Climate change vulnerability assessment for Beung Kiat Ngong Ramsar Site, Lao PDR

Peter John Meynell, Oudomxay Thongsavath, Khamphat Xeuasing, Vilavong Vannalath and Raphaël Glémet

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The Mekong Water Dialogues is coordinated and facilitated by IUCN and supported by the Ministry of Foreign Affairs of Finland. It was initiated to work with countries of the Mekong Region, Cambodia, Lao PDR, Thailand and Viet Nam, to improve water governance by facilitating transparent and inclusive decision-making to improve livelihood security, human and ecosystem health.

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Acronyms and abbreviations

3S	Sekong, Sesan and Srepok Rivers
BCA	Biodiversity Conservation Area
CCAI	Climate Change Adaptation Initiative
CCD	Climate Change Department
CPA	Community Protected Area
EIA	Environmental Impact Assessment
FAO	Food and Agriculture Organization of the United Nations
ha	Hectare
IBA	Important Bird Area
ICEM	International Centre for Environmental Management
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
GCM	Global Circulation Model
km	Kilometre
m	Metre
mm	Millimetre
MAFF	Ministry of Agriculture, Forestry and Fisheries
MEA	Millennium Ecosystem Assessment
MRC	Mekong River Commission
NGO	Non-Governmental Organization
NIS	National Institute of Statistics
NMC	National Mekong Committee
NTFP	Non-Timber Forest Products
PA	Protected Area
PRA	Participatory Rapid Appraisal
PPA	Participatory Poverty Assessment
SEA START	South East Asia Global Change System for Analysis, Research and Training Network, Regional Centre

Executive summary

In 2014, IUCN carried out a vulnerability assessment of the impacts of climate change on the Ramsar site at Beung Kiat Ngong in southern Lao PDR. This follows earlier vulnerability assessments that were carried out as part of the MRC's study on wetlands and climate change in the Lower Mekong Basin, for which relevant case studies at Xe Champhone, Siphandone and Lower Stung Sen in Cambodia were particularly instructive. In addition, climate change projections for Champasak province that had been prepared for the USAID-funded Mekong ARCC project were directly relevant and used for the downscaled projections at Beung Kiat Ngong. The thematic studies of the Mekong ARCC project on fisheries, agriculture, livestock and NTFPs were also used and the vulnerability assessments for particular agricultural systems, crops and species were tailored to the projected conditions in Beung Kiat Ngong.

The overall description of the wetland ecosystem and its components were drawn from the Ramsar profiles of the wetland and the recent biodiversity surveys. The statistics related to the local communities and their perceptions about climate change were drawn from consultations with the communities in each of the eight core villages located around the wetland which are dependent upon its natural resources. These were held in January 2014 and further information was collected through subsequent visits by IUCN staff.

The projections for 2050 in Beung Kiat Ngong indicate that during the dry season, there would be a likely increase of up to 3°C in maximum temperatures, with the average daily maximum temperature rising steadily from 32°C from January to 37°C in April. These changes will increase evapotranspiration in the dry season and would decrease the availability of water in the wetland. In January, February, March and April, there would be about 6% less rainfall in a typical year, though in May there would be an 11% increase for the month. This increase would then continue throughout the wet season, with an average 10% increase in rainfall between May and October. In August the maximum monthly rainfall is likely to increase from 398 to 425 mm. Wet season temperatures are also projected to increase by 3–4°C, but would not reach such high maximum temperatures as in the dry season.

In terms of extreme events, there is likely to be an additional heavy rainstorm each year of over 100 mm in a day, and the intensity of the storms is also likely to increase, with the heaviest rainfall increasing from 120 to 144 mm in a day. Overall the wet season volume of available water will generally be higher and during a high rainfall year the risk of flooding will increase. Historically, flooding events occur once every 10 years. This frequency may increase slightly. Flooding may also result from back flows from the Xe Kampho river.

The vulnerability assessments, which generally followed the CAM methodology developed by ICEM in the earlier studies, focused on the wetland habitats and ecosystem components that were directly used by the local communities. Thus in addition to an overall vulnerability assessment of the whole wetland, assessments were carried out for sedges, shrubs and flooded forest trees, followed by assessments of black and white fish species, eels, snails, frogs and turtles. The livelihood components which were assessed included rain-fed rice, a small area of irrigated rice, small holder cattle and buffalo livestock systems, drinking water supply, fisheries and the Malva nut harvest.

Overall, the Beung Kiat Ngong wetland ecosystem is considered to be moderately vulnerable, largely because of the dynamic and resilient character of the wetlands, which are able to respond to the main threat of increased temperature and decreased rainfall in the dry season, which in turn tend to make the seasonally inundated areas of the wetland shrink faster during the dry season. However, this is likely to be more than compensated for by the increased rainfall in the wet season. It is expected that whilst there may be some shifts in the distribution of some vegetation types and habitats, these are likely to be small and the overall character of the wetland will remain the same. However, there is one area of concern, namely the peat land, which, if it dried out excessively, could give rise to acid sulphate soils and acidification of the water in parts of the wetland.

Assessments of the wetland vegetation types indicate that they are minimally or moderately vulnerable, though it is expected that the spread of the invasive species *Mimosa pigra* will be enhanced due to climate change. It has not yet invaded Beung Kiat Ngong but has been observed on the wetland's edges and will likely to become an increasing problem.

In terms of the different wetland products used by the villagers, fish are the most important, and appear to be generally quite resilient to climate change, especially black fish and eels resident in the wetlands, which can tolerate poor water quality and higher temperatures experienced in the dry season. White fish migrating into the wetlands in the wet season are likely to benefit from the increased inundation, though they may be more threatened by climate change when they return to the main rivers for the dry season. The main concern for fish is that during the dry season, access to the pools and ponds will be easier and with lower water levels over harvesting of fish may place additional stress on the populations.

Two snail species compared in the study are the invasive Golden Apple snail and the native apple snail, *Pila* species. In terms of their biology there does not seem to be much to compare which would indicate different vulnerabilities. Both seem to be quite resilient to higher temperatures and changes in the dry season, but the Golden Apple snail appears to be able to take advantage of the increased inundation more than the native species, and this, in addition to its natural competitiveness, will enhance its invasiveness. It does have a natural predator in the form of the Open Bill stork, which needs to be protected and encouraged in the area.

Frogs are moderately vulnerable, and may suffer from the shrinking inundated area in the dry season, but will reestablish themselves during the wet season. Turtles on the other hand are a particularly valued catch by local communities, but are becoming increasingly rare in the wetlands. As with most reptiles, turtles are dependent upon ambient temperature, and the gender of their hatchlings depends upon the nest temperature. Higher temperatures will result to all-female hatchlings. The impact of climate change could be a very skewed population, leading to extirpation of the turtles from these wetlands.

The main rain-fed rice production of the wetland communities is considered to be highly vulnerable, principally because increased temperatures will reduce the growth rate and production of the crop, with annual yields projected to decrease by about 5%. Increased floods and storm damage may affect the crop towards the end of the wet season, resulting in complete loss in some years. Irrigated rice is cultivated on only 50 ha in the wetland communities, and will also suffer from increased temperatures, especially in the late dry season, and there may be problems of irrigation water availability.

Fishing is not expected to be vulnerable to climate change threats because the fish species generally have a high resilience to the climatic changes, especially the black fish. In the dry season, the resident species may become more concentrated in pools and ponds as the inundated area shrinks, and this may make them easier to catch. Eventually this may reduce the populations substantially, although the increased rainfall and inundation during the wet season may counteract this pressure to some extent. The white fish catch in the wet season is likely to continue at similar levels in Beung Kiat Ngong, unless climate change and other threats in the main rivers affect the populations of white fish during the dry season.

Smallholder cattle and buffalo herds around Beung Kiat Ngong are considered to be highly vulnerable to increased temperatures especially during the dry season, when they will need suitable shade and sufficient water availability. This is the time when they are allowed to roam loose and feed in the fallow paddy fields. Fodder will become scarce towards the end of the dry season and water availability will also fall. The combination can decrease growth rates and reproductive health and make the livestock more susceptible to diseases such as Foot and Mouth disease.

Drinking water availability is already an issue during the dry season for most of the communities. From March to May the water table falls and dug wells are no longer deep enough. It may take several hours or even overnight to refill the wells. Climate change, with increased temperatures and reduced rainfall in the dry season will lead to additional pressure on drinking water resources. With increasing populations in these communities and increasing herd sizes of cattle (though not of buffalo), the demand for drinking water will become hard to satisfy at this time of year. In addition in Kiat Ngong village, there is an issue of arsenic contamination in some tube wells, and this may limit the supply.

One of the most valuable NTFPs for the communities surrounding Beung Kiat Ngong is Malva nuts which are collected during late dry season. The Malva tree is a “masting” species producing bumper crops every three to four years, but flowering and fruiting is likely to be affected by increased temperatures and the reduced rainfall in January/February during flowering. The impact of climate change upon honey bees that are important pollinators for this tree species may also be significant. The Malva tree is considered to be highly vulnerable to climate change, reducing both the yield and perhaps the frequency of masting years.

The contrast in vulnerability between the overall wetland ecosystem and its connection to the livelihoods of the communities around it is marked. In general the wetland ecosystem is quite resilient to climate change, although there may be some minor structural and distributional changes in the habitats. If the other stresses and threats to the wetland such as overharvesting of wetland products, encroachment of agricultural land, tree cutting and the invasion by alien species do not become too excessive, then the impacts of climate change on the wetland will be manageable. However, in combination with high pressures from other threats, the wetland could become highly vulnerable to climate change.

With the exception of fishing, wetland livelihoods appear to be much more vulnerable, and the concern is that if yields begin to fall and cattle growth rates and drinking water availability are reduced in the dry season, then there will be additional pressure on the natural resources of the wetlands as communities cope and maintain their livelihoods. Dry season irrigation does not yet depend upon abstraction of water from the wetland, but if this were to become a normal part of agriculture around the wetlands, then there would be a much more serious threat to the viability of the wetlands.

1 Introduction

The Lower Mekong Basin (LMB) covers the four countries of Cambodia, Lao PDR, Thailand and Vietnam. It has a total area of 606,000 km^2 and a population of more than 60 million people. The region is rich in natural resources, particularly forests, rivers and wetlands. These form important refuges for biodiversity and support the livelihoods of a large proportion of the LMB population, many of whom rely directly on natural resources. There are an increasing number of studies related to climate change and its potential impacts in the LMB, although these are largely focused on the regional level.

The LMB's wetlands are vulnerable to changes in the transaction zone between aquatic and terrestrial environments, based upon their hydrological regimes and relatively low capacities for adaptation (Bates et al., 2008, Bezuijen, 2011). A range of pressures caused by humans, including population pressure, overexploitation, infrastructure development, agricultural intensification and mismanagement, affects the functions and services of wetlands. These already damaged systems are being further stressed by climate change. One aspect central to adaptation strategies for natural systems is to address the adaptation deficit (existing stresses that exacerbate climate change impacts) by increasing ecosystem resilience and rehabilitating ecosystem integrity. There is a need for analysis of these inter-linkages and an understanding of the implications of climate change to the health and function of the region's wetlands.

Two sets of studies have to some extent filled the gap for specific ecosystems such as wetlands and these are:

- Mekong River Commission (2012),'Wetlands of the Lower Mekong Basin – Basin-wide climate change impact and vulnerability assessment'. This included case studies of specific wetlands:
  - Cambodia – Stung Treng
  - Cambodia – Lower Stung Sen
  - Lao PDR – Siphandone
  - Lao PDR – Xe Champhone
  - Thailand – Lower Songkhram river basin
  - Thailand – Keang La Wa
  - Vietnam – Tram Chim
  - Vietnam – Mui Ca Mau
- USAID(2013), 'Mekong Adaptation and Resilience to Climate Change' (Mekong ARCC). This developed downscaled climate and hydrological modelling for assessing the vulnerability of different agricultural systems in selected priority provinces (Chiang Rai in Thailand, Gia Lai and Kien Giang in Viet Nam, Khammouane in Lao PDR and Mondulkiri in Cambodia), including:
  - Agriculture
  - Aquaculture and capture fisheries
  - Natural systems – NTFPs and crop wild relatives in protected areas
  - Livestock
  - Socio-economics – focusing on health and infrastructure

This study extends the climate vulnerability assessment of another wetland in Lao PDR, the Beung Kiat Ngong Ramsar site. It draws upon the findings of the previous studies, especially the vulnerability assessment of the Xe Champhone and Siphandone wetlands undertaken as case studies in the MRC's vulnerability assessment of wetlands in the Lower Mekong Basin and the downscaled projections for climate change for Champasak province used in the Mekong ARCC project.

The purpose of this study is to provide an initial vulnerability assessment of the wetland resources of Beung Kiat Ngong as a part of the development of the management plan for the Ramsar site, and as a contribution for the development of the large Global Environment Facility (GEF) project currently being developed by FAO and IUCN, called the 'Climate Change Adaptation in Wetlands in Lao PDR' (CAWA). As stated in the guidance for the preparation of case studies of climate change vulnerability of wetlands (ICEM, 2012), the purpose of this assessment is:

> To identify the specific threats to the target wetland biodiversity, ecosystem services and livelihoods resulting from climate change and to develop a range of adaptation and management measures to ensure the continued existence of the wetland, its biodiversity and the ecosystem services that it provides.

The study has been funded through the Mekong Water Dialogues project with funds from the Ministry for Foreign Affairs of Finland.

2 Methods

The methods used for assessing the vulnerability of the wetlands and wetland livelihoods to climate change received guidance from the MRC's case studies on climate change vulnerability of Mekong wetlands, the VCA analysis for community vulnerability, and the ICEM Climate Change Vulnerability Assessment and Adaptation (CAM). Climate change threat profiles for Kampong Thom province were taken from the USAID Mekong ARCC study.

2.1 Wetland and climate change case studies guidance

One of the products of the MRC's basin-wide study of the impacts of climate change on wetlands was a manual providing guidance for wetland case studies (ICEM, 2012). This manual suggested nine steps for conducting such wetland climate change assessments:

1. Review institutional and policy frameworks at the local and national level for those elements which influence management and use of the site;
2. Describe the main biodiversity and ecosystem service characteristics of the site, their status and the ways they contribute to livelihoods;
3. Define the main features which determine the wetland type/category;
4. Document the nature and impact of past climate extremes on the wetland and the "adaptation" responses by communities, government and others;
5. Assess the impact of projected climate change threats on the key "assets" of the wetland;
6. Document the other development threats to the wetlands and the main drivers of change;
7. Define the adaptation options and their phasing to maintain and enhance the wetland's natural systems and services;
8. If resources permit, assess the cost of the impact of climate change on wetlands if no action is taken and the cost of adaptation; and
9. Define a road map for implementing an adaptation plan for the wetland.

These steps together with component aspects to be studied are shown in Figure 2.1.

This study focused on steps 2–6.The adaptation and management steps, and wetland valuation are for further follow-up and development. Of particular use for this study was the guidance provided in the manual for carrying out the assessments for:

- Wetland hydrology field survey checklist;
- Wetland habitat and biodiversity vulnerability;
- Wetland ecosystem services trend analysis; and
- Wetland livelihood vulnerability.

Figure 2.1: Nine-step approach for wetland and climate change case studies

1

- **Review institutional and policy frameworks for wetland management and climate change adaptation**
- National level institutions, laws, policies and regulations for wetlands and for climate change
- Describe local level arrangements for management of case study wetlands, tenure, instruments, decision making processes and plans

2

- **Describe or characterise the wetland case study area in terms of its:**
  - Biodiversity, including key habitats
  - Ecosystem functions and services
  - Livelihoods
  - Values of key ecosystem services (if possible)

3

- **What are the features that determine the character of the wetland?**
  - Elevation, topography, geomorphology, climate, hydrology and its seasonality, and its connectivity

4

- **Inventory of historic climatic events and adaptation responses in the wetland**
- Prepare a seasonal calendar for the wetland identifying predictable climate and hydrological events
- Through consultation with wetland communities identify the years in which extreme events took place over the last 50 years - storms and typhoons, floods, drought, long dry spells in the wet season
- Through consultation with wetland communities identify the historic changes in the wetland and the adaptation responses of these communities and wetland users

5

- **How will climate change affect the character of the wetland by 2050?**
  - Rainfall patterns, Temperature, Evaporation, Sea level rise and Extreme events (floods, drought and storm)
  - Affecting hydrology, seasonality of the flood pulse, water quality
  - In turn affecting biodiversity, habitats and ecosystem services
  - In turn affecting livelihoods and livelihood responses
  - In turn affecting the values of key ecosystem services

6

- **What other specific threats or development pressures are there upon the case study wetland?**
  - Population growth, with increase in hunting and fishing pressures
  - Urbanisation, with increases in risks of water pollution
  - Increase in land use and intensity of agriculture, with risks of encroachment and drainage of the wetland and contamination with agricultural chemicals
  - Hydrological changes from dams, irrigation and water abstraction
  - Watershed degradation and sediment build up in the wetland
  - Disturbance from tourism and recreational uses
  - Other

7

- **What adaptation measures would be needed to maintain and enhance the existing levels of biodiversity/ecosystem services to counteract the impacts of climate change by 2050?**
  - Acceptance of irretrievable losses and search for off-sets elsewhere
  - Measures that enhance the positive impacts of climate change
  - Measures that reduce the negative impacts of climate change
  - Measures that maintain and enhance wetlands in the face of other threats and development pressures
  - Institutional and management measures

8

- **Wetland valuation**
- Assess current values of wetland ecosystems in the case study site
- Assess changes in value of ecosystem services due to climate change

9

- **Develop a road map for progressive implementation of adaptation measures to 2050 if necessary, together with review points with monitoring and indicators.**
- Estimate the cost of first steps in adaptation (e.g. first five years)

2.2 Village consultations

Village consultations were held in eight villages around the Beung Kiat Ngong wetlands in early January 2014. Half-day meetings were held in each village with about 30–40 participants, both men and women, from the communities. The meetings consisted of the following agenda items:

- Introduction and explanation of the purpose and agenda;
- Outline of potential climate changes and their implications;
- Discussion on the village boundaries;
- Discussion on the most important wetland products that the village obtains from the wetlands, mapping where these products are found and the seasonal calendar for collection and lifecycle of the wetland species;
- Discussion on extreme events that have occurred over the last 40 years, and coping strategies; and
- Discussions with the village head about village statistics (population, agriculture, livestock etc.).

Where possible the results of the discussions were captured on sketch maps, calendars, and priority lists.

2.2.1 Key questions – wetland resources

1. What are the most important wetland resources that you collect and use? Rank their importance for your household.
2. At what time of year do you collect or process these resources? For each identify the most important times of year (seasonal calendar).
3. Where in Beung Kiat Ngong do these wetland resources come from? Draw a wetland resource map identifying the main zones for collection of these resources.
4. Do you know if these wetland fauna use other areas for breeding, or as refuges during the dry season? This is a question about what they know of the life history of these animals.
5. How much of these resources does each household collect (each day, how many days a month, which months)?
6. Do you just use these resources for your own household use, or do you sell some of them? If so how much do you sell?
7. How much (LAK) can you sell them for (per piece, bundle, or per kilogram)?
8. Does every household in the village collect these products or only some of them? What sort of people: poor families only, poor and middle class families only, rich families only or everybody?

2.2.2 Climate patterns

1. Discuss the climate generally and try to fit to seasonal calendar.
2. Are there any seasons or events that are important for each of the main wetland products?
3. Are there good or bad years for these wetland resources, and are these linked to the climate or events?
4. What extreme events have you experienced in the last 20–30 years? Put a date on them or can you link these to other memorable events? E.g. drought, storms and

typhoons, strong wind, floods, hailstorms, wild fire, crop diseases or infestations? (Box 2)
5. When these events occurred, describe what happened.(Box 3)
6. Was there any change in availability of wetland products afterwards?
7. What did you do to cope with these extreme situations?
8. What did you do to manage the collection of the wetland products afterwards?

Box 2. Examples of extreme weather events
Drought
Extreme Heat
Floods
Hailstorms
High winds
Rainstorms
Storm surges
Typhoons
Wildfires

Box 3: Examples of climate impacts	
Damage to dwellings	Crop damage/loss
Reduced frog stocks	Reduced fish stocks
Disease	Loss of important wetland species
Fuel shortages	Disrupted transport
Personal injury	Income loss
Reduced water quality	Reduced soil fertility
Social conflict/tension	Sick livestock
Water shortage	Unemployment

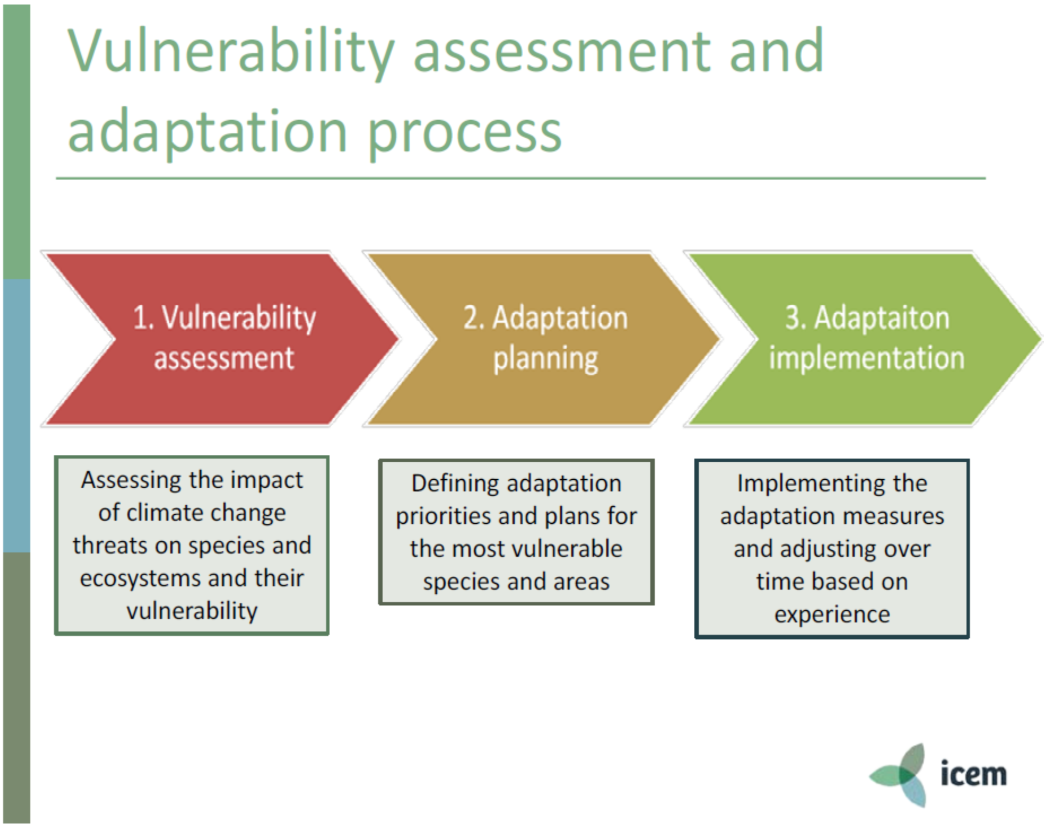
2.2.3 Wetland and threats

1. What are the main areas of different habitats that you can describe in Beung Kiat Nong? Mark these on the map.
2. What have been the main changes in the Beung Kiat Nong wetland over the last 20–30 years(size, area of wetland habitat, types of plants, types of fish and other animals)?
3. What have been the main changes in availability of the most important wetland products over the past 20–30 years?
4. What are the main challenges that you face in the community with regards to water (for drinking, washing or watering the crops)?
5. Where do you currently get this water from? How far do you have to walk to collect drinking water?
6. What are the main challenges that the wetland faces (e.g. extension of new rice fields, peat extraction, drainage of water, cutting of vegetation)?

2.3 Climate Change Adaptation and Mitigation Methodology (CAM)

The **ICEM Climate Change Adaptation and Mitigation Methodology (CAM)** is an integrated approach to climate change mitigation and adaptation planning developed by ICEM. The methodology has been and continues to be developed and adapted to project and case-specific needs. CAM is an overall conceptual approach that has been designed to integrate a wide range of tools and processes that can be applied at different levels and stages of climate change mitigation and adaptation planning. This description of the CAM process is taken from the USAID Mekong ARCC Main report. (ICEM, 2013)

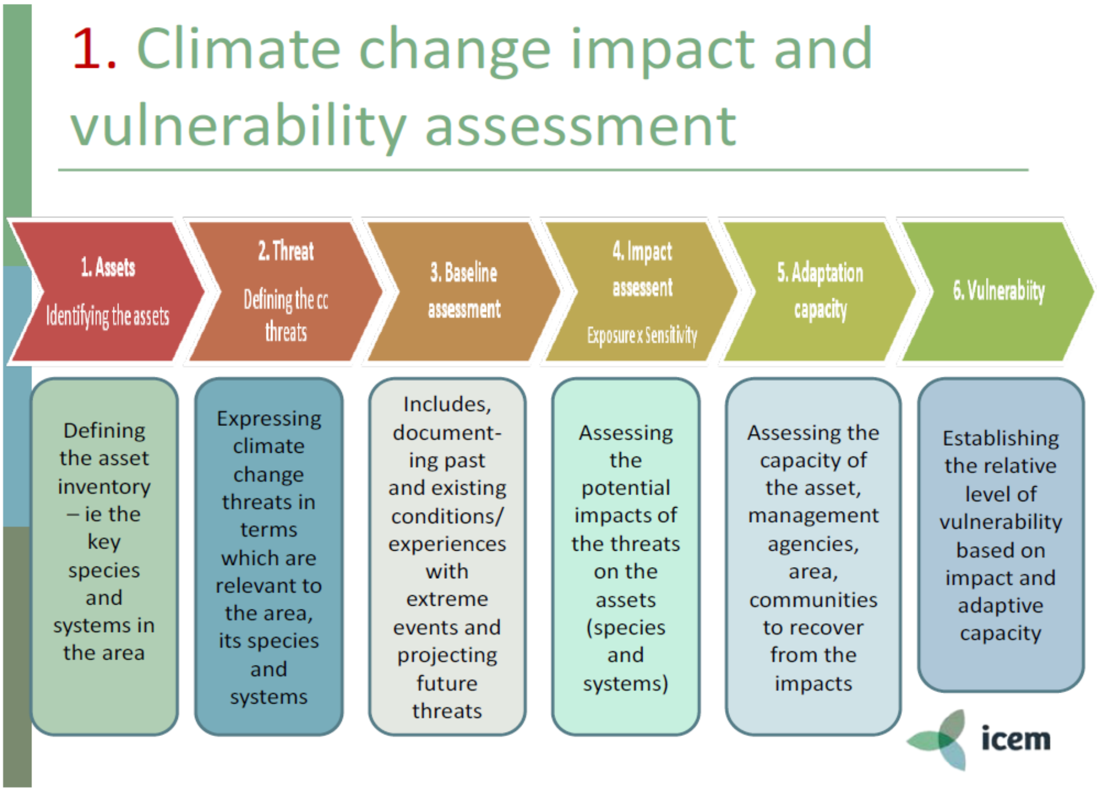
Figure 2.2: Vulnerability assessment and adaptation process



Source: ICEM

Figure 2.2 to Figure 2.4 summarize the CAM process steps and concepts. It has three main phases: vulnerability assessment, adaptation planning, and then adaptation implementation (Figure 2.2). This study has gone only part way along the adaptation process, focusing on the first phase of identifying impacts and assessing vulnerability for Beung Kiat Ngong habitats and species of relevance for livelihoods (Figure 2.3).

