %	42 %	18 %
Prachinburi	1,113,560	(178,170)	28,656	38.9	6.2	52 %	38 %	11 %
Chachoengsao	1,923,681	(307,789)	54,518	35.3	5.6	6 %	30 %	65 %
Chonburi	1,719,457	(275,113)	22,744	75.6	12.1	21 %	46 %	33 %

Most of the land of the Bang Pakong River Basin is within Chachoengsao Province. Since more than half (58%) of its land is being used for agriculture and only 6% is legally owned by farmers that use the land, most farmers in the province lack land security. This also applies to people in other provinces, although less extreme; based on discussions in various communities, farmers face similar risks across the basin. For example, local fishermen in Saeng Phu Dhak Sub-district, Bang Pakong District (Chachoengsao) were chased out of their homes to make way for a golf course. Similarly, over half the people in Baan Kho Klang, Bang Pakong District (Chachoengsao) are renting land from someone who comes from elsewhere and whom they hardly know; people used to rent relatively cheap, but since land prices have increased because of economic investment, the owner wants to use the land for other purposes. Other cases include farmers in

Bangtan Sub-district of Baan Srang District (Prachinburi) and some in Bang Kanak Sub-district in Bang Nam Prieo (Chachoengsao), where over half the farmland is leased from large landowners outside the village, whose motives and incentives are unknown.

3.5 Governance

Wetland management in Thailand falls under the jurisdiction of the National Environment Board, and is composed of a committee, a sub-committee and a working group. Their role is to specify the policy and plans for the management of wetlands in Thailand (see Annex 3 for wetland management policy since 1997). The management structure started to operate in 1993, as authorized through Section 18 of the National Environmental Quality Promotion and Conservation Act 1992.

The National Environmental Board appointed a sub-committee for wetland management, which is composed of representatives from relevant agencies, both governmental and non-governmental, and experts on the subject matter. The wetlands subcommittee is to assist in setting up rules and regulations, policies and national plans, and guidelines for the management and protection of wetland areas – in line with the policy for monitoring and evaluation of the implementation as indicated in the Wetland Convention and relevant international agreements.[34] It should also support education and research, promote participatory problem-solving, and establish networks for cooperation between relevant agencies and domestic and international organizations. The Wetlands Working Group was appointed to support the work of the Wetlands Sub-Committee.

Most recently, the Office for Natural Resources and Environmental Policy and Planning (ONEP) developed the Master Plan on Integrated Biodiversity Management 2015-2021. The Master Plan was approved by the Cabinet in March 2015 and integrated into the Wetland Action Plan. Wetland conservation measures were set up according to the Cabinet Resolutions of November 2009 and May 2015 (see Annex 4). These measures are currently being implemented and involve many agencies. There are no specific governance structures for the Bang Pakong River Basin as a whole, nor for each of the National Important Wetlands.

3.6 Stakeholder analysis

Several stakeholder groups can be identified for the Bang Bakong River Basin:

- **Farmers:** About 70% of the wetlands' population are farmers engaged in agriculture. They are particularly concerned with the management of water resources. In the dry season, there is not enough water for the agricultural sector and there are conflicts over the use of water, especially between farmers and industrialists.
- **Industry:** The expansion of industrial activities in the eastern zone will create extra pressure on soil, water and other resources in the ecosystems of the Bang Pakong River Basin. There are some standalone industry businesses and also industrial zones (Ban Suan Nong Bon Industrial Zone; Sinn Ratana Steel Industrial Zone; Alpha Technopolis Industrial Zone; Panthong Industrial Community) and industrial estates (Amata Nakorn Industrial Estate; Wellgrow Industrial Estate; Gateway City Industrial Estate). These are powerful entities with a strong interest in resource use.
- **Tourism/service industry sector:** The area is close to Bangkok (80 km) and already an important tourist area. Hotel accommodation and tourist destinations are expected to

[34] E.g., the International Convention on Wetlands or RAMSAR Convention, the Biodiversity Convention, the Convention on the Conservation of Migratory Species (Bonn Convention), the Man and Biosphere Reserve Project, and the United Nations Framework Convention on Climate Change (UNFCCC); in addition, there are at least 22 articles/acts of legislation dealing with the management of wetlands (ONEP, 2017).

further expand. The service sector is also expected to grow as result of increased demand from residential and industrial areas.

- **Community:** People living in the area have raised concerns about water quality impacts from community, agricultural and industrial wastewaters, specifically in highly populated areas. Wastewater accumulates in the canals when gates of the Bang Pakong Dam are closed to prevent seawater intrusion. When they are opened, the release of polluted water into the river can lead to a lack of oxygen in the water, threatening the lives of aquatic animals. There are also other cases where the Bang Pakong Dam caused negative effects, such as the difference in water levels causing riverbanks landslides and the massive spread of water hyacinth during the freshwater season.
- **Civil society networks (CSOs):** Environmental conservation groups in the area such as the Pakee Bang Pakong Alliance have campaigned for and promoted the registration of Bang Pakong River Wetland as a Ramsar Site. They argue that without proper management and law enforcement, the exploitation of natural resources will deteriorate the ecosystem and biodiversity will be lost due to the use of agricultural chemicals, erosion, and destruction of natural forests.
- **Governmental agencies/authorities:** Besides the agencies/authorities responsible for developing measures for wetland conservation (see Annex 3), there are other local agencies that are responsible for the management and utilization of resources, including the Local Administrative Organization, academic institutions or schools and academic institutions in the wetland area, and the Provincial Natural Resources and Environment Office.

3.7 Gender and vulnerable groups

Several vulnerable groups can be identified in the basin. Older people (including women) who are not able to work in the industrial or service sectors and who have turned to natural resource-based livelihood activities are very vulnerable to changes to the natural environment. In addition, small-scale farmers and ditches orchard owners, whose ways of life depends on the rise and fall of the river water levels, are vulnerable. Farmers with no land ownership may be the most vulnerable group. The assessment team found that rice farmers often have large debts and are highly dependent on weather conditions (rain and floods) and market prices, which makes their land security situation even more precarious. Local fishermen and women who live and depend on forest resources such as *Nypa fruticans*, small shrimps and crabs with almost no other income are also among vulnerable groups.

3.8 Perceived threats to wetland habitats and livelihoods

Threats to people who are dependent on the wetland can be classified into man-made threats and threats from natural causes.

(1) Human-induced threats. In the Bang Pakong River Basin, pollution to the wetlands as results of increased urbanization and industrialization is a major threat.

- **Water pollution.** The Bang Pakong River Basin, from Bang Khla District to Muang District in Chachoengsao Province is degraded. The amount of dissolved oxygen has decreased, and the water is dirty and contaminated with coliform bacteria, especially during March and April. There is an accumulation of pollutants and subsequent eutrophication. In the dry season, there are high concentrations of organic matter causing sulphide to build up. In addition, there is contamination from heavy metals such as lead, which was found to exceed the standard limit. The average concentration is higher in the rainy season than in dry season because it comes with the surface water that is contaminated with leaching of heavy metals from various activities on land. The area around the Bang Pakong Dam is

another area where the accumulation of heavy metals in the soil is relatively high. This is the result of poor water circulation, which enabled the accumulation of heavy metals.[35]

- **Waste management**. This includes waste disposal from communities and households, as well as from labourer's accommodation areas. The problem of waste in Chachoengsao is such that solid wastes produced in Bang Pakong Municipality, Tha Kham Subdistrict Municipality, and Song Khlong Subdistrict of Bang Pakong District are about 10, 25 and 2 tons per day, respectively. Likewise, there are approximately 12 tons of solid waste per day produced by Klong Tum Hru Subdistrict Municipality in Chonburi, which are not effectively managed. There is no sanitary waste disposal system and often the garbage is dumped onto land areas where they would occasionally be pressed into landfills.
- **Toxic pollution.** Hazardous waste from industrial estate zones is being illegally disposed of in wetland areas; this has contributed to water pollution, but also soil quality has deteriorated due to contamination from the industrial sector. There is also toxic pollution of the land as result of chemicals used for agriculture.

(2) Threats due to natural causes:

- **Droughts and salt water intrusion.** During the dry season, salt water has been able to reach into the Bang Pakong river as far as 200 km to Sri Mahabhodi District in Prachinburi Province; plants on the river banks of Bang Pakong River that cannot tolerate saline water died, such as *Salix tetrasperma Roxb*., *H. ilicifolia King*, and bamboo species.
- **Spread of water hyacinth.** The discharge of water from the Dam (reservoir) to push back saline water, had a side effect of accelerating the spread of water hyacinth in the canals. Normally, when the water salinity is high, water hyacinth will die because it cannot tolerate salt. The prolific growth of water hyacinth causes problems for people who use the water for transportation or whose livelihoods depend on river resources such as fish and shrimp.
- **Climate change.** While droughts, floods and seawater intrusion are already affecting the area, the impacts of these phenomena are expected to become more intense and frequent as result of global climate change.

[35]Department of Marine and Coastal Resources as retrieved from http://marinegiscenter.dmcr.go.th/km/biodiversity_bang-prakong-basin/#.WQgDzNwxXIV on 2 May 2017

4 CLIMATE PROJECTIONS FOR THE SITE

4.1 Climate change profile for Thailand

A modelling study by the Office of Natural Resources and Environmental Policy and Planning on historic climate and climate change projections for Thailand has projected rainfall patterns/trends and temperature changes for the period 1961 to 2100.[36] It was found that monsoons from the southeast will become more severe; the duration between rainfall events will become longer, but the amount of rain per event will increase with a greater chance of floods. The Thai summer will extend, delaying the start of rainy season. Turbulent weather will increase, with Thailand facing more flood problems due to changes in the direction of monsoon winds – blowing more to the west when it used to blow north – including typhoons that move down to the south from October to December. The climate model indicates that in the next 60 years, there will be 20% more rain compared to the past 100 years. Bangkok will be at risk of becoming a typhoon-prone area. The northeastern typhoons that blow to the south will not only bring rain, but also create 3-4 m high ocean waves, causing erosion for up to 400 km of coastline. The area most effected will be the Gulf of Thailand, with Samut Parkarn Province being the most critical area. The estimated erosion is up to 35 m/year inland, which means that at least 1 km of land has already disappeared from the coastline. In the future, this may accelerate to 65 m/year in Bangkok and neighbouring provinces, meaning 100 years from now, up to 6.5 km of land from Bangkok's coastal lines will be gone.

4.2 Climate change in Bang Pakong River Basin

More detailed climate change projections for Bang Pakong River Basin are presented below. Results show changes in temperature and rainfall patterns based on a study by Jaruwan Kasemsap et al. (2013), using 2040-2099 as future years and 1990-2009 as base years.[37] In addition, sea level rise projections in the Gulf of Thailand are provided for 2010-2029 and 2030-2049, based on historic years of 1985-2000.

Temperature. Overall, temperatures tend to increase in the Bang Pakong River Basin (see Figure 10). The increase will be similar throughout the basin with the southern areas near the sea (estuary) showing higher temperatures compared to the areas in the north. Data show that average minimum temperature for the base years (1990-2009) was 23.0ºC and may rise to 24.4ºC for future years (2040-2099), while the average maximum temperature of 33.3ºC may rise to 34.3ºC over the same period. Temperature increase will be similar throughout the year, with January remaining the month with the lowest temperatures and May the month with the highest temperature. The future temperature increase may affect the evaporation rate of surface water and the transpiration processes of plants. If temperature rises to more than 35ºC for a period of 1 hour or longer, male pollen of rice will become sterile, impacting agriculture in the area.

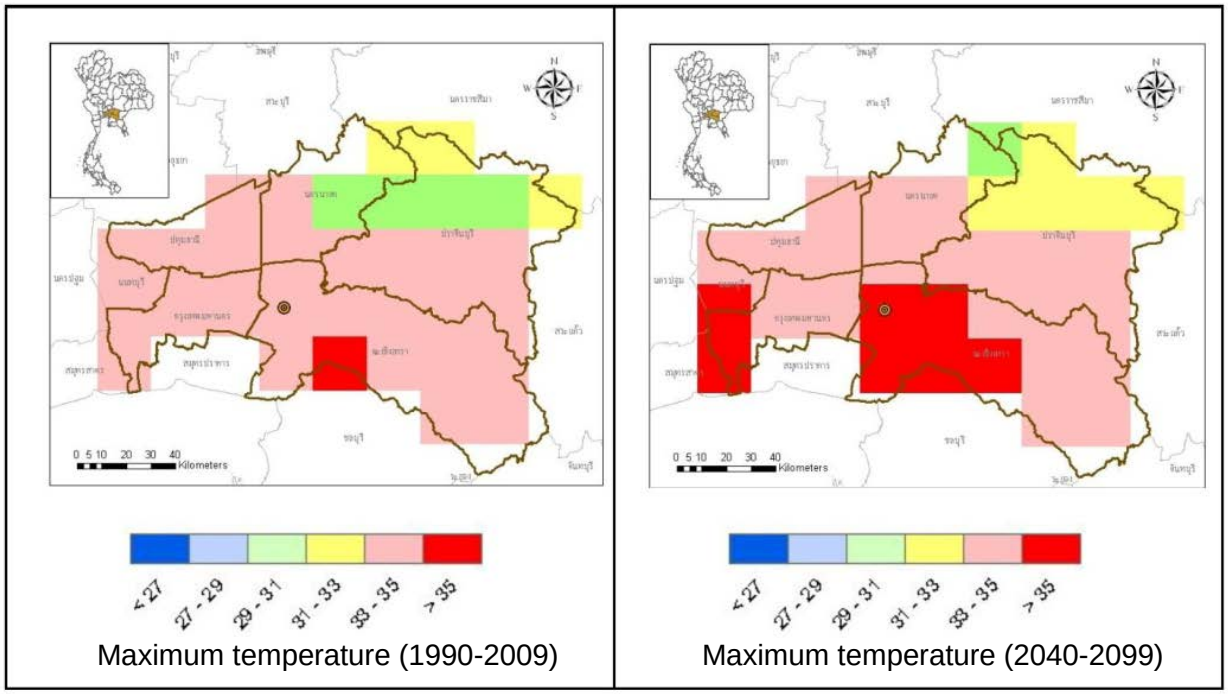
[36] http://www.onep.go.th/bangpakong-river/index.php?option=com_content&view=article&id=48&Itemid=62 (using Providing Regional Climate for Impact Studies (PRECIS) method).

[37] Vulnerability, Awareness and Adaptation to Climate Change for Agriculturalists in Water Resource Management Project for Bang Nam Priew District, Chachoengsao Province under the Climate Change and Adaptation Project supported by Thailand's Research Funds Office (TRF) (based on the ECHAM41 A22 climate model and the PRECIS3 climate model using the base years of 1990 – 2009 and future years of 2040 – 2099).