Figure 2.3: Climate change impact and vulnerability assessment process



Source: ICEM

The vulnerability assessment follows a recognized pattern of assessing the exposure and sensitivities to climate change threats, and the likely impacts that may result. When combined with the adaptive capacity of the species or system, a ranking and analysis of their vulnerability can be made. Figure 2.2, Figure 2.3 and Figure 2.4 are conceptual in nature. For their practical application, a precise step-wise process is defined and supported by a tool box which facilitates appropriate information inputs at each step. The operational vulnerability assessment and adaptation planning process involves six main components:

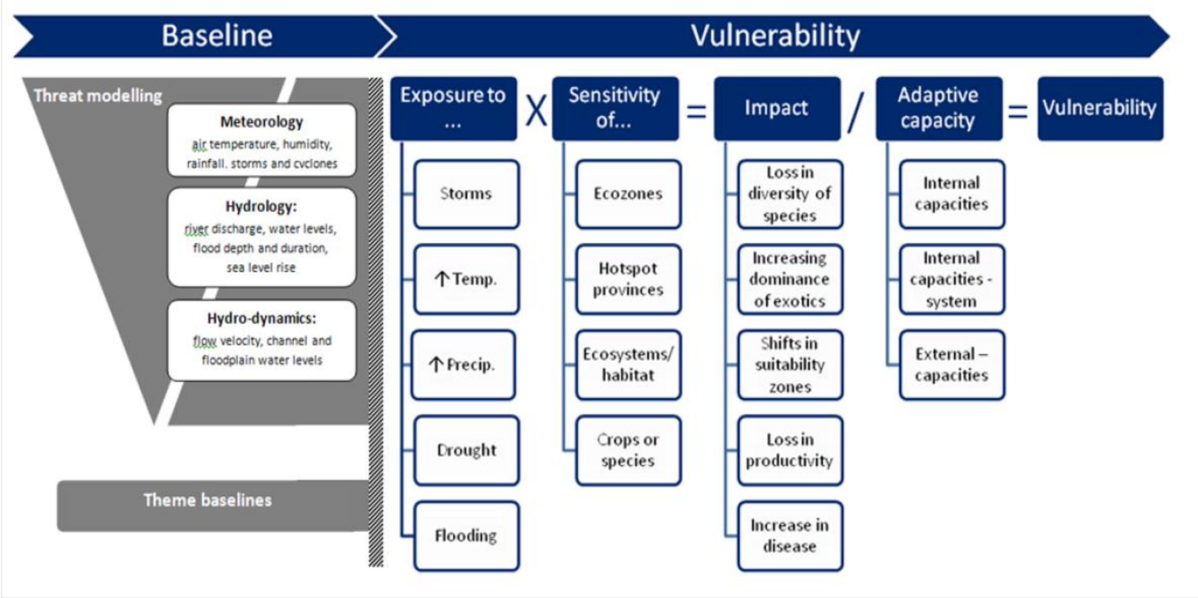
1. ***Determining the scope***, by identifying the geographic and sector focus of the assessment and the species and systems (natural, social, economic, institutional, and built) which will be impacted.
2. ***Determining the climate change threats*** through an analysis of past extreme events and trends and through climate modelling and downscaling of future climate and hydrology against various scenarios. The definition of projected climate change threats is part of the baseline—it needs to be fine-tuned to the specific sensitivities of the species and areas under focus in the form of *threat profiles*.
3. ***Conducting a baseline assessment*** to describe the past and existing situation, trends and drivers across each of the identified systems, and projecting the changes to these systems which will occur irrespective of climate change. The baseline involved the review of scientific, socio-economic and development literature, existing databases, consultation with other experts, and team expert judgment. The theme baseline assessments are provided in the separate theme volumes prepared for this study and include:
    - Identification of key species/systems,

    - Description of key species/systems,
    - A species/systems database including climate tolerances, and
    - Description of impacts of past extreme events.
4. ***Conducting the impact assessment***: for each of the target species and systems, the exposure, sensitivity, impact, and adaptive capacity were defined using the baseline and climate threat modelling results and matrix support tools developed by ICEM. The theme vulnerability assessments are summarized in the separate theme volumes to this report.

The CAM method outlines four important factors in assessing vulnerability of the target species and systems to the defined climate change threats: exposure, sensitivity, impact, and adaptive capacity, and provides a set of tools to facilitate assessments at each stage (Figure 2.4).

- **Exposure** is the degree of climate stress on a particular system or species; it is influenced by long-term changes in climate conditions, and by changes in climate variability, including the magnitude and frequency of extreme events.
- **Sensitivity** is the degree to which a species or system will be affected by, or responsive to climate change exposure.
- The potential **impact** (or level of risk) is a function of the level of **exposure** to climate change-induced threats, and the **sensitivity** of the target assets or system to that exposure.
- **Adaptive capacity** is understood in terms of the ability to prepare for a future threat and in the process increase resilience and the ability to recover from the impact. Determinants of adaptive capacity include:
    - ***Natural systems***
        - Species diversity and integrity
        - Species and habitat tolerance levels
        - Availability of alternative habitat
        - Ability to regenerate or spatially shift
        - For individual species: dispersal range and life strategy
    - ***Infrastructure***
        - Availability of physical resources (e.g., materials and equipment)
        - Backup systems (e.g., a plan B)
    - ***Social factors***
        - Social networks
        - Insurance and financial resources
        - Access to external services (medical, finance, markets, disaster response, etc.)
        - Access to alternative products and services
    - ***Crosscutting factors***
        - The range of available adaptation technologies, planning, and management tools
        - Availability and distribution of financial resources
        - Availability of relevant skills and knowledge
        - Management, maintenance, and response systems including policies, structures, technical staff, and budgets
        - Political will and policy commitment.

Figure 2.4: Parameters and issues considered in the baseline and vulnerability assessment process



Source: ICEM

When impact and adaptation capacity are considered, a measure of relative vulnerability can be defined.

The CAM method can use numerical scoring for exposure, sensitivity, impact, and adaptive capacity leading to a comparative score for vulnerability, or it can use qualitative terms from very low to very high with the aid of assessment tools which come with the method. Table 2.1 and Table 2.2 show the scoring matrices used in this study to assess impact and vulnerability.

Table 2.1: Determining impact: exposure X sensitivity

		Exposure of system to climate threat				
		Very Low	*Low*	*Medium*	*High*	*Very High*
Sensitivity of system to climate threat	*Very High*	*Medium*	*Medium*	*High*	*Very High*	*Very High*
	High	*Low*	*Medium*	*Medium*	*High*	*Very High*
	Medium	*Low*	*Medium*	*Medium*	*High*	*Very High*
	Low	*Low*	*Low*	*Medium*	*Medium*	*High*
	Very Low	*Very Low*	*Low*	*Low*	*Medium*	*High*

Source: ICEM

Table 2.2: Determining vulnerability: impact / adaptive capacity

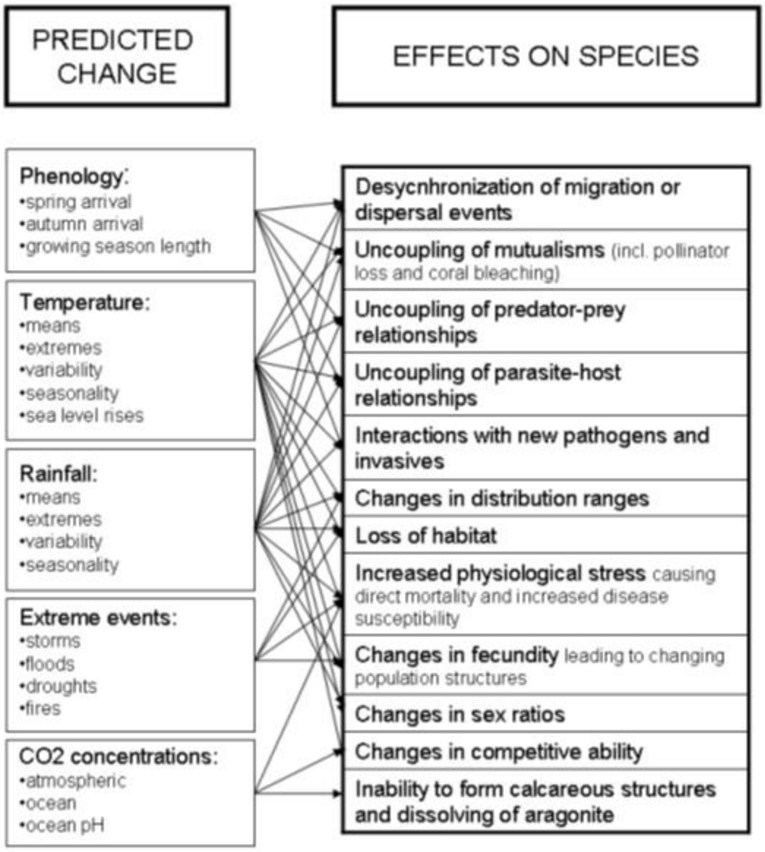
	Impact					
Adaptive Capacity		*Very Low Inconvenience (days)*	*Low Short disruption to system function (weeks)*	*Medium Medium term disruption to system function (months)*	*High Long term damage to system property or function (years)*	*Very High Loss of life, livelihood or system integrity*
	Very Low Very limited institutional capacity and no access to technical or financial resources	*Medium*	*Medium*	*High*	*Very High*	*Very High*
	Low Limited institutional capacity and limited access to technical and financial resources	*Low*	*Medium*	*Medium*	*High*	*Very High*
	Medium Growing institutional capacity and access to technical or financial resources	*Low*	*Medium*	*Medium*	*High*	*Very High*
	High Sound institutional capacity and good access to technical and financial resources	*Low*	*Low*	*Medium*	*Medium*	*High*
	Very High Exceptional institutional capacity and abundant access to technical and financial resources	*Very Low*	*Low*	*Low*	*Medium*	*High*

Source: ICEM

2.4 Determining ecological response to climate change

In 2008, IUCN Species Programme (Foden, 2008) produced a paper on species susceptibility to climate change in which the effects on different species could be associated with different predicted changes. A linkage diagram from that report is presented in Figure 2.5 and demonstrates the complex relationship between climatic factors and biotic response. This was used in the manual for rapid climate change assessments for wetland biodiversity in the Lower Mekong Basin (ICEM, 2012). It identifies some of the impacts that can be expected on wetland biodiversity in the Lower Mekong Basin.

Figure 2.5. Summary of some of the predicted aspects of climate change and examples of the effects that these are likely to have on species



Source: Foden, 2008

The methods for determining the ecological response of habitats and species to climate change depend upon knowledge of the biological requirements for temperature and water availability/water level at different stages of the lifecycle of species, or in the year for habitats. Whilst complex ecological models may be available, at this level of analysis it is necessary to base the vulnerability assessment upon scientific judgment, based upon information from published papers on the biology and behavior of the habitats or species, their tolerances to temperature and drought etc. and local knowledge about these issues. It is important to identify key life stages where the organism is likely to be less tolerant, e.g. during breeding and juvenile development; flowering, fruiting and seed dispersal. It may also be important to note the critical times of the year when the organism is hibernating or sheltered from climate extremes, e.g. eels in their burrows. Other factors may include availability of food sources, or the resistance to parasites and diseases that may be reduced by climate change.

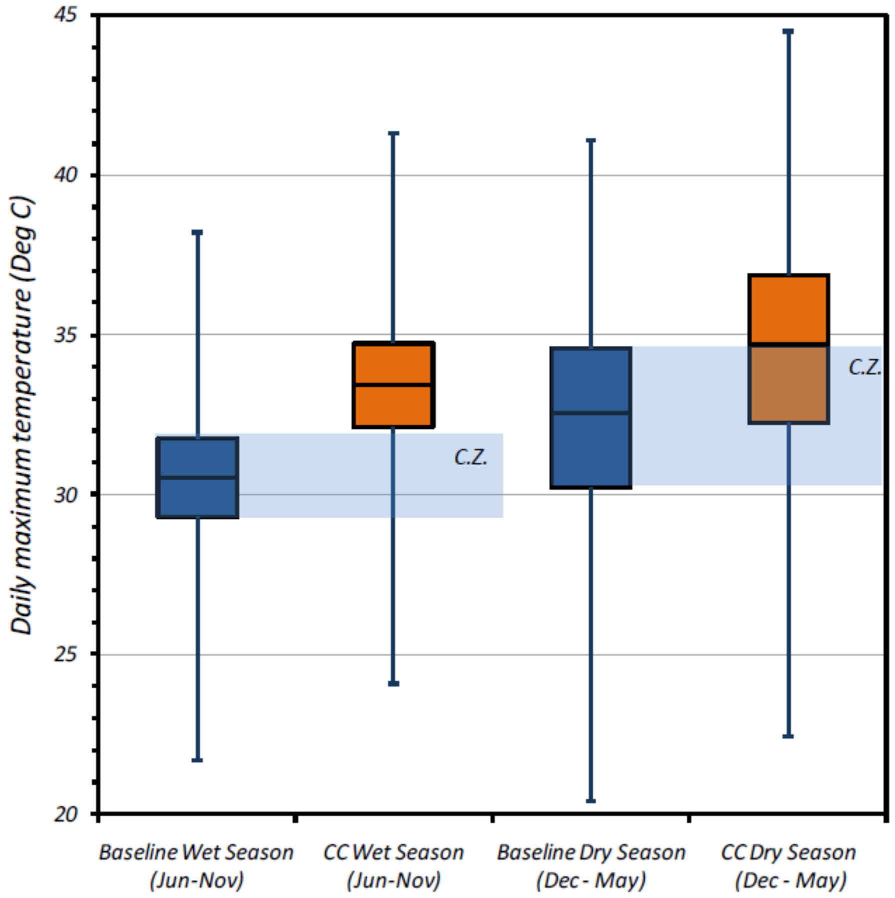
2.4.1 Comfort zones

Comfort zones are where species and ecosystems experience the most suitable growing conditions in terms of the range and timing of temperature and rainfall. They are defined to include 50% of the baseline variability around the mean in temperature and rainfall for typical months, seasons and years.

All species have a range of climate in which they grow most comfortably. For agricultural crops usually that range is well understood—climate parameters have been studied in detail and published widely. For example, it has been shown that maize grows well in areas that have a total annual precipitation of between 500 and 5,000 mm and mean maximum temperature in the range of 26°C to 29°C. Outside this range the growth of the plant is constrained or inhibited entirely. For wild species and habitats, the comfort range is poorly researched and documented, even if known anecdotally by local communities and managers.

Comfort zone analysis requires information on the range of rainfall and temperature that was experienced during 50% of the historical baseline around the mean. For example, Figure 2-6 shows the wet season and dry season daily maximum temperature comfort zone for the Champasak. In this area the ecosystem is adapted to and comfortable within a daily maximum temperature of between 29°C and 32°C during the wet season and 30°C and 34.5°C during the dry season. By 2050 the daily maximum temperature during the wet season will shift completely outside the baseline comfort zone: in the dry season the maximum daily temperature will shift so that 50% of the maximum temperatures will occur in the range between 32 to 37°C. The comfort zone analysis enables the researchers to make rapid assessments on the relative impact of climate change on species and habitats.

Figure 2.6: Maximum temperature comfort zone analysis of temperature range shifts during wet and dry seasons, Champasak Province.



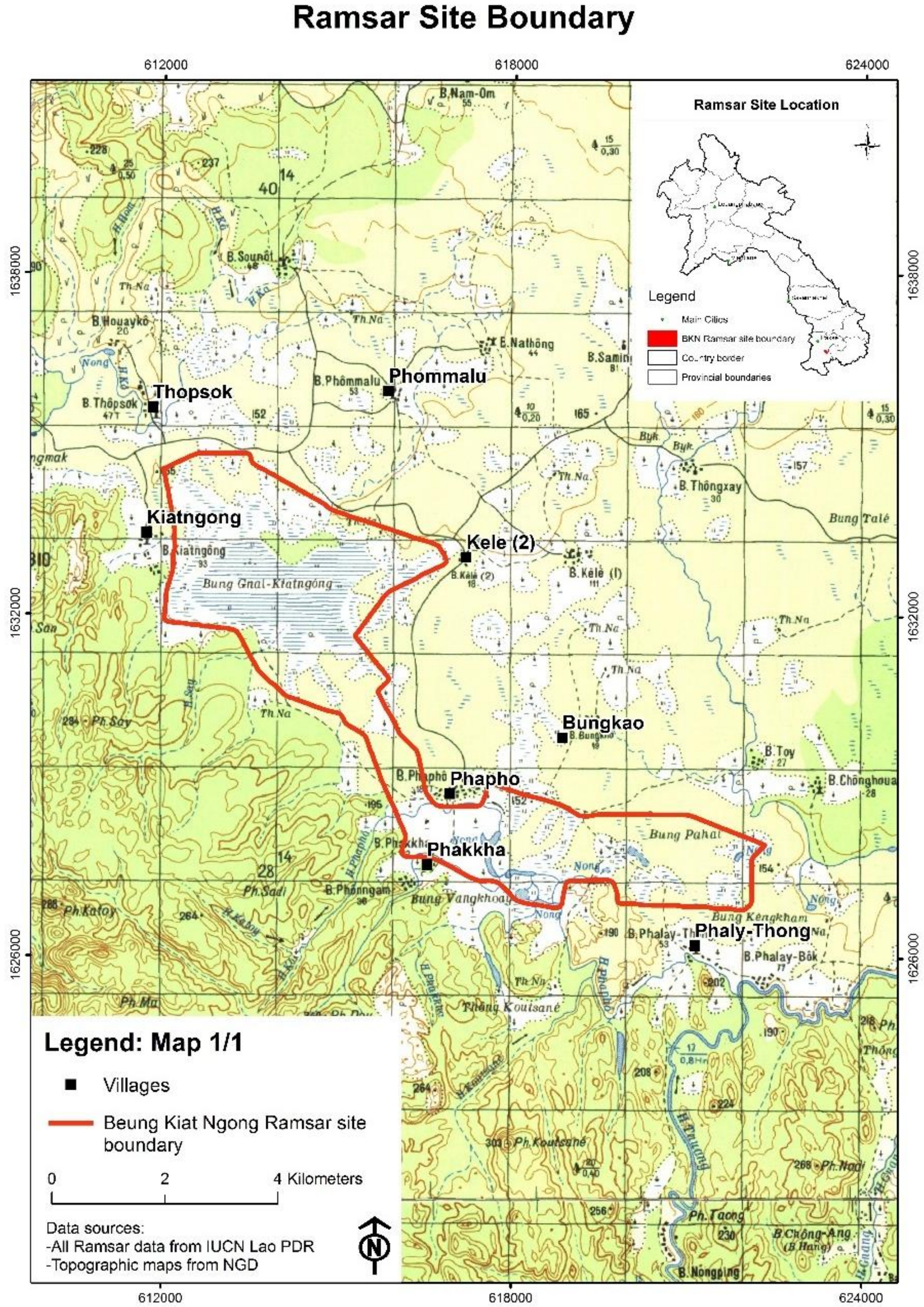
Source: (ICEM, 2013)

3 Description of Beung Kiat Ngong

3.1 Location and site description

The Beung Kiat Ngong wetlands cover about 2,360 ha in Pathoumphone district in the southern Lao province of Champasak. It lies between 120–200 m above sea level, partly within the Xe Pian National Protected Area (NPA) and to the south of Dong Hua Sao NPA which covers the southern slopes of the Bolaven Plateau. Both of these NPAs provide the streams which feed the wetland.

Figure 3.1: Location of Beung Kiat Nong wetlands



Source: IUCN 2011

The Ramsar site boundary in Figure 3.1 shows that the site has two almost separate wetland areas: the northern part, Beung Gnai Kiatngong on the map, and the southern wetland area between the villages of Phakha, Phapho and Phaly-Thong. The two areas are linked by a narrow corridor. The water in the northern area of wetlands is fed by streams from the north and from hills to the west, while the water flowing into the southern wetland area comes from a larger catchment to the south. The general direction of the water flow in the wetland is from north to south, flowing out into the Houay Tauang, and from there into the Xe Khampho which then joins the Xe Pian river and Sekong.

The wetlands lie in a series of shallow basins, which have filled with peat and form a wetland complex of marsh, swamps, perennial and seasonal ponds, and seasonally flooded grasslands. Around the perimeter of the wetlands, the land has been converted to rain-fed rice paddy, especially in the southeastern portion where the wetlands have naturally filled in with accumulated sediment and decayed vegetation. Interspersed within these marshes and open waters, there are islands with shrubs and trees, and there are areas of rich semi-evergreen and seasonally flooded forest.

Much of the wetland is not open water, but consists of relatively shallow water covered by a thick layer of decaying grasses with new shoots and emergent weeds as well as bushes growing on top of this layer. The deepest parts of the wetland may be as deep as two to three metres in the dry season. Within the main part of the wetland water permanence during the dry season is 300–400 ha with other scattered small marshes and pools that retain water throughout the year. During the wet season the whole area becomes inundated with water levels rising to two metres above the dry season levels.

The soils within the wetland area are black, peaty soils, while outside the wetland they are reddish soils which are naturally fertile with fine texture basalt and alluvial components. The forest in the wetlands is rich due to the good quality of the soil and abundance of water.

The ecosystem services of the wetland have been recognized in the Ramsar site profile as:

- Flood mitigation
- Sediment trapping due to the slow water flow
- Storing and maintaining of ground water
- Fish spawning ground, plus habitat for other aquatic animals such as frogs, snails and turtles
- Habitat for other wild animals, including a number of threatened species
- Contribution to securing local livelihoods with villagers earning direct income from wetlands resources(fish, frogs, wetland vegetables)
- The wetlands provide grazing for livestock(buffalo, cattle and elephants)
- The site is an important for its eco-tourism opportunities.

3.2 Current and historic climate

The Beung Kiat Ngong wetlands have a distinct dry season between late October and early May, with the wet season extending from mid to late May to October. Temperatures range from a minimum low of 14.5°C in January, when the humidity ranges between 32–95 % to a maximum high of 38.3°C in April with humidity ranging between 39–96%. During most of the wet season the humidity approaches 99%. The average rainfall at the site is around 2,000 mm annually with one third of the rainfall usually occurring in August (IUCN, 2011). Further details of the community perceptions of the climate are provided in Chapter 5, and of climate projections and extreme events in Chapter 6.

3.3 Hydrological characteristics

The Beung Kiat Ngong catchment is split into a smaller northern section, just draining the immediate slopes around the wetland and a larger southern portion as shown on the Google earth maps. The northern section of Beung Kiat Ngong appears to be extremely complicated hydrologically. The estimated area is about 46 km^2, with most of the run-off coming from short seasonal streams running from the eastern slopes of the Xe Pian hills (Phou Asa etc.) and some run-off coming from the flat lands to the north. It is difficult to distinguish where are the main flows amongst the complex streams in this flat area; do they flow from north to south into the wetland, or west into Houay Tomo?

The southern catchment feeds into the Houay Tauang which is a tributary of the Xe Khampho. This catchment is part of the Xe Khampho catchment and has a total area of 442.57 km^2. Some characteristics of this catchment area are shown in Table 3.1(Meynell, 2013). Estimates of the total volume of rainfall on the catchment in wet and dry seasons are shown below in Table 3.2.

Table 3.1: Characteristics of the catchment of the Houay Tauang flowing into the southern part of Beung Kiat Ngong

Geology	**Area km^2**	**Soils**	**Area km^2**	
Basalt, laterite	126.83	Ferric acrisol	15.34	
Conglomerate, siltstone, sandstone	315.74	Ferric acrisol skeletic	207.34	
		Haplic acrisol	39.04	
		Haplic acrisol/Dystric cambisol	86.71	
		Dystric leptosol	94.14	
Ecological zone type		**Land use**		**Protected area**
Floodplain, wetland, lake	2.0	Paddy	24.18	PA = 393.02 km^2
Low elevation dry broadleaf	2.55	Swamp/wetland	8.95	KBA = 378.90 km^2
Mid-elevation dry broadleaf	438.02	Water body	1.5	
		Forest	407.94	
Altitude (masl)	**Areakm^2**	**Slope**	**Area km^2**	**Stream order**
101 – 200	160.99	0 - 2%	137.79	1 = 61.9 km
201 – 300	174.90	2.1 – 5%	54.06	2 = 12.03 km
301 – 400	68.14	5.1 – 8%	39.38	
401 – 500	23.51	8.1 – 15%	62.37	
501 – 600	8.86	15 – 30%	87.62	
601 – 700	3.95	30 – 60%	57.41	
701 – 800	1.93	>60%	3.78	
801 – 900	0.16			

Table 3.2: Estimates of total volume of rainfall in Beung Kiat Ngong

Section		Catchment area	Current rainfall	Volume of rainfall
		km^2	mm	mm^3
Northern section	Wet season	46	1,578	72.6
	Dry season		463	21.2
Houay Tauang	Wet season	443	1,578	699.1
	Dry season		463	205.1
Total for Beung Kiat Ngong	**Wet season**	**489**		**771.7**
	Dry season			**226.3**
Total rainfall				**998.0**

Most of the rainfall in the dry season would have evaporated, and the graph of drought months shows that potential evapotranspiration (PET) is likely to increase during the dry season. This will create extra pressure on the water in the wetlands, which may tend to shrink more than they do at the moment. This is counterbalanced by more water from run-off in the wet season, so the wetland area would tend to increase in size by about 8% (the percent increase in rainfall volume in the wet season).

The situation is further complicated by the fact that there may be backwater effects coming from the Xe Khampho and preventing the outflow of water from Beung Kiat Ngong when the water levels in the Xe Pian and Xe Khampho are very high (late in the wet season). By contrast it may be that flooding in the northern part of Beung Kiat Ngong may be more dependent upon local rainfall. There is an indication of this in the reports of local people of two distinct major floods in 1978 (in the southern part) and 1979 (in the northern part).