1990 - 2009

Minimum temperature (1990-2009)

Minimum temperature (2040-2099)

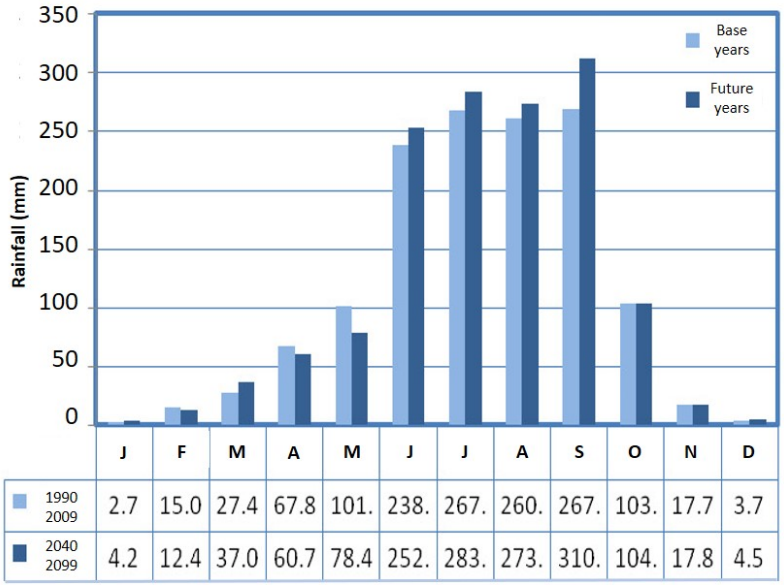


Maximum temperature (1990-2009)

Maximum temperature (2040-2099)

Figure 10: *Average minimum and maximum temperatures for Bang Pakong River Basin and adjacent areas for base years 1990 – 2009 (left) and future years 2040 – 2099 (right)*

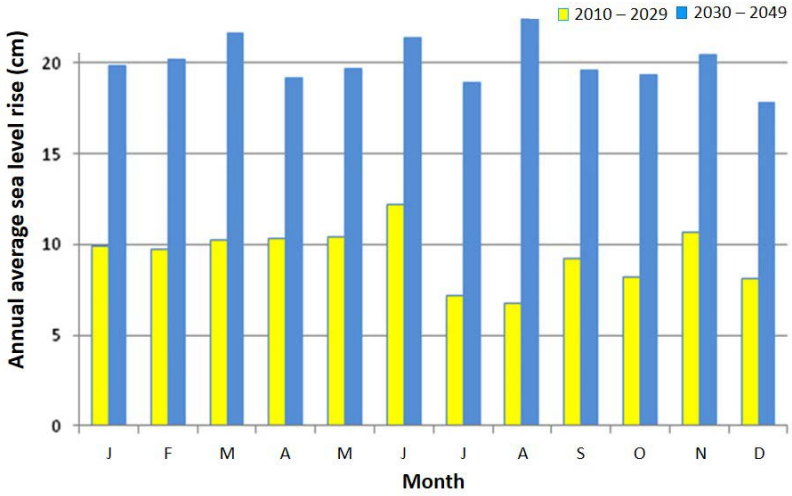
Rainfall. Annual rainfall tends to increase from 1,374 mm to 1,439 mm per year (+5%) in the future.[38] The amount of rain will increase during the rainy season from May to October, but decrease in the dry season from November to April (see Figure 11).



	J	F	M	A	M	J	J	A	S	O	N	D
1990 2009	2.7	15.0	27.4	67.8	101.	238.	267.	260.	267.	103.	17.7	3.7
2040 2099	4.2	12.4	37.0	60.7	78.4	252.	283.	273.	310.	104.	17.8	4.5

Figure 11: *Annual rainfall per month for base years (1990-2009) and future years (2040-2099)*

Sea level rise. Due to global climate change, sea level in the inner part of the Gulf of Thailand will increase in the future (see Figure 12). The increase in wind speed, and especially of the monsoons that blow into the Gulf of Thailand, adds to the rising sea level. Based on historic data from 1985–2000, average sea level change in the Gulf of Thailand for 2010–2029 and 2030–2049 are 9.4 and 20.0 cm, respectively.[39] This will lead to increased salinity intrusion in the Bang Pakong River Basin.



[38]Date based on lower Chao Praya River Basin and Pasak River Basin (bordering Bang Pakong River Basin to the west and north)

[39]START RC global changes research and training network modelled sea level rise in Gulf of Thailand to determine magnitude of using the Dynamic Interactive Vulnerability Assessment (DIVA) and Princeton Ocean Model (POM) models; wind speed and wind direction data were obtained from the PRECIS model for ECHAM4 A2 between 2010 and 2029 and 2030 - 2049.

Figure 12: *Sea level rise Upper Gulf of Thailand 2010-2029 and 2030-2049*

The long-term forecast for the eastern region indicates that the area is at risk and vulnerable to climate change.[40] The area is prone to hydrological disasters and most of the problems will occur in the central and lower coastal areas, especially in Prachinburi and Chachoengsao provincial areas of the Bang Pakong – Prachinburi River Basin. The areas most vulnerable to floods and droughts in the eastern region water basins are mainly in Chachoengsao, Prachiburi and Sakaeo provinces.

4.3 Implications for Bang Pakong River Wetland

Climate change projections indicate that ecosystems and communities in the Bang Pakong River Wetland will be affected, especially in those areas already vulnerable to floods and droughts. Main implications are:

- Higher **temperature** will lead to more water evaporation and farmers will be increasingly confronted with droughts in the dry season, with the number of hot days increasing and the number of cold days decreasing.
- The average annual **rainfall** increases by 5%, but this is not equally distributed over the year. Farmers will face droughts in the winter and face more flooding problems due to an increase of rainfall in the rainy season. Farmers, communities and industrial areas are all at risk.
- The **sea level** increases. Farmers, communities and industrial areas will face more salinity problems than in the past. The plants near the riverbanks may also be affected from the effects of saline water, which will impact the larger ecosystem and biodiversity.
- Severe **storms and waves** accelerate coastal erosion. As the surface temperature increase and sea level rises, severe rainstorms increase by 10–20%. The estuary, the coastal wetland areas, and small islands will be strongly affected. There will be inland waves and flooding along the coastlines.
- There are risks of flash **floods** in the lower Bang Pakong River Basin and the coastal areas from heavy and continuous rains over several days. The urban areas will face the river flooding. The flood will cover a distance of 5–10 km from the riverbanks. There may also be a seawater surge during the end of the rainy season or between October to December due to high water levels.

5 RESULTS OF VULNERABILITY ASSESSMENT

5.1 Habitat vulnerability

The assessment team focused on the 9 habitat types identified in Section 2.4 to assess the vulnerability of the ecological system of the Bang Pakong River Wetland to climate change. Data was based on consultations with communities, relevant institutes and resource persons/experts.

5.1.1 Baseline and threats

Baseline information and main threats are summarized for each habitat.

(1) Estuary. The estuary forms a diverse coastal ecosystem, including freshwater, brackish water and saltwater. The tides are a major factor impacting the physical and biological characteristics of the ecosystem. Mangrove forests with various types of plants are along the coastal area; providing an important breeding and nursery ground for aquatic animals. There

[40] http://www.onep.go.th/climatechange/index.php/about-east-5

are more than 40 canals and ponds scattered over the area with shrimp and salt farms, in which rare marine animals can be found. The brackish water area of the estuary is home to several types of dolphins and whales, including Irrawaddy dolphin, Indo-Pacific hump-backed dolphin and finless porpoise. Land use changes due to industrial expansion and infrastructure development (including the construction of the port area) have put the ecosystem under severe pressure; moreover, wastewater discharged into the estuary affects aquatic animals and plants. Flash floods during the rainy season and high salinity in the dry season are increasingly problematic.

(2) Salt farms. Salt farming is traditionally practiced in the estuary, passed down through generations in Baan Klong Pii Khud (Bang Pakong Subdistrict, Bang Pakong District of Chachoengsao). This village is more than 300 years old and is located next to the sea. Each of the farms has a canal system connected to the sea for bringing in saltwater to the salt field. The area around the salt fields also have trenches that can be used for naturally raising aquatic animals such as shrimp and fish. It is an economic resource for the community and an important habitat for migratory birds. The system is under pressure of the expansion of community and industrial area; it is also facing occasional flash floods from heavy and continuous rains and seawater surges during the end of the raining season from October to December.

(3) Mangrove and Nypoideae forests. Mangrove and Nypoidideae (*Nypa fruticans*) forests are scattered in the Bang Pakong Estuary and along the main river. These forests play an important role in preventing coastal and riverbank erosion. Both are sources of aquatic biodiversity and food, and important as nurseries for aquatic animals. The mangrove forest, the main ecosystem around the estuary, and Nypoideae forests are affected by land use changes due to the expansion of urban, industrial and tourism areas, infrastructure development and transportation projects such as the construction of the port. Sudden changes in salinity during the dry season or due to heavy rainfall are impacting marine animals in these habitats. The Bang Pakong Dam near the centre of the basin has been constructed to push back the saltwater during the high sea level season, but it also decreases the amount of sedimentation in the estuary and causes riverbanks to collapse due to the differences in water levels.

(4) Mainstream river Water from the Bang Pakong River passes communities and low plains and flows into the Gulf of Thailand. The flowrate of freshwater into the sea is very low in the dry season, which is related to the physical characteristics of the estuary, which has very gentle slopes; it also allows sea water from the Gulf of Thailand to push deep into the river body, especially in dry seasons when there is little water in the river. The difference in water salinity makes the river a suitable habitat for a large diversity of fish species, including migratory ones. However, the Bang Pakong Dam and the built-in water gates in the canals affect the natural flow of the river and its branches. These were built to reduce saltwater intrusion, but its management is causing conflicts in some area due to the accumulation of polluted water. Besides being an important source for fisheries, the river is also an important source of water for both people and industry. There have been several complaints by communities along the river that water is being prioritized for the industrial sector.[41] Expansion of the industrial development has not only increased water utility requirements but has also led to waste discharge and toxic heavy metal (e.g. lead) contamination of the water.

(5) Tributary/canal system. The Bang Pakong River has many river branches and natural canals. The network of branches/canals in the basin changes with the seasons and the

[41]A private company is taking care of water management for the industrial sector, while there is a local agency responsible for taking care of water management for consumption and utilization purposes.

amount of water; when the amount of water decreases, ponds, swamps, pools and trenches emerge that are connected to the river. In the dry season, the area will face severe dryness and high temperatures, and saltwater may intrude into river branches and/or into some ponds. A water gate development project will be put in place to control the water from the estuaries and branch rivers so that they do not flow out too fast, dry up or have poor quality water. An unexpected problem is that water from the Chao Phaya River Basin is also drained into the Bang Pakong River Basin to protect the Bangkok metropolitan area against floods; this is causing flash floods and riverbank overflows.

(6) Islands/oxbows Island and oxbows along the lower part of Bang Pakong River are an important habitat for aquatic animals and a food source for migratory birds. However, there are threats from droughts, especially in dry season when there is less rainfall and the water in the river is low; some parts may have low water level or be dry for longer periods, causing high salinity levels. Since islands and oxbows are so closely linked to the main river, they face similar risks, such as flooding, especially in the rainy season, and the collapse of river banks around the oxbow.

(7) Na Kha Wang rice system. Trenches are dug around rice fields for aquatic animals such as shrimp, crabs and fish to grow alongside rice. When harvesting the rice, water is let out of the fields and the animals will also be ready to collect. When salt water seeps into the land, it is allowed in for saltwater shrimp and crabs, ensuring farmers have an income year-round. These systems are vulnerable to seasonal fluctuations such as late rains or out of season heavy rains will impact the heading, flowering and harvesting of rice. Flash floods and seawater surges in the lower Bang Pakong River Basin can affect this system.

(8) Ditches orchards. Ditches orchards are commonly found in the central and lower areas of the basin. The orchard is developed to modify the lowlands where the salt water reaches to create a brackish water condition. This is possible because of the many river branches that flows through the area. However, there is little water in the dry season, so the salt water pushes up very high, increasing salinity levels. At the same time, more wastewater is being drained into river branches and canals. Another problem is eutrophication due to the opening and closing of the water gates of the dam that obstruct the flow of water, making the river shallow. Flash floods from heavy and continuous rains over a period of several days can cover an area of 5-10 km from the riverbanks and overflow urban areas. Seawater surge may occur during the end of the raining season or between October to December. The land used for ditches orchards is being reduced because of urban and industrial expansion.

(9) Flood plain (Tung Pak Phlii) This area receives water from the central and upper part of the river basin where the Nakhon Nayok and Prachinburi rivers flow out to the Bang Pakong River. The flood plains provide space for water and are an important nursery for aquatic animals and a food habitat for migrant birds. The Somphong's rasbora can be found in specific ecosystems of the flood plains such as at the top of the Yothaka Estuary or where flood plains receive water from the Nakhon Nayok River. Tung Pak Philii is a lowland plain in Nakhon Nayok connected to the Khao Yai World Heritage Forest; the area is a rest area for migratory black kites (*Milvus migrans*) and eagles. Other than that, club-barbels have been reported. The flood plains are also an important economic resource for people in the area; the people of Pak Phlii grow rice in the form of "Na Khao Khun Nam" (floating rice paddies). Water quality is degrading due to chemicals used for agricultural activities and discharged water from the Chao Phaya River Basin. In addition, it is an area prone to drought.

5.1.2 Climate change vulnerability

Based on Chapter 4, several issues were identified as being critical in the region in terms of climate change: extra rainfall in the rainy season and increased risk of prolonged flooding; less rainfall in the dry season and droughts, combined with high temperatures; and higher sea levels

and salinity intrusion, enforced by storms and harsh winds. These climatic conditions are further characterised by increased variation in seasonal patterns. The vulnerability of habitats to climate change depends on their exposure and sensitivity to the projected changes – which determines the impact – and their ability to recover from these impacts (see Chapter 1, Box 1). Table 6 provides a summary of the expected exposure, sensitivity and adaptive capacity of key habitats in the Bang Pakong River Wetland.

Most habitats are sensitive to floods, droughts, salinity, and seasonal variations. The estuary and lower Bang Pakong River Basin are particularly exposed, although mangrove forests are able to cope relatively well with changes in weather conditions. The specific characteristics of the tributary/canal system and the flood plains, for which water levels and duration of floods/droughts are critical, also make them vulnerable to climate change impacts. Ditches orchards and the Na Kha Wang rice system are somewhat impacted, but these farmers can mitigate the impact through management practices. The Bang Pakong Dam was constructed to reduce salt-water intrusion in case of high seawater levels, but the opening and closing of the dam has led to other problems and conflicts in some areas.

Table 6: *Exposure, sensitivity and adaptive capacity of habitats in Bang Pakong River Wetland to climate change*

	Exposure	Sensitivity	Adaptive capacity
Estuary	- Some areas exposed to floods and/or sea surges during and at end of rainy season - Exposed to droughts/high temperature during dry season leading to high salinity - Coastal area exposed to high sea/storms - Overflow Chao Phraya and Paa Sak River Basins diverted to Bang Pakong River Basin	- Sensitive to coastal erosion (surges/storm) and collapse of river banks (floods) - Plants/animals sensitive to high salinity - Farms, plantations, community and industrial areas sensitive to floods	- Limited capacity to adapt; dependent on coastal system and river body - Forest replanting to resist erosion limited/not enough
Salt farms	- Located in the estuary, this habitat is highly exposed to flood, rainfall, drought, high temperatures, storms, and changes in weather patterns	- Rain and/or seasonal variation impacts salt production and ecosystem - Damage from fresh water contamination	- Cannot cope well with rain, flash floods, variation
Mangroves/Nypoidea e	- Mangroves mainly in estuary and lower river; Nypa fruticans along river banks. - Exposed to floods/heavy rainfall in rainy season (drop in salinity) and high salinity due to droughts in dry season - Some areas long exposed to freshwater flows; other dry up for longer periods	- Droughts/high temperatures affect flowering and fruit of Nypa fruticans and other mangrove trees - Mangrove/Nypa fruticans sensitive to extremes and changes in salinity	- Mangrove adapts faster than Nypa fruticans, but is tested by land use, urban expansion, industry, tourism
Mainstream river	- Exposed to high water levels in rainy season and low levels in dry season - Water nearby basins drained into Bang Pakong River Basin - Intrusion seawater (high sea level/drought) goes deep inland, up to 200 km into Bang Pakong River	- Plants along river banks/near river impacted by high salinity - Changes in water currents increase risk of erosion of river banks - Changes in water levels/flow (with floods) affect (migratory) fish and aquatic animals	- River is large and able to cope with local changes - Dam to push back salt water during high sea level (but causes conflicts)
Tributary/canals	- System exposed to droughts/low water levels in dry season and high levels (floods) in rainy season. - Seawater (high sea level, drought) goes deep inland, incl. tributaries and canals	- Some branches/canals dry up during drought and/or cause floods in large areas in rainy season (affect species) - Water quality wanes when water level low - Species/aquatic animals sensitive to salinity	- Dam and water gates to manage water but cannot prevent impact extremes/ changes
Islands/oxbows	- Islands and oxbows exposed to low water-levels/droughts in dry season and high water-levels/floods in rainy season - Changes in water currents - High salinity levels in dry season	- Floods, droughts and change in water currents affect local conditions - High salinity level affects local plant and animal communities.	- Dynamic system used to change - Takes longer to recover from high salinity
Na Kha Wang rice system	- Traditional rice/aquaculture system near river exposed to floods, droughts, seasonal variation - System exposed to saltwater intrusion (especially dry season)	- Sensitive to droughts (not enough water for in-season rice), long flood periods (damages rice, fish/shrimp escape), seasonal variation (affects flowering/sprouting, harvest time) - High temperatures affect growth/lead to death raised aquatic animals - High salinity damage to rice/pest outbreaks	- Although system is sensitive to climatic change, improved management can mitigate impact
Ditches orchards	- Exposed to floods, drought, high temperature and seasonal variation - Area vulnerable to storms/harsh winds - Saltwater intrusion leads to high salinity	- Floods/drought periods damage plants; weather change affect flower (fruit) setting - High temperatures affect culturing animals in ditches and lead to pest/disease outbreak - Trees fall/fruits damaged (storms) - Droughts/high salinity affect aquaculture	- Farmers well informed and know how to adapt, but frequent impacts affect income

Flood plain (Tung Pak Phlii)	- Exposed to droughts, floods, high temperature - Saltwater intrusion into tributaries due to high sea level/droughts - Large open plains exposed to storms/winds - Water diverted from central region and Bangkok metropolitan area	- Areas may dry up for longer periods - Droughts/high temperature increase risk field fires (due to hay burning) - High average temperature impact rice (growth, flowering/sprouting seeds) - Open plains sensitive to storm (big trees) - Sensitive to prolonged floods, affecting water quality (agricultural chemicals)	- Dam to push back saltwater during high sea level (but causes conflicts) - Irrigation system, but lacks in efficiency and good participation

5.1.3 Overall vulnerability

Baseline conversation risk and climate change vulnerability scores and status are summarized in Table 7.