Figure 3.2: A Google Earth interpretation of the catchment area of Houay Tauang into southern part of Beung Kiat Ngong (note the map is oriented in a west-east direction) by the authors.

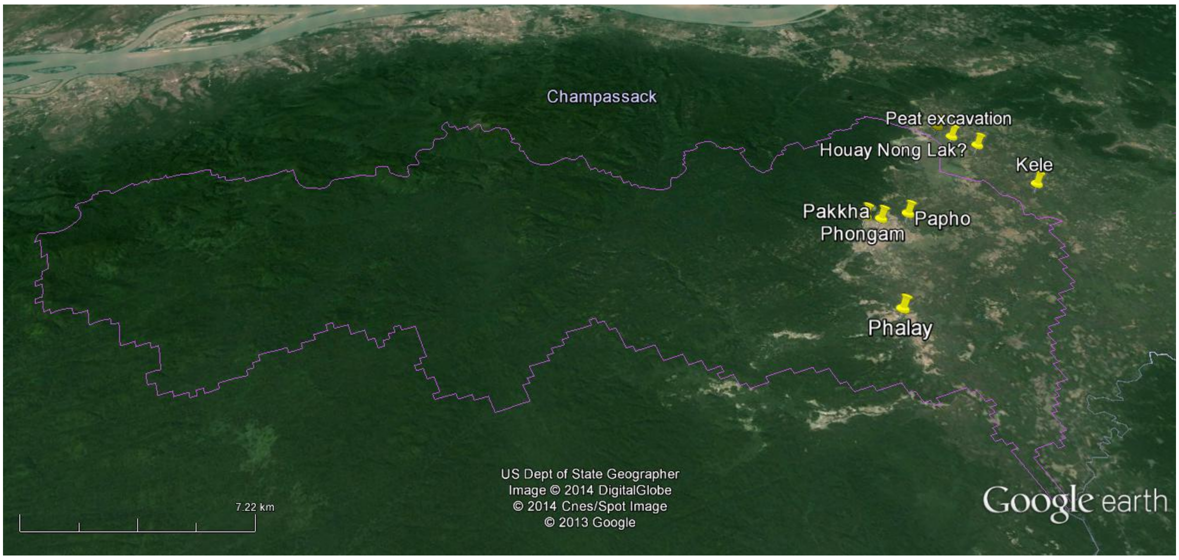
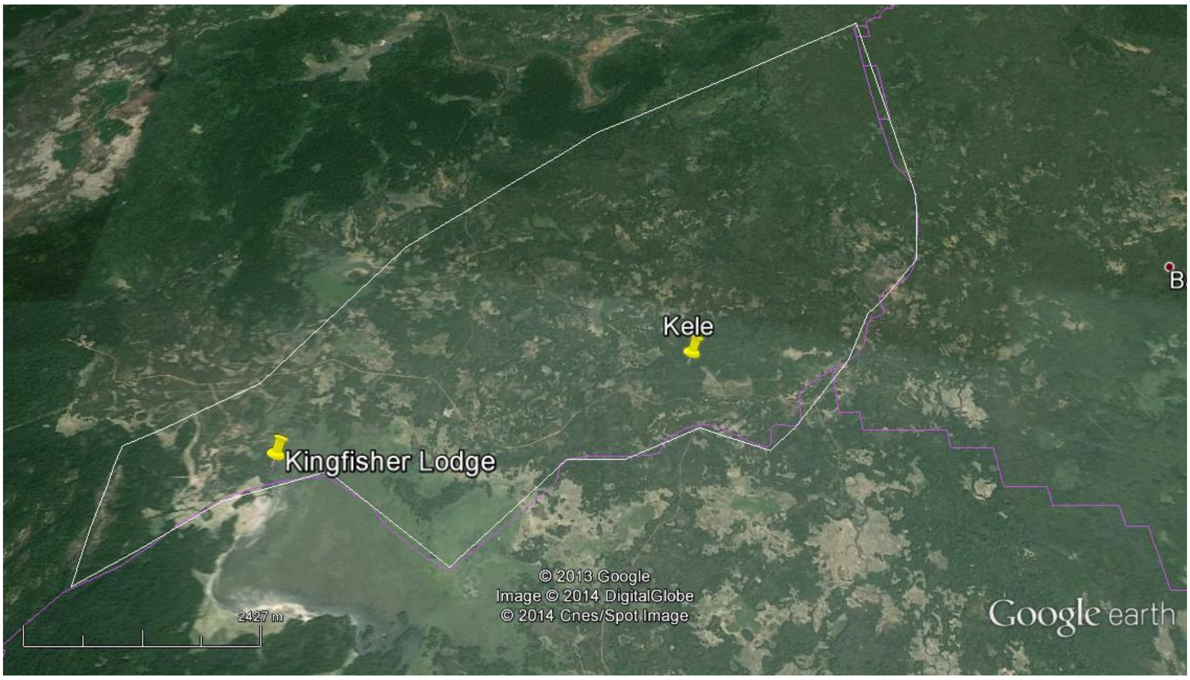


Figure 3.3: Catchment area for the northern part of Beung Kiat Ngong



3.4 Wetland habitats

The wetland habitats in and around the Ramsar site have developed in a series of basins in the low lying plain, sandwiched between the Bolaven Plateau and the hills of Xe Pian NPA[1]. Lava flows from the ancient volcanic activity on the Bolaven have created a system of basins formed by natural dykes and dams. These basins have filled up with alluvial sediments and peat formation, and small areas of permanent wetland remain with open water at the centres of these basins. The Bung Gnai-Kiat Ngong (BGKN) in the northern part of the Ramsar site is the largest area of permanent marsh. The Ban Phapho basin is not much smaller but has now almost totally filled, and has therefore been converted largely to paddy.

In contrast to the larger basins, many small but often steep-sided basins have larger proportions of permanent wetland. These small basins are often tree-covered and have open water rather than marsh vegetation. A complex network of streams may connect all the larger basins. Precise drainage patterns are not at all obvious and often convoluted, although drainage is roughly north to south. Some of the small basins are either isolated or are connected to the rest of the system only at very high water levels. Some larger basins may also be relatively isolated.

Wetland types vary considerably in the Pathoumphone wetlands. Seasonal wetlands predominate in total area, but their ratio to permanent wetlands, hard to estimate, may vary year to year. The full wetland extent is hard to visualize because of forest cover, as are patterns of connectivity between wetlands. No accurate map yet exists. Most basins appear to interconnect, rather than to be connected by drainage channels *per se*.

The different wetland habitat types that can be distinguished are:

- **Perennial ponds-** Areas of relatively permanent open water with aquatic plants seem rather limited in the large basins, especially within the main BGKN marsh. There are three main types of permanent ponds: open water with various aquatic herbs (both floating and submerged), open water below shrubs and bushes (and, in smaller basins, trees), and floating vegetation mats.

- **Seasonal ponds-**During the wet season, open-water habitats become relatively common throughout the edges, although patches are often small. These have abundant ephemeral floating and aquatic herbs, as well as species with above-ground structures presumably dying back during the dry season. More deeply, but not permanently, inundated regions hold Lotus *Nelumbo nucifera*, such as around the southern edge of the permanent main BGKN marsh.

- **Small seasonal and perennial streams-**There are a number of small seasonal and perennial streams which flow into the wetland from the surrounding hills, and interconnecting streams between the basins flowing in a generally north to south direction.

- **Peatmarshes –** Peat marshes have formed from decaying vegetation under acidic and anaerobic conditions in some areas, particularly in the northern part of the

[1]This section of the report has been drawn from the recent biodiversity survey of Beung Kiat Ngong for IUCN by Timmins and Duckworth (Timmins, 2014).

wetland. There are about 400 ha of high quality peat land in the northern part and about 1,000 ha of lower quality seasonal semi-peatlands in the southern part. Between 2006–2009 commercial peat extraction removed up to 650 m^3 of peat per day for making natural fertilizer. This has left a number of open pools up to two metres deep. Peat extraction in Beung Kiat Ngong ceased after 2009.

- **Freshwater marshes -** Lengthier inundation probably favours sedges over grasses, apparently giving the deeper areas a greater sedge component. However, extensive sedge beds seem relatively scarce: the most extensive seen were on the south-west edge of the main BGKN marsh. In this latter region a tall, robust sedge, typically known as *purr* in Lao, predominates. This is possibly *Scirpus grossus*, based on observations of a structurally similar sedge in the Xe Champhone wetlands (Timmins 2014).

- **Seasonally flooded grassland -** In large open basins the predominant 'natural' cover appears to depend highly on seasonality, with soil type and disturbance regime also probably significant. Where inundation and soil water logging are not prolonged, the predominant cover appears to be various grass species. In places such as the north-east of the main BGKN marsh, one species of grass forms almost a monoculture over about a tenth of the total marsh.

- **Floating vegetation mats -**The extent of floating mats is hard to estimate: in most areas they are not readily distinguishable from areas of graminoids rooted into the wetland bed. They probably occupy 20–30% of the main BGKN marsh. Mats are typically difficult to reach, so their composition is uncertain. Mat vegetation in the main BGKN marsh seems predominantly graminoid-based, with *Imperata cylindrica* prevailing. Very few, if any, shrubs grow in the mat itself, although, apparently rooted in the wetland bed, they are common but sparse in a zone around the mats. Some mats in the Pathoumphone wetlands do have shrubs: dense shrub and small tree growth (probably involving willows Salix) e.g. Nong Pakham andmuch of central Nong Boua had what appeared to be most likely a floating mat composed of a dense mix of shrubs, aroids, sedges (but not 'purr') and ferns.

- **Shrubland -** In other parts of the main BGKN marsh the community is richer with a mix of grasses, sedges and herbs. A shrub probably *Sesbania* often occurs in quite extensive clumps, possibly in association with ground depressions with longer inundation.

- **Swamp forests-** Larger basins typically have small clumps of taller vegetation, varying in composition, but include various tree and shrub species. Commonly the shrubs were overgrown with vine, ferns and a large aroid. These areas probably indicate deeper ground depressions, corresponding to elements of swamp forest, especially around the basin edges. In the main BGKN marsh, they tend to occur on edges furthest from frequent human use (e.g. paddies, grazing land and villages). The swamp forest areas on the edge are in general larger and taller, with trees rather than the smaller bush-like trees and shrubs within the marsh. Bruselaceous trees, such as *Barringtonia*, are conspicuous in such swamp forest edges. These swamp forest areas are generally small patches less than a hectare in size, typically bounding the wetland edge in direct contact with remnant 'dry-land' forest. All swamp forest is probably disturbed, primarily through timber removal and clearance of adjacent areas for agriculture. As usual under a swamp forest canopy, plant growth is relatively sparse.

- **Rice paddies-** Images on Google Earth suggest paddies already comprise perhaps 30–40% of total cover in these large basins. However, the main Beung Kiat Ngong basin retains a larger extent of more natural cover. Paddies cover only about a tenth of it, mainly along the western and northern edge, and probably receive shorter inundation than is typical in areas of more natural cover(Timmins, 2014). Established paddies are almost confined to basins, with mostly alluvial soils (rather than organic 'peat' soils). 'Dryland' agriculture including plantations is increasing at the expense of forest. The shallow soils, perhaps minerally rich, seem not to hinder seasonal agriculture significantly.

- **Surrounding dry-land habitats,** generally degraded, would originally have consisted of two broad forest categories. The lava flows themselves support predominantly deciduous communities, variously named by different classification systems (e.g. mixed deciduous forest; nearly-deciduous forest; nearly fully deciduous semi-evergreen forest). Aerial imagery graphically shows such forests concentrated in the most recent lava flow's footprint: presumably the young, relatively shallow, soils have low water retention.

- In contrast, Xe Pian NPA's hills hold mostly semi-evergreen forest with a relatively low deciduous component. There, soils are older, deeper and retain much more water. Where the hill bedrock is close to or exposed on the surface, such as Phou Asa, communities are also predominantly deciduous. Seemingly older lava flows, to both the north and east, have transitional or predominantly semi-evergreen forest. This presumably reflects more developed soils of greater age. The very valuable NTFP tree, *Scaphium macropodum* from which Malva nuts (*Mak chong*) are gathered occur in these forest areas.

3.5 Changes in vegetation

Marsh vegetation is likely to be very dynamic, through various factors, notably fire, livestock grazing and timber removal. Consultations with local people by Timmins and Duckworth (Timmins, 2014) indicate:

- An increase in tall sedge (*purr* in Lao). In most wetlands, this was said to have been scarce and almost absent in the main BGKN marsh about 20 years ago.
- The main BGKN marsh c.20 years ago had reportedly much more open water, when *'Imperata cylindrica'*, with its characteristic cottony seed-head, was apparently scarce. This suggests that floating mat vegetation was also then scarce.
- *Salvinia* ('*chok*') was then reportedly much more common. In 2013–2014 only sporadic small dense patches were found, amongst other vegetation in the seasonally inundated edge.
- Bush and tree cover had also reportedly decreased, especially in the main BGKN marsh.

However, this timeline may be inaccurate, because Salter (1989) described, 25 years ago, essentially the same habitat mix for the main BGKN marsh as now: “Margin adjacent to forest now dry (but seasonally flooded) grassland up to 500+ m wide. Very heavily grazed by cattle and water buffalo and also by domestic elephants. Central area appears permanently saturated and supports dense growth of tall (1 m) sedges and patches of low (<2 m) shrubs. Open water limited to small patches <0.1 ha in size with water lettuce [Pistia] and other floating aquatics”.

The loss of tree and bush cover is almost certainly attributable to human activities. Several local people considered that trees and shrubs surrounding deeper depressions might be cut to reach the wetland products in these more permanent wetlands. When cut, the trees and shrubs are placed in the water to create ‘substrate and structure’ in order to attract fish and other aquatic animals.

Other damage is likely to arise from activities including fodder collection, timber and other wood removal, livestock trampling, especially by elephants, and fire. Similarly, the fringing forest that until recently dominated the edges of even the open wetlands, is being rapidly degraded and lost by a combination of timber removal and agricultural clearance, primarily for non-rice crops.

Livestock use of the wetlands can change the vegetation structure. Livestock using the marsh, especially buffalo, have reportedly decreased substantially as local economies move from subsistence- to market-based systems. Buffalo can modify and maintain various marsh characteristics, including species composition via selective grazing and browsing, and if there are fewer animals remaining, then the species composition is also likely to change.

The larger basins’ open nature reflects three interacting factors: fire, large ungulates and people. Without these, swamp forest would predominate in all seasonally inundated areas (including those that might dry only in very rare dry years). Even without people, herbivores and fire would maintain many large basins as open seasonal wetlands. But the three factors also tend to remove seasonal tall cover of grasses, sedges and *Sesbania*. This latter factor is particularly significant because in the late dry season when the wet area is at its lowest the cover available for wetland animals is also most limited.

3.6 Biodiversity - key species

This section focuses on the main species found in the wetlands that are important to the livelihoods of the communities surrounding the wetlands.

3.6.1 Flora

There is not a great deal of information about the floral species in the Beung Kiat Ngong wetlands. In 2009, a survey of medicinal plants found in the wetlands and surrounding forests identified more than 240 species (180 genera and 80 families of vascular plants) used by traditional healers in the area including *Tinospora crispa,* a climbing woody liana in mixed deciduous forests, used in the treatment of diabetes; *Desmodium lanceolatum,* a perennial non-climbing woody shrub in the forest understory used for a variety of ailments including hypertension, dysentery, worms, fevers and stomach upsets; *Orthsiphon stamineus,* a herb distinguished by its white or purple-coloured flowers used as herbal tea; *Vitex trifolia,* a large shrub or tree used for fever and as a mosquito deterrent. One of the most important economically important trees in the forests around Beung Kiat Ngong is the

Malva nut tree, *Scaphium macropodum*. This is a masting species, flowering and fruiting in large quantities on a three to four year cycle. The nuts contain a bassorine gum, which though not soluble in water, swells up to form a gel, which is then used for a variety of medicines against diarrhea, sore throats, coughs, inflammation and urinary complaints.

Of the wetland plants that have been mentioned in the habitat discussion:

- **Grasses** that form the floating mats and seasonally inundated grassland. The main species mentioned is *Imperata cyclindrica* or similar.

- Of the **shrubs**, *Sesbania sesban*is a wetland species with a yellow flower that is collected as vegetable in many parts of the Mekong region. It grows in the depressions where the water tends to be too deep for the grasses. Though perennial it is a nitrogen fixing plant with an annual growth pattern similar to graminoids, leaving bare stems after the flood water go down, which then sprout again. The stems are also used for fibre, baskets and fish traps in other parts of the Mekong.

- The villagers of Nong Mak Ek and Thopsok both mention **tall weeds** for mat making, locally known as *Kha* and *Pheu.*

- **Sedges** such as *Scirpus grossus*is, a stout, erect, coarse plant with a tufted, robust and strongly three-angled stem reaching about 1.5–2.5 m tall. It is strongly tillering with long stolons ending in small tubers. It can be an invasive in commercial rice fields, but also has some economic value. It serves as good herbage when ploughed in as green manure. In India and Malaysia, the tubers are a good source of starch, where it is also used in traditional medicine. In the Philippines and Malaysia it is harvested for mat-making and string(Plantwise, 2014).

- **Wetland trees** include *Xanthophyllum flavescens (*Khok seng), which grows on the edges of the wetlands and swamp forest. The leaves are very popular as vegetable or salad. *Barringtonia spp.* include a number of typical flooded forest tree species in this genus.

- **Invasive species -**The giant mimosa, *Mimosa pigra* is not yet widely established in Beung Kiat Ngong, but patches of this invasive alien species have been observed in Ban Sanot, at Ban Phommaleu and in the Ban Phalay area. *Mimosa pigra* is well adapted to colonize disturbed seasonal wetlands, and can quickly form an almost monoculture-like cover. Its spines and chemical irritants discourage animals from eating it. The species tends to be most prevalent in agricultural margins and in areas recently cleared for agriculture.

- Several other exotic wetland plants are present, including Water-hyacinth, *Eichhornia crassipes* and Water-lettuce, *Pistia stratiotes*. None was found to be particularly prevalent (Timmins, 2014).

3.6.2 Fish

The fish species living in the wetlands can be grouped into those that remain in the wetlands throughout the year and those that move into the wetlands in the wet season for spawning and feeding. A total of 43species have been recorded in the wet season, with 20 species remaining during the dry season.

Scientific name	Common name	Local name
Resident species		
Anabas testudineus	Climbing perch	
Channa striata	Snakehead murrel	*Pa kho, Pa kor kang*
Channa gachua	Dwarf snakehead	*Pa kang*
Clarias batrachus	Walking catfish	*Pa douk*
Clarias macrocephalus	Bighead catfish	*Pa douk oui*
Esomus metallicus	Striped flying barb	*Pa cheo*
Monopterus albus	Swamp eel	*Pa ein*
Oreochromis niloticus	Nile tilapia	*Pa nin*
Rasbora aurotaenia	Pale rasbora	*Pa cheo oa*
Trichogaster trichopterus	Blue gourami	*Pa kadeut*
Wet season migrant species		
Channa sp.	Channidae	*Pa kuane*
Channa sp.	Channidae	*Pa do*
Cirrhinus sp.	Cyprinidae	*Pa keng*
Cirrhinus sp.	Cyprinidae	*Pa kha yang*
Danio sp.	Cyprinidae	*Pa vienphai*
Notopterus notopterus	Asian knifefish, featherback	*Pa tong*
Tetraodon sp.	Tetraodontidae	*Pa pao*

Source: WREA 2011

Generally the resident species, also known as black fish, inhabit relatively clear-water swamps and plains year round and make limited lateral migrations. The waters they inhabit are tea-coloured by chemicals dissolved from floodplain vegetation, the decomposition of which increases acidity and depletes oxygen, stresses to which black fish are adapted. Most species are specifically adapted to such conditions, and can breathe air, are able to move overland in search of freshwater bodies, and some can survive out of water for long periods e.g. Climbing perch. Black fish are mostly carnivorous and detritus feeders, and include the *Channidae* (Snakeheads), *Clariidae*, *Bagridae* (*Mystus spp*.) and *Anabantidae*.

The fish that move into the wetlands in the wet season, also known as white fish, are mainly associated with the main channels and streams, and exhibit strong lateral and longitudinal migrations, including into floodplains. They will move into the wetlands from the main channels of the Sekong, Xe Pian and Xe Kampho as the waters rise in the early wet season (from May), remaining there to feed and reproduce, until the waters begin to recede (from November). The white fish includes many cyprinids, but also the featherback, *Notopterus notopterus* and puffer fish, *Tetraodonspp*.

The main species of eel living in Beung Kiat Ngong is the swamp eel, *Monopterus albus.* They are differentiated from other fish species because of their seasonal dormancy behaviour and their importance to fishery in Beung Kiat Ngong. When ranked for their importance as a wetland product in community consultations, eels came second after fish.

Adult eels inhabit streams, ponds, canals, drains and rice fields in both clear and turbid water. They are nocturnal and carnivorous and are facultative air-breathers. At the start of the dry season when there is a decline in water level, it digs a tubular burrow in a bank or on the bottom. Although breathing is slowed down, the fish remains active and flees if it is disturbed. They emerge from their burrows at the beginning of the wet season as the water level starts to rise.

3.6.3 Molluscs

Shells or snails are ranked the third most important wetland product by the communities of Beung Kiat Ngong. There are believed to be two native species of large operculate snails collected: the large apple snail, *Pila polita,* and another large apple snail, probably *P. pesmei* or *P. ampullacea,* recorded in Nong Kasay, which appears to be less common(Timmins, 2014). The third large snail species which is now widespread in many areas of the Beung Kiat Ngong wetlands is the South American invasive Golden apple snail, *Pomacea canaliculata*, which was first reported in about 2008. In contrast to *Pomacea*, *P. polita* appears to require permanent wetland, and has been found in the main Beung Kiat Ngong marsh, the Nong Pakau complex and Nong Kasay.

According to Timmins (2014), local sources have reported declines in the native snails following the arrival of the Golden Apple snail, which now appears to be more common than the native apple snail. The invasion has also been reported to be linked to significant damage to rice crops. Although the invasive species is eaten, it was commonly reported to taste inferior to the two native apple snails.

Pila polita, is a widespread species throughout south and South East Asia, found in calm freshwater habitats, such as paddy fields, ponds, klongs, pools and slow moving streams. They are unisexual, with females laying eggs near the banks. The species harbours metacercariae of *Echinostoma ilocanum* which can cause Garrison's fluke infection (Echinostomiasis) and Angiostrongyliasis. It is listed as of Least Concern in the IUCN Red List of Threatened Species(IUCN, 2014).

Pomacea canaliculata feeds on floating or submersed higher plants, detritus and animal matter. Diet may vary with age, with younger smaller individuals feeding on algae and detritus, and older, bigger (15mm and above) individuals later shifting to higher plants. In tropical areas, reproduction is continuous. The egg masses laid on the stalks of plants just above the water surface are a very obvious pink or orange colour. Listed under the IUCN Red List of Threatened Species as of Least Concern, it is recognized as being one of the top 100 globally invasive species.

3.6.4 Amphibians and Reptiles

Frogs

There is no information on the species of amphibians found in Beung Kiat Ngong. However, community consultations indicate that all villages collect frogs, and they are ranked overall as the fourth most important wetland product while in two villages, Nong Mak Ek and Kele frogs are ranked second to fish in importance.

Turtles

The turtles found in Beung Kiat Ngong wetlands include:

- Malayan snail-eating turtle, *Malaemys subtrijuga* – Listed as Vulnerable in the IUCN Red List of Threatened Species and also known as the "rice field turtle". It is favoured for its meat and is also used in traditional medicine;
- Yellow headed temple turtle, *Hieremys annandalii* – Listed as Endangered in the IUCN Red List of Threatened Species; and
- Elongated tortoise, *Indotestudo elongata* – Listed as Endangered IUCN Red List of Threatened Species.

Timmins (2014) considers that because of the extent and complexity of the Beung Kiat Ngong wetlands several species of turtle are still likely to persist, of which Yellow-headed Temple Turtle *Hieremys annandalii* would be the most significant. Populations of all species are very likely to be highly depleted. Nevertheless, the Beung Kiat Ngong wetlands still have considerable national and regional significance for aquatic turtles, particularly *H. annandalii* which is large and easily exploited and depleted, and has a relatively small global range.

The Elongated Tortoise, *Indotestudo elongata,* a terrestrial species characteristic of deciduous dipterocarp forest and highly deciduous semi-evergreen forest, is unlikely to survive in significant numbers and might already have been extirpated.

Most of the community discussions highlighted the importance of turtles and ranked them 6th amongst the most important wetland products. The communities also indicated that collection of turtles was still continuing despite their declining numbers.

3.6.5 Birds

Beung Kiat Ngong is considered to be an important site for bird feeding and nesting, as part of the Xe Pian NPA. It is particularly important for small and medium-sized water birds, and for seed eating birds that depend upon the grasses in the wetland. Large water birds that have been known to occur here in the past, such as Sarus Cranes, Grey Heron, Spot-billed Pelican and Greater Adjutant no longer visit the wetlands, and a number of other bird species are considered to be at "real risk of local extinction" (IUCN, 2011). The recent surveys by Timmins and Duckworth confirm the steady decline in bird numbers in Beung Kiat Ngong since the previous surveys in 2008(Timmins, 2014). The birds that were recorded recently include: Cotton Pygmy-goose, Buttonquail, Stork-billed Kingfisher, Green Bee-eater, White-breasted Waterhen, Eurasian Marsh Harrier, Pied Harrier, Black-crowned Night Heron and weavers. The Asian Open-bill stork appears to be increasing in numbers, and this is of interest because it is the main predator of the invasive Golden Apple snails (Timmins, 2014).

Birds ranked eleventh in the list of important wetland products and were only listed for Nong Mak Ek, Kiat Ngong and Kele. They are also important as one of the ecotourism attractions.

3.6.6 Mammals

The large mammals of conservation significance that may have existed in these wetlands are already known to be extirpated. Four species of otter should occur in these wetlands, but the lack of signs of otters would indicate that these are rare. Two species of cat, Jungle Cat (*Felis chaus*) and the Endangered Fishing Cat (*Prionailurus viverrinus*) are thought to occur in the corridor between Xe Pian NPA and Dong Hua Sao NPA. The most common signs of mammals are from wild pigs, muntjacs, squirrels (*Callosciurus finalysonii williamsoni* and *Tamiops* spp), Northern tree shrew, Small Asian mongoose and Siamese Hare (IUCN, 2011). Hunting pressure and the illegal wildlife trade results in major pressure on both mammals and birds.

3.7 Land use

As indicated above, the coverage of rice fields in the Beung Kiat Ngong Ramsar site is between 30–40% with only about 10% in the northern section of Beung Gnai Kiat Ngong(Timmins, 2014). The rest of the Ramsar site is the natural wetland area. Rice fields are generally used for a single rain-fed crop, apart from 30 ha of irrigated rice in Phalai and 10 ha each in Phapho and Phakha. After harvesting the fields are left for grazing animals, and dung collection from the fields was mentioned (and observed) in Phapho village, where they can get LAK 5,000 for one sack of dung. Table 3.3 shows the village land-use statistics obtained from village records during consultation meetings. There are some anomalies here, but rain-fed rice shows a total 1,387 ha and 50 ha of irrigated rice amongst the eight communities. This is about 50% of the total wetland area, but does not take into account the rice fields belonging to the communities outside of the Ramsar site boundaries, but roughly confirms the estimates mentioned above. There are about 540 ha of gardens (which may be an overestimate), 5 ha of graveyards, 3 ha of sacred forests and 11 ha of reforested area in Kele. Fish conservation zones are recognized in Kele and Kiat Ngong.

The Beung Kiat Ngong baseline report (IUCN, 2011) shows that there were a total of 323 ha of rice fields in the wetland area and about 4.5 ha of gardens according to field measurements in 2009.

Table 3.3: Village land use statistics

Village	Population	Number of Households	Number of Families	Village Total Areas	Total Areas of different use Purposes											
					Land for Shelters	Agriculture Production area (Rainfed rice)	Irrigated Ricefield	Garden	Grave yard	Village Sacred forest	Village land	Flatplain area	Plateau area	Others (island, Streams, ponds)	Reforestated forest	Village Fish conservation Zone
	Total			ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha	ha
PhaPho	1,826	319	382	682	85	236	10	-	-	3	-	-	-	-		Wet season: 1.5 km long; 15 m wide; Dry season:1.5 km long; 10 m wide (Houay PhaPHo)
Nong Mak EK	1,036	107	141	61,085	1	144	-	1	3	-	61	-	-	-		
Pha Lai	1,496	283	309	5,252	128	276	30	10	2	0	1	-	-	271		
Kiat Ngong	1,055	196	223	3,752	840	229	-	500	-	-	-		-	-		2 (01 Vang Paa Orr Fish conservation Area (1ha); 01 Vang Paa Boua FCA (1ha))
Phommaleu	7,646	134	162	773	48,166	96	-	-	-	-	-		-	-		
Kaelae	1,009	163	188	10,300	34	118	-	19	-	-	10,300	-	-	-	11	
Thopsok	617	90	94	750	118 land pieces	120	-	48 (Kitchen garden)	3 land pieces	-	750			-		
Phak Kha	838	130	161	5,004	32,178	167	10	10	-	-	-	752	4,263	2,487,473		
Totals	**15,523**	**1,422**	**1,660**	**87,598**	**81,432**	**1,387**	**50**	**539**	**5**	**3**	**11,112**	**752**	**4,263**	**2,487,744**	**11**	

3.8 Conservation and zoning of Beung Kiat Ngong

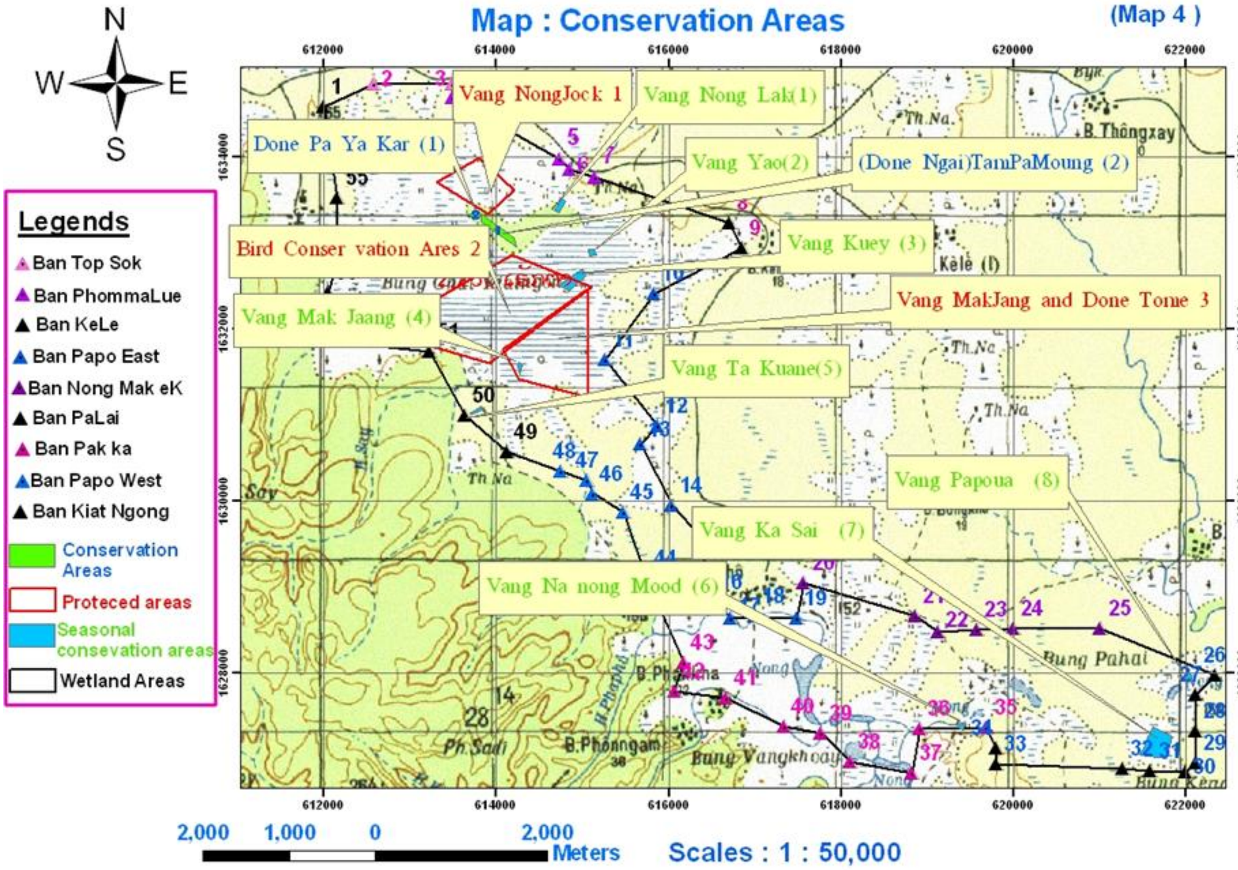
The southern part of the wetlands lies in Xe Pian which was declared a nationally protected area (NPA)in 1993. The Beung Kiat Ngong Ramsar site was declared one of the first two Ramsar sites when Lao PDR acceded to the Ramsar Convention in 2010.

For most of the wetland, there is free access and use of the wetlands and wetland products. However, certain small areas have been designated as fish conservation areas, both continuously and seasonally, and other areas have restricted use, limiting agriculture and forestry as shown in Table 3.4 and in Figure 3.4.

Table 3.4: Zoning of the Beung Kiat Ngong Wetlands, as set out in the Regulations

I. Protected areas								
No.	**Local Name**	**Areas (ha)**	**Responsible village**	**Location**				**Remark**
				North	South	East	West	
1	Done Yang (Nong Joke)	28.5	Kiat Ngong	Done Yang	Done Ya Ka	Done Time Pa Moung	Done Lao Kao	Fish conservation pond
2	Done Ka Dun	164	Kiat Ngong	Done Ka Dun	Done Kuang	Done Tome Done Hor	Done Lao Kao	Fish conservation pond
3	Done Nok Hor	73	Papho	Done Thome	Pak Thong Hi	Done Kork	Done Kuang	Fish conservation pond
	Total	**265.5**						
II. Seasonal protected areas								
1	Wang Nong Lak	0.7	Kiat Ngong	None Pa Kok, nr. Nong Lak river	Done Ngai (Time Pa Moung)	Na Nong Lak areas	Leuam + Khem's rice paddy	Fish conservation pond
2	Wang Takuang	0.5	Kiat Ngong	Done Pa Pao	Phuta Khuane	Phuta Khuane	Upland rice paddy	Fish conservation pond
3	Wang Mak Jeng	0.3	Kiat Ngong	Beung field	Done Nok Hor – End	Done Nok Hor – Begin	Mango tree, Done Mak Jeng	Fish conservation pond
4	Wang Kuai	3.2	Kiat Ngong	To's rice paddy	?	?	?	Fish conservation pond
5	Wang Yao	0.6	Kiat Ngong	Bounthavy's rice paddy	?	?	Soun's rice paddy	Fish conservation pond
6	Wang Nong Na Mood	0.3	Pakka	None Hin Lang (small Dou	Lee's rice paddy	Kork Hin Lang (Peuy Tree)	Pone Hin Lang (Nom's rice paddy	Fish conservation pond
7	Wang Nong Pa Poi	0.4	Palai	Kisang's rice paddy (village	Kok Lang near Papoi	Kok Lang near field	Upland rice fall to Papoi pond	Fish conservation pond
8	Wang Kasai (Beung Kasai)	8.5	Palai	Hong Tami	Sai + Pheung's rice paddy	Irrigation	Hong Kae	Fish conservation pond
	Total	**14.5**						
III. Conservation areas for some activities								
9	Done Yai Time Pa Mouang	4	Kiat Ngong	Sing,Leum,Khem's rice paddy & Nong Lak conservation	Khamvong's rice paddy	Nu Phone's rice paddy or Na None Ngai Done Pa Mouang	Done Pa Ya Ka	No logging and agriculture areas
10	Done Pa Ya Ka	0.7	Kiat Ngong	Done Yang (Nong Joke)	?	Done Ngai (Time Pa Muang)	?	No logging and agriculture areas
	Total	**4.7**						
Overall total: 19.2 ha								

Figure 3.4: Map of Beung Kiat Ngong wetlands showing designated conservation areas



Source: IUCN 2011

4 Communities and wetland livelihoods

4.1 Communities and populations

There are eight main villages surrounding the Beung Kiat Ngong wetlands. Village consultations were used to gather population figures which are shown in Table 4.1. This indicates that there are 9,523 people living around Beung Kiat Ngong in 1,422 households and 1,660 families. The total proportion of women in the villages is low at 43.5%, with the lowest proportion in Phommaleu and Nong Mak Ek at 25% and 35% respectively. The average number of people per household is 6.7 with 5.7 people per family. The main labour force consists of 3,061 people of whom 1,413 are women (46%). The secondary labour force consists of 2,151 of whom 1,107 are women (51%).

According to the IUCN baseline report (IUCN, 2011)about 11,500 people in the eight core villages and several outer villages are heavily reliant on the wetlands. It is difficult to correlate the socio-economic census data reported in that document because several of the village names are different.

Table 4.1: Demographic statistics of the eight villages using Being Kiat Ngong

Village	**Pop.**	**Gender**		**HH**	**Nos./HH**	**Families**	**Nos./ Family**	**Main Labour Force**		**Secondary Labour Forces**	
	Total	**Fem.**	**% F**					**Total**	**Female**	**Total**	**Female**
Phapho	1826	928	50.82	319	5.7	382	4.8	633	357	522	315
Nong Mak Ek	1,036	360	34.75	107	9.7	141	7.3	331	127	162	104
Phalai	1,496	746	49.87	283	5.3	309	4.8	645	315	849	431
Kiat Ngong	1,055	530	50.24	196	5.4	223	4.7	NA	NA	NA	NA
Phommaleu	1,646	408	24.79	134	12.3	162	10.2	377	183	94	58
Kele	1,009	489	48.46	163	6.2	188	5.4	488	286	386	199
Thopsok	617	307	49.76	90	6.9	94	6.6	355	NA	93	NA
Phakha	838	375	44.75	130	6.4	161	5.2	232	145	45	NA
Total	**9,523**	**4,143**	**43.51**	**1,422**	**6.7**	**1,660**	**5.7**	**3,061**	**1,413**	**2,151**	**1,107**

A wealth ranking exercise was carried out in consultation with the villagers (Table 4.2). When aggregated across all the villages just under 7% of households were considered to be poor, 64% were considered to be middle class and 29% to be rich. There was considerable variation in the wealth of these villages, with Nong Mak Ek appearing to have the highest proportion of poor households (39%) compared to Phapho which had no poor households. Most of the others considered between 2–10% of the households poor. In Phommaleu most of the households were considered to be middle class (93%) whilst most of the others ranged between 50 and 85% middle class households, except for Phapho and Nong Mak Ek, which had about 33 - 35% middle class households. The village with the highest proportion of rich households was Phapho, with 65%, compared to Nong Mak Ek and Phommaleu which had only 3.5 and 4.3% respectively. In the other villages, between 10 and 40% of households were considered rich. These estimates are based upon the villagers own perceptions of wealth and this is likely to vary somewhat between villages.

Table 4.2: Wealth ranking estimates of households in each wetland village

Village	Pop.	Gender	HH	Families	Wealth ranking of families (rich, medium and poor)					
	Total	**Female**			**Poor**	**% age**	**Medium**	**%age**	**Rich**	**%age**
Phapho	1,826	928	319	382	0	0	132	34.6	250	65.4
Nong Mak Ek	1,036	360	107	141	55	39.0	47	33.3	5	3.5
Phalai	1,496	746	283	309	6	1.9	240	77.7	63	20.4
Kiat Ngong	1,055	530	196	223	6	2.7	191	85.7	26	11.7
Phommaleu	1,646	408	134	162	5	3.1	150	92.6	7	4.3
Kele	1,009	489	163	188	18	9.6	98	52.1	47	25.0
Thopsok	617	307	90	94	2	2.1	51	54.3	37	39.4
Phakkha	838	375	130	161	10	6.2	100	62.1	20	12.4
Total			**1422**		**102**	**6.5**	**1009**	**64.4**	**455**	**29.1**

4.2 Key livelihood activities

The key livelihood activities identified during the consultations showed considerable variation in the level of detail provided by each village. The activities listed are:

- Agricultural families (probably safe to assume that this includes most families)
- Business families (a relatively low proportion in each village)
- Teachers
- Students(presumably this includes school children)
- Village health volunteers
- Medicine Bags
- Pharmaceutical shops
- Village tourist groups
- Homestay services
- Elephant rides
- Forest trekking
- Boat services
- Community services
- Pha Khouane services
- Cooking services
- Massage services
- Handicraft services
- Rice mills.

This inventory shows how significant the tourism services are for livelihoods in Kiat Ngong village, while the only other village to benefit from tourism is Phapho.

Village	Occupation																	
	Agriculture families	Business families	Teachers	students	Village Health Volunteers	Medicine Bags	Pharmaceutical shops	Village Tourist Groups	Homestay services (families)	Elephant ride services (families)	Forest Trekking service (families)	Boat services (families)	Community services (families)	PhaKhouane servicees (families)	Cooking services (families)	Massage services (families)	Handicraft services (families)	Rice mills
PhaPho	290	18	0	0	0			0	1	1	0	0	0	0	0	0	0	
Nong Mak Ek		4																
Pha Lai		17 (14 reg)		337 (173 f.)	3 (2 f.)	2	1											2
Kiat Ngong	211	12	11 (05 f.)	186 (103 f.)	1			9	24	41	30	10	23	11	13	9	19	
Phommaleu																		
Kaelae		18	31 (16 f.)															
Thopsok		14	4		2 (1 f.)													
Phak Kha		9	4 (4 f.)	109 (53 f.)														

4.3 Facilities

The facilities in each village, including schools, health centres, temples, latrines, dug wells and pumped wells, and biogas are shown in Table 4.3. All villages have a primary school, with secondary schools in Phapho, Phalai and Kiat Ngong. None of the villages mentioned a health centre. All villages had at least one temple except for Phakha which has two. There was quite a lot of variation in the number of latrines, dug and pumped wells. In Kiat Ngong there were 10 biogas plants, though one of these was recorded as being not in operation.

Table 4.3: Facilities in each of the wetland villages

Village	Population	Number of Households	Number of Families	Schools							Latrines			Gravity Pumping Wells		BioGas
	Total			No. of schools	Kindergarten	Basic Primary (Mounla pathom)	Primary	Secondary	Health center	Temples	Total	Funded	Dug wells	Total	Electric pumps	Total
PhaPho	1,826	319	382	2	0		0	0		1						
Nong Mak EK	1,036	107	141	2 with 10 rooms			2			1	5	0	10	25	0	
Pha Lai	1,496	283	309	2 with 10 rooms	1		1	1		1	239			16	17	
Kiat Ngong	1,055	196	223	2 with 5 and 3 rooms	1		1	1		1	138	32	2	56	52	10*
Phommaleu	1,646	134	162	1 with 5 rooms			1			1			2*	94		
Kaelae	1,009	163	188	3	0	2	1			1	57		2	78		
Thopsok	617	90	94	1 with 5 rooms			1			1			16	75		
Phak Kha	838	130	161	1 with 5 rooms			1			2	29		50			

*1 broken

4.4 Livestock

Livestock, especially buffalo, cattle and elephants, play an important part in the ecology of the wetlands, particularly as large wild herbivores no longer exist in Beung Kiat Ngong. The village consultations gave estimates of the numbers of livestock in each village as shown in Table 4.4. There are a total of 991 buffalo, 2,611 cows, 13 elephants(of which only one remains in Phapho and all the rest are in Kiat Ngong), 1,559 pigs and 8,814 poultry. Kiat Ngong has the largest number of buffalo and Phapho the largest numbers of cattle. This perhaps reflects the main difference between cattle and buffalo: the buffalo go into the areas with floating grass mats, i.e. around the main marsh areas in the north, compared to cattle which feed around the edges and rarely go into the water, i.e. in the farmland around Phapho.

10 out of the 12 elephants in Kiat Ngong are females, and the herd is declining despite the demand for elephant tourism, because the owners do not wish to breed with their animals. One of the two remaining elephants in Phapho died recently and will not be replaced. Around Kiat Ngong, elephants are released to graze in the grasslands overnight.

Table 4.4: Livestock numbers in each of the eight wetland villages

Village	Population	Number of Households	Number of Families	Livestock numbers										
				Buffaloes		Cows		Elephants		Pigs		Goats		Poultry
	Total			Total	Fem.	Total	Fem.	Total	Fem.	Total	Fem.	Total	Fem.	Total
PhaPho	1,826	319	382	149		604		1		416		46		
Nong Mak EK	1,036	107	141	25	19	217	163	-		138	98	156	36	1,729
Pha Lai	1,496	283	309	176		243				306				2,014
Kiat Ngong	1,055	196	223	433	260	371	263	12	10	87	43	26	17	897
Phommaleu	7,646	134	162	51		346				87		34		425
Kaelae	1,009	163	188	23		366				310		36		1,500
Thopsok	617	90	94	36		126				78		92		
Phak Kha	838	130	161	98		338				137		15		2,249
TOTAL				991		2,611		13		1,559		405		8,814

Changes in livestock numbers since an IUCN survey in 2008 are shown in Table 4.5. When converting these livestock numbers to “grazing units” (GU) (Elephants = 10 GU; Buffalo = 1.5 GU; Cattle = 1 GU). It can be seen that the number of grazing units of animals using the wetlands has fallen slightly from 4,752 in 2008 to 4,228 in 2014. In analyzing this further there has been a decrease in the numbers of buffalo by 34%, and 38% in the numbers of elephants, but an increase of 13.5% in the numbers of cattle. In some villages such as Phapho and Nong Mak Ek, there have been overall increases. However, all of the other villages recorded slight decreases in the grazing units. Some additional animals may be grazed in the wetlands from other non-core villages: the 2008 report indicates a total of 1,174 grazing units using the wetlands, making a total of 5,430.

Table 4.5: Changes in livestock numbers and grazing units in the eight main wetland villages

Village	Livestock numbers 2008				Livestock numbers 2014			
	Buffalo	**Cows**	**Elephants**	**Grazing units**	**Buffalo**	**Cows**	**Elephants**	**Grazing Units**
Phapho	197	436	3	762	149	604	1	838
Nong Mak Ek	47	117	-	188	25	217		255
Phalai	424	315	-	951	176	243		507
Kiat Ngong	437	347	15	1,153	433	371	12	1,141
Phommaleu	81	327	1	459	51	346		423
Kele	54	362	-	443	23	366		401
Thopsok	83	96	1	231	36	126		180
Phakkha	169	301	1	565	98	338		485
TOTAL	**1,492**	**2,301**	**21**		**991**	**2,611**	**13**	
Grazing Units	1.5	1.0	10.0		1.5	1.0	10.0	
Total Grazing Units				**4,752**				**4,228**

4.5 Use of wetland products

Table 4.6shows some estimates of areas of wetland in relation to the total village area. These results are somewhat varied, depending on the discussions with villagers. Perhaps the most relevant figure is that for Kiat Ngong, which recorded that the total village area was 3,752 ha of which 2,573 ha were considered to be wetland, while in Phalai the village area was 5,252 ha of which 270 ha were wetland. Other villages had only relatively small areas of wetland within their village boundaries.

The estimates of open water remaining in the dry season were usually between one and five hectares near most of the villages, except for 100 ha around Phapho and 900 ha around Kiat Nong. Estimates of marsh, forest areas and streams with rapids and riffles were mixed. Fish conservation zones were mentioned in Phapho, Thopsok and Phakha.

In discussions, the villagers did not distinguish the different wetland habitats very clearly, mentioning generally grass mats, floating vegetation, open water and forest. The key species mentioned include fish (particularly snakehead and walking catfish) and eels, frogs and snails, and birds such as ducks.

Table 4.6: Wetland habitats and areas noted by the village consultations

				Wetlands								
Village	population	Number of Households	Village area	Total Hectares?	What are the major habitats?	What are the key species ?	Hectares open water in the dry season?	Hectares of marsh?	Kilometers of rapids and riffles?	Hectares of wetland forest during wet season?	Fish conservation zone	Area (ha)
	Total		ha	ha		ha	ha	ha	km	ha		
PhaPho	1,826	319	682	Do not know	Grass, open area, Grass mats; forest	Pa Khor, Pa Douk, Eel, Duck, Birds (Nok Kho Ngou, Nok Hep, Nok pet)	100	Donot know	Donot know	20	Houay Phapho	1,5 km long, 15m wide (rainy season), 10m (dry season)
Nong Mak Ek	1,036	107	61,085	11	Grass, open area, floatlaying vegetation, forest	Fish, buffalo and cows	3	Donot know	Donot know	Donot know		
Pha Lai	1,496	283	5,252	270	Grass, open area, Grass mats, forest		4-5		2			
Kiat Ngong	1,055	196	3,752	2,573	Grass, open area, floatlaying vegetation, forest	Fish, Eel, frog, shells, Birds (Nok Pet, Nok Kai na)	900	540	150 (Mouang island)	150 (Island forest)		
Phommaleu	7,646	134	773	10	Grass, open area, floatlaying vegetation, forest	Fish, Eel, frog, shells, Birds	Decrease 1 km; 2 points: Hong Saeng; Hong Yao	1km	1km	1km		
Kaelae	1,009	163	10,300	4	Grass, open area, floatlaying vegetation, forest		1	2				
Thopsok	617	90	750	11	Grass, open area, floatlaying vegetation, forest	Pa Khor, Pa Douk, Eel	1	Approx. 10	Approx. 11	2	10 FCAs	
Phak Kha	838	130	5,004		Grass, open area, floatlaying vegetation, forest		1	Approx. 150			Vang Namoud FCA(Breeding season conservation)	

Table 4.7 shows the importance ranking of wetland products in each village. Overall the ranking is as follows:

1. Fish
2. Eels
3. Shells (Snails)
4. Frogs
5. Wild vegetables
6. Turtles
7. Shrimps
8. Mushrooms
9. Bamboo shoots
10. Kha and Pheu (tall weeds for mat making)
11. Birds
12. Crickets

The top six wetland products will be considered for the climate change vulnerability assessment.

There was some variation between the villages, but all noted the importance of fish and eels, while snails and frogs were consistently ranked 3rd and 4th. Turtles varied considerably and only Phalai did not including them. Other villages ranked turtles quite low, while others ranked them 4th or 5th. This would indicate that they are still found throughout the wetland, still valued although rare.

In Kele and Phommaleu, the communities noted that there were declines in wetland products, especially fish, due to overfishing and the use of electric fishing.

Table 4.7: Ranking of wetland products

Village	population	List the 10 most important wetland resources used in the village.			Fish	Eel	Shell	Frog	Wild vegetables	Turtles	Shrimps	Mushroom	Bamboo shoot	Kha & Pheu (tall weeds)	Birds	Crickets
	Total	**items**	**Use**	**Status**	**Importance rank**											
PhaPho	1,826	1.Fish; 2. EEl; 3. shell; 4.Frog; 5. Wild vegetables; 6. Bamboo shoot; 7. Mushroom; 8. Shrims;9. crickets and 10. Turtles	Eat and sale		1	2	3	4	5	10	8	7	6			9
Nong Mak EK	1,036	1. Fish and EEL; 2. Frog; 3. Shells; 4. Vegetable; 5. Turtles; 6. Birds; 7. Kha and Pheu (tall weeds)	Eat, mat weaving and sale		1	1	3	2	4	5				7	6	
Pha Lai	1,496	1.Fish; 2. EEL; 3. Shell and Shrimp; 4. Frog; 5.Vegetable, 6. Mushrooms	Eat and sale		1	2	3	4	5		3	6				
Kiat Ngong	1,055	1. Fish; 2. EEL; 3. Frog; 4. Shell (Hoi Choup, Hoi Khong, Hoi Katay); 5.Turtle; 6. Shrimp; 7. Natural 8. Mushroom; 9. Vegetable; 10. Birds	food and sale and for seeing (birds)		1	2	4	3	9	5	6	8			10	
Phommaleu	7,646	1.Pakhor. 2. Hoi Choup; 3. Frog; 4. Turtle	Eat and sale	Declining	1		2	3		4						
Kaelae	1,009	1.Fish and EEL; 2. Frog; 3. Shell (Hoy Choup, Hoy Khong); 4. vegetable; 5. Turtles; 6. Mushrooms; 7. Shrimps; 8. Birds; 9. Bamboo shoot	Eat, sale and sighting	Declining because some electic shocks, over population;	1	1	3	2	4	5	7	6	9		8	
Thopsok	617	1. Fish and EEL; 2. Shells; 3. Vegetable; 4. Frog; 5. Turtles; 6. Shrimps; 7. Mushroom; 8. Kha (tall weeds)	Eat, sale and mat weaving		1	1	2	4	3	5	6	7		8		
Phak Kha	838	1. Fish; 2. EEL; 3. Shells; 4. Frog; 5. Vegetable; 6. Bamboo shoot; 7. Mushroom; 8. Shrimps; 9. Crickets; 10. Turtles	Eat and sale		1	2	3	4	5	10	8	7	6			9
		Position			**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**

4.6 Perceived non-climate threats to wetland habitats and livelihoods

It is clear the wetland products are a substantial livelihood resource for communities living around the wetlands, but declines in these resources are already being noted. The IUCN baseline report (IUCN, 2011) on Beung Kiat Ngong lists a number of threats and the recent biodiversity survey by Timmins and Duckworth (2014) has further elucidated some of the other threats:

- **Peat extraction for fertilizer**, which was stopped in 2010, has left a number of pits in the wetland which have now filled with water and are used as fish ponds. Timmins and Duckworth (2014) comment that peat extraction has targeted several areas, including the northern edge of the main Beung Kiat Ngong marsh and Thong Namniap (both of which have been halted) as well as Nong Phommaleu (where it is still ongoing). In general peat extraction was not particularly extensive: in the main Beung Kiat Ngong marsh, at most around 3 ha had been affected.