Table 7: *Vulnerability assessment of different type of habitats relevant to Bang Pakong River Wetland*

	Location	Baseline conservation risk		Climate change vulnerability	
		Score	Status	Score	Status
1	Estuary	2.3	H	2.5	H
2	Salt farms	2.2	M	2.3	H
3	Mangrove forests	2.1	M	1.9	M
	Nypoideae forests*	2.2	M	2.5	H
4	Mainstream river	2.2	M	2.2	M
5	Tributary/canal system	2.2	M	2.3	H
6	Islands/oxbows	2.4	H	2.2	M
7	Na Kha Wang rice system	2.3	H	2.0	M
8	Ditches orchards	2.3	H	2.0	M
9	Flood plains (Thung Pak Phlii)	2.2	M	2.3	H

Note: risk categories are Very Low (1.0- 1.4), Low (1.5-1.8); Moderate (1.9-2.2); High (2.3-2.6); Very High (2.7-3.0); since mangrove and Nypoideae forests differ in their vulnerability, scores and status are indicated separately.

All habitats are at risk at present and face additional risks due to climate change in the future. They can roughly be divided into the following categories:

- **High vulnerability**. This mainly applies to the larger estuary area. The estuary already has a high baseline conservation risk due to pollution and activities in the area and this will be further compromised by a high climate change vulnerability, with specific risks of changes in salinity levels, storms/harsh winds, and erosion.
- **Medium-high vulnerability**. Here we can make a distinction between two types of habitats.
  - Salt farms, Nypoideae forest (both in the estuary), and the tributary/canal system and flood plains are all presently moderately vulnerable, but vulnerability may increase over time due to the impacts of climate change. Particularly true for Nypoideae forests.
  - Islands/oxbows, the Na Kha Wang rice system, and ditches orchards are currently at high risk, but seem to be able to mitigate (to some extent) further impact of climatic change, partly due to natural capacity to adapt (islands/oxbows) or due to management practices (Na Kha Wang rice system, ditches orchards).
- **Medium vulnerability**: The mainstream river and mangrove forests are both under pressure, but relatively less compared to most other systems; these habitats cover large and diverse areas, while management/conservation practices help them to cope with changing climatic conditions.

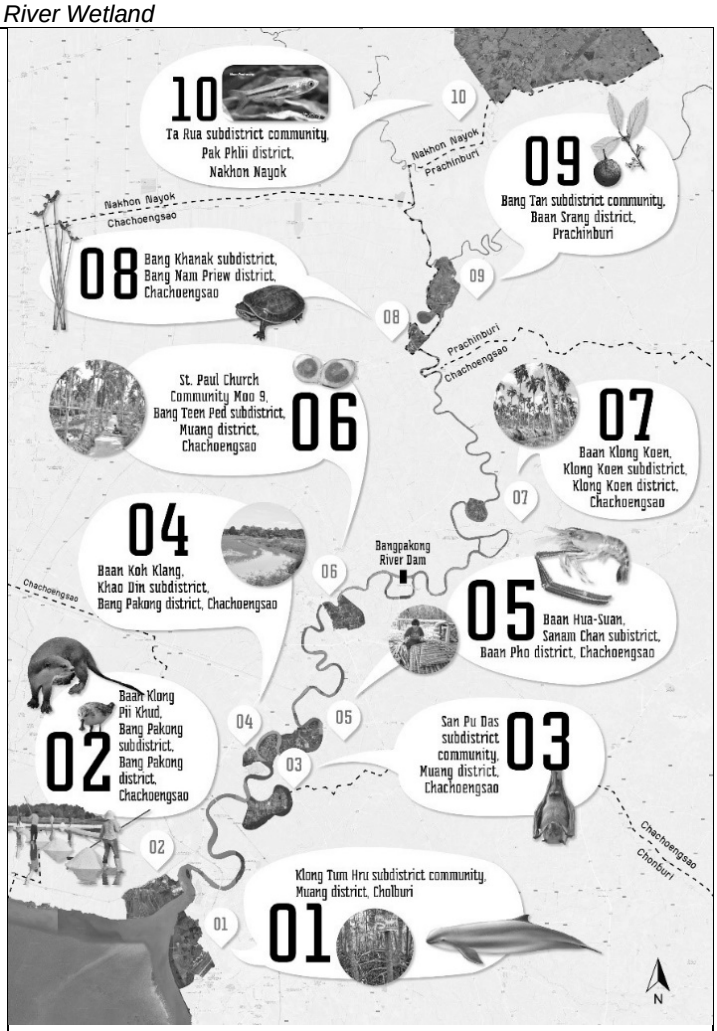
Differences in assessment scores between habitats are small, suggesting a need for further assessment and regular monitoring of ecosystem risk.

5.2 Livelihood vulnerability

The focus of the assessment was on Bang Pakong River Wetland, but to emphasize the connectivity of the wetland with the wider landscape, the assessment team included communities in Nakhon Nayok River Wetland, the lower part of the Central Plains of Thailand Wetland, and the Upper Gulf of Thailand Wetland. Communities were selected based on habitat types. Table 8 presents the selected 10 communities with key characteristics and locations, starting with those close to the estuary and then moving up along the Bang Pakong River; most of them are from Chachoengsao, others are resource-dependent villages in the wetlands of Chonburi, Prachinburi and Nakhon Nayok.

Table 8: *Key characteristics of selected communities in the Bang Pakong River Basin, with a focus on Bang Pakong River Wetland*

1. **Klong Tum Hru Subdistrict Community** Estuary/mangrove forest with Irrawaddy dolphins, mudskippers, monkeys; aqua-nursery and mangrove rehabilitation.
2. **Baan Klong Pii Khud** Estuary delta, river-banks, and salt fields; rest area for migratory spoon-billed sandpiper, painted storks; smooth-coated otter.
3. **San Pu Das Subdistrict Community** Next to main river, small scaled fishery activities and Lyle's flying fox in area.
4. **Baan Koh Klang** On island (canals on all sides); linked to main river with stretch of *Nypa fruticans* forest; "Na Kha Wang" rice system with aquaculture (brackish/saltwater)
5. **Baan Hua-Suan** Abundant *Nypa fruticans* (used for multiple purposes), mixed shrimp-culture where linked to river.
6. **St. Paul Church Community Moo 9** Homes at riverbank (mangrove forest); system to cope with water near homes at high tide, ditches orchards (betel, coconut, vegetables).
7. **Baan Klong Koen** Canal system/ponds linked to ditches orchards, good for (famous) mangoes.
8. **Bang Khanak Subdistrict** Flood plain, Klong Saen Saeb estuary, rice fields/mixed agriculture; Siamese box terrapin/pond turtle; most Juncellus inundates C.B. Clarke plants before, now rare.
9. **Bang Tan Subdistrict Community** Prachinburi and Nakhon Nayok rivers form Bang Pakong River; rice farming and aquaculture; Indian willow (*Salix tetrasperma Roxb.*), *Hydnocarpus* (rare).
10. **Ta Rua Subdistrict Community** Large plain facing surface run-off; rice pro-water type; rest-area for migratory black hawks; Somphongs's rasbora.



5.2.1 Resource dependency

An assessment was made of key wetland resources in the 10 communities by asking women and men to prioritize their top 10 wetland resources; the results are presented in Table 9A (men) and 9B (women) for each community, starting with those close to the estuary and then moving upstream to slightly higher located areas (see also Annex 5). Based on the initial list of resources in Thai, about 60 resources/living species were identified; however, many of these names referred to the same species in English (although there may local differences within species). The prioritized resource can be clustered into 14 groups. These groups represent aquatic species

(fish, shrimp, crab, shellfish), non-cultivated trees/plants (mangrove, *Nypa fruticans*, flood plain trees, grassland and forest), cultivated trees/plants (fruit trees, vegetables, rice) and other (animals, salt). In general, men and women identified similar resources, and although there were some priority differences, overall results were similar.

Table 9A: *Resource ranking by men in 10 communities in the Bang Pakong River Wetland*

Rk	Klong Tum Hru Subdistrict Community	Baan Klong Pii Khud	San Pu Das Subdistrict Community	Baan Koh Klang	Baan Hua-Suan	St. Paul Church Community Moo 9	Baan Klong Koen	Baan Khanak Subdistrict Community	Bang Tan Subdistrict Community	Ta Rua Subdistrict Community
1	Saltwater crab	Nypa fruticans	Krill	White shrimp	Giant freshwater prawns	Nypa fruticans	Coconut	Rice	Naked catfish	Fish
2	Meder mangrove crab	Rhizophora mucronata	Giant freshwater prawns	Whiteleg shrimp	Greasy back shrimp	*Bruguiera gymnorrhiza*	Mango	Giant freshwater prawns	Wallago attu	Forest
3	Tiger shrimp	Xylocarpus granatum	Saltwater crab	Saltwater crab	Small shrimp	Coconut	Betel palm	Striped snakehead fish	Luciosoma	Catfish
4	Tiger shrimp	Meder mangrove crab	Giant sea perch	Giant sea perch	Soft-shelled shrimp	Betel palm	Fish	Common silver barb	Danio	Marian Plum
5	Whiteleg shrimp	Saltwater crab	Whiteleg shrimp	Long-whiskered catfish	Whiteleg shrimp	Betel	Nypa fruticans forest	Minnow	Giant sea perch	Mango
6	Greasy-back shrimp	Suaeda maritima	Long-whiskered catfish	Mullets	Mullets	Mango	Vegetables	Marsh clam/ Asian Clam	Giant freshwater prawns	Grassland
7	Long-whiskered catfish	Salt	Croakers	Meder mangrove crab	Naked catfish	Banana	Lemongrass	Water crest	Rice field	Black hawk
8	Mullets	Shells	Mullets	Tiger shrimp	Giant sea perch	Mullets	Fireflies	Lotus stem	Salix tetrasperma	Rice
9	Tilapia	Mangrove forest	Soft-shelled shrimp	Giant freshwater prawns	Long-whiskered catfish	Giant freshwater prawns	Ditches orchard	Sesbania javanica	Chaulmoogra	Buffalo
10	Threadfin	Smooth-coated otter	Naked catfish	Long-whiskered catfish	Serrated mud crab	Naked catfish	Rice field	Duck	Bamboo	Vegetables

Aquatic species				Non-cultivated trees/plants					Cultivated trees/plants			Other	
Fish	Shrimp	Crab	Shellfish	Mangrove forest	Nypa fruticans	Flood plain trees	Grassland	Forest	Fruit trees	Vegetables	Rice	Animal	Salt
30 x	20 x	8 x	2 x	4 x	3 x	3 x	1 x	1 x	11 x	7 x	4 x	5 x	1 x

Table 9B: *Resource ranking by women in 10 communities in the Bang Pakong River Wetland*

Rk	Klong Tum Hru Subdistrict Community	Baan Klong Pii Khud	San Pu Das Subdistrict Community	Baan Koh Klang	Baan Hua-Suan	St. Paul Church Community Moo 9	Baan Klong Koen	Baan Khanak Subdistrict Community	Bang Tan Subdistrict Community	Ta Rua Subdistrict Community
1	Saltwater crab	Nypa fruticans	Rice	Nypa fruticans	Giant freshwater prawns	Nypa fruticans	Mango	Rice	Rice	Fish
2	Nypa fruticans	Rhizophora mucranata	Nypa fruticans	Ivy gourd, Coccinia	Greasy back shrimp	Bruguiera hainesiixc.G .Rogers	Coconut	Giant freshwater prawns	Naked catfish	Forest
3	Suaeda maritima	Xylocarpus granatum	Saltwater crab	Meder mangrove crab	Small shrimp	Giant freshwater prawns	Nypa fruticans	Striped snakehead fish	Wallago attu	Catfish
4	Meder mangrove crab	Meder mangrove crab	Giant sea perch	Green tidal crab	Soft shelled shrimp	Naked catfish	Rice	Common silver barb	Luciosoma	Marian plum
5	Tiger shrimp	Saltwater crab	Long-whiskered catfish	Krill	Whiteleg shrimp	Krill	Vegetables	Minnow	Danio	Mango
6	Tiger shrimp	Suaeda maritima	Mullets	Giant freshwater prawns	Mullets	Striped sea catfish	Fish	Marsh clam/ Asian clam	Giant sea perch	Grassland
7	Whiteleg shrimp	Salt	Meder mangrove crab	Saltwater crab	Naked catfish	Dolphins	Nypa fruticans	Water crest	Giant freshwater prawns	Red hawk
8	Greasy back shrimp	Shells	Tiger shrimp	Giant sea perch	Giant sea perch	Mullets	Betel palm	Lotus stem	Salix tetrasperma	Rice
9	Long-whiskered catfish	Mangrove forest	Giant freshwater prawns	Whiteleg shrimp	Long-whiskered catfish	Coconut	Grown lemon grass	Sesbania	Chaulmoogra	Buffalo
10	Mullets	Smooth coated otter	Long-whiskered catfish	Long-whiskered catfish	Serrated mud crab	Betel palm	Fireflies	Ducks	Bamboo	Vegetables

Aquatic species				Non-cultivated trees/plants					Cultivated trees/plants			Other	
Fish	Shrimp	Crab	Shellfish	Mangrove forest	Nypa fruticans	Flood plain trees	Grassland	Forest	Fruit trees	Vegetables	Rice	Animal	Salt
26 x	18 x	10 x	2 x	4 x	7 x	3 x	1 x	1 x	7 x	9 x	5 x	6 x	1 x

Because the people are living in different ecological areas, the top 10 wetland resources varied from community to community, but there are some clear patterns that can be derived:

- Aquatic species are the most important ones in the Bang Pakong River Wetland composing almost 60% of all key resources. Crabs (10% of key resources, including Meder mangrove crab, saltwater crab, green tidal crab, serrated mud crab) are especially popular in the estuary and the lower part of the Bang Pakong river. Shrimp (20% of key resources, including tiger shrimp, whiteleg shrimp, greasy back shrimp, krill, softshell shrimp, small shrimp, white shrimp and freshwater prawns) can be found along the estuary and upstream the river and is most popular in the central part of the wetland. Fish (30% of key resources, including catfish, sea perch, mullets, snakehead, barbs and other species) is being caught throughout the wetland but increases in priority ranking in upstream communities.
- Among the non-cultivated trees/plant species, mangrove species and *Nypa fruticans* found in the estuary and lower Bang Pakong area are highly valued (*Nypa fruticans* was mentioned more often by women than men). In communities that mentioned mangrove species or *Nypa fruticans*, they were among their top three resources. Flood plain trees, including rare species as *Salix tetrasperma* (Indian Willow) and *Hydnocarpus* (Chaulmoogra), grassland (livestock feed) and forests are mainly found in the central and higher located areas.
- Cultivated species include fruit trees (mango, coconut, betel, banana, marian plum), vegetables (lotus, sesbania, water crest, lemon) and rice are highly valued resources in the central and higher located areas; some vegetables (*Suaeda maritima*, Ivy gourd), however, are collected in the lower Bang Pakong area. Rice cultivation is more dominant in the higher areas, and generally valued higher by women than men; in three communities, women even prioritized rice as their most important resource, including in San Pu Das in the lower Bang Pakong River area (while not being mentioned by men in that community).[42]
- Salt is a valued livelihood resource by women and men in Bang Klong Pii Khud. Animals, such as smooth-coated otter, dolphins, fireflies, ducks, hawks and buffalo are also valued by several communities, either for their value for tourism (otter, dolphin, hawks) or agriculture (ducks/buffalo); it is slightly surprising that dolphins were mentioned by St. Paul Church Community Moo 9 (only by women), which is located in the central area and not by the communities near the estuary.