- **Unsustainable harvest of aquatic resources such as fish and wildlife**, and of NTFPs such as Malva nuts is an additional pressure. Trees have been cut down to harvest the Malva nuts more quickly. Hunting pressure has reduced the bird and mammal populations dramatically, and decline is also beginning to show in fish populations. Turtles are particularly favoured and hunting pressure on these species is strong. Timmins and Duckworth (2014) state that “Hunting is without any doubt the primary reason for the paucity of species observed, and especially the lack of any resident species of global conservation concern.”

- **Changes in numbers of cattle and buffalo**. The 2008 report states that with 5,400 “grazing units” the wetlands provide a very important function for the local economy. It raises concern that with the numbers of grazing units increasing as the population grows, there will be increasing pressure on the wetlands. The trends in livestock numbers discussed above would seem to indicate an overall reduction in grazing units, particularly in buffalo and elephants, but an increase in the number of cattle. In fact cattle do not venture very far into the marsh areas and feed mainly in the dried paddy fields and surrounding areas, so the grazing pressure on the wetlands is in fact lower than before, though there may be increased pressure on the surrounding forest habitats.

- **Agricultural practices** such as increased fertilizer use and future irrigation projects that may divert water from the wetlands are significant threats to the wetland. Agricultural water demands are also likely to become a significant factor in future ecological changes, potentially both decreasing and increasing water levels, depending on the use of the basin in question, e.g. water abstraction for irrigation or dyking of basins to increase water retention.

- **Tree and bush loss** in general is a serious threat to the wetlands, especially the swamp forests. Timber removal is most serious around the wooded edges of the large open wetlands, where relatively large old trees are targeted. The demand for timber is such that even relatively small trees are now being cut. Timber removal is a lesser threat within swamp forests, where the trees have lower timber value.

- **Illegal encroachment of forest and wetland areas** for conversion to agricultural land and plantations. Swamp forests seem threatened most prominently by agricultural clearance either within the wetlands or directly adjacent to them. There has probably been substantial loss of forest between the early 1990s and 2014. Other reasons for swamp forest clearance include: to ease the harvesting of fish from open water pools and to create duck or fish ponds. Swamp forest trees, may also be cut for livestock fodder and firewood. The swamp forests observed by Timmins and Duckworth showed frequent signs of anthropogenic damage.

- **Fire** probably has an important role in maintaining grasslands by preventing its succession to scrub and, eventually, forest. With the loss of wild herbivores from the area and recent declines in the numbers of domestic livestock, it is likely that some level of fire is important for maintaining the non-woody wetland vegetation. However, if all areas are burnt then this will be a threat for ground-nesting species, and will destroy invertebrate food sources found in the vegetation.

- **Escape of invasive and non-native fish** species, such as Tilapia, from aquaculture ponds into the wetland is another source of concern.

- **Invasion by alien species** such as the Golden Apple snail and the very real threat of invasion by the Giant Mimosa is a threat. The Golden Apple snail appears to have taken hold and the native apple snails appear to be declining. Giant mimosa has been observed on the edges of the marsh and will certainly invade extensively into the shrubland areas.

- Inadequate human and financial resources to implement regulations and management plans;

- Inadequate assessment of the social and environmental impacts of tourism on the wetland areas and communities;

- Upgrading of existing roads e.g. the road from Pathoumphone to Sanamxay may result in negative impacts on the wetlands

- Construction of hydropower projects in the catchments.

5 Community perceptions of climate change

5.1 Current climate and hydrology

The village consultations included a series of discussions about the past climate and historic extreme events. The overall picture of the climate is that the hottest months are April and May, and the wettest months are July and August. According to the people in Phalai, strong winds tend to occur in May. The people of Kele say these last about two hours.) Lightning occurs in August/September. In Phapho, forest fires are said to occur every year.

The small streams entering the wetlands tend to flow during the wet season. In Phommaleu and Thopsok, the Houay Nong Lak and Houay Kout Pao flow into the wetland from the north respectively. In the wet season the latter stream is recorded to be too high for people to cross easily. In Phakha, the streams drain Phou Asa and Phou Phaema and flow towards the Pha Moud river. The out-flowing streams mentioned by villagers from Nong Mak Ek include Houay Leng Kharm, H. Ta Kouane, H. Sisalieo, Vang Kae and Vang Imoune.

5.2 Historic extreme events

In terms of extreme events, discussions raised memories in all villages of the big flood in 1978 which lasted for 15 days in Phakha. Floods in other years affected individual villages usually in July and August. Only in 2013 were floods mentioned in three villages, Phommaleu, Kele and Phakha, and this occurred in September. In addition, in Phalai, floods occurred in 2002 and 2008, and in Phommaleu in 1988, 1991 and 2011. In Thopsok they occurred in 1987 and 1996, and in Phakha they occurred in 2000, lasting for 30 days, and 2010, lasting for 10 days.

The flooding causes damage to the rice fields, and houses and tends to reduce the yields of rice. In Phommaleu, people indicated 40% lower rice yields when floods occurred in 1984, 1988, 1991, 2011 and 2013. In Phakha the people mentioned the issue of shortage of fodder for livestock during flooding.

Droughts tend to be remembered as occurring in June/July, i.e. during the early wet season, when there is not enough rainfall for rice farming. Droughts were remembered in 1984 in Phapho and Phakha, in 2008 in Phalai and Phakha, and in 2013 in Kele and Phakha. Other individual drought years were remembered in Kele in 1988 and in Phommaleu in 1993, in Phalai in 2003, and in Phakha in 2009. From this discussion, Phakha would appear to be the most drought-prone of the communities.

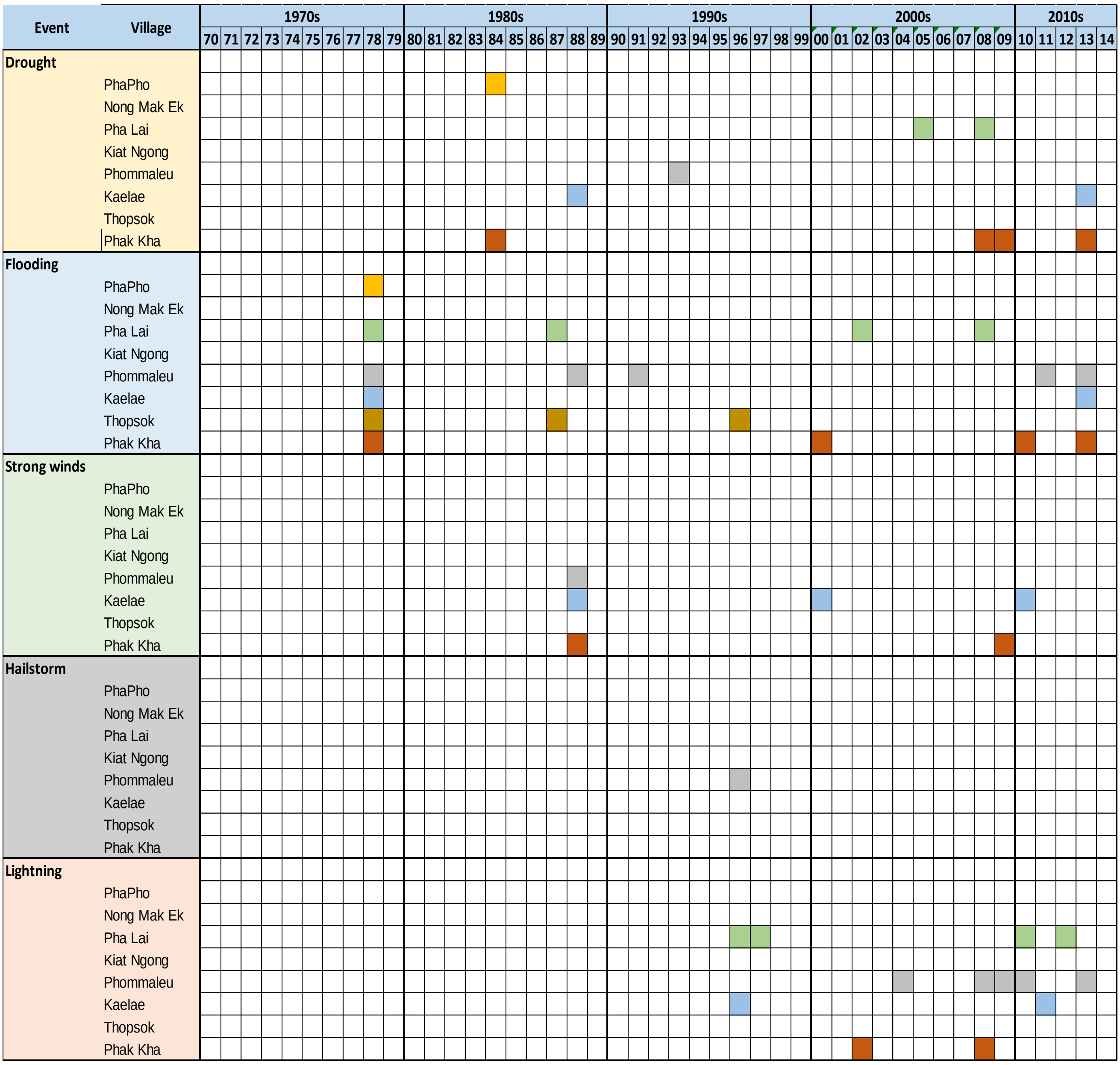
During the drought of 1984 villagers did not plant rice because there was not enough water. During other years rice seedlings died and livestock died. In 1993 in Phommaleu, the response to the drought was to dig a well 15 m deep to reach the groundwater.

Whilst no typhoons occurred, a number of villages mentioned strong winds in 1988 in Phommaleu, Kele and Phakha, and again in Kele in 2000 and 2010, and in Phakha in 2009. Strong winds are remembered as being associated with high temperatures and occur in April, May, June, and August. In Kele the strong winds caused damage to houses and electric posts.

Hailstorms were remembered to occur only once in Phommaleu, in 1996. Lightning storms seemed to be remembered in more recent years, especially in Phalai, Phommaleu, Kele and Phakha, but without any particular pattern. In Phommaleu cows were killed by lightning, and a buffalo was killed in Kele. There was electricity cut out and damage to electric equipment and TVs.

Animal disease (foot and mouth disease) was recorded in February and March (i.e. dry season) in Phapho and Phommaleu in 2009.

Figure 5.1: Climatic events remembered by communities in Beung Kiat Ngong



5.3 Perceptions of climate change

During discussions with the communities about the history of extreme events they noted that there was a trend towards lower water levels in the dry season and more water in the rainy season. They felt that this would lead to a decline in the fish populations and to yield losses due to both drought and floods.

5.4 Current coping strategies

Community discussions concerning what villagers did when they experienced drought, flood, forest fires and livestock disease yielded the following responses:

For drought the current coping strategies ranged from maintaining and repairing irrigation schemes, building canals and digging wells and waterholes and ponds along the wetland banks, to seeking employment elsewhere. During drought livestock are allowed to roam free to forage for themselves.

For floods, the livestock are taken to higher ground and grass may be cut for forage, rice crops may be replanted, and when yields decrease there may be rice sharing and exchanges within the community. Fishing in the flooded wetland areas may be an alternative source of food and income. Seeking employment elsewhere is also a livelihood strategy during floods.

For forest fires, when houses and rice stock stores are damaged especially between February and April, the response is to repair them, with help from neighbours in the village.

For animal diseases, there are some traditional remedies involving boiling tree bark and red wood.

Table 5.1: Coping strategies after extreme events identified in community discussions

Village	Population	1. When your village experiences drought, what do you do?	2. When your village experiences flood, what do you do?	3. When your village experiences forest fires what do you do?	4. When your village experiences livestock disease, what do you do?
	Total				
Phapho	1,826	Maintain and repair irrigation system			
Nong Mak Ek	1,036	Seek employment Release livestock	Seek employment	Repair and ask neighbours to help	
			Take livestock to higher ground		
Phalai	1,496	Cleaning canals	Plant irrigated rice	Rebuild	
			Prepare for moving, problem solving		
Kiat Ngong	1,055	Dig wells or waterholes along the wetland banks	Replant crops/rice	Rebuild	
Phommaleu	7,646		Fish in the wetland	Home owners rebuild	Use tree bark, for example boil redwood
Kele	1,009		Rice sharing and exchange		
Thopsok	617		Clean drainage	Repair	
Phakha	838	Dig wells when there is a water shortage	A variety of protection; take livestock to higher ground	Rebuild	

6 Future projections for climate change

The following projections were made for Champasak province by the Mekong ARCC project.

Overview: Champasak Province in southern Lao PDR is characterized by a specific agro-ecosystem, including the Bolaven Plateau to the northwest that supported smallholder, rain-fed Robusta coffee culture and the Mekong corridor where there is development of commercial agriculture. The rubber concession covers a large area and cassava culture has expanded in recent years. Crops in Champasak Province will face threats from increased precipitation (+175 mm/year) and temperature (+2.5°C mean annual temperature) that will affect several crops' yields. Farming systems in the province for both small-holder and commercial plantations will face radical changes in terms of climate suitability in their production systems. Commercial crops for both exportation and subsistence for food security will be affected with high vulnerability for smallholders working with predominantly rain-fed farming systems. Agriculture will also have to cope with increased incidences of extreme climatic events.

- **Temperature** -a 2.5°C increase in mean annual temperature. The average daily maximum temperature will rise from33 to 36°C.
- **Precipitation** -annual rainfall for a typical year will increase from 2,041 mm/yr to 2,216 mm/yr (+175mm/yr. December will see 35% increase in monthly rainfall, while January and February will see a 12% reduction.
- **Storms** -large rainfall events (>100 mm/day) will increase in frequency to more than 7 events per year resulting in increased flash flooding.

Sectoral vulnerabilities:

- **Lowland rain-fed and irrigated rice –** Heat stress (e.g. in March, April, May), 50% of days above critical 35°C and more large rainfall events will decrease yields;
- **Cassava –** Increase in precipitation during growth cycle, particularly during wet years causing water-logging and flash floods;
- **Maize –** Monthly precipitation of 400 mm in July to August will be above suitable range and decrease yield;
- **Smallholder cattle/buffalo –** heat stress impacts fodder availability and reproduction rates while flood events increase the spread of disease and herd loss; and
- **Small commercial pigs –** high temperature sensitivity as they are already outside their ideal temperature range; likelihood of reduced growth rates, reproductive rates and immunity

6.1 Climate projection methods

Climate change threats for temperature and rainfall were assessed using six global circulation models (GCMs[2]) under the International Panel on Climate Change (IPCC) Special Report on Emissions Scenario (SRES) A1B. The modelling approach was selected in order to incorporate the range and variability associated with predicting future climate change. The magnitude and timing of future climate change is dependent on the IPCC scenario selected as each encapsulates a different trajectory for future greenhouse gas (GHG) levels in the

[2] GCMs utilized in this study include: CCMA_CGCM3.1 (Canada); CNRM_CM3 (France); NCAR CCSM3 (NCAR USA); MICRO3_2hires (Japan); GIIS_AOM (GODDARD USA); MPI_ECHAM5 (Germany); and MPI_ECHAM4 (Germany).

atmosphere[3]. A1B, selected for this study, represents a world of rapid economic growth, introduction of more efficient technologies, global population peaking by 2050 and a balance between fossil intensive and non-fossil energy sources (IPCC, 2000). A1B is considered a conservative GHG emissions scenario, and there is already evidence that GHG emissions during the period 2000–2007 exceeded even the most extreme IPCC scenarios for that period (SIDA, 2008).

GCMs include a full description of atmospheric and ocean circulation dynamics which can vary depending on the GCM used. Studies at the global level have identified that GCMs have varying levels of accuracy for different regions (Cai *et al*., 2008), which means that some GCMs are better at predicting the future climate of the Mekong River Basin than others. The selection of GCMs for use in this study was made based on the GCMs ability to replicate historic precipitation data (Kummu *et al*., 2011).Seventeen GCMs have been considered in past studies for the Mekong Basin (Cai *et al*., 2008; Eastham *et al*., 2009), of these, outputs from six GCMs showed good agreement with historic precipitation records for the Mekong and have been selected for use in this study.

All discussion in this report on changes in climate refers to the change in parameters between two 25-year periods: (i) baseline 1980 – 2005, and (ii) future climate, 2045 – 2069. For both time slices models generated daily data for maximum temperature, rainfall, run-off, soil moisture and stream flow. Statistical analysis was then used to extrapolate results for more than a dozen specific hydro-meteorological parameters for example: number of rainy days during the wet and dry season, seasonal rainfall volumes, mean annual rainfall and flow, duration of flood season, occurrence of consecutive hot days and peak and minimum flows, and these were applied as relevant to specific wetland types and case study sites.

Although the models show some differences in results they are in agreement regarding the general trends in temperature and rainfall. The methods for climate projections are more fully described in Climate Change Modelling Manual produced for the MRC(ICEM, 2012) and in the Mekong ARCC study (ICEM, 2013).

6.2 Climate change projections to 2050

The following sections examine the potential climate change trends that are likely to occur in Beung Kiat Ngong up to 2050.

6.2.1 Temperature

Maximum temperature

A comparison of the current and future maximum daily temperatures is shown in Figure 6.1.

Current maximum temperatures are highest between mid-March and beginning of May. The mean maximum temperature range at this time is between 34 to 35°C. The highest daily temperatures recorded during this time were 40/41°C. The mean maximum temperature falls rapidly after beginning of May, and during the wet season of mid-June to mid-October, the mean maximum temperature ranges between 30 and 31°C with daily maxima between 34 to 36°C. The lowest mean maximum temperatures occur during December between 28 and 29°C and there are some very high and very low daily maxima between 32 and 36°C. Between January and mid-March, the temperature rises rapidly from about 30 to 35°C.

[3]The IPCC published a new set of scenarios in 2000 for use in its Third Assessment Report, known as Special Report on Emissions Scenarios (SRES). The SRES scenarios were constructed to explore future developments in the global environment with special reference to greenhouse gas emissions. Four narrative storylines were defined, A1, A2, B1 and B2. Each storyline represents different demographic, social, economic, technological and environmental developments (IPCC DDC, 2011a).

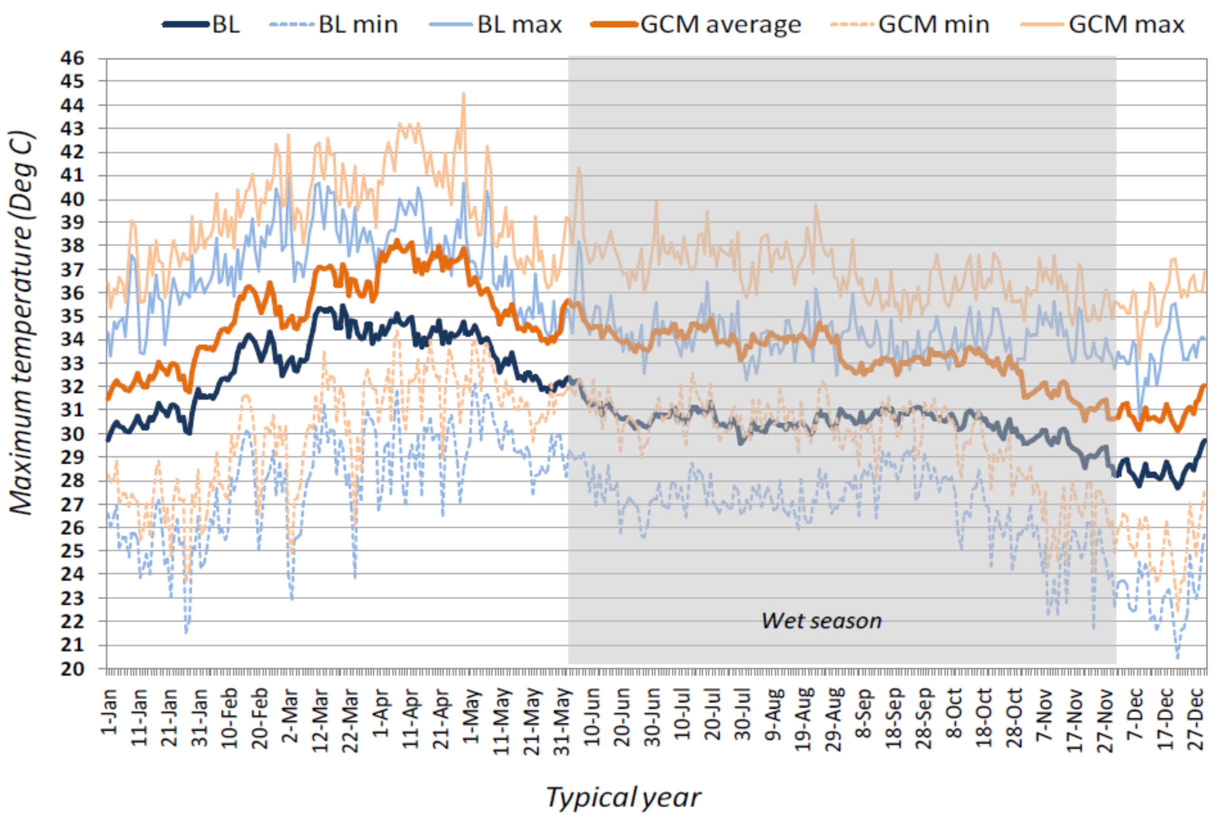
With climate change, similar patterns are observed, but with an increase of about 2 to4°C. In January to mid-March projected mean maximum temperature increases from about 32 to 37°C with daily maxima from 36 to 42°C. March to early May, mean maxima lie between 36 and 38°C with daily maxima up to between 42 and 44°C. Between May to October, mean maximum temperatures range about 34°C and can be up to 4°C higher than current. Daily maximum temperatures range about 38°C. Late wet season there is a slight cooling to about 33°C,falling to about 31°C in December, but daily maxima may go as high as 37°C in December.

The relative change in temperature is highest in the early to midwet season. Change is also more marked at end of dry season in April.

The number of days of maximum temperature shows that currently there are about 36 days (10%) of the year in which the temperature exceeds 35°C. With climate change it is likely that this would increase to about 33% of the time or about 120 days per year (Figure 6.2). Figure 6.3 shows the range of maximum temperatures expected.

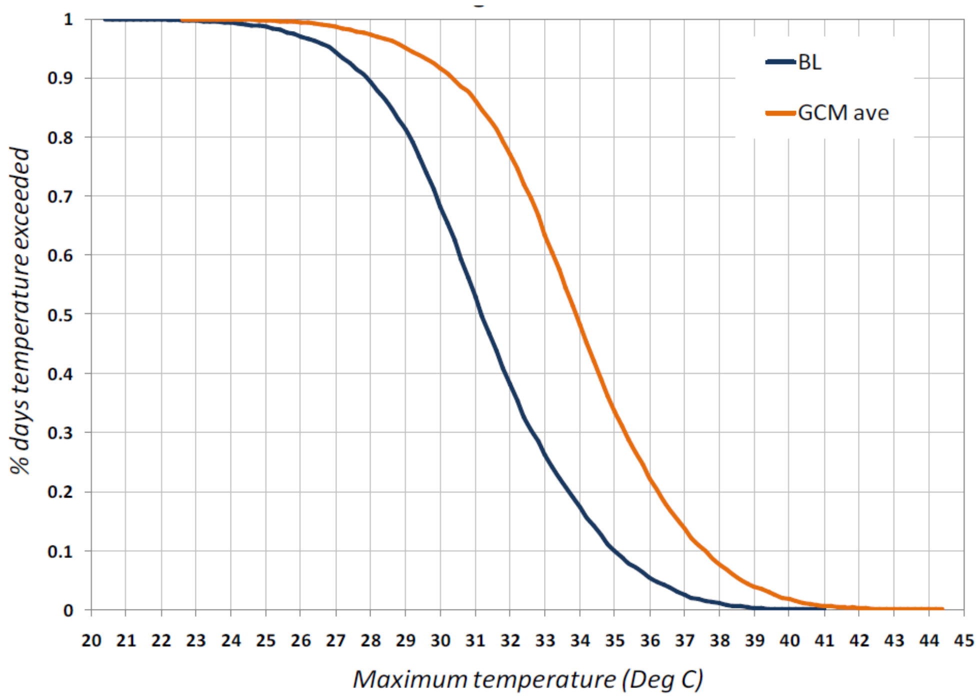
During the wet season the comfort zone of expected maximum temperatures is fully exceeded (mean 30.5 to 33.5°C). In the dry season the maximum temperature comfort zone is at least half outside the 75% percentile of maximum temperatures, and it is only in the dry season when the overall comfort zone is exceeded (Figure 6.4).

Figure 6.1: Projected changes in daily maximum temperatures in Champasak province



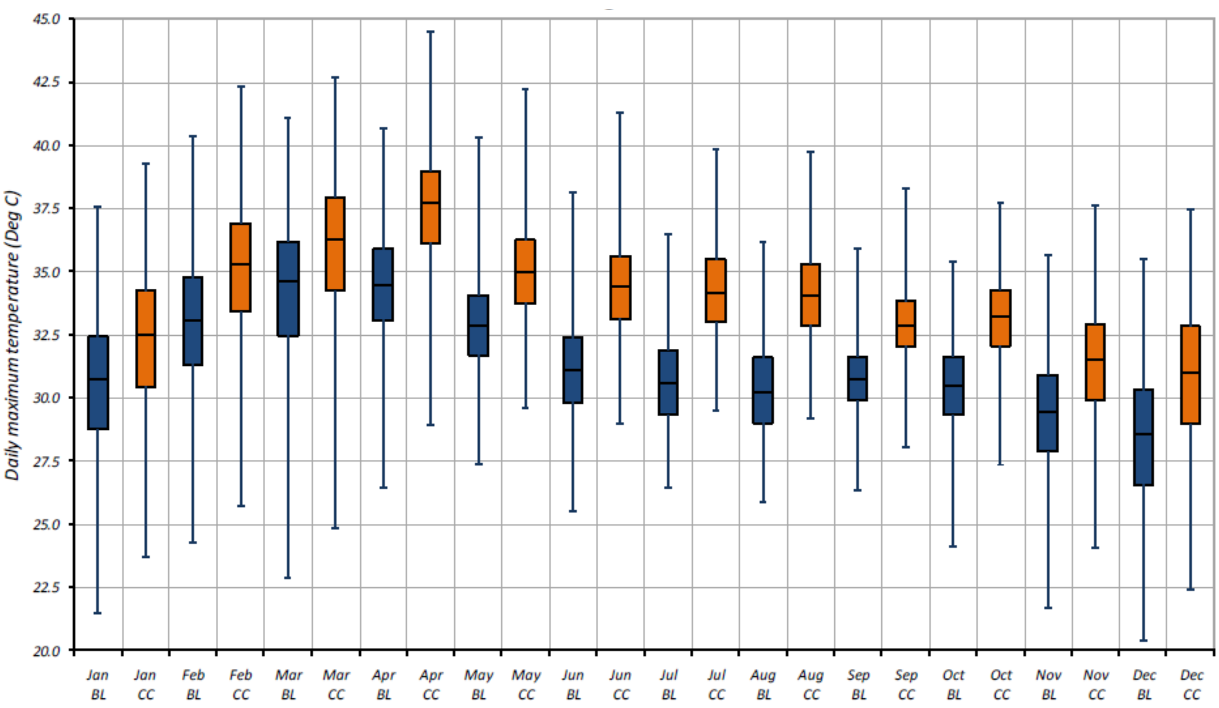
Source: ICEM (2013)

Figure 6.2: Proportion of the year exceeding maximum daily temperature



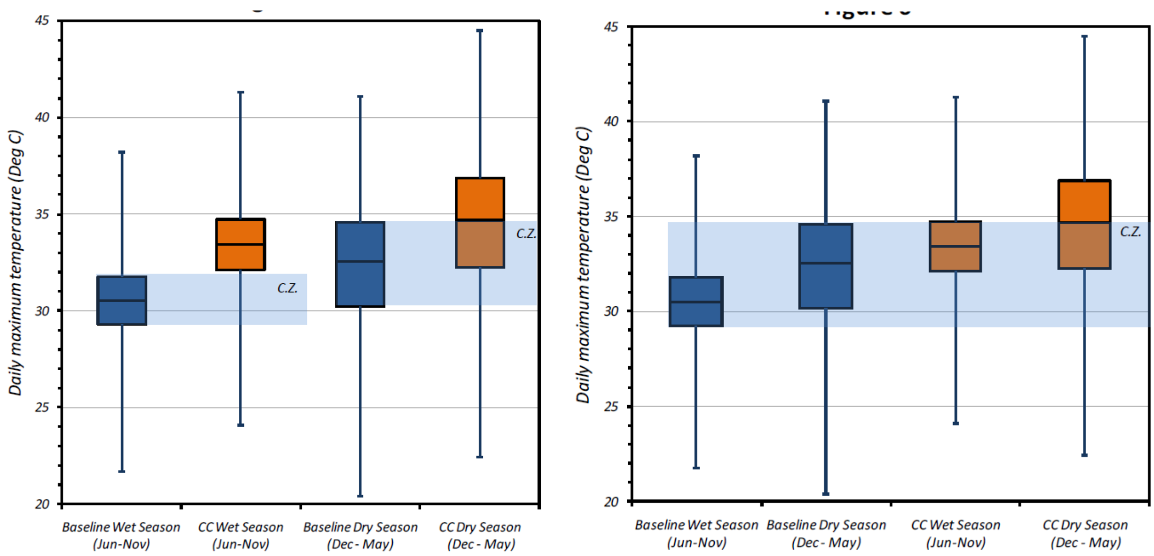
Source: ICEM (2013)

Figure 6.3: Comparison of ranges of daily maximum temperature between current baseline and climate change projections



Source: ICEM (2013)

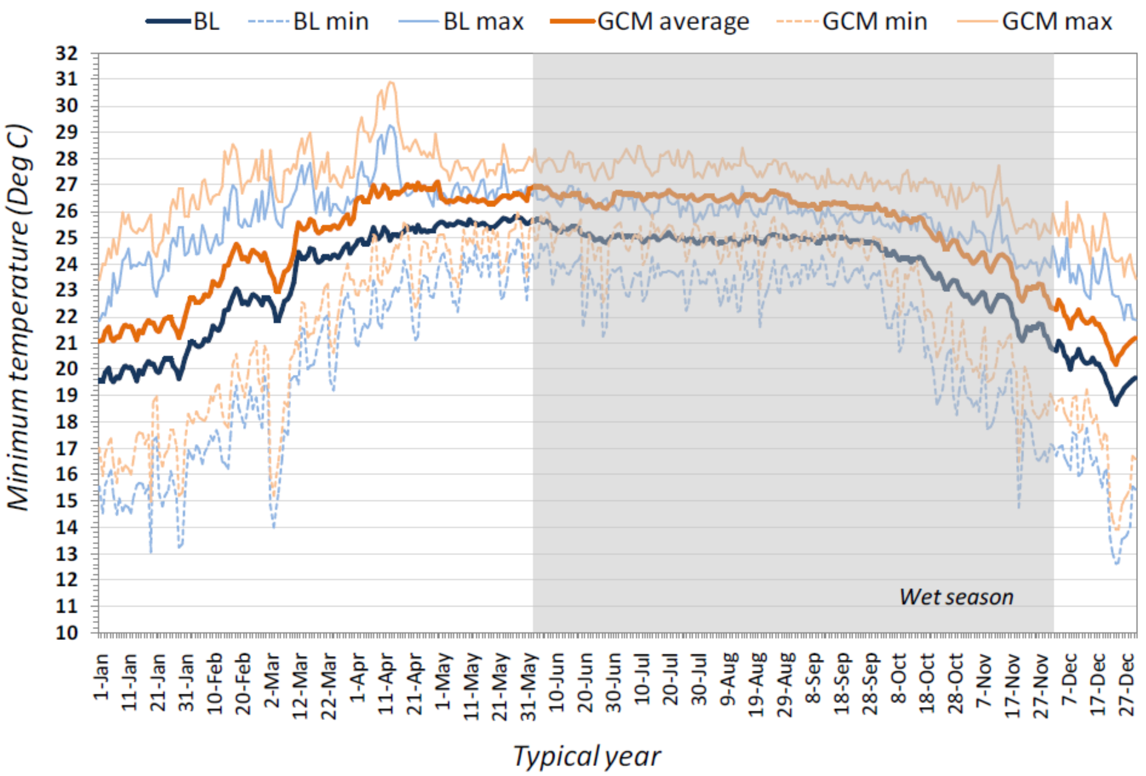
Figure 6.4: Maximum temperature comfort zones during wet and dry season



Source: ICEM (2013)

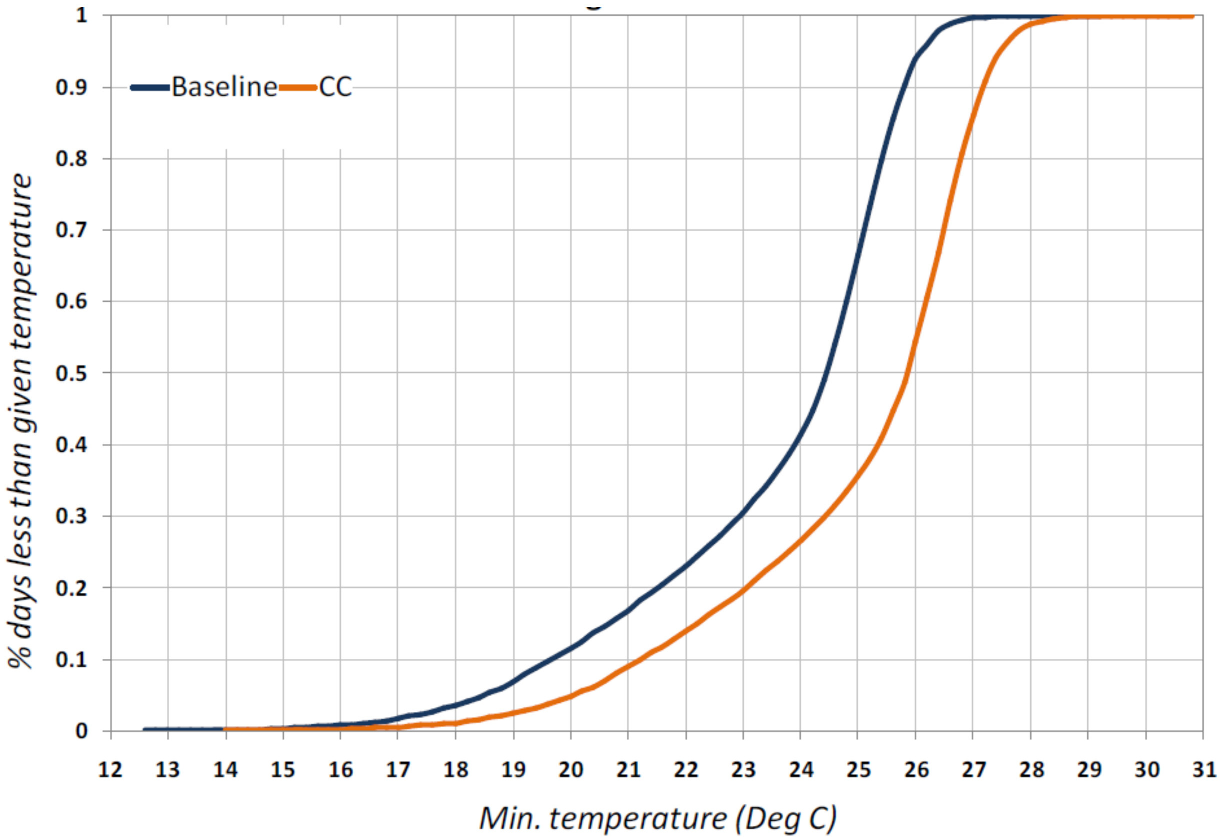
Minimum temperatures are probably of less significance ecologically, but mean minimum temperatures currently fall as low as 19°C in December/January, and between March to October range around 25°C (Figure 6.5). Minimum daily temperatures have been recorded as low as 13°C. In the future the mean minimum temperatures may rise by between 1–2°C. The biggest differences are likely to occur in December to February. The number of days in which temperature falls below 20°C decreases from 44 days to 15 days per year (Figure 6.6).With climate change the minimum temperature comfort zone will be fully exceeded in the wet season and partially in the dry season (Figure 6.8). Figure 6.9 shows the combined maximum and minimum temperature comfort zones for Champasak province for both wet and dry seasons. This shows that while the minimum temperatures lie within the comfort zones in both wet and dry seasons, the maximum daily temperatures in the wet season lie completely outside the current normal experience, and in the dry season the maximum temperatures will lie outside of the normal range for 50% of the time.

Figure 6.5: Comparison of daily minimum temperatures between current baseline and climate change projections



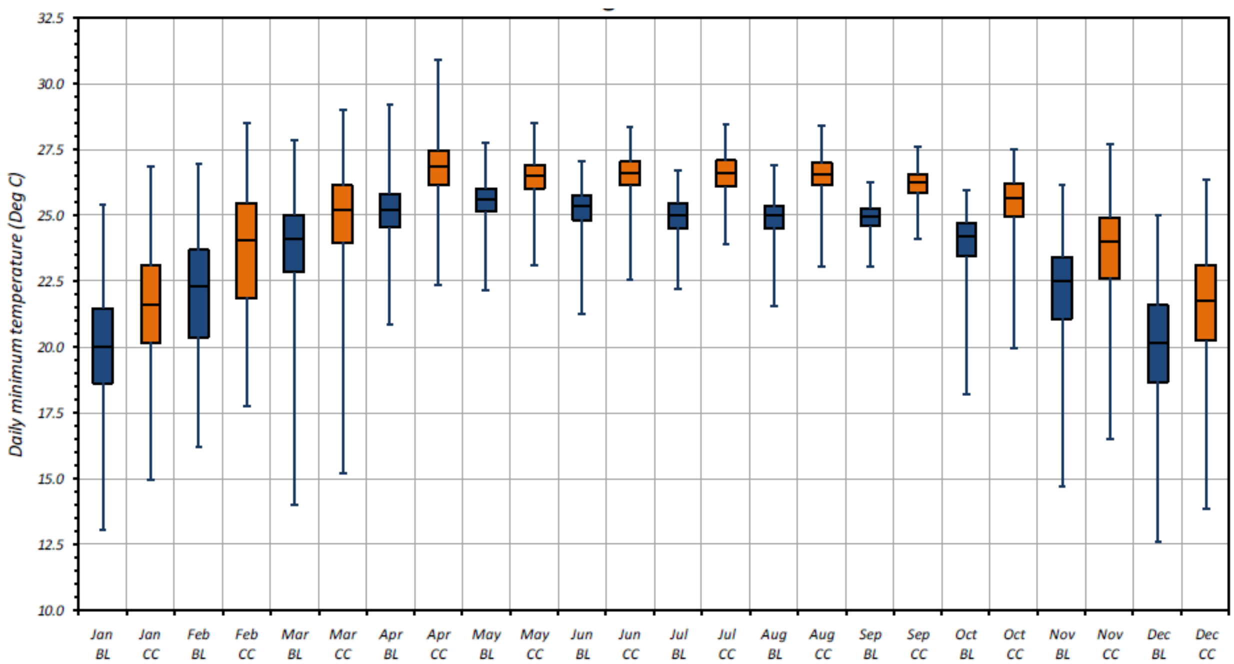
Source: ICEM (2013)

Figure 6.6: Changes in the number of days with minimum temperatures less than given temperature



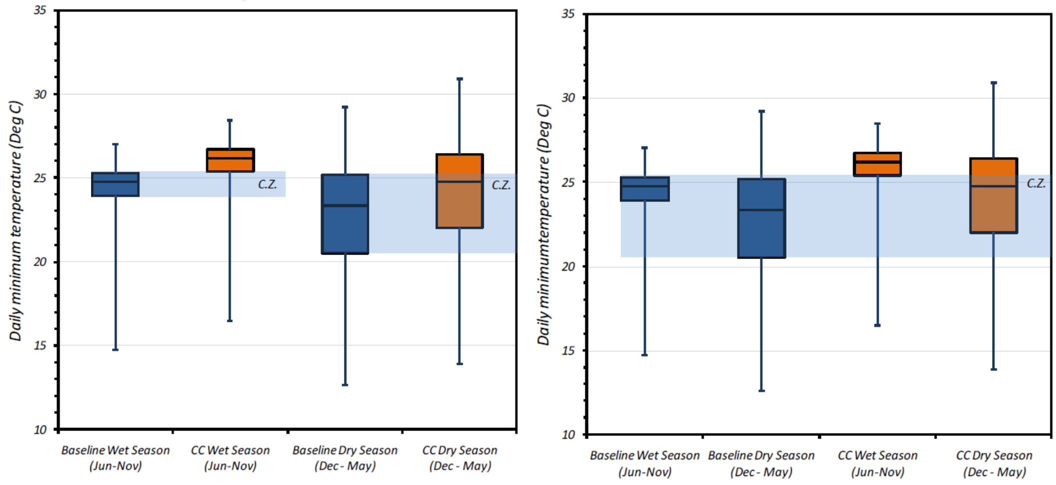
Source: ICEM (2013)

Figure 6.7: Comparison of ranges of daily minimum temperature between current baseline and climate change projections



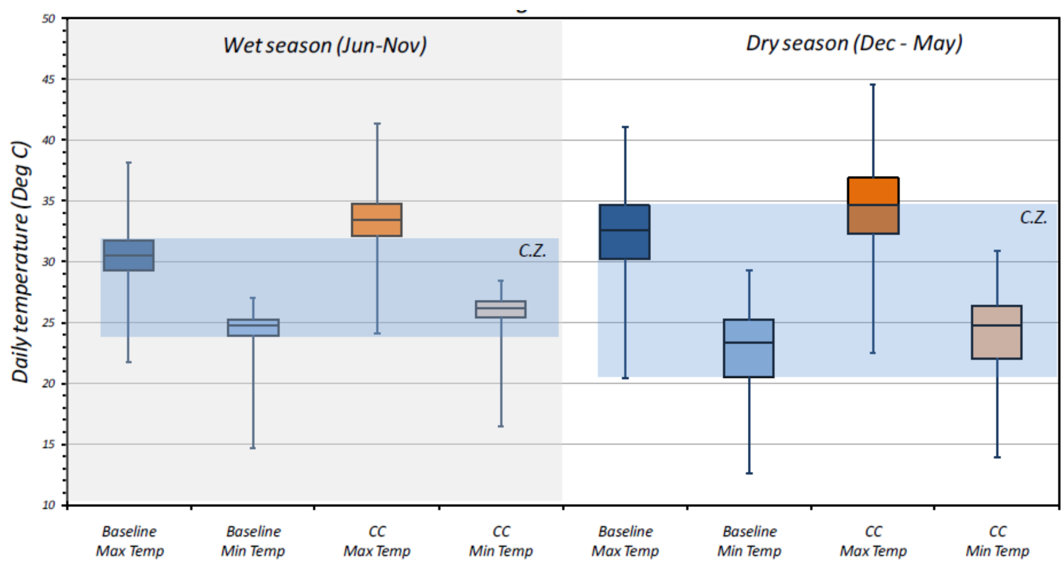
Source: ICEM (2013)

Figure 6.8: Minimum temperature comfort zones during wet and dry seasons



Source: ICEM (2013)

Figure 6.9: Maximum and minimum temperature comfort zones during wet and dry seasons



Source: ICEM (2013)

6.2.2 Rainfall

The left image in Figure 6.10 shows the current rainfall distribution pattern in Champasak province indicating that Beung Kiat Ngong lies in one of the wetter areas of the province to the south of the Bolaven plateau that has the highest rainfall. The right hand map shows the distribution in the projected increases in annual rainfall throughout the province, with about 5% increase, i.e. slightly lower than the overall provincial figures quoted here.

Current total rainfall each year is 2,041 mm (463 dry season, 1,578 mm in wet season). This is predicted to increase to 2,216 mm (493 mm in dry season, 1,723 mm in wet season). This is an overall increase of 8.6% (6.5% in dry season, 9.2% in wet season) (Figure 6.11). Rainfall distribution during the year shows slight reduction in January, February, March and April but a significant increase in May, and significant increases (between 5–15%) throughout the wet season from June to October. There will be significant decreases of 11 and 12% in February and January and 7% in April. December rainfall shows a marked increase of 35% (increasing from 5 to 7 mm) (Figure 6.12). Figure 6.13indicates predictions of the start of the monsoon. This is measured by the projections for the first month in the wet season when the monthly rainfall exceeds 200 mm. This shows that the probability of receiving 200 mm of rainfall in April is likely to decrease from the current 12% of years to 8% of years. In May the likelihood of the start of monsoon will increase from 60% of years to 76% of years, and in June this will decrease from 28% to 16% of years. This would indicate greater regularity of monsoon starting in May.

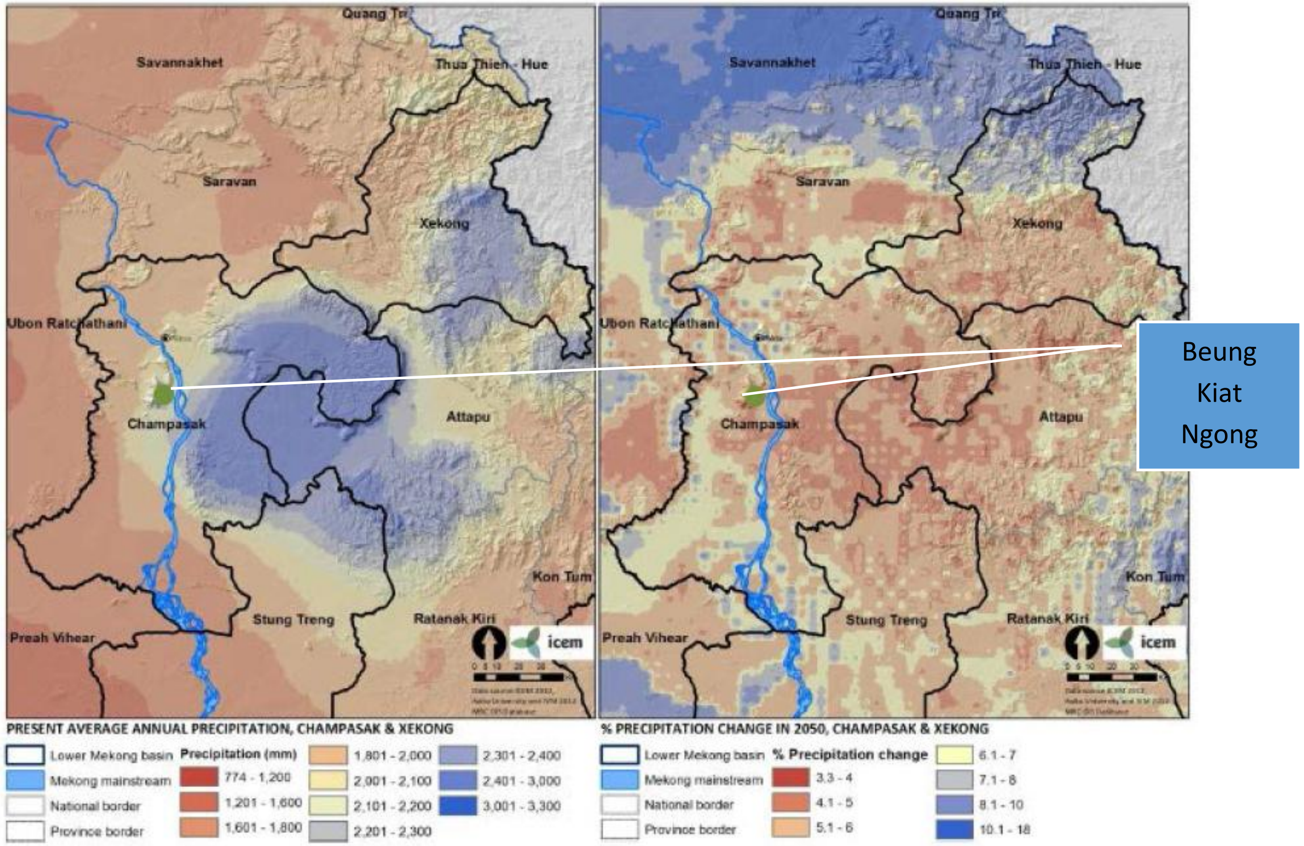
Figure 6.14 shows the ranges of monthly rainfalls with the normal range of 50% of years falling in the median boxes. The total precipitation ranges in June, July and August i.e. the months when droughts during the rice growing season may occur are shown:

- In June rainfall ranges from 120 mm to 440 mm with mean at 300 mm currently changing to 130 mm to 450 mm with mean at 320 mm;
- In July rainfall ranges from 130 mm to 600 mm with mean at 370 mm changing to 140 mm to 630 mm with mean at 400 mm; and
- In August rainfall ranges from 220 mm to 630 mm with mean at 380 mm changing to 240 mm to 680 mm with mean at 410mm.

This means that minimum rainfall years in June/July/August will only increase slightly, i.e. risk of drought years will not be significantly reduced.

Comfort zone estimates show the dry season more or less within comfort zone, and the wet season partially exceeded (Figure 6.15). This means that the projected dry season rainfall is more or less within the current range expected, and in the wet season there will generally be more rainfall than previously expected.