For men, the prioritization seemed mainly based on economic value or good selling price, followed by the benefits in terms of household consumption. Easy access, livelihood benefits and utility purposes seem to be the main considerations in women's prioritization of resources, as expressed by the high valuation of women of *Nypa fruticans* and rice. Besides economic criteria, both women and men took conservation values into account, e.g. in relation to dolphins, fireflies, and rare tree species in the flood plains.

Resource distribution and seasonal calendar. The distribution of resources is closely linked to the different habitats that can be found near each community. Key resources differ due to various biophysical and hydrological factors such as the highs and lows of the water level, the amount of

[42]In a way this is surprising, as one would expect rice to be mentioned in Baan Koh Klang (Na Kha Wang rice system) instead of Saan Pu Dan Subdistrict Community

fresh or salt water and the amount of rain. Table 10 provides a summary table of the main habitats in the Bang Pakong River Wetland with key resources as reported by community members.

Four areas can be distinguished in the wetland: 1) The river mouth is characterized by the estuary, salt farms and mangrove forest. These areas are home to various aquatic species including flagship species with tourism value such as Irrawaddy dolphin and spoon-billed sandpiper. 2) Mangroves are mainly found near the estuary, but also to some extent along the river. The lower part of the river is mainly the domain of Nypoideae forest (*Nypa fruticans*) and includes various islands/oxbows (up to the lower central area), with Lyle's flying fox as main tourist attraction. Na Kha Wang rice cultivation, suitable for brackish water species, is practiced here – and can only be found in Khao Din sub-district (below the dam). 3) Further upstream, ditches orchards are found in the central area close to the river (below and above the dam). The central area includes the flood plains and is home to various fish species. The upper part of the flood plain in Pak Phlii district of Nakhon Nayok Province is a freshwater wetland, where the very rare rasbora species is found. 4) The Bang Pakong River, branches and canals can be found throughout the landscape; these are home to various species depending on salinity and/or water levels.

Table 10: *Key resources found by communities in different habitats of Bang Pakong River Wetland*

	Habitats	Prioritized species
River mound	Estuary	Irrawaddy dolphins (*Orcaella brevirostris*), mudskipper (*Periphthalmodon schlosseri*), long-tailed macaque (*Macaca fascicularis*), serrated mud crab (*Scylla serrata*), *Scylla oceanica* (Dana), mangrove crab (*Sesarma* mederi), cockle (*Anadara granosa*), stripped sea catfish (*Plotosus lineatus*)
	Salt farms	Spoon-billed sandpiper, fish, shrimps, *Sueda maritima*, painted stork (*Mycteria leucocephala*) other types of birds, smooth-coated otter
	Mangrove forest	*Bruguiera gymnorrhiza*, *Rhizophora*, *Xylocarpus granatum*, serrated mud crab (*Scylla serrata*), *Scylla oceanic* (Dana), mangrove crab (*Sesarma* mederi), *Sueda maritima*
Central – Low	Nypoideae forest	Nypoideae (Nypa fruticans), serrated mud crab (*Scylla serrata*), *Scylla oceanic* (Dana), mangrove crab (*Sesarma mederi*), green tidal crab (*Varuna litterata*)
	Islands/oxbows	Nypoideae, fish, shrimps, *Bruguiera cylindrica* (L.) Bume, Lyle's flying fox
	Na Kha Wang rice system	Rice, crab, stripped snake-head fish, catfish, Nile tilapia, snapper, shrimps,
High – Central	Ditches orchards	Vegetables, mango, marian plum, coconut, areca nuts, betel, catfish, Nile tilapia, snapper, lemon grass, lotus stems, morning glory
	Flood plains	Rice, long-whiskered catfish (*Mystus gulio*), naked catfish/Bagrid catfish, anchovy, striped snake-head fish, carp, *Wallago attu*, silver rasbora, blue danio, catfish, tilapia (*Oreochromis mossambicus)* and Nile tilapia, freshwater prawns, various birds, black hawk
Throughout landscape	Mainstream river	Black tiger shrimp, tiger prawns, banana shrimp (*Fenneropenaeus merguiensis*), *Metapenaeus affinis*, krill, giant freshwater prawns, whiteleg shrimp, soft shelled shrimp, long-whiskered catfish (*Mystus gulio*), *Bahaba taipingensis*, snapper, mullet, naked catfish/ Bagrid catfish, anchovy, striped snake-head fish, carp, *Wallago attu*, silver rasbora, blue danio, catfish, tilapia (Oreochromis mossambicus), Nile tilapia
	Tributary/canal system	Black tiger shrimp, tiger prawns, banana shrimp (*Fenneropenaeus merguiensis*), *Metapenaeus affinis*, fireflies, long-whiskered catfish (*Mystus gulio*), snapper (*Lates calcarifer*), mullet, naked catfish/Bagrid catfish, anchovy, *Corbicula arata*, morning glory, lotus stem, *Sesbania*, striped snake-head fish, carp, tilapia (*Oreochromis mossambicus*)

The utilization characteristics for different habitats and resources also depend strongly on seasonal characteristics. Hydrological maps were made based on activity calendars in each community, i.e.: saltwater area, brackish water area (below and above the dam) and fresh water area (see Figure 13 A-D).

Klong Tum Hru Subdistrict Community and Baan Klong Pii Khud are near the estuary. These communities mainly depend on salt farming, which consists of several steps of transforming salt water into salt. The process starts with the preparation of the land in October, after which the water is let in and dried in several steps and moving it to different fields until the salt starts to crystalize and it can be harvested. These cycles can be repeated until the rainy season starts mid-May. While this is their main activity, they are also engaged in various other activities which

are not indicated in the calendar, such as culturing blood clams/mussels and catching fish by pontoon (November-April), collecting and harvesting *Nypa fruticans* leaves (year-round), flowers (February-July), and fruit (October-December), fishing in coastal/estuary waters and providing Irrawaddy dolphin watching services to tourists.

San Pu Das Subdistrict Community, Baan Koh Klang, Baan Hua-Suan, and St. Paul Church Community Moo 9 are all located below the Bang Pakong Dam. Activities centre around two seasons: June-November (freshwater season) and December-May (saltwater season). During the freshwater season, rice is cultivated using in-season rice and through the Na Kha Wang rice system; the latter starts with land preparation/planting in June and harvests in November and is combined with the cultivation of different types of tiger prawns and whiteleg shrimp. People also collect white beans during the freshwater season. At the start of the saltwater season (December/January), communities try to regulate the salinity level by closing the water gates to prevent salt water from entering the canals and narrowing the gaps of the dam's shutters to slow down the breach of salt water into the fresh water area. They also release freshwater from the dam to push back the saltwater. Tiger prawns and whiteleg shrimps that are being cultured during this season have slightly higher salt tolerance. In addition, people catch krill and crabs during the saltwater season. *Nypa fruticans* is being collected/harvested throughout the year.

Baan Klong Koen, Bang Khanak Subdistrict, and Bang Tan Subdistrict Community are located above the Bang Pakong River Dam. Similar to below the dam, there are two seasons. May-December is the natural freshwater season, in which off-season rice is cultivated in several rounds; planting starts in May with a first crop being harvested between June-August and a second crop between November-February. Janunary-April is the saltwater season. The dam gates are opened slightly, to slow down the salt water coming in and to let in the freshwater from the dam to push out the saltwater. Before the saltwater comes, the communities need to lift the trenches in the orchards to store freshwater for use during the salt-water season. Mangoes are being grown/harvested in ditches orchards from February up to June, with betel in July. At the same time, multiple types of fish can be raised on a year-round basis in the ditches.

Finally, Ta Rua Subdistrict Community is situated in the freshwater area of Nakhon Nayok. In season water rice varieties are grown from April to December. In October, the water gates are closed to keep water in the fields, which are drained by mid-November. Multiple types of fish species can be raised throughout the year.

Livelihood activities of different communities in the wetland are closely interlinked with the seasonal conditions and dynamics, whether it is the saltwater, brackish or freshwater areas. This makes these communities highly vulnerable to changes in climatic conditions and weather patterns, especially if they are highly specialized in their livelihood. Diversifying activities and integrated systems may help to overcome some of the obstacles that communities face.

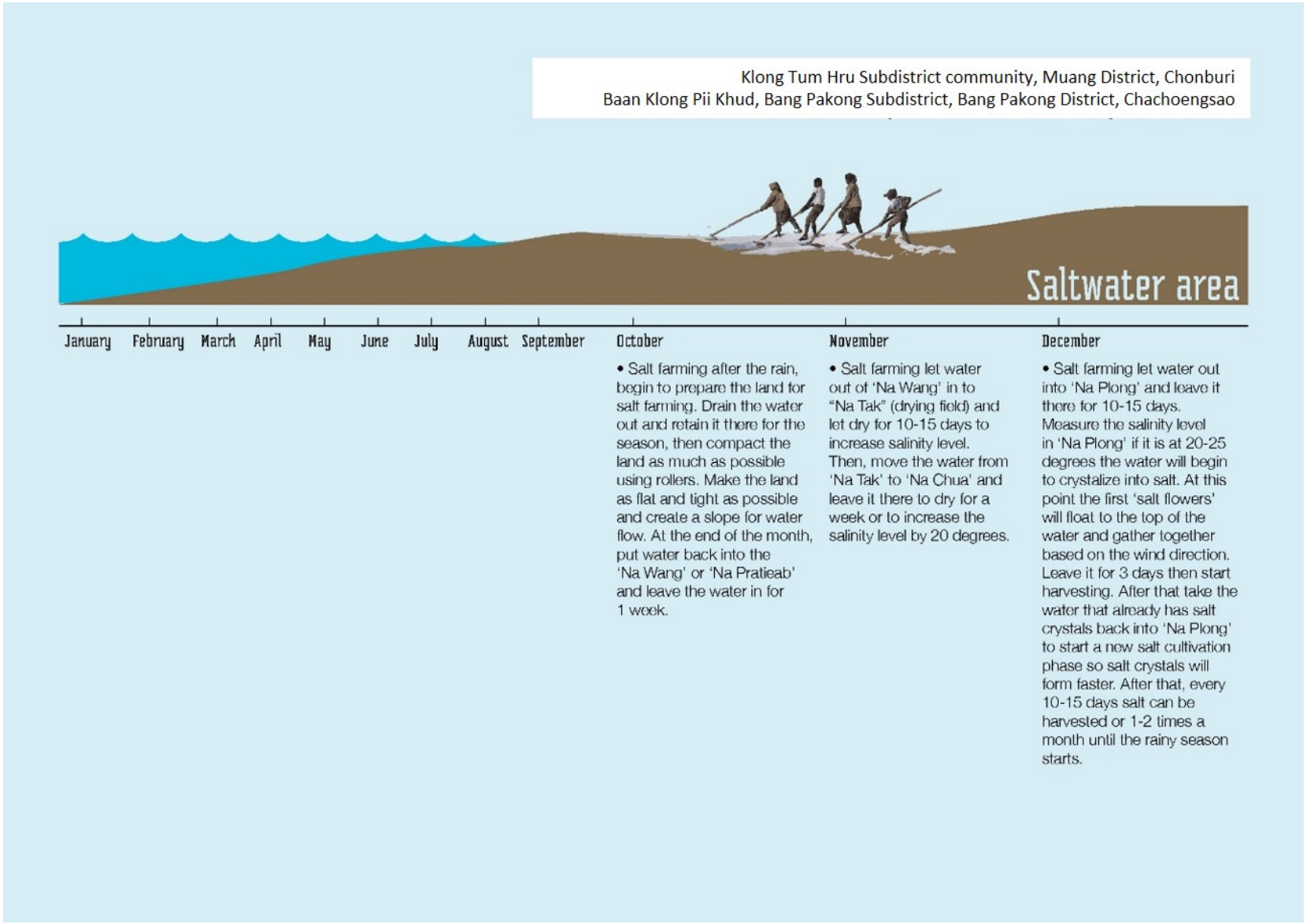


Figure 13A: *Seasonal calendar for salt water area in Pang Pakong River Wetland (Community 1,2)*

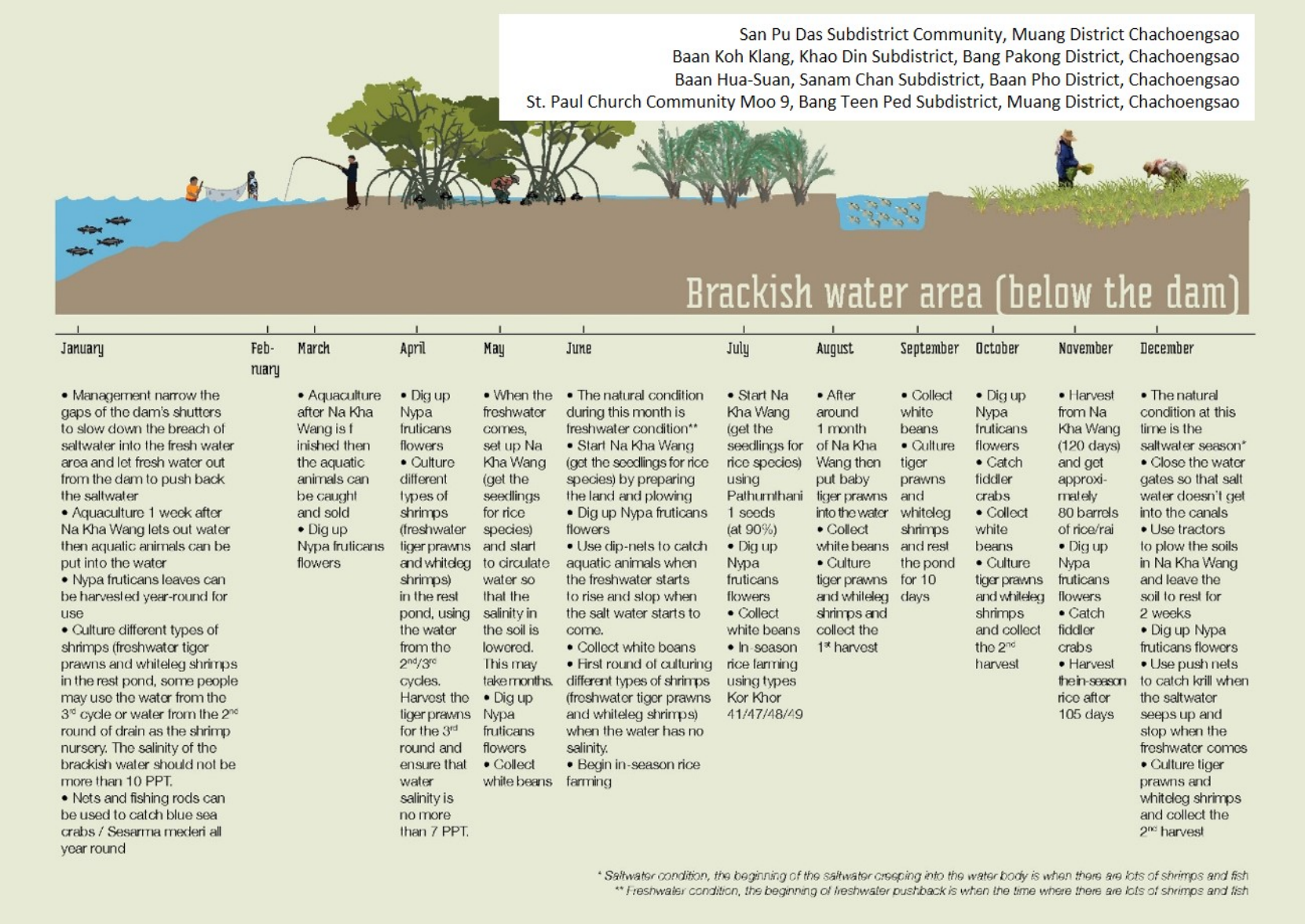


Figure 13B: *Seasonal calendar for brackish water area (below the dam) in Pang Pakong River Wetland (Community 3-6)*