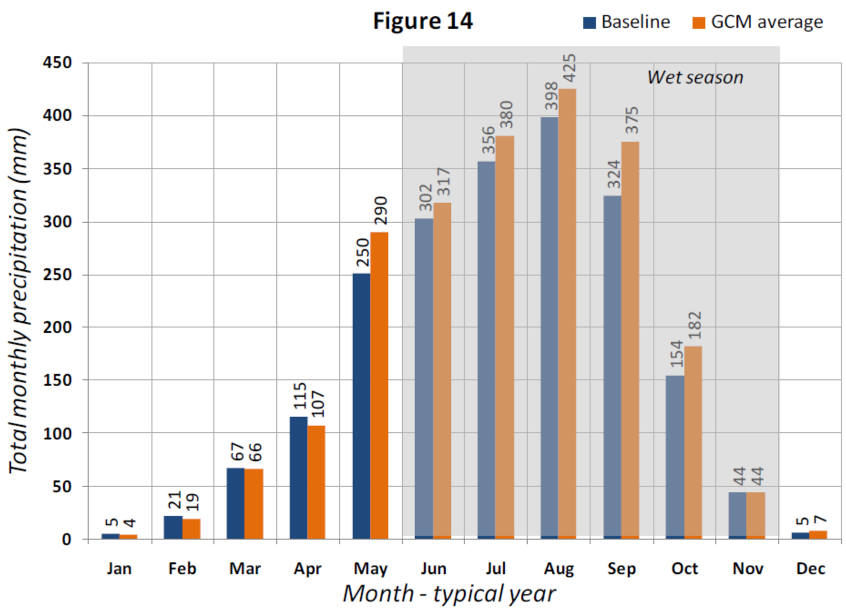
Figure 6.10: Annual average precipitation and % precipitation change in 2050 in Champasak province, Lao PDR



Note: the green dot indicates the location of the point time series data

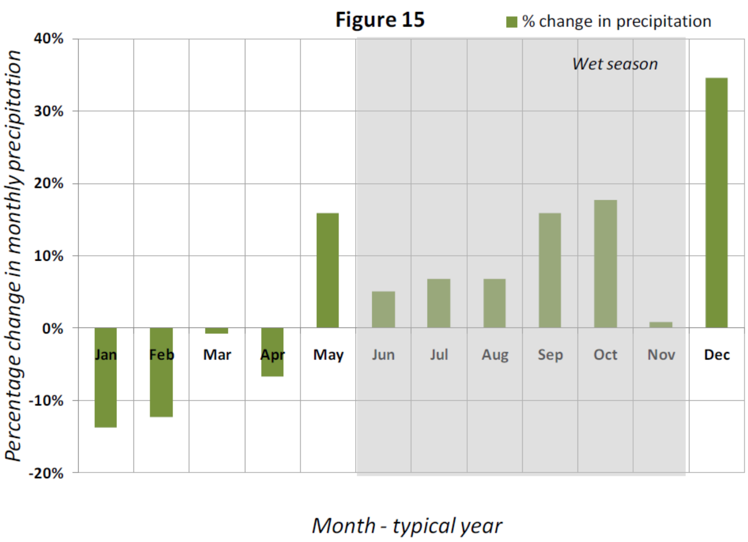
Source: ICEM (2013)

Figure 6.11: Comparison of mean monthly precipitation in a typical year between baseline and climate change projections



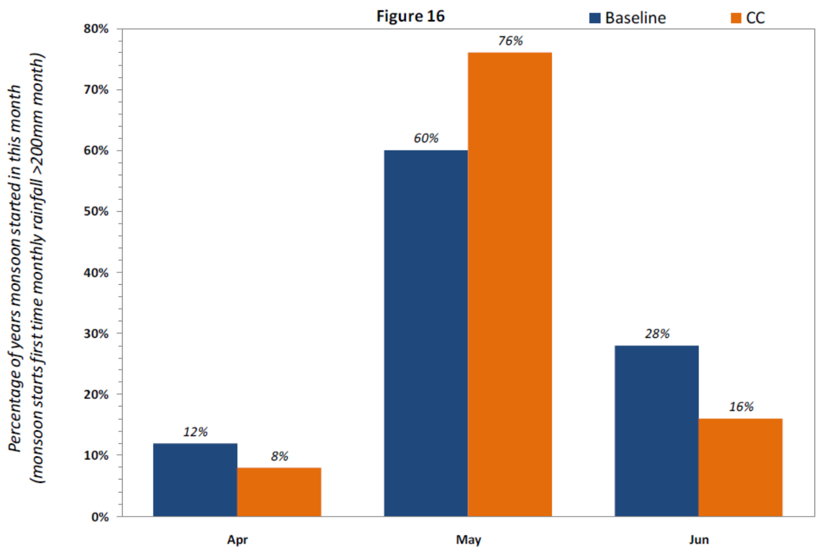
Source: ICEM (2013)

Figure 6.12: Percentage changes in monthly precipitation between baseline and climate change projections



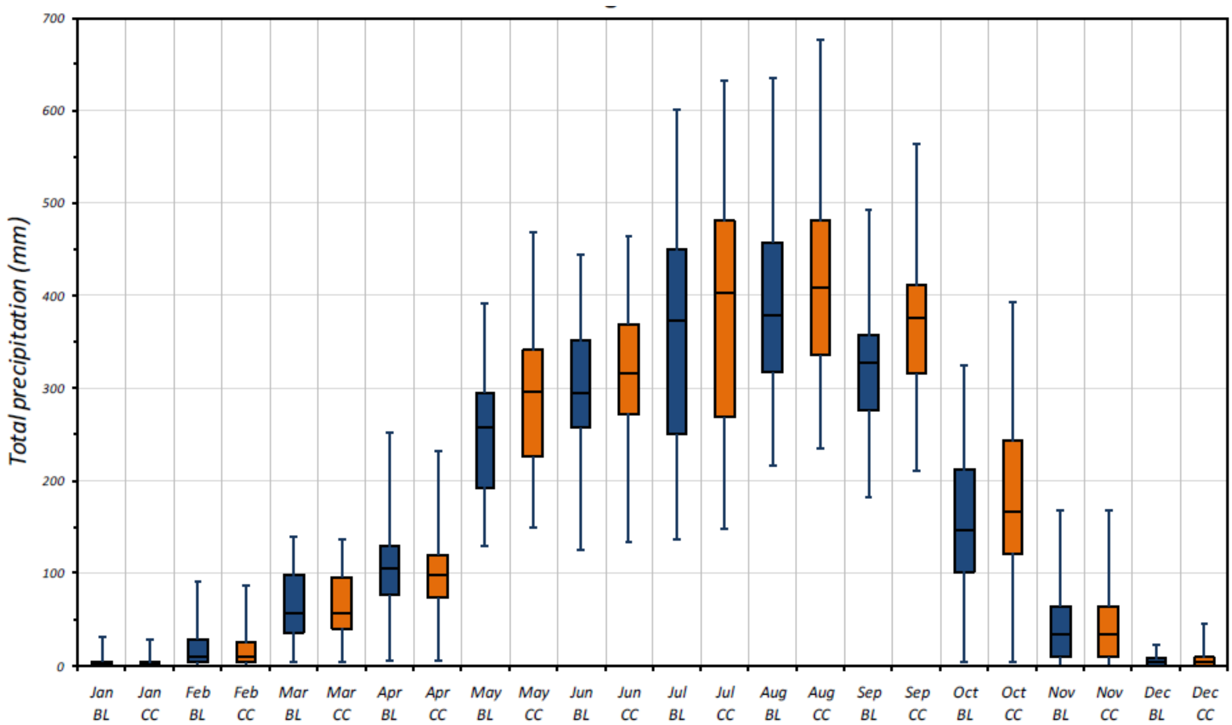
Source: ICEM (2013)

Figure 6.13: Percentage of years of the months when the monsoon is expected to start



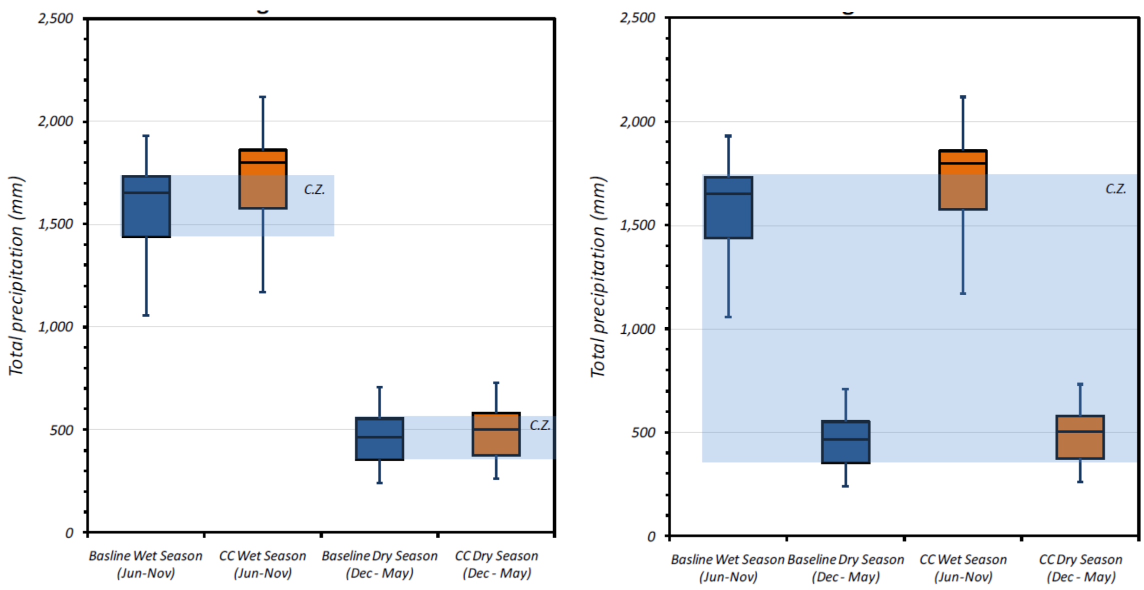
Source: ICEM (2013)

Figure 6.14: Comparison of ranges of monthly rainfalls between baseline and climate change projections



Source: ICEM (2013)

Figure 6.15: Rainfall comfort zones for wet and dry seasons (left) and for whole year (right)



Source: ICEM (2013)

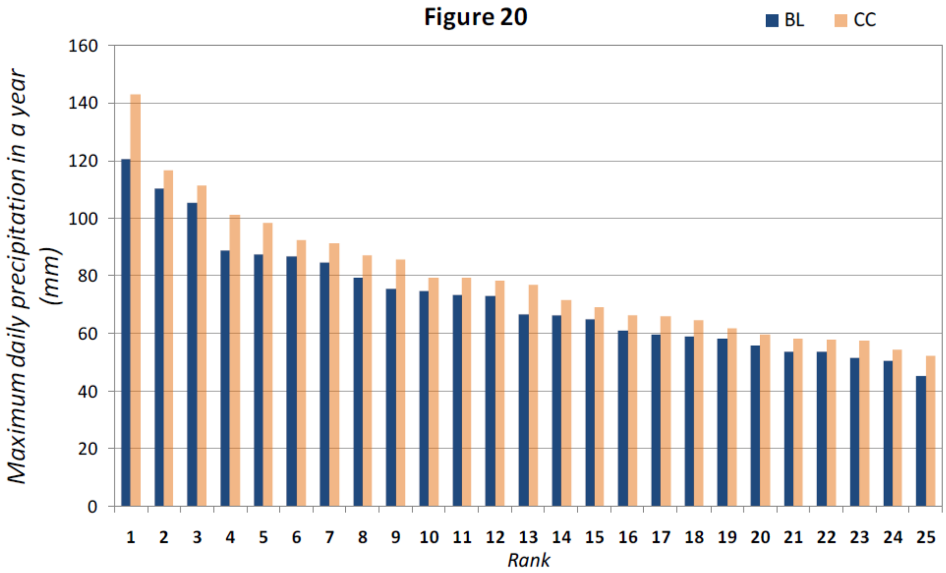
6.2.3 Storms, droughts and extreme events

It is generally considered that storms and extreme events are likely to increase in frequency and intensity with climate change. Figure 6.16 shows a ranking of the maximum daily precipitation in the year. This is taken as an indicator for storm events, when the rainfall in one day ranges between 50 to 150 mm per day.

Storms, as measured by daily events of more than 100 mm in a day, currently occur three times per year. With climate change this is likely to increase to four times per year. The intensity of storms is likely to increase. The largest storms will increase in intensity from 120 mm in a day to 142 mm in a day, or around 8.5%.

Figure 6.17 is an indication of the dryness in each month when precipitation is less than half of Potential Evapotranspiration (PET). During the wet season between May to September, as is to be expected, the rainfall is always more than the PET, but in February, March, April and November the probability that rainfall will be less than half of the PET tends to increase, i.e. these months will be drier. Note that this figure does not make predictions about drought during the rainy season, which is when the rice farmers recognize drought. This is best measured by the length of a period of consecutive days without rain during June, July and August. Figure 6.18 provides an estimate of the projected changes in soil water availability for a typical year. This shows that during the dry season between January and May there would be less soil water available for plant growth, falling from about 1.5% in January to 5% at the end of April. Thereafter as the wet season starts, the soil water availability increases sharply so that by the beginning of June the soil water availability would be only 1% lower than currently experienced. After a slight decrease of 2.5% in June/July the soil water availability reaches saturation, i.e. 0% change in September. This has ecological implications for the wetland areas of Beung Kiat Ngong.

Figure 6.16: Ranking of annual maximum rainfall events



Source: ICEM (2013)

Figure 6.17: Percentage of years when drought occurs in a month

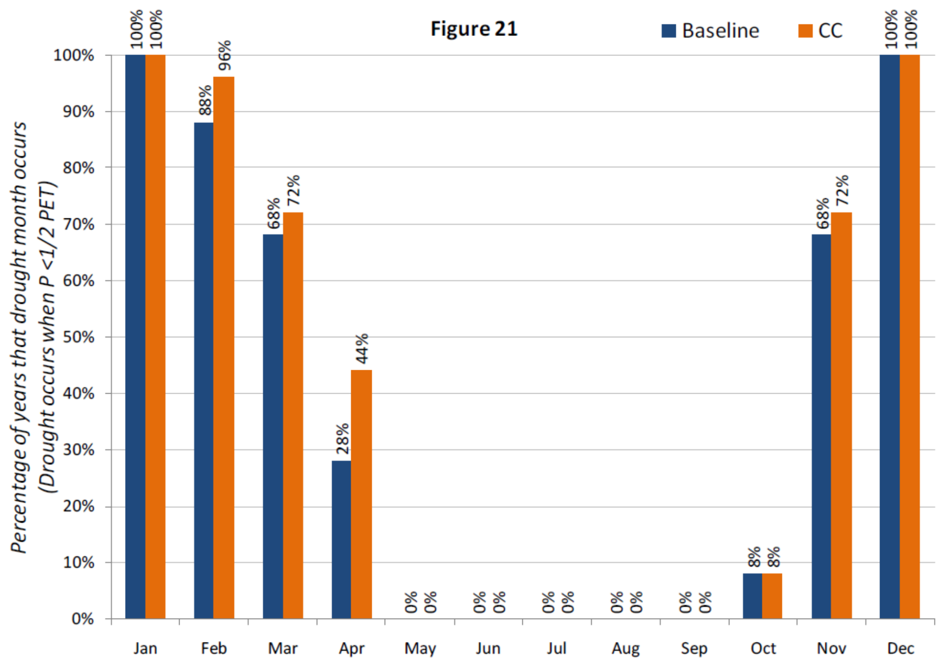
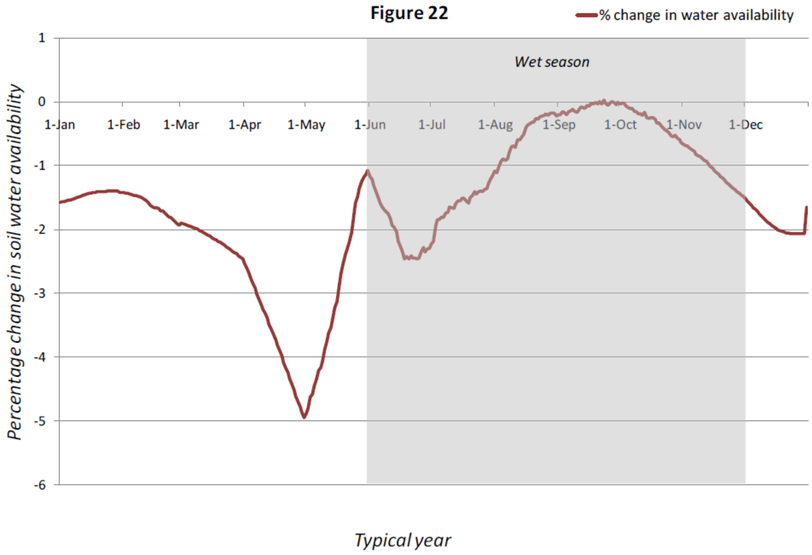


Figure 6.18: Percentage changes in soil water availability for a typical year with climate change projections



6.3 Hydrological changes in Beung Kiat Ngong

In this study, we take the current and projected rainfall figures from Figure 6.11 and consider these alongside information on the two catchments of the Beung Kiat Ngong wetlands from Table 3.2. There is projected to be a slight increase in the volumes of rainfall running into the wetland during the dry season: from 226 mm^3 to 241 mm^3 or an increase of 6.5%. However, most of this increase will occur during May when the increase in rainfall is projected to be 11.6%. During the wet season the volume of rainfall is likely to increase from 772 $mm^3$to 843 mm^3, or an increase of 9.2%.

Table 6.1: Estimates of total volume of rainfall falling on Beung Kiat Ngong

Section	Season	Catchment area	Current rainfall	Volume of rainfall	Projected rainfall in 2050	Volume of rainfall
		km^2	**mm**	**mm^3**	**mm**	**mm^3**
Northern section	Wet season	46	1,578	72.6	1,723	79.3
	Dry season		463	21.2	493	22.7
Houay Tauang	Wet season	443	1,578	699.1	1,723	763.3
	Dry season		463	205.1	493	218.4
Total for Beung Kiat Ngong	**Wet season**	**489**		**771.7**		**842.6**
	Dry season			**226.3**		**241.1**
Total rainfall			**2,041**	**998.0**	**2,216**	**1,083.7**

The climate change implications for the hydrological functioning of Beung Kiat Ngong are that during the main dry season from January to April there will be a reduction in the total rainfall of about 5.8%. With less rainfall and increased evapotranspiration due to increased temperatures during January to April as shown Figure 6.17, there will be less water in the wetland. A comparison for different climate change factors during these dry season months is shown in Table 6.2. During the dry season it is likely that there will be a tendency for the wetted areas of Beung Kiat Ngong to dry quite rapidly, and for the overall wetland to shrink.

Pools of open water are likely to remain but may become shallower as the dry season progresses.

Table 6.2: Comparison of climate changes factors affecting the hydrology of Beung Kiat Ngong during dry season

	Mean maximum temperatures increases	Rainfall decreases	% of years when rainfall <½ of PET changes
January	from 31°C to 32.5°C	from 5 to 4 mm	100%
February	from 33°C to 35.1°C	from 21 to 19 mm	increase from 88 to 96%
March	from 34.5°C to 36°C	from 67 to 66 mm	increase from 68 to 72%
April	from 34.5°C to 37.6°C	from 115 to 107 mm	increase from 28 to 44%

In May, however, there will be an increase in rainfall, which will be maintained throughout the wet season. During the early wet season, the increased run-off will fill up the wetted areas of the wetland first, before flowing on out of the southern streams into the Houay Taung and on to the Xe Khampho and Sekong rivers. The total area of the wetland in the wet season is likely to remain more or less the same, since the water levels will be determined by the overall topography of Beung Kiat Ngong and backing up of the flood water levels in the downstream Xe Kampho.

7 Vulnerability assessment for Beung Kiat Ngong

7.1 Wetland habitats

A vulnerability analysis of the Beung Kiat Ngong wetland as a whole complex is provided in Annex 1. The system appears to have a high sensitivity and potential impact to the combination of higher temperatures and lower rainfall in the dry season between January and April. It is anticipated that this will lead to drying out and eventual shrinkage of the areas of seasonally inundated grasslands and peatlands, especially around the edges of the wetland. Within the open water bodies, the water levels may be lower during the dry season and in combination with the increased maximum temperatures, the dissolved oxygen in these pools may fall.

However, such wetland complexes are extremely dynamic and will quickly re-establish themselves in the wet season with the increase in rainfall and inundated areas. **Because of the high resilience and adaptive capacity of these wetlands it is considered that the overall vulnerability is medium**. There may be some shift or redistribution of wetland vegetation types and habitats, but this is unlikely to be substantial, and will occur gradually without change to the character of the main habitats in the Beung Kiat Ngong wetlands.

With the increased temperatures, the grasslands and shrublands drying out during the late dry season are likely to experience greater risk of fire, and this may damage the forested areas on the islands and shorelines.

The increase in rainfall in the wet season between May and October is likely to have a high impact, with the inundated area quickly refilling after the drier dry season. But because the water levels in the Beung Kiat Ngong are to some extent regulated by the topography of the basin, excess run-off will pass down the river system into the Xe Kampho river. If this river is flooded and backs up into the wetland, the flood extent will increase, with some inundated areas becoming deeper, such that the grassland may be affected. If this deeper inundation is prolonged and occurs most years, there may be some habitat shifts within the wetland, but these are unlikely to be significant.

Events such as storms and floods may increase as a result of increasing intensity from the largest storm in the year (increasing from 120 to 144 mm in a day) and the slight increase in the frequency of storm events. However it is considered that the wetland has a high ecological adaptive capacity to be able to cope with such events, such that there would only be moderate vulnerability. If the Xe Kampho floods and backs up into the southern portion of the wetland, floods may be more prolonged, especially for the villages of Phapho and Phakha.

The summary of the vulnerability assessment of the overall wetland habitat of Beung Kiat Ngong is shown in Table 7.1.

Table 7.1: Vulnerability matrix of the overall wetland habitats of Beung Kiat Ngong.

Threat	Exposure	Sensitivity	Impact Level	Adaptive capacity	Vulnerability
Increase of temperature especially at end of dry season	H	VH	VH	H	M
Irregular distribution of rainfall in dry season	H	H	H	H	M
Increase in rainfall in wet season	VH	L	H	H	M
Increased frequency and intensity of storms	H	L	M	H	M
Increased risk of flooding	M	L	M	H	M

No precise delineation or estimate of the areas of the main habitats of Beung Kiat Ngong wetlands has been undertaken because the whole complex is a mosaic of open water, marsh and seasonally flooded grasslands, with forested islands, surrounded by rice fields and forested shorelines. Using the hydrological changes associated with climate change described above, the impacts of climate change upon these different wetland habitats are described qualitatively in Table 7.2.

Table 7.2: Hydrological implications and potential habitat change for main habitats in Beung Kiat Ngong

Habitat	Hydrological implications	Potential habitat change
Perennial ponds	Dry season: ponds remain, but water level falls further in late April Wet season: ponds fill up and remain	Little change in extent. Depth will vary more from 2 – 3 m in wet season, to <1 m in the dry season
Seasonal ponds	Dry season: ponds tend to dry out faster Wet season: ponds fill up fast in early wet season and are maintained	In the wet season the seasonal ponds will cover a larger surface area, but will shrink further in dry season. There may be a change in flora to cope with deeper wet season water levels.
Small seasonal and perennial streams	Seasonal streams will dry out faster in the dry season, but have larger flows, and flash flows in the wet season. Perennial streams running through the wetland, and coming from the southern part of the catchment will remain, though with lower flows in dry season, and higher flows in wet season.	Little change in flowing water habitats Potential for increased soil erosion and channel cutting in seasonal streams on the hillsides
Peatland	Dry season: higher temperatures and low rainfall causes drying of	During the dry season, the edges of peat land may dry out and give rise to

Habitat	Hydrological implications	Potential habitat change
	peatlands Rehydration of the peat land in the wet season	acid sulphate soils. When such soils are rehydrated, acid is released into the water causing a drop in pH. If fires occur in these dry and damaged areas, the peat itself may catch fire.
Freshwater marshes	Dry season: higher temperatures and low rainfall causes lowering of ground water and drying of fresh water marshes Water table in the freshwater marshes returns to surface in the wet season. If flooding is prolonged, seasonal ponding may occur.	There may be some changes in the extent of freshwater marshes due to drying at the edges in the dry season. Some of the land may become suitable for agriculture, so this may lead to encroachment.
Seasonally flooded grassland	Dry season: higher temperatures and low rainfall cause rapid lowering of levels and drying of grassland areas Grasslands inundated relatively quickly at start of rains. Water level in grasslands may reach higher levels than at present.	Extent of dry grassland areas may change along with changes in species composition. At the landward edges, the grass species may become more terrestrial. In the deeper parts the grassland species that can tolerate higher water levels for longer will be favoured. In the dried out grassland areas, fires may become more prevalent in the dry season.
Shrubland	Seasonally inundated shrubland on the higher edges of the marsh and islands will be drier in the dry season and more flooded in the wet season.	There may be some expansion of these areas since the shrubs are able to withstand both the dry periods and the deeper water levels, with some potential for invasion by *Mimosa pigra.*
Forested areas on islands and around the shoreline	Drier dry seasons and lower water tables Areas of forests may be more extensively and deeply flooded. Increased winds and storms	Forested areas will not be affected by the slightly drier dry seasons since most are relatively dormant during this time. Many tree species around the wetland will be tolerant to flooding, but if the floods cover the roots of the trees for too long, then they may die. More intensive storms and stronger winds may damage exposed trees in the wetland. Forest fires in the dry season may damage the trees and cause loss of forest cover.

Habitat	Hydrological implications	Potential habitat change
Rice paddies	Most paddies around the wetland are rain-fed with active water management during the wet season. Before harvesting, the rice paddies are allowed to dry out and remain as fallow until the next rainy season. Livestock grazing during the dry season Increased risk of flooding due to storms and back flow from the rivers	Rice paddies will benefit from more reliable onset of rains in May, and potentially more rain during the rainy season. Increased risk of flooding will reduce yields of rice and cause complete loss if prolonged or deep. There will be little impact of drier dry seasons and higher evapotranspiration on rice paddies after the harvest. There is potential for expansion of rice paddy into the wetland

7.2 Wetland plant species

7.2.1 Sedges – *Scirpus grossus*

Scirpus grossus, or greater clubrush, is a "principal" weed of four Southeast Asian countries, presumably as a weed of rice crops. It occurs in swampy and inundated places, pools, ditches, and marshes and is locally abundant, especially in the lowlands. It is also a host of *Chilo polychrysus*, the dark-headed rice borer. It is a robust, widespread and important weed, spreading by stolons and capable of dominating rice crops and wetlands.[4]

The Mekong ARCC study carried out a vulnerability assessment of a similar species within the Cyperaceae, *Lepironia articulata*, Grey Sedge, in the Kien Giang in the Mekong Delta. The study states that

> *Lepironia* propagates with seeds and rhizomes. *Lepironia* seeds germinate well although the germination rate is slow initially. It grows in open wet areas, from littoral areas to deep water, in swamps, ex-mining ponds, lakes, and ditches. It is typically grown in swamps with low pH (up down to pH 3). (ICEM, 2014).
>
> Increase in temperature will cause water surface temperature to increase but this will likely not affect *L. articulate* as it grows in deep water. As a sedge, *L.articulata* is also tolerant to drought. Increase in projected depth and frequency of flooding is certainly not an issue for *L. articula*ta as it is known to grow in depths up to 5.5 metres.
>
> The drier dry season might lead to higher frequency of grassland wildfires. The above-ground stems might be burnt off but will regenerate quickly from rootstocks once moisture conditions returns. The vegetative reproduction mode allows the plant to wait out adverse conditions.
>
> In terms of habitat requirements, *L. articulata* has fairly specific requirements for habitat. It can grow well in acidic and nutrient poor soils but is unlikely to be able to compete with other species in non-acidic soils. The plant has low genetic diversity due to vegetative reproduction.

[4]http://wssa.net/wp-content/uploads/Actinoscirpus-grossus.pdf

It is expected that in the future the non-climate stresses will increase for *L.articulata* from (a) land use pressure for conversion to aquaculture and agriculture (b) invasion of alien species, Mimosa pigra in particular, and (c) increase in demand for handicraft making that might lead to overexploitation.

Scirpus grossus has very similar characteristics to *Lepironia* and the responses to climate change are expected to be the same. It is expected to show **low vulnerability to climate change conditions in Beung Kiat Ngong**. The more extreme changes between the dry and wet season sizes of the seasonally and permanently inundated areas in Beung Kiat Ngong may lead to some changes in the distribution of the sedge. The increased risk of fire during the late dry season may also enhance these changes. However, as with *Lepironia*, the vegetative reproduction of *Scirpus grossus* will allow it to re-establish the stands of sedge as soon as favourable wetted conditions return.

7.2.2 Shrubs – *Sesbania sesban*

The Mekong ARCC study used *Sesbania sesban* as one of the indicator species for wetland NTFPs (ICEM, 2014). That report found that *Sesbania* grows in a wide range of soils from loose sand to heavy clay. It is native to monsoonal, semi-arid to sub-humid regions with annual rainfall ranging from 500– 2000 mm. It grows best where periodic water-logging or flooding is followed by progressively drier conditions. The plant does not require a large habitat: small clumps of *S. sesban* occur in the wild in moist riverine areas and can be domesticated at edges of ponds and canals. The plant can disperse long distances by water: the ripe fruits and seeds are buoyant.

In terms of tolerance, it has outstanding ability to withstand waterlogging and is ideally suited to seasonally flooded environments. When flooded, it initiates floating adventitious roots and protects its stems, roots, and nodules with spongy aerenchyma tissue. It is common along streams, swamp banks, and moist and inundated bottomlands.