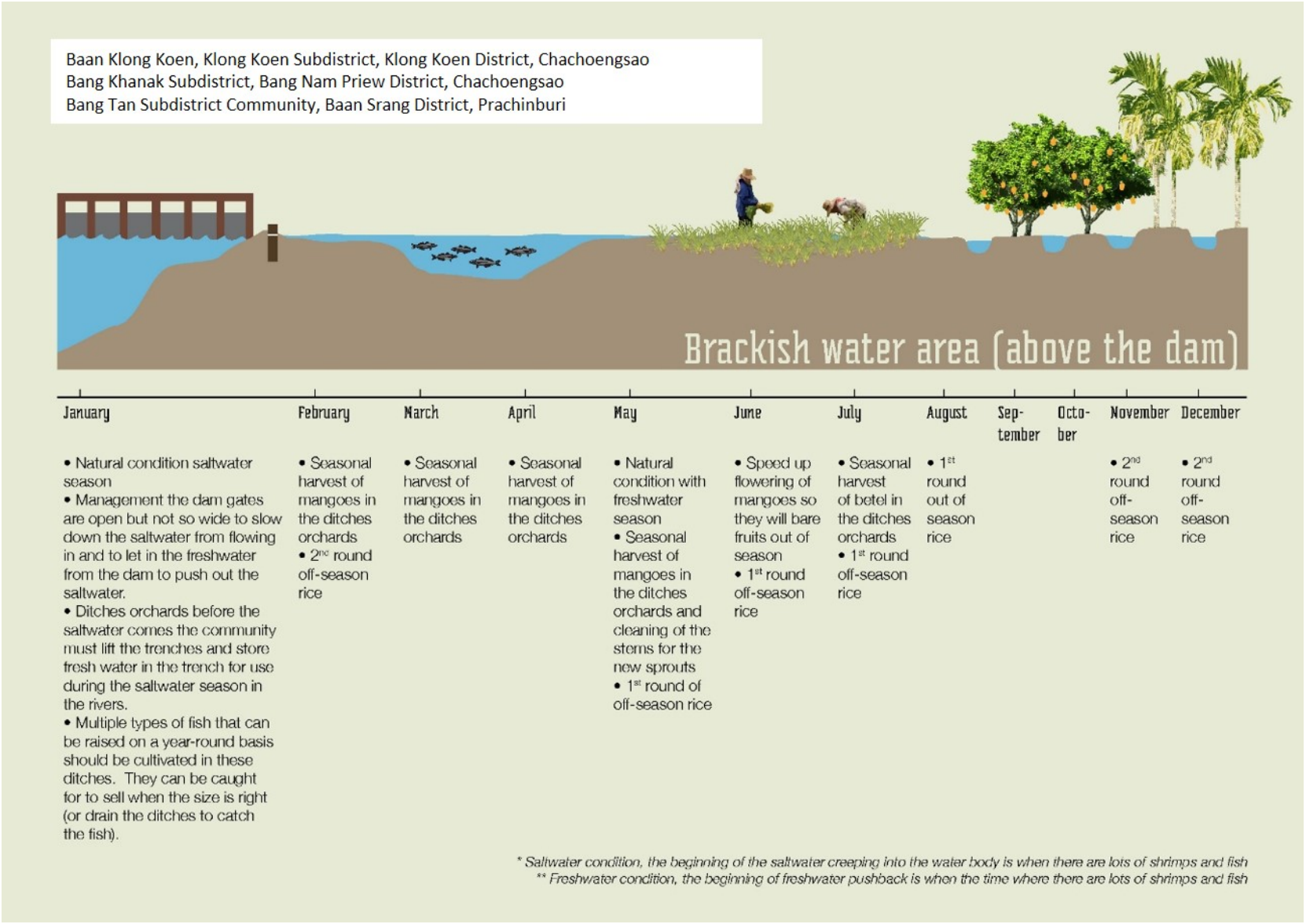


Figure 13C: *Seasonal calendar for brackish water area (above the dam) in Pang Pakong River Wetland (Community 7-9)*

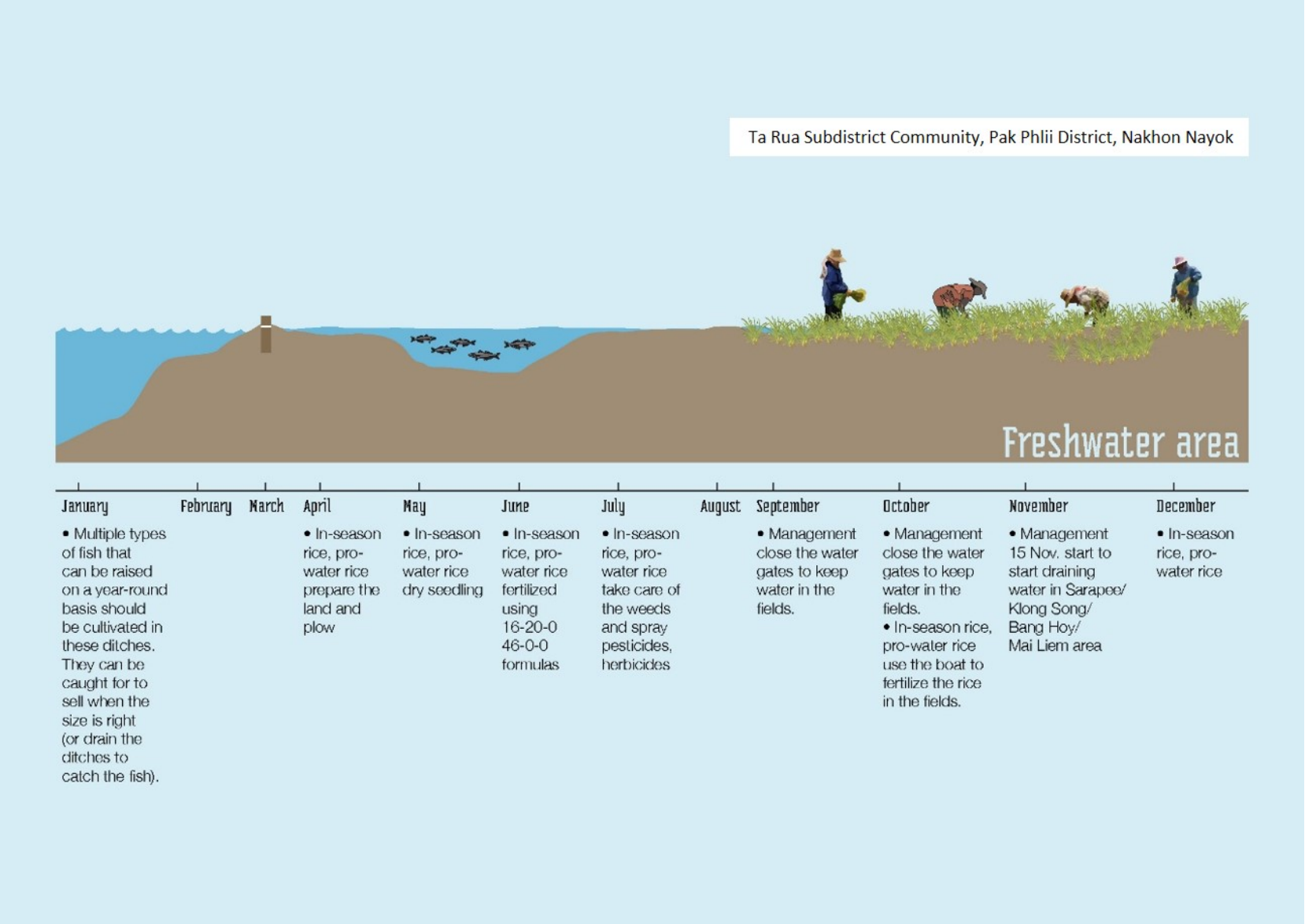


Figure 13 D: *Seasonal calendar for fresh water area in Pang Pakong River Wetland (Community 10)*

5.2.2 Climate change impacts

The lives and livelihoods of people in the Bang Pakong River Wetland are directly affected by changes in weather patterns and climate change. People from the selected communities were asked to recall extreme weather events and their impacts over the past 10 years. They distinguished four type of events: heavy floods, extreme droughts, typhoons/storms, and irregular weather (rainfall) patterns. Table 11 summarizes the data.

Table 11: *Historical timeline of extreme weather events and impacts by women and men in the Bang Pakong River Wetland*

Weather events	Year	Men's perspectives on impact	Women's perspectives on impact
Heavy flood	2011 2013	- Houses flooded, rice fields damaged - Ditches orchards damaged (flood plains receive flood water from Bangkok) - Freshwater remains longer in canals than normal (salt-water cannot come in) - Affects transportation - Landslides at river banks	- Houses flooded - Agricultural equipment, rice fields and ditches orchards damaged - Fish in fish cages affected
Extreme drought	2013 2014 2015	- Rice damaged and needed to be replanted several times - Salt water seeping; salt water build-up in canals and mangrove forests - Thousands of trees died due to high salinity - Shrimps/fish in farms and fish cages died - Salinity level led to insect outbreaks and trees were damaged** - Lack of water	- Water salinity too high for Na Kha Wang rice system. - Many trees died with salt found at roots - Plants like papyrus near riverbanks died due to salinity - Insect outbreaks in ditches orchards and coconut - Leaf-eating black worms in mangrove forest, especially *Avicennia alba* - Other worm outbreaks more frequent
Typhoons, storms	2014 2015	- Trees fell, houses damaged	- Facilitates fires (due to hay burning) to spread in fields
Irregular weather (rainfall) patterns*	2015 2016 2017	- Low rice productivity (too much rain or rain in harvest season) - Delay in saltwater circulation (30-45 days) resulted in low salinity levels in canals, affecting animals that need salt water, such as krill, as well as the people who trap them for a living.	- Low rice productivity (too much rain or rain in harvest season) - Outbreaks of plant diseases/pests - More and bigger mosquitoes are found than before

*Refers to monsoons, continuous/heavy rain, non-seasonal rain, no rain in raining season, and other unpredictable conditions

**Arid air/saline soils and insect outbreaks occurred in same period but may be unrelated.

There were some differences among observations between communities, with those in lower parts having more salinity problems due to droughts, those in upper lower (orchard) areas facing insect/disease outbreaks, floods and river bank erosion, and the central plains being confronted with heavy storms and spread of fires during dry season (due to burning straw). According to their recollection, extreme events such as floods, extreme droughts, typhoons/storms and irregular weather patterns have become more common. For example, floods were reported as becoming more frequent and regular due to rainfall, although the divergence of floodwater via the canals of Bangkok metropolitan area was also mentioned as a possible explanation – and would suggests the interrelatedness of impacts in distant areas. An increase in typhoons/storms would be surprising, given that the frequency of heavy storms between 1952 and 2012 decreased from 6 to 2 per decade (see Section 2.2); recent and follow up data may provide more insight to what extent this observation by the community is a coincidence or part of a new trend. Droughts/floods and irregular weather patterns are highly problematic considering the dependency on fresh and/or saltwater and importance of timing for most of people's livelihoods.

5.2.3 Current and future coping

Taking past extreme weather events and impacts into account, men and women from selected villages were asked how they coped with these events, and how they would deal with them in the future. Their responses are summarized in Table 12A-B.

People already employ a diversity of mechanisms to cope with the impact of extreme events such as floods, droughts, heavy storms and irregular weather patterns; although there were some differences between men and women, these were minor (Table 12A). The outcomes of the ranking in the assessment showed that so far, most response strategies are working relatively well, but they do vary in level of success. Coping mechanisms that received low success scores are short-term fixes such as repairing houses, replanting after the damage or even requesting local government agencies to assist in terms of compensation for flood damage or fires. These methods receive low scores because they are only temporary solution and the same requests will be made every time there is a disaster. At the same time, they may not receive the support they ask for from the government agencies.

Adaptation methods that received medium success scores are those that can withstand the problem for some time. These include: setting up a local emergency crisis response unit; changing aquaculture equipment and changing aquaculture species to ones that can live naturally in freshwater and brackish water; releasing aquatic animals (shrimp) into the ponds in appropriate numbers; digging a backup freshwater storage pond; dredging the ditches and canals; selecting appropriate rice varieties for cultivation; and establishing conservation measures for rivers, ponds or mangrove forests. From the discussion, it was determined that to achieve this level of success, knowledge is required and the time needed for rehabilitation or change may not be as fast as they would like it to be. These measures would still require high investments and most would require partners and/or alliances.

Adaptation methods with high success scores were the ones that offered long-term solutions to the problem, such as growing a variety of vegetables and plants, implementing integrated/mixed farming, and converting to organic farming and natural aquaculture methods. Through groups discussions, several factors were identified that will contribute to success, including knowledge, collaboration and development of a learning network and community level management. This will take a relatively long time and requires ongoing action.

In terms of future coping (Table 12B), people have elaborated on more successful approaches and proposed various mechanism/strategies on how to cope with future impacts due to climate change. Measures will remain a mixture of short-term and longer-term solutions. Some of the impacts suggest that a more structural and comprehensive plan for the area will be needed, which takes the different impacts and their interrelations into account. Moreover, besides natural phenomena, non-climate factors need to be addressed, such as the issue of pollution and waste water and unsustainable water and land use. Community members have already indicated that community and basin level agreements are needed, including regulations for monitoring, management and treatment of water, with fines for those who do not abide, and appropriate land use planning.

Table 12A: *Coping mechanisms for extreme weather impacts by men/women in the Bang Pakong River Wetland*

Extreme event / impact	Current coping mechanisms			
	Men	Success level*	Women	Success level*
Heavy floods				
Damaged houses	Fixing the house	1	Fixing the house	1
	Set up emergency handling unit for the locality	2	Set up emergency handling unit for the locality	2
Agricultural area affected	Multiple rice planting is required	2	Grow mixed plants and vegetables	3
	Dig up ditches to make walls higher	2	Reforest/replant damaged trees	3
Freshwater stays too long/longer in canals than normal	Change tools for catching different type of aquatic animals and/or change to raising freshwater species	2	Raise freshwater aquatic animals such as snappers, giant prawns, etc.	2
			Grow fast maturing vegetables after water level has gone down	2
Extreme droughts				
Rice fields damaged	Negotiate with authorities about better water management (water is being prioritized for industry)	1	Limit rice growing area and grow other crops	2
Salt water seeps up deep inland and for longer period	Change tools to catch other type of aquatic animals and raise animals that can be raised in salt water	2	Increase fish and shrimps that grow well in saline conditions in the ditches	2
Dying of trees (esp. estuary)	Set up coastal protection measures (environment protection area)	2	Set up coastal protection measures (environment protection area)	2
Shrimp in farm ponds die due to high water temperature	Dig up subordinate freshwater pond; release adequate amounts of aquatic animals (shrimp) into pond	2	Dig up subordinate freshwater pond; release adequate amounts of aquatic animals (shrimp) into pond	2
Outbreaks of insects and plant diseases	Uses pesticides	2	Grow different types of plant/use mix-agriculture in ditches orchards	3
Lack of water for consumption/use	The Municipal Office provides water for affected families	1	The Municipal Office provides water for affected families	1
Typhoons/storms				
Houses are damaged	Fix the house	1	Fix the house and make it stronger	1
Trees fall	Take care of trees near the house	1	Do not know/no response	0
Fires in the fields	Campaign to prevent burning hay	1	Do not know/no response	0
Irregular weather (rainfall) patterns				
Low rice productivity (too much rain or rain in harvest season)	Grow different types of plants and use mix-agriculture system	2	Select appropriate type of rice	3
Outbreaks of insects and plant disease	Use pesticides	1	Use pesticides	1
More and larger mosquitos	Control areas where there is water	1	Clean up and control areas where there is water	1
Low salinity of canal system due to delay in sea water circulation	Do not know/no response		Do not know/no response	
Less aquatic animals in the water	Set up conservation area in the river or mangrove forest	2	Set up conservation area in the river or mangrove forest	2

People's lives affected	Request help from local authorities	2	Request help from local authorities	2

Note: level of success on a scale of 1-3, with 1 being low and 3 being high

Table 12 B: *Coping mechanisms for future climate change impacts by men/women in Bang Pakong River Wetland*

Extreme event and impact	Future adaptation mechanisms	
	Men	Women
Heavy floods		
Damaged houses	Fix the house and make it stronger	Fix the house and make it stronger
Agricultural area affected	Reforest/replant damaged trees	Reforest/replant damaged trees with more variety
Fresh water stays too long/longer in canals than normal	Build water gates to control the water	Grow only freshwater plants in or near the water (vegetables or trees), which do not require brackish water
Extreme droughts		
Rice fields are damaged	Dig up a subordinate freshwater pond; create alternative livelihood activities, e.g. ecotourism	Alternative livelihood activities such as mixed agriculture, processed food and other products
Salt water seeps up deep inland and for longer period	Dig up a subordinate pond in ditches orchards	Dig up a subordinate pond in ditches orchards
	Rehabilitate the community's water source and set up a backup water storage system at the household level such as ponds and lakes.	Rehabilitate the community's water source and set up a backup water storage system at the household level such as ponds and lakes.
	Install water gates at the canals or water channels to prevent water flow.	Fast maturing plants before saltwater comes up; proper land-zoning for utility purpose
	Keep appropriate amounts of aquatic animals in ponds	Culture a variety of aquatic animals in the same pond as naturally as possible
Dying of trees (esp. estuary)	Set up land use planning/zoning areas.	Set up land use planning/zoning to ensure sustainability and environmental protection
Shrimps in farm ponds die due to high water temperature	Make additional water storage pond; Reduce use of chemicals in raising aquatic animals	Set up a water circulation system and make additional water storage pond; Develop a biological system for aquaculture
Outbreaks of insects and plant diseases	Learn how to use organic insecticides and pesticides	Learn how to use organic insecticides and pesticides
Lack of water for consumption/use	The Municipal Office provides water for affected families	The Municipal Office provides water for affected families
Typhoons/storms		
Houses are damaged	Fix the house and make them stronger	Fix the house and make them stronger
Trees fall	Do not know/no response	Do not know/no response
Fires in the fields	Campaign to prevent burning hay and tree stumps	Perform research to see if tree stumps can be used for value adding products
Irregular weather (rainfall) patterns		
Low rice productivity (too much rain or rain in harvest season)	Use appropriate type of rice, e.g. in-season rice for years with lots of water and light-sensitive out of season rice for years with little water	Change to rice species appropriate to the conditions of each year.
Outbreaks of insects and plant disease	Learn how to use organic insecticides and pesticides	Use mixed-agriculture system
More and larger mosquitos	Monitor and protect diseases that come with mosquitos	Remove water puddles
Low salinity of canal system due to delay in sea water circulation	Develop a water management system for the basin using participatory methods to manage and disseminate water appropriately	Develop a water management system for the basin using participatory methods to manage and disseminate water appropriately
Less aquatic animals in the water	Rehabilitate aquatic species and expand aquatic conservation area	Rehabilitate aquatic species and expand aquatic conservation area
People's lives affected	Set up a protection and disaster relief centre in locality to take care/provide timely assistance	Set up a protection and disaster relief centre in locality to take care/provide timely assistance

5.3 Species vulnerability

The impact of climate change does not only affect habitats and livelihoods but may even threaten the existence of certain plant and animal species; this may not only have consequences for the functioning of larger ecosystems, but also undermine the social systems that depend on them. Hence, six species were selected for the vulnerability assessment based on their uniqueness or status (flagship species), their role in the ecosystem (keystone species), and/or their economic relevance. The species included:

- **Somphongs's rasbora** (*Trigonostigma somphongs*)**,** a 'critically endangered' ray-finned fish species endemic to Thailand;
- **Irrawaddy dolphin** (*Orcaella brevirostris*)**,** a 'vulnerable' oceanic dolphin, which is found in a healthy population in the Bang Pakong Estuary and important for tourism;
- **Lyle's flying fox** (*Pteropus lylei*), a 'vulnerable' flying fox species in the family Pteropodidae, which plays an important role the ecosystem by spreading seeds and is a tourist attraction;
- **Spoon-billed sandpiper (***Calidris pygmaea*), a small 'critically endangered' wader which breeds in north-eastern Russia and winters in Southeast Asia, which is specifically found in the salt-farm ecosystem of the estuary;
- **Giant freshwater prawn** (*Macrobrachium rosenbergii*), a commercially important species of palaemonid freshwater prawn found throughout the tropical and subtropical areas of the Indo-Pacific region, from India to Southeast Asia and Northern Australia;
- **Giant freshwater stingray** (*Himantura* polylepis, also widely known by the junior synonym *H. chaophraya*), an endangered species of stingray in the family Dasyatidae found in large rivers and estuaries in Indochina and Borneo, though historically it may have been more widely distributed in South and Southeast Asia.

The current situation and threats for each species were assessed and discussed by experts. Key findings are presented below.

1) Somphong's rasbora are small ray-finned fish species that can only be found in the central flood plains (Thung Pak Plii). They are rare and nearly extinct. The scientific name is in honour of Mr. Somphong Lekari who was one of the people to initiate an export market for decorative fish in Thailand.[43] They live in schools and feed on small aquatic animals from mid-depth water to the water surface. They are known to migrate to flood areas and lay 5-10 eggs a day, which must remain in the fields for months before hatching. Their life cycle is about 3-4 years, which may be a factor in its sharp population decrease. Tung Pak Phlii is like a grassland with an underground water source with oxygen. If the area changes its floating rice paddies to out-of-season rice or if rice is cultivated many times a year, then this will have a negative impact on its habitat. Droughts would be serious problem affecting the habitat of these fish species, while an increase in salinity levels may directly affect them; higher temperatures are a risk since they affect egg-laying behaviour and environmental conditions for the eggs.

2) Irrawaddy dolphin is an important and prominent marine species, which inhabits the Bang Pakong Estuary (with freshwater, saltwater and brackish water). Irrawaddy dolphins rely on a variety of small benthic species such as barnacles, worms and arthropods, which also feed various fish species of all sizes. Data for the upper part of the Gulf of Thailand, reports the population of Irrawaddy dolphins to be approximately 250, although monthly monitoring and photo sightings since 2014 have only counted 89. The Bang Pakong Estuary is home to 30-50 dolphins. The main threat in the Upper Gulf of Thailand is poor quality seawater due to discharge water from industrial sources or from the community directly into the main river. The

[43] http://siamensis.org/species_index?nid=36238#36238--Species%20:%20Trigonostigma%20somphongsi

dolphins do no longer come into the main river itself because of a decrease in food and increase in river activities. At present, only one calf is found in a group of 10-15 dolphins, but this also depends on the sex ratio and the health of the dolphins in the group. Dolphins are sensitive to excessive amounts of freshwater. A sudden increase of freshwater from the rain or drained from above the dam to the estuary causes can stress the dolphin's health. More fresh water may impact their skin and eyes and their soft tissue may be damaged. It will affect their ability to find food. However, if less freshwater flows into the sea than normal, it is likely to affect their food sources. Currently 6-8 months of the year have lots of freshwater at the estuary. Floods and droughts as result of climate change may exacerbate these extremes. Changes in the hydrological flow of water is the main factor limiting the existence of dolphins within the habitat boundaries. The dolphins can withstand the heat from temperature changes within a five degree range, but if it is too high, they will get blisters on their skin; heat waves dramatically increase the health risk. Dolphins can adapt to changes (e.g. by moving to other areas), but a reduction in food supply can make them stressed. The concentration of pollutants is the biggest problem; so far, there are no clear regulations for protecting the dolphins.

3) Lyle's flying fox has recently been included as a protected wildlife species in Thailand. The largest population in the world, around 70,000-80,000, is found in Thailand and a third (20,000-30,000) of this is found in the Bang Pakong River Basin (on 6-8 islands). In Thailand, the species is threatened through loss of roosting habitat, as existing trees die and are not replaced, and it is also subject to hunting. The species' life cycle in the dry season (surveyed in April) involves flying around for food with their nearest flight path being 0.6 km and the longest 18 km. During this time, they feed on jambolan plum, mangoes, bananas, figs and Jamaican cherries. In November, the nearest flight path is 1.2 km and the longest 22.4 km; their feed during this this time includes gourds, bananas, acacia, eucalyptus, and coconuts. They feed on these trees in the season that they are without fruits. Furthermore, they help to grow gourds through spreading seeds and help pollinate the *Sonneratia caseolaris* (L.) Engl. (cork tree) and the *Sonneratia ovata*. Seasonal fluctuations and abnormal rain due to climate change may affect the life cycle of Lyle's flying fox because it affects the flowering of fruits.

4) Spoon-billed sandpiper is a very small mangrove forest bird, with a unique 'flat' beak. It was classified by IUCN as critically endangered in 2008. The numbers have dropped from almost a thousand pairs years ago to currently just over a few hundred. The main cause of the decline is the loss of staging area in China and Korea during migration. In addition, some birds are trapped every year for food during the winters in Myanmar and Bangladesh. However, it is not difficult to find them in the salt fields and lagoon in the inner part of the Gulf of Thailand and in the salt farms around the Bang Pakong Estuary. The spoon-billed sandpipers feed by walking in the shallow waters and dipping their beaks into the mud and "ploughing" the ground forward. Spoon-billed sandpipers often migrate north as soon as they begin to shed their feathers and prepare for the breeding season. Temperature change is the main factor affecting migration. The higher the temperature, the longer it takes for them to move to their destination and/or the shorter the period they will stay in that area.

5) Giant freshwater prawn is the largest type freshwater prawn and is an economically valuable aquatic species. They live in freshwater connected to the sea. They can live both in brackish water and freshwater. They used to be found in abundance in the Chao Phraya, Tha Chin and Bang Pakong Rivers. The giant freshwater prawns head and chest are larger and heavier than the body. They are relatively long, flat and have a thick upper side, the middle part is curved down and the end has upward spikes like saws for both upper and lower pieces. The population of giant freshwater prawns is decreasing due to overfishing and pollution. The use of chemicals to catch the prawns has a high impact on them. They are being cultured to compensate the wild population decline. Giant freshwater prawn farming is a profitable business and it is widely practiced in Chachoengsao. However, rising temperatures can affect juvenile prawns and alter their development and affect the health of mature prawns in the farmed ponds. High salinity or pulses of freshwater due to rainfall may also affect their health and lead to disease outbreaks.

6) Giant freshwater stingray is the largest freshwater stingray in the world, with a width of up to 3 m and a head-to-tail length up to 5 m. The heaviest stingray ever found was 600 kg. The shape of the body is flat and almost circular with a long whip-like tail and two sharp spines at the base of the tail, which are highly poisonous. Females are larger than males and give birth to babies, which can be 50 cm long. In Thailand, they are found in the sandy-mud estuaries area of the river, such as at the Chao Phraya River, Bang Pakong River and Nam Khong River. They live in deep, turbid water and feed on other fish such as catfish, goby and sometimes on animals living on the topsoil of the waterbed. Giant freshwater stingrays also face heavy pressure of fishing for commercial purposes. IUCN classified this type of ray as an endangered species at the global scale, but for Thailand it is considered critically endangered. The main reason is its habitat is heavily threatened by human actions and pollution; toxic pollution, wastes and sediments are a major threat for its main food sources. Climate change will only further deteriorate habitat conditions. Although sting rays seem able to adapt to the environment quite well, they give birth to only 2-3 offspring at a time which poses a serious risk for the survival of its population.

The assessment scores and risk status for baseline conservation and climate change vulnerability are summarized in Table 13.

Table 13: *Vulnerability assessment of selected species in Bang Pakong River Wetland*

	Species	Baseline Conservation Risk		Climate Change Vulnerability	
		Score	Status	Score	Status
1	Somphongs's rasbora	2.8	VH	2.9	VH
2	Irrawaddy dolphin	2.8	VH	2.3	H
3	Lyle's flying fox	2.6	H	2.1	M
4	Spoon-billed sandpiper	2.2	M	2.6	H
5	Giant freshwater prawn	2.2	M	2.1	M
6	Giant freshwater stingray	2.9	VH	2.6	H

Note: risk status categories are Very Low (1.0- 1.4), Low (1.5-1.8); Moderate (1.9-2.2); High (2.3-2.6); Very High (2.7-3.0)

Overall, vulnerability of the assessed species, whether based on baseline conservation or climate change vulnerability, is relatively high. Still, there are clear differences them, which are even more clearly expressed in Figure 14.

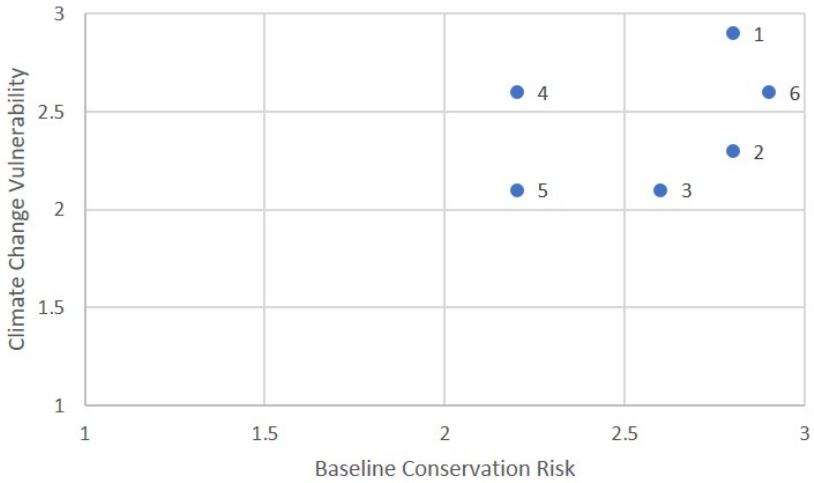


Figure 14: *Vulnerability diagram of selected species for the Ramsar Site*

Roughly, species can be divided into three categories:

- **High to very high vulnerability**. Somphong's rasbora (1) and giant freshwater stingray (6) have a very high baseline conservation risk, which will be further

compromised by high to very high climate change vulnerability. Somphong's rasbora is a very rare and near extinct species in the flood plains, an ecosystem vulnerable to change. They are sensitive to an increase in temperature and this may affect them when they lay eggs. Droughts will also strongly affect them because they live in landlocked floodwater. If the flood remains for too long, the quality of the water in the plains will deteriorate due to fermentation processes and affect the life cycle and egg laying conditions. Giant freshwater stingrays are critically endangered in Thailand due to habitat degradation and overfishing; climate change will put further pressure on their habitats and main food sources. These species need immediate protection against non-climatic factors, as well as changes expected from climate change.

- **Moderate to high vulnerability**. Irrawaddy dolphins (2), Lyle's flying fox (3) and spoon-billed sandpiper (4) are also highly vulnerable, but their vulnerability is different for current, mainly non-climatic threats and future climate threats. Irrawaddy dolphins in the estuary are mainly threatened by increased pollution and fishing activities, but seasonal variations and temperature may exacerbate their situation. Lyle's flying fox's main threats are also due to non-climatic factors, such as habitat loss and hunting, with seasonal fluctuations and abnormal rain affecting the flowering of fruit trees, its main food sources. Spoon-billed sandpipers, are relatively easy to find on the salt farms in the estuary, but sensitive to climate change. An increase in temperature can have a severe long-term impact on the duration of migration. The higher the temperature, the longer it takes for spoon-billed sandpipers moving to their destination or the shorter the period they will live in that area; moreover, too much freshwater will impact their food sources in the salt fields.
- **Moderate vulnerability.** The giant freshwater prawn (5) shows both a moderate baseline conservation risk and a moderate climate change vulnerability. It is the largest type of freshwater prawn and an economically valuable species. There are common although their natural habitats are becoming less. Temperature rise may affect their health and lead to disease outbreaks in the farms; juvenile prawns are also sensitive to higher water temperatures and cannot withstand sudden changes in the environment, such as changes in salinity levels due to flash floods.

6 CONCLUSIONS

6.1 Summary of vulnerabilities

The Bang Pakong River Wetland and the larger Basin is a unique ecosystem with high biodiversity as result of freshwater, brackish water, and saltwater habitats. Over time, the area has developed from a large freshwater fishery resource, with rice, salt, vegetables and fruits, aquaculture and livestock, to an area with an expanding industry and large supporting infrastructure as result of the linkages with the Bangkok metropolitan area. There has been an expansion of urban areas and the service sector, but more than 70% of people in the area today are still dependent on natural resources for their livelihood that links them to the major economies for food production. Industrial development is causing intensive land and water use, accompanied with large-scale pollution and waste management problems. This has put increased pressure on the wetland ecosystem and its resources. Climate change is expected to further complicate these matters. In this report, we have assessed the current situation of key habitats, species and livelihoods and their vulnerability to climate change impacts, with the intention to develop appropriate measures and actions that can help to mitigate some of these impacts while providing a sustainable and healthy environment.

At present, all habitats in the wetland are at risk and face additional risks due to climate change. The estuary area has the highest vulnerability of all habitats assessed. The estuary

is already at risk due to pollution and activities in the estuary and this will be further compromised by floods, droughts, high sea levels and storms. High salinity levels and high temperatures will influence the health of mangrove and Nypoideae forests and affect the distribution of some of their plant species. However, where Nypoideae forests seem to have difficulties to cope with these changes, mangrove forests seem more resilient and adaptive, partly due to strong protection/restoration programs.

Among other natural habitats, the island/oxbow ecosystem and the mainstream river system seem to be able to cope relatively well with climatic changes. The tributary/canal ecosystem, despite being closely connected to the mainstream river, is more vulnerable due to the challenges to manage water quality and salinity, and this is likely to get worse due to climate change. The flood plains are also vulnerable to climate change. The flood plains are susceptible to changes in temperature and drought. In addition, flash floods and longer flooding periods will result in poor water quality. When this water is released into the river, it will cause sudden shortages of oxygen in the water and fish kills in the area. This situation is often found in Bang Tan Sub-district, which receives water from the flood plain.

All of the cultivated ecosystems, (ditches orchards, the Na Kha Wang rice system, and the salt farms), all vulnerable. Both ditches orchards and the Na Kha Wang rice system are currently at risk and sensitive to droughts, because there is not enough freshwater to cultivate in-season rice. High salinity destroys the rice crops. Disease and pest outbreaks come with rising temperature and as a result, aquatic animals do not grow or die. They are also susceptible to long-lasting floods, which damage rice crops and allows cultivated fish or shrimp to swim out of the farms. In both cases, impacts can be mitigated through management practices. This is more problematic in case of salt farms, which is an important ecosystem for migratory birds. Climate change will indirectly affect the diversity of their food sources. The higher temperatures will also affect the time and duration of migration, while increasing rainfall or changes in the onset of the rainy season will result in reduced salt yield.

The deteriorating state of habitats is also threatening key species in the area, such as flagship species, keystone species, and economically important species. The conditions are especially precarious for the rare and ‘critically endangered’ Somphong’s rasbora and the ‘endangered’ giant freshwater stingray. If they are not protected, they may become extinct or may relocate to other habitats in the same way as the spoon-billed sandpiper and Irrawaddy dolphin. Populations of other key species may also be affected, such as the Lyle’s flying fox. The population of economically important species such as giant freshwater prawns or other types of fish may be reduced as well due to weather fluctuations or the effects of higher temperatures.

The impact on the ecological system and its species directly affects the people that depend on the wetland for their livelihood. Droughts, floods and irregular weather patterns are highly problematic considering people’s dependency on water for their livelihood. They rely on the wetland for water consumption and utilization, the use of natural water sources for animal husbandry, for ditches orchards and the cultivation of seasonal rice. Activities that are closely linked to seasonal dynamics are highly sensitive to unpredictable changes in weather patterns. The people most vulnerable to the changes and impacts of climate change include the elderly people who cannot work in the industrial or service sectors. They make a living from resource-based occupations, such as the women who make handicrafts from *Nypa fruticans*, collect *Bruguiera cylindrica* (L.) Bume, catch crabs, shrimp, and krill. Along with local fishermen, they will be affected when wetland resources decline or when water quality deteriorates. Meanwhile, smallholder farmers face higher risk of losing income during high tides and high seawater levels. This risk is shared with farmers raising fish, who will also be affected by drought and higher temperatures. The effect of climate change at the community level is reflected in the economic impacts such as damage to crops, food sources and capital. Climate change may also affect living conditions and health due to reduced water quality and

outbreaks of disease transmitting mosquitoes and insects or threaten lives in case of floods and wild fires.

When it comes to land rights, most farmers have no ownership of the land they have been using. The region was integrated as part of Thailand's economic development zone in 1977 and large plots of land have changed ownership from local people to land investors, real estate developers and/or industrial groups. Most people using the land for agricultural purposes in the region lack stability in terms of land rights and title deeds.

6.2 Adaptation planning

The implementation of Thailand's wetland conservation measures is complex and generally not participatory. In August 2017, the Wetlands Management Enhancement Project of Thailand Natural Resources and Environmental Policy and Planning Office by the Science and Technology Research Institute of Thailand (IEAT), proposed: 1) the development of community and local participation in wetland management; 2) the dissemination of information on socio-economic and environmental impacts to local people from wetland development projects; 3) legislation that promotes conservation and protection of wetlands; and 4) the development of operational guidelines, knowledge building and understanding of the value and importance of wetlands. The wetlands conservation approach taken, is taking time to implement.

As part of Thailand's economic policy, Chachoengsao Province has been designated as part of the special Eastern Economic Corridor (EEC). This strongly political and economically driven direction is the major development scheme in the Bang Pakong River Basin. The business and industry sectors are benefitting most from these developments, enabling employment and investment. Similarly, the tourism and service sector has benefited through market expansion. Farmers, who constitute 70% of the population, have reported problems of water resources management. In the dry season, there is not enough water for agriculture and they must compete with the industrial sector for water; and there is the problem of pollution and land security. Meanwhile, traditional wetland communities complained about water quality due to wastewater from community, agricultural and industrial sectors. This is especially a problem in densely populated urban areas where water gates have been closed, resulting in accumulation poor water quality and waste in the canal. When the water gate is opened to discharge water into the Bang Pakong River, it causes acute oxygen deficiency. There are also cases of the Bang Pakong Dam having varying impacts on the ecosystem including variations in tide levels that resulted in severe coastal erosion and the spread of water hyacinth during the fresh water season.

Community members already employ a diversity of mechanisms to cope with the impact of extreme event such a floods, droughts, heavy storms and irregular weather patterns, but these needs to be improved and strengthened. Plans for adaptation to future climate change scenarios can be envisioned at three levels:

- **Household Level.** After disasters, houses should be repaired, made stronger, and raised higher than the flood level. For farmers, the selection of types and species of plants should be modified including cultivating in-season rice in years where there is lots of water and changing to out-of-season rice for years with little water. Short-lived plants can also be grown before the saltwater penetrates. Strengthening adaptation responses can include learning how to reduce pests and insects using organic pesticides and herbicides. Land use zoning should be completed in each plot and alternative livelihood activities should be developed such as the promotion of eco-tourism. Other measures include digging secondary storage ponds, creating reservoirs and a water circulation system, as well as biological methods for aquaculture and breeding/raising of multiple species in the same pond.

- **Community and local level.** Local management plans, such as emergency disaster prevention and relief centres, are needed to provide immediate help. The community should establish common agreements at community and river basin level on rehabilitation of aquatic species, increasing conservation areas, rehabilitating the canal system, and dredging canals, public waterways and water sources. A secondary water storage system should be installed at the household level such as ponds and wells. In addition, policy level management plans need to be developed and include urban planning for sustainable land use, regulations on effluent discharge, and regulations on preventive actions and wastewater disposal, including penalty clauses. Proper waste management should be enforcement at local and river basin level.

- **River basin level.** Specific plans for land use zoning and urban planning are needed to ensure sustainability and environmental protection, as well legislation, policies or measures to protect the wetlands. Discussions on water management should be held in a participatory manner with stakeholders. Sound management practices include the mechanisms for allocating and draining water, and managing runoff into the river. Water consumption and utilization in the river basin should be controlled and managed properly for each sector. Research should be conducted to identify ways to prevent fires in the fields during the dry season.

The community, local and national government, relevant NGOs and the private sector should be involved in developing a coordinated and sustainable wetland management plan for the area. In addition, important habitats such as estuary areas, mangrove forests and floodplains (Thung Pak Phlii), should be protected and conserved under law. Special attention must be given to the critically endangered species that use the Bang Prakong River Wetland.

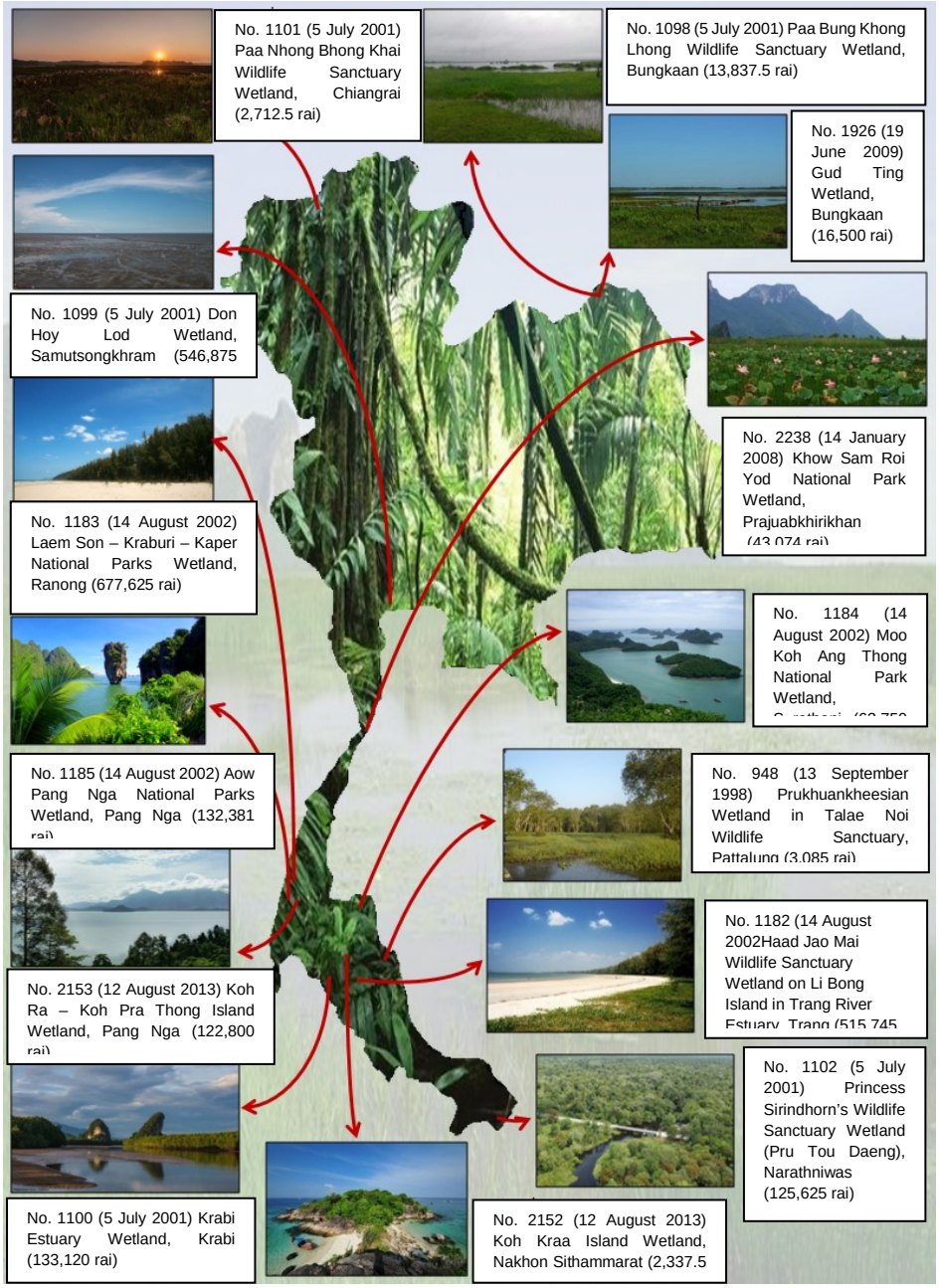
Annex I: VA Team Members

Name	Organization	Role

Bampen Chaiyarak	International Union for the Conservation of Nature (IUCN), Thailand Programme	Overall coordination
Mr. Petch Manopawitr	IUCN Thailand Program (at time of study)	Provide information on ecology and support coordination
Dr. Surachit Vangsorn	Director of Sakaerat Environmental Research Station, Thailand Institute of Scientific and Technological Research.	Provide information and prepare general information on Bang Pakong Wetland.
Patchara Paisawasut	The Upper Gulf of Thailand's Marine and Coastal Resources Research and Development Center	General support/information on species; species vulnerability assessment (Irrawaddy dolphin)
Parinya Leelahannon	Natural Resources and Environmental Policy and Planning Office Ministry of Natural Resources and Environment (ONEP)	Provide information on ecology and policy regarding wetland management/conservation
Asst.Prof.Dr. Prateep Dusangkarn	Faculty of Forestry, Kasetsart University	Species vulnerability assessment (Lyle's Flying Fox)
Dr. Sansanee Chuweaw	Wetland University Network	Habitat vulnerability assessment
Dr. Nonn Panitvong	Siamensis.org	Biodiversity information in general and on endangered species
Mr. Gun Tattiyakul	Phakee Bang Pakong People Alliance	Habitat and community vulnerability assessment
Mrs.Naruemol Karnsunthad	Independent consultant	Habitat and community vulnerability assessment
Dr. Chavalit Witthayanon	Specialist in the field of fishery resources.	Information on biodiversity; species vulnerability assessment (general and specific on fish species)
Mr. Dom Pratumthong	Naturalist Mammal expertise, Museum of Natural History National Science Museum (NESDB)	Species vulnerability assessment (spoonbill)
Ms. Kitima Khunthong,	Faculty of Humanities and Social Sciences, Sakon Nakhon Rajabhat University.	Community vulnerability assessment
Paiboon Sophonsuwaphap	Faculty of Fine Arts, Burapha University	Community vulnerability assessment
Mr. Pornchai Visutthacharn	Office of Natural Resources and Environment, Chachoengsao	Community vulnerability assessment

ANNEX II Ramsar Sites in Thailand

Thailand joined the Ramsar Convention in 1998. The country has a total of 14 wetlands of international importance registered as Ramsar Sites; of these, 9 sites are within conserved areas such as National Parks and Wildlife Sanctuaries and 5 are in community and/or public areas as shown in the following figure.



Source: Office of Natural Resources and Environmental Policy and Planning[44]

[44]Accessed from http://wetland.onep.go.th/images/Ramsarsite_edit.png on 2 December 2017

ANNEX III Wetland Management Policy In Thailand

At present, there are 22.9 million rai of wetland in Thailand, which is equivalent to 6.8% of the total area of the country. Thailand has 14 registered Ramsar Sites of international significance, 69 internationally important wetlands, 47 nationally important wetlands and 119,295 locally important wetlands. Of these, 28 areas should be considered as protected areas. Since 1997, several policies on wetland management and measures have been issued by the Office of Natural Resources and Environmental Policy and Planning. These policies are integrated in the National Biodiversity Strategies and Action Plan (NBSAP), which has a 5-year implementation and revision cycle as follows.

1) **Policy, Measures and Management Plan for Wetlands 1997-2002.** This included 28 implementation plans and 43 projects from 14 agencies. The total budget was 472.50 million THB and was approved by the Cabinet on 15 July 1997.
2) **Policy, Measures and Management Plan for Wetlands 2003-2007.** This plan was put together with the NBSAP which has 4 supporting action implementation plans, making up of 168 projects from 41 agencies. The total budget for this phase is 2,600.56 million THB and was approved by the Cabinet on 11 June 2002.
3) **Wetland Management Plan 2008-2012 .** This falls under the NBSAP 2008-2012 on measures for wetland management schemes. There are two main measures including 1) conservation of marine and coastal ecosystems and island ecosystems and, 2) protecting the wetland ecosystem and promoting sustainable utilization. These are based on the following principles for action plans:
    - Implement according to obligations, working programs, and consensus of alliances and initiatives of the Ramsar Convention and Biodiversity Convention;
    - Participatory approach is used in the development process of the management plan and for the presentation of wetlands with international significance, including setting up conservation zones, utilization zones, and Management Committee for each of the Ramsar sites;
    - A survey of the wetland area in all dimensions including physical, biological, social and economic aspects to be performed to support the revision of the status and to make amendments for the registration of the wetlands that are important for Thailand as well as to create back-up methods in case anything goes wrong, so that relevant legal changes can be mobilized to efficiently protect the wetland areas;
    - Cooperate between various agencies, working units, private sectors and relevant communities in the wetland areas for implementation of activities, which will assist in significantly reducing the loss of wetland ecosystems by 2010.

The Office of Natural Resources and Environmental Policy and Planning prepared an integrated Master Plan for Biodiversity 2015-2021. This plan was approved by the Cabinet on 13 March 2015 and integrated into the strategy on conservation and rehabilitation of biodiversity, specifically at the provincial, local and community levels, including the following measures:

- Provide support to relevant sectors that deal with implementation of the wetland management plan for wetlands with national and international significance. It should also push the relevant agencies to make use of the plans and streamline it into provincial, local and community plans and policies.
- Prepare and support implementation based on good practices for wetland management in urban and sub-urban areas. Try to integrate the practice into provincial and local plans and policies so they can be mobilized in line with the above-mentioned master plan.

The Office of Natural Resources and Environmental Policy and Planning proposed an Action Plan for Biodiversity Management 2017-2021 to the Cabinet and it was endorsed on 28 March 2017. Implementing measures and guidelines for practices are as follows:

- Integrating issues of wetland areas into the policy and plans, finding tools, mechanisms and networks to support and to increase the efficiency in management of the wetlands.
- Enhance capacity of government agencies, private sector development organizations, and local communities to increase efficiency in implementation of conservation and sustainable utilization of wetland areas.
- Prepare a registrar for important wetlands surveyed and prepare them for registration as wetlands at the various levels of significance accordingly.
- Monitor threats for wetland and promote sustainable utilization of the area along with controlling and protecting the wetland from activities that will create mal-impacts to the area, such as the expansion of community area, over fishing, alien species invasion, pollution and climate change impacts.

For wetland management at national level, there is a mechanism for wetland area conservation according to the Cabinet Resolution, which needs to be implemented along with the task of creating policies/plans.

Even though activity plans, project and responsible working unit have been identified, implementation has not fully taken place. From the report by the Office of Natural Resources and Environmental Policy and Planning in 2015 on increasing efficiency of wetland management practices in Thailand, it was found that there was a problem with the efficiency in implementing conservation measures according to Cabinet Resolution. Therefore, following changes were proposed:

- The government should scale up the wetland management policy to give it national significance. This will ensure that it will receive the recognition and is important for the implementation under the Ramsar Convention, other than that the management of the wetland is also the basic component of water resources management, the solution to climate change problems and the deterioration of natural resources and area-based environmental problems.
- Promote and support the local, provincial, wetland management committee organization in the province and local areas, and the responsible agencies according to the laws in terms of budget to develop the implementation plan for the wetlands. The policy, measures and management plan for the wetland in the country that are approved by the Cabinet under the implementation framework for should be funded accordingly to allow the management of the wetlands to move in the same direction and be implemented accordingly.

The legal mechanism and regulations in wetland management in the present is up to the lead agency which was legally appointed and holds the highest authority to implement in the area and/or by the unit that is set up which is backed by on agency or the other. However, there are some areas where these responsible agencies or lead agencies are still not clearly identified because of some overlapping administrative glitches. Another problem is that for some areas there are many agencies that has to do with the same roles and responsibility in the same area.

A report on how to increase the efficiency of wetland management practices for Thailand was prepared for the Office of Natural Resources and Environment Policy and Planning by the Thailand Science Development and Research Institute (TDRI) in August 2017, and can be summarized as follows:

- Survey on status and studies on biodiversity management in wetlands with high significance has been implemented in the 14 wetlands with international and national

significance (from 20 target sites). Conservation/sustainable utilization plans were developed for 7 of the prioritized wetlands.

- In terms of conservation and rehabilitation of wetlands, the target was set for 35% of total national wetland areas; current practices focus mostly on marine and coastal ecosystems.
- Target for strengthening community and local administrative organizations in conservation and utilization of wetland areas was set at 50% of communities/organizations in Thailand in 5 years.

ANNEX IV: WETLANDS CONSERVATION MEASURES: CABINET RESOLUTION NOV 2009 AND MAY 2015

	Conservation measures for wetland areas	Lead and supporting agencies
1	Announced that all wetlands in the country are public areas with special specifications that the fresh water wetlands are to be zoned off as green area and the government is to maintain and take care of it for use as a source of water supply and storage but nothing else.	**Lead**: Ministry of the Interior **Support**: Local Administration Organization; Department of Fisheries; Department of Lands; Royal Irrigation Department; Department of Water Resources; Department of Marine and Coastal; Natural Resources and Environmental Policy and Planning Office
2	Conduct surveying and monitoring activities to identify the boundaries of the wetland area according to the locally prioritized list of wetlands approved by the Council of Ministers on 1 August 2000. This area is to be kept as a sink to tap water from natural sources and slow down the flow of water to prevent floods and droughts.	**Lead**: Ministry of Natural Resources and Environment **Support**: Academic institution; Department of the Interior; Department of Local Administration Promotion; Local Administration Organization
3	Keep track, monitor and maintain the wetland sites registered as locally important areas. They should be reserved as a natural source of water, especially wetlands that have been registered as public water resources. At the same time, controls and prevention measures should be taken to ensure that there are no intrusions that will adversely affect wetlands that are public areas.	**Lead**: Ministry of the Interior **Support**: Marine Department; Department of Lands Department of Water Resources; Natural Resources and Environmental Policy and Planning Office Academic Institutions
4	Create awareness and instil knowledge so that people understand the value and importance of the area so that sustainable utilization of wetlands for all sectors and people at all levels can be ensured. The community is to be allowed to participate in the planning of international and national wetlands management schemes.	**Lead**: Ministry of Natural Resources and Environment **Support**: Academic Institutions; Department of Public Relations; Department of Local Administration Promotion; Ministry of Education; Local Administration Organization; Department of Water Resources
5	Propose the wetlands to be important international and national wetland sites under the Convention on Wetlands (Ramsar Sites)	**Lead**: Ministry of Natural Resources and environment **Support**: Department of National Park Wildlife and Plant Conservation; Department of Fisheries; Department of Local Administration Promotion; Department of the Interior; Local Administrative Organization; Department of Marine and Coastal Resources
6	Declare the wetland to be of international and national importance and as non-hunting zones or environmentally protected area or other types of conservation area as relevant.	**Lead**: Ministry of Natural Resources and Environment **Support**: Department of Fisheries; Department of Local Administration Promotion; Department of the Interior; Local Administration Organization
7	Accelerate the process of issuing the announcement/declaration/official statement to support the wetlands as important international and national public areas. Also, accelerate the implementation on clear identification of boundary lines to prevent invasion and without affecting the ecology of wetlands.	**Lead**: Ministry of the Interior **Support**: Local Administration Organization
8	Urgently restore internationally and nationally the important wetlands ecosystems that have been deteriorating so that they can function naturally in their roles for the ecosystem and hydrological system.	**Lead**: Ministry of Natural Resources and environment **Support**: Land Development Department; Academic institution; Navy Department of Water Resources
9	Develop a management plan for the wetland which is important both at international and national levels for both short and long-term implementations. This is to protect restore wetlands by zoning utilization areas into conservation zone and the development zone as	**Lead**: Ministry of Natural Resources and environment **Support**: Department of Fisheries; Marine Department; Academic institution; Land Development Department; Local Administrative Organization; Department of Water Resources

	well as the buffer zone area. Also, specific activities that can be done and prohibited in the area must be specified.	
10	Ensure that an Environmental Impact Assessment (EIA) is performed and reported for projects or businesses that affect the environment according to the Notification issued under Section 46 of the National Environmental Quality Promotion and Conservation Act 1992.	**Lead**: Project owner **Support**: Natural Resources and Environmental Policy and Planning Office; Department of National Park Wildlife and Plant Conservation; Department of Fisheries; Academic institution
11	Allow, promote and support researches and studies about the wetland ecosystems with international and national level significance and disseminate the information to the public.	**Lead**: Ministry of Natural Resources and environment **Support**: Department of Environmental Quality; Natural Resources and Environmental Policy and Planning Office
12	Continuously monitor and assess the changes in the wetlands with international and national significant ecosystems. The factors and indicators for the studies must be specified specifically.	**Lead**: Ministry of Natural Resources and environment **Support**: Academic institution
13	Continuously study and survey the wetland and its biodiversity to modify and improve the wetland registration with international and national significance according to the standard criteria.	**Lead**: Ministry of Natural Resources and environment **Support**: Academic institution
14	Provide pollution control and prevention measures and practices from the various sources such as communities', industrial, agricultural activities and other activities.	**Lead**: Local administration **Support**: Department of Public Works and Town Planning; Academic institution
15	Provide for the control of wildfires in internationally and nationally significant wetlands that may be caused by the community or other activities. The measures are as follows: (1) Forest fire prevention measures (maintain constant water level in the wetlands; Build a wet-line firebreak; Conduct all types of pro-active public relations activities to raise awareness and understanding of the danger of forest fire which will stop the community from setting fire to the forest. (2) Firefighting measures (Establish a forest fire control station to take care of the area, monitor and act to control forest fires in the key wetland areas; Provide training firefighting skills for wetland forest fires to forestry officers/ rangers; Use modern and appropriate tools and equipment for handling forest firefighting in wetlands).	**Lead**: Local administration; Ministry of Natural Resources and environment **Support**: Academic institution
16	Arrange for studies and prepare both short and long term a plan for physical landscape design of the surrounding international and nationally significant wetland area to conserve and restore the area as a whole.	**Lead**: Ministry of the Interior **Support**: Department of National Park Wildlife and Plant Conservation; Local Administrative Organization; Department of Fisheries; Department of Lands; Royal Irrigation Department; Department of Water Resources; Department of Marine and Coastal Resources
17	Prepare an evaluation report on the performance according to the Cabinet Resolutions No. 1-16 by monitoring the works of the lead agency and present to the Sub-committee for Wetland Management.	**Lead**: Ministry of Natural Resources and environment **Support**: Natural Resources and Environmental Policy and Planning Office

ANNEX V: RESOURCE PRIORITY RANKING BY WOMEN AND MEN IN BANG PAKONG RIVER WETLAND

1	**Klong Tum Hru Subdistrict Community**	
Rank	Men	Women
1	Saltwater crab	Saltwater crab
2	Meder mangrove crab	Nypa fruticans
3	Tiger shrimp	Suaeda maritima
4	Tiger shrimp	Meder mangrove crab
5	Whiteleg shrimp	Tiger shrimp
6	Greasy-back shrimp	Tiger shrimp
7	Long-whiskered catfish	Whiteleg shrimp
8	Mullets	Greasy back shrimp
9	Tilapia	Long-whiskered catfish
10	Threadfin	Mullets

2	**Baan Klong Pii Khud**	
Rank	Men	Women
1	Nypa fruticans	Nypa fruticans
2	Rhizophora mucronata	Rhizophora mucranata
3	Xylocarpus granatum	Xylocarpus granatum
4	Meder mangrove crab	Meder mangrove crab
5	Saltwater crab	Saltwater crab
6	Suaeda maritima	Suaeda maritima
7	Salt	Salt
8	Shells	Shells
9	Mangrove forest	Mangrove forest
10	Smooth-coated otter	Smooth-coated otter

3	**San Phu Das Subdistrict Community**	
Rank	Men	Women
1	Krill	Nypa fruticans
2	Giant freshwater prawns	Lvy Gourd, Coccinia
3	Saltwater crab	Meder mangrove crab
4	Giant sea perch	Green tidal crab
5	Whiteleg shrimp	Krill
6	Long-whiskered catfish	Giant freshwater prawns
7	Croakers	Saltwater crab
8	Mullets	Giant sea perch
9	Soft-shelled shrimp	Whiteleg shrimp
10	Naked catfish	Long-whiskered catfish

4	**Baan Koh Klang**	
Rank	Men	Women
1	White shrimp	Rice
2	Whiteleg shrimp	Nypa fruticans
3	Saltwater crab	Saltwater crab
4	Giant sea perch	Giant sea perch
5	Long-whiskered catfish	Long-whiskered catfish
6	Mullets	Mullets
7	Meder mangrove crab	Meder mangrove crab
8	Tiger shrimp	Tiger shrimp
9	Giant freshwater prawns	Giant freshwater prawns
10	Long-whiskered catfish	Long-whiskered catfish

5	**Baan Hua-Suan**	
Rank	Men	Women
1	Giant freshwater prawns	Giant freshwater prawns
2	Greasy back shrimp	Greasy back shrimp
3	Small shrimp	Small shrimp
4	Soft-shelled shrimp	Soft shelled shrimp
5	Whiteleg shrimp	Whiteleg shrimp
6	Mullets	Mullets
7	Naked catfish	Naked catfish
8	Giant sea perch	Giant sea perch
9	Long-whiskered catfish	Long-whiskered catfish
10	Serrated mud crab	Serrated mud crab

6	**St. Paul Church Community Moo 9**	
Rank	Men	Women
1	Nypa fruticans	Nypa fruticans
2	*Bruguiera gymnorrhiza*	Bruguiera hainesiiXC.G.Rogers
3	Coconut	Giant freshwater prawns
4	Betel palm	Naked catfish
5	Betel	Krill
6	Mango	Striped sea catfish
7	Banana	Dolphins
8	Mullets	Mullets
9	Giant freshwater prawns	Coconut
10	Naked catfish	Betel palm

7	**Baan Klong Koen**	
Rank	Men	Women
1	Coconut	Mango
2	Mango	Coconut
3	Betel palm	Nypa fruticans
4	Fish	Rice
5	Nypa fruticans forest	Vegetables
6	Vegetables	Fish
7	Lemongrass	Nypa fruticans
8	Fireflies	Betel palm
9	Ditches orchard	Grown lemon grass
10	Rice field	Fireflies

8	**Bang Khanak Subdistrict**	
Rank	Men	Women
1	Rice	Rice
2	Giant freshwater prawns	Giant freshwater prawns
3	Striped snakehead fish	Striped snakehead fish
4	Common silver barb	Common silver barb
5	Minnow	Minnow
6	Marsh clam/ Asian Clam	Marsh clam/ Asian clam
7	Water crest	Water crest
8	Lotus stem	Lotus stem
9	Sesbania javanica	Sesbania
10	Duck	Ducks

9	**Bang Tan Subdistrict Community**	
Rank	Men	Women
1	Naked catfish	Rice
2	Wallago attu	Naked catfish
3	Luciosoma	Wallago attu
4	Danio	Luciosoma
5	Giant sea perch	Danio
6	Giant freshwater prawns	Giant sea perch
7	Rice field	Giant freshwater prawns
8	Salix tetrasperma	Salix tetrasperma
9	Chaulmoogra	Chaulmoogra
10	Bamboo	Bamboo

10	**Ta Rua Subdistrict Community**	
Rank	Men	Women
1	Fish	Fish
2	Forest	Forest
3	Catfish	Catfish
4	Marian Plum	Marian plum
5	Mango	Mango
6	Grassland	Grassland
7	Black hawk	Red hawk
8	Rice	Rice
9	Buffalo	Buffalo
10	Vegetables	Vegetables

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