S. sesban shows some tolerance to moisture stress and tolerates soil alkalinity and salinity to a considerable degree. The plant is resilient to drought. Re-sprouting from the rootstocks can occur easily when moist conditions return.

S. sesban is not threatened by human use: flowers are harvested for food and stems are harvested for fuel wood of low value. *S. sesban* is attacked by nematodes, insects, fungi, and viruses. The leaf-eating beetle *Mesoplatys ochroptera* can completely defoliate *S. sesban*, leading to mortality. Caterpillars, Hymenoptera, and stem borers are normally associated with *S. sesban*. Some potentially destructive root-knot nematodes have been recorded in India as associated with *S. sesban*.

Exposure to temperature is not an issue for *S. sesban*. The plant temperature comfort zone is between 18°C to 23°C (min. 10°C, max. 45°C). For rainfall exposure, as a tree legume, the plant is found growing in a very wide range of rainfall environments. *S.sesban* is less tolerant to drier environments. When soil moisture drops below 12.5%, 55% of leaves will fall. As the plant shows excellent tolerance for inundation conditions, exposure to flooding is not an issue. The change of timing of the onset of the rainy season is likely to affect the flowering of the plants as it flowers at the onset of the rainy season in June-July. This is unlikely to affect the plants in Beung Kiat Ngong.

For extreme events, strong winds and storms will cause the stands to collapse but are unlikely to kill the plant. In terms of fire risk, in dry conditions the above-ground stems can be burnt but stands quickly recover when moist conditions return from seeds in the soil.

S. sesban has some good traits for adapting to adverse conditions:

- Water-impermeable seed coat enabling seed dormancy can help seed to wait out adverse conditions;
- Provided there are flooded and moist areas, the plant will survive;
- Populations are widespread; excellent tolerance of waterlogged conditions;
- Individual plants live for 1.5 years with rapid establishment and early growth; and
- Seeds are carried long distances by water.

It is considered that *Sesbania sesban* generally shows **low vulnerability to climate change** in Beung Kiat Ngong because the species has a wide range of tolerance for heat, inundation, and drought. The projected conditions in Beung Kiat Ngong would not exceed these tolerance ranges. However, if other plants become stressed by temperature and decline, the additional pressure from human collection will increase. If climate change affects the *S. sesban* pollinators, then pollination and fruit/seed setting may be reduced.

7.2.3 Shrubs – *Mimosa pigra*

The MRC case study of climate change and wetlands in Xe Champhone carried out a vulnerability assessment for *Mimosa pigra*, where the level of invasion was higher than in Beung Kiat Ngong. The CAM matrix for that study is shown in the Annex(ICEM, 2012).This assessment shows that giant mimosa is an extremely hardy species that is tolerant of extremes of both flood and drought. It is spread by the seeds being carried by flood waters reaching new areas, and because it has no uses or natural enemies to keep populations under control, it tends to dominate and exclude other similar shrubs. It is to be expected that the climate changes expected in Beung Kiat Ngong with higher floods in the wet season will tend to enhance its spread. However, because it cannot survive in permanently flooded areas, the increase in seasonally exposed areas due to the lower rainfall and increased drying in the dry season may mean that the areas where it can survive may increase. *Mimosa pigra* shows **low vulnerability to climate change and this will tend to increase its invasiveness.**

7.2.4 Swamp forest trees – *Barringtonia sp*

The MRC wetlands and climate change study on Lower Stung Sen considered the vulnerability of *Barringtonia acutangula,* one of the keystone species in the flooded forests of the Tonle Sap (ICEM, 2012). In that study the vulnerability of the species was considered to be low largely because of its high resilience to flooding and prolonged inundation and its ability to grow in rocky and pebbly substrates in strong currents nearest the water's edge.

The species can establish itself in areas with only a brief exposure to drying. Flowering and fruiting occurs throughout the year. It responds to drought and increased temperature by shedding leaves to reduce evapotranspiration. When under water, leaves are retained and photosynthesis continues for several months.

Assuming that the species in Beung Kiat Ngong is similar to *Barringtonia acutangula,* which is a widespread species growing in wetlands, lakes and along rivers throughout Southeast Asia, a CAM matrix has been applied for the species growing in these wetlands (see Annex).

Overall, *Barringtonia acutangula* shows **medium vulnerability to climate change**. It is well-adapted to living in areas that have prolonged inundation and is especially resilient to increased flooding. The trees are able to survive periods of drought and increased temperatures, though increased temperatures in the wet season may have inhibitory effects on flowering, fruiting and seed setting. If the areas that are currently exposed for too short a period to allow other trees and shrubs to survive have increased exposure, then *Barringtonia* may experience increased competition from these species.

Summary of Vulnerability assessment for *Barringtonia*

Threat	Exposure	Sensitivity	Impact Level	Adaptive capacity	Vulnerability
Increase of temperature especially at end of dry season	M	M	M	H	M
Irregular distribution of rainfall in dry season	M	M	M	L	M
Increase in temperature during wet season	M	H	M	M	M
Increase in rainfall in wet season	VH	L	H	H	M
Increased frequency and intensity of storms	H	L	M	M	M
Increased risk of flooding	M	L	M	VH	L

7.3 Key species

7.3.1 Fish

A comprehensive vulnerability assessment of the impacts of climate change on capture fish species and aquaculture was carried out under the Mekong ARCC project for several provinces. Although Champasak was not included, the nearest provinces were Khammouane in Lao PDR and Mondulkiri in Cambodia(ICEM, 2013). The study included detailed vulnerability assessments for several of the species of interest in Beung Kiat Ngong, including *Channa striatus*, *Cirrhinus microlepis*, *Clarias batrachus*, *Trichogaster pectoralis, Oreochromis niloticus* (aquaculture). The database entries of these fish species are included in Annex 2 and the CAM matrices for these species are found in Annex 1. The main climate change threats considered were increase in temperature, increase/decrease in precipitation, increase/decrease in water availability, drought, flooding, storms and flash floods.

The general findings of the Mekong ARRC fisheries study were:

- Black fish tend to be less vulnerable to climate change because they are able to survive poor water quality conditions (e.g. low dissolved oxygen, low pH, high turbidity and high ammonia);
- Black fish are able to withstand harsh dry season environments including high temperatures and anoxic conditions;
- Their limited migratory habits make them less vulnerable to wetlands fragmentation;
- Most white fish species require higher water quality conditions in terms of dissolved oxygen and alkalinity;
- White fish are more vulnerable to increased temperatures, especially at maturation and fry stages; and

- White fish are more vulnerable to decreases in water availability e.g. in the dry season.

Fish and other aquatic animals in this ecological zone have evolved to survive the harsh conditions through the dry season and at the onset of the rains, to mature quickly and breed. The survival of fish through the dry season depends to a large extent on the availability of perennial water bodies, such as in Beung Kiat Ngong. Shifting rainfall patterns, including longer dry periods, could affect the survival of fish in the dry season.

Any changes in temperature will influence their metabolism, growth rate, reproduction, recruitment and susceptibility to toxins and disease. The response of fish to increased temperatures is likely to be a shift in behaviour, and it could be that some species extend their ranges at the expense of others. Because of the higher tolerance of black fish to temperatures compared to white fish, there could be a shift towards greater populations of black fish.

Increased CO_2 levels are likely to affect fisheries through the acidification of some water bodies. This may affect white fish more than black fish. In Beung Kiat Ngong, the peat swamp waters will tend to be quite acidic, so there may be a tendency for the pH to fall further with increases in CO_2 in the atmosphere. With longer dry periods, exposed peat soils may dry out and increase the acidity of the waters when the wet season rehydrates the peat. Increased acidity in the water is likely to be less hospitable for fish, especially white fish.

The following are summaries of the vulnerability assessments of particular species.

***Channa striatus* (*Pa kho*).**This is a species of black fish found in a wide range of wetland environments, including rice fields, reservoirs and canals. It is considered to have a low vulnerability to increased temperatures, because the projected temperature increases are well within the tolerable range for this species. It is an air breathing fish, so dissolved oxygen levels are not important. It shows low vulnerability to increased rainfall in the wet season since this will allow easier access to the wetland areas of Beung Kiat Ngong. Flooding will also increase the inundated area, providing additional breeding and feeding areas around the wetland, and will increase population numbers. In the dry season, the species would have moderate vulnerability to the reduced rainfall which is likely to decrease the extent of inundated areas of the wetland, so this will tend to concentrate this species in the remaining areas of open water with increased predation and fishing pressure. Generally the species shows low vulnerability to climate change impacts expected in Beung Kiat Ngong.

***Clarias batrachus* (*Pa douk*).**[5] The walking catfish is a black fish species resident in Beung Kiat Ngong throughout the year. The projected increase in temperatures is well within the range of this species, and it is tolerant of both high turbidity and low dissolved oxygen. In the natural habitats of Beung Kiat Ngong, it is likely to have a low vulnerability to increased temperature, and will be able to survive in the conditions in the remaining open water refuges in the dry season. Its ability to “walk” means that it is able to move overland to more favourable pools as the wetland dries. During the wet season, increased rainfall and water availability, and increased size of the inundated area will be beneficial for this species. It will be unaffected by flooding, though drought in the dry season will cause stress. Generally, vulnerability to climate change impacts expected in Beung Kiat Ngong is low.

[5]Note that for this species the CAM vulnerability assessment was carried out for aquaculture in earth ponds.

Trichogaster pectoralis **(*Pa kadeut*).**This is a non-migratory, small black fish, important for food security. It is known to be tolerant to a wide range of temperature, with optimum temperatures between 23 – 28°C. It is considered to be moderately vulnerable to increase in temperature. It is a resilient black fish species able to withstand reduced rainfall and water availability in the dry season, provided that it has the remaining open water bodies as refuge. This species is considered moderately vulnerable to reduced rainfall, but during drought conditions, as the refuges contract, it will experience greater stress from reduced space and food and increased fishing pressure. With rainfall increasing in the wet season, the rapid expansion of aquatic habitats will encourage its growth, maturity and spawning. Generally, vulnerability to climate change impacts expected in Beung Kiat Ngong is low.

Oreochromis niloticus **(*Pa nin*).** Tilapia is an exotic species, introduced through escapes from fish culture. Table 7.3shows the temperature range for different species of cultured fish, indicating that this species is particularly tolerant to higher temperatures. With an optimum range between 30 – 32°C, it will be unaffected by increased temperatures. It is also tolerant to low dissolved oxygen, though perhaps not as tolerant as snakeheads and catfish. As with other resident species, it will be stressed by reduced rainfall and more rapid drying of the wetland in the dry season, which will tend to concentrate the fish into the remaining pools, making them more susceptible to predation and fishing pressure. It will benefit from the increased rainfall in the wet season and flooding, which will extend the inundated area for breeding and feeding. Generally the species shows low vulnerability to climate change expected in Being Kiat Ngong.

Table 7.3. Optimum water temperature ranges for commonly cultured fish in the Lower Mekong Basin

Temperature ©	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46
Species																						
Oreochromis niloticus														OP	OP							
Cyprinus carpio													OP	OP								
Pangasius sp.												OP	OP									
Clarias sp.													OP	OP								
Penaeus mondon										OP	OP											

Source: ICEM (2013)

Cirrhinus microlepis**, (*Pa keng*).**Also called small-scale mud carp, this species is a white fish that moves into the wetland from the Mekong mainstream and tributaries during the rainy season. It breeds during June and July, with juveniles nursing in the floodplains and leaving at the end of the wet season as the waters in the floodplain recede. It is herbivorous, consuming leafy plant matter and phytoplankton and also insects. It is recognized as a Vulnerable species in the IUCN Red List of Threatened Species. White fish tend to be less tolerant of higher temperatures than black fish, but this species will be living in the larger bodies of flowing water during the dry season, and so will be less exposed to the lower water quality conditions experienced in Beung Kiat Ngong during the dry season. The increased water temperature in the wet season may affect the nursing juveniles more than the adults. During the wet season, the white fish move into take advantage of the inundated wetland area, with the higher dissolved oxygen and overall improved water quality. Thus they will benefit from the increased rainfall and the larger size of the wetland in the wet season. They may also benefit from the more reliable start of the rains in May. Overall, this species shows medium vulnerability to climate change during its movements into Beung Kiat Ngong.

In summary, the black fish populations of Beung Kiat Ngong generally show fairly low vulnerability to climate change. They are adaptable, hardy species that have evolved to be able to cope with the long dry seasons when conditions are at their most stressful.

White fish populations only enter the wetlands during the wet season when generally higher rainfall, increased inundation and lower temperatures make the conditions acceptable, and even beneficial, for white fish populations. The populations may depend upon how climate change and other threats affect them outside of Beung Kiat Ngong during the dry season.

An unquantifiable cause for concern may be an increase in acidity in the peat areas of the wetland, if the acid sulphate soils release acid into the water as the inundation returns at the beginning of the wet season.

7.3.2 Eels

Eels are considered separately from the other black and white fish, partly because the communities consider them differently, rating eels as the second most important wetland product after fish, and partly because they have different behaviour patterns. The eel species found in Beung Kiat Ngong is the Asian swamp eel, *Monopterus albus.* The swamp eel is a voracious general predator, feeding on fishes, amphibians, and aquatic invertebrates.

It has versatile motility and is even capable of moving over dry land for short distances. This behavior is used for relocation according to resource availability. In the absence of water and food, it is able to survive long periods of drought by burrowing in moist earth.

The Asian swamp eel is hermaphroditic. All young are females. As juvenile fish begin to mature, some take on the masculine phenotype. Males have transgendered capabilities, allowing them to replenish female populations when female densities are low. This change from one sex to another can take up to a year. Spawning can occur throughout the year. Eggs are laid in bubble nests located in shallow waters. These bubble nests float at the water's surface and are not attached to aquatic vegetation. Females produce up to 1,000 eggs per spawning event.

Swamp eels are an important host for the parasitic nematode *Gnathostoma spinigerum*. Eating raw or undercooked swamp eel can cause gnathostomiasis, an important disease in Thailand, Lao PDR, Burma and Vietnam.

In terms of climate change vulnerability, the Mekong ARCC fisheries study carried out a vulnerability assessment of a similar eel-like fish species, *Mastacembalus armatus,* in Khammouane province. The CAM matrix for this species is included in the Annex. This species is more of a river species compared to the swamp eel, and does not have the same adaptive capacity in terms of it being able to move overland and burrow. Nevertheless, the species is tolerant of high water temperatures and low dissolved oxygen, and the projected increases in temperature are within the tolerance range of the species. For *M. armatus* the drying out of water bodies during prolonged dry seasons would render it moderately vulnerable, but the swamp eel can move away to find other remaining bodies of water, and it can burrow into the mud and survive. **Climate change vulnerability of the eel would therefore be low**.

Increased rainfall during the wet season, the increase in size of the inundated area and flooding are likely to be beneficial for the species, providing both more habitat for its populations as well as larger populations of prey species.

7.3.3 Molluscs

The CAM matrix for the Golden Apple Snail was copied from the Mekong ARCC Fisheries report (ICEM, 2013)where the impact of climate change on the invasiveness of the species was assessed. The report also assessed the vulnerability of the ecosystem of the Mekong delta in Kien Giang to this invasive species rather than the vulnerability of the species itself. The following comparison of the climate change vulnerabilities of *Pila pilota* and *Pomacea canaliculata* has been developed from a review of the differences in the physiology, reproductive behavior and response of the two species to environmental conditions, as reported in a review of Ampullariid (Apple) snails as agricultural pests(Cowie, 2006).

Both species inhabit slow moving or stagnant water in lowland swamps, marshes, ditches, lakes and rivers. Both species are amphibious, being able to spend substantial periods of time out of water breathing air. There may be differences of habitat preference and an indication of this is reported by Timmins (2014) which notes that *Pila pilota* may have a requirement for permanent water.

Both *Pila* and *Pomacea* can aestivate under adverse environmental conditions, e.g. during the hot dry season as the water bodies dry up. Aestivation consists of burrowing into the mud and closing the operculum to restrict water loss. Under natural conditions this may last for up to three months until the rains come, but under experimental conditions, aestivation periods longer than one to two years have been recorded in some species. Aestivation can take place at different depths in the mud, with *Pila* species tending to burrow up to one metre deep into the mud. *Pila* species tend to undergo anaerobic metabolism during aestivation and may experience considerable weight loss. *Pomacea* species tend to aestivate nearer the surface with aerobic respiration.

For most of these snail species the upper tolerance limit of water temperature is about 40°C. Cowie (2006) suggests that with *P. canaliculata* originating in more temperate climates, it has a slightly lower temperature tolerance than the native tropical species. The normal temperature tolerance range for *P. canaliculata* lies between 15.2° and 36.6°C. The projected increases in maximum temperature in the wet season are generally within this range, though the dry season maximum temperature comfort zone will exceed this slightly. *Pomacea* species may be able to regulate their body temperature during aestivation through evaporative cooling for up to air temperatures of 41°C. During the hot dry season experienced in Beung Kiat Ngong, both species of snails will be able to avoid the higher and potentially lethal maximum temperatures projected with climate change, through aestivation. During the wet season, the temperatures are lower and there is plenty of water, so the high temperatures are not expected to stress the snails.

Breeding for both snails tends to be seasonal, depending upon latitude, temperature and rainfall. Under the tropical conditions of the Beung Kiat Ngong wetlands the rainfall is likely to determine reproduction, with breeding and oviposition occurring from the start of the rainy season. Cowie (2006) has suggested that in the tropical regions of Southeast Asia, release from the seasonality of its natural range (based upon temperature) may be one of the reasons why *P. canaliculata* is so prolific. Rapid growth and breeding and hence a rapid succession of generations are permitted year round (or at least as far as water availability permits) leading to rapid population expansion and high population densities.

The eggs of *Pomacea* are laid on the stalks of vegetation above the water and are coloured pink or orange, whereas the eggs of *Pila* are colourless and deposited in depressions in the banks or mud made by the snails. There is a hypothesis that the brightly coloured eggs of *Pomacea* are a warning to predators that they are distasteful compared to the eggs of *Pila*. Eggs of both species will hatch within two weeks and the newly hatched snails fall or crawl into the water. The temperature threshold for normal maturation of snail eggs may be between 35 – 37°C. Above this temperature, the eggs may not develop normally.

The populations of these snails depend upon a number of factors, especially the availability of food and suitable habitat area, and the duration and intensity of the dry season. The increased rainfall and increased inundation area of the wetland will favour the rapid population growth and spread of the snails, as will flooding when it occurs. However, *P. canaliculata* is known to be a particularly voracious eater in comparison to other snail species, and though it has its food preferences, e.g. rice plants, it is a generalist. Competition for food sources between the two species is likely to be a factor determining the population sizes.

The CAM analysis for *P. canaliculata* in the Mekong delta supported the hypothesis that climate change would enhance the invasiveness of the Golden Apple snail. However, in comparison to *P. pilota,* both would appear to be well adapted to cope with a hotter and drier dry season, and both would be able to take advantage of the increased rains and larger wetland area in the rainy season. From the above comparisons it may well be that it is the habitat requirement for permanent wetland areas that determines the populations of *Pila* and hence the reduction in the dry season size of the wetted area of Beung Kiat Ngong may be limiting. On the other hand, it may be that the higher reproductive capacity and voraciousness of the feeding habits of *Pomacea* drive its invasiveness, rather than climate change.

7.3.4 Frogs

No information on the species of frogs that are found in Beung Kiat Ngong is available. However, a vulnerability assessment of two commonly caught species of frog in Xe Champhone wetlands was carried out as part of the MRC study on impacts of climate change on Mekong wetlands: *Rana lateralis* (Kiat leuang) and *Hoplobatracus rugulosus* (Kop). The CAM matrix for these two species is included in Annex 1(ICEM, 2012).

In Xe Champhone, both species of frog were considered to have moderate vulnerability, increasing to high when the market and collection pressure for frogs was considered. For *Hoplobatrachus rugulosus,* the exposure as a result of lower rainfall (in the dry season) was considered to lead to fewer suitable habitats (pools and ponds) and that there was potential for breeding failure if dry periods in the early wet season lead to the drying out of ponds after spawning has occurred.

R. lateralis has a more restricted habitat in the forested areas in the south of Xe Champhone, and a combination of drier conditions in the forests leading to lower soil moisture content, and loss of habitat due to conversion could affect the suitability of these habitats for the frogs. As with the other species of frog, the collective pressure would be compounded by increased climate vulnerability.

In Beung Kiat Ngong, climate projections indicate that the monsoon will start more predictably in May, but there is no analysis for the frequency dry periods in the early wet season when seasonal pools may dry out. The frogs are opportunistic spawners, responding to rainfall and availability of suitable pools of water. It is considered that the wetland area of Beung Kiat Ngong is more uniformly inundated with water than in Xe Champhone, and the pressure from suitable habitats becoming fewer, or from areas drying out in the early wet season, is lower.

7.3.5 Turtles

The Malayan snail-eating turtle is found in slow-moving bodies of water with muddy bottoms and lots of vegetation such as marshes, swamps, rice paddies and irrigation canals. It helps to control populations of snails, which form almost its entire diet, although it also consumes earthworms, aquatic insects, crustaceans and small fish. It is preyed upon by monitors, and the young can be taken by large fish, snakes, wading birds and crows.

The Malayan snail-eating turtle nests during the dry season, laying a clutch of four to six white, elongated eggs. After being incubated at 28 to 30°C for around 167 days, the young turtles hatch. Timing is thus critical so that the young hatch at the same time as the rains start in June and July, taking advantage of the availability of food and enlargement of the inundated habitat. Like other turtles, this species takes a long time to reach maturity; males mature after about three years while females are sexually mature at about five years.

The Yellow-headed temple turtle is a larger turtle that can grow to 60 cm across. It is herbivorous feeding on vegetation found growing in its aquatic habitat, as well as land plants that overhang the water and fallen fruits. Mating usually takes place between the months of December and January, after which female excavates a nest into which a clutch of around four elongated, hard-shelled eggs are laid.

Turtle nests are vulnerable to egg collectors with dogs, and also have a variety of natural predators such as mongoose and rats, as well as birds such as coucals and crows. Fire is sometimes used for hunting turtles in the dry season.

Turtles, in common with other reptile species, experience Environmental Sex Determination (ESD) such that the temperature of incubation of the eggs determines the sex of the hatchlings. Males tend to be selected when the incubation temperatures lie between 28 and 30°C, whilst females develop above and below this temperature range. The position of the egg in the nest, and the depth of the nest below the soil surface affects the incubation temperature. One of the serious climate change threats that has been identified for turtles is that with increasing temperatures, the proportion of males in the population will decrease, potentially completely (Loudon, 2012). The pivotal or “switch-over” temperature can be as little as 1°C, so that small increases in incubation temperature can completely change the sex ratio of a clutch.

Turtles are ectothermic animals with body temperatures dependent upon environmental conditions. This means that all their behaviour, growth and metabolism are dependent upon air and water temperatures. During the hot dry season, many turtles will spend much of their time at the bottom of pools, where it is cooler, to avoid the heat. However, it may be that high temperatures during the early development of the young turtles also lead to behavioural change. Researchers in Queensland, Australia have found that eggs of the Mary river turtle which are incubated at higher temperatures tend to produce hatchlings that showed reduced swimming ability and a preference for shallower waters. This means that the survival chances of turtles incubated at higher temperatures may be reduced, since deeper water, where their food supply is found, provides the young turtles with protection from predators. Young turtles with poor swimming abilities and which linger near the surface are unable to feed and are very likely to get preyed on by birds(Society for Experimental Biology, 2011).

The female turtles may show some adaptive capacity to alter the depth of the nests depending on environmental conditions, but research with a marine turtle (*Chrysemys picta*) did not show consistent results to indicate that this was a reliable mechanism for adaptation to climate change. The research found no effect of nest depth on six parameters of incubation regime, nor on resultant offspring survival, size or sex ratio. However, deeper nests produced hatchlings that weighed less, and were faster at righting themselves and swimming, than hatchlings from shallower nests(Refsnider, 2013).

A CAM matrix assessment was carried out for both turtle species included in Annex X, of which the summary is shown below. The major climate change threat to turtles is increased temperature, especially during the period of nesting and incubation of the eggs which takes place during the dry season, when temperatures are highest. Increased temperatures can affect the sex of the hatchlings and skew the sex ratios of populations, with greater numbers of females being produced at higher temperatures. There is little adaptive capacity available for turtles to adjust to this. Also increased temperatures at incubation have been shown to affect the behaviour of turtles which exhibit slower swimming speeds and a tendency to swim closer to the surface.

Lower rainfall and higher evapotranspiration in the dry season, which are likely to cause shrinkage of wetland habitats with smaller wetted areas and shallower pools make the turtles easier to catch (i.e. they are more vulnerable at this time). When the rains come and expand the wetted area again, the turtles are likely to benefit from the expanded area and higher availability of food sources. Increased intensity and frequency of storms and flooding should not have any effect on turtle populations.

Table 7.4: CAM vulnerability assessment matrix for both species of turtle found in Beung Kiat Ngong

Threat	Exposure	Sensitivity	Impact Level	Adaptive capacity	Vulnerability
Increase n temperature especially at the end of dry season	H	VH	VH	L	VH
Irregular distribution of rainfall during dry season, including drought	H	H	H	M	H
Increase in rainfall during wet season	H	L	M	H	M
Change and shift in events					
Increased frequency and intensity of storms	M	VL	L	H	L
Increased risk of flooding	L	VL	L	VH	L

A vulnerability assessment of the terrestrial tortoise, *Indotestudo elongata,* had been carried out in Xe Champhone wetland as part of the MRC's wetland and climate change study. The study indicates that the species in general shows high vulnerability to climate change especially because increased floods may further restrict the species in the wetlands and its natural habitats in the dry forest areas are already under threat. A similar analysis would apply to Beung Kiat Ngong (ICEM, 2012).

8 Vulnerability of livelihood activities

8.1 Rain-fed rice production

The main agricultural activity surrounding the Beung Kiat Ngong wetlands is the cultivation of rain-fed rice in paddy fields. In the eight core villages there are reported to be 1,387 ha of rain-fed rice and 50 ha of irrigated rice. In the past the farmers planted three varieties of rice with different maturation periods:

1. Short maturation period (90–100 days), in the uplands,
2. Medium maturation period (120–130 days), and
3. Long maturation period (140–160 days).

The 90 day varieties are planted early in the wet season in order to provide quicker replenishment of rice stores which become depleted by the end of the dry season, overcoming the rice deficit common at this time of year. The later maturing varieties are planted to be harvestable later in the season, and are likely to be more commercial varieties so surplus may be sold. Nowadays villagers mainly use hybrid varieties with a medium maturation period 120–130 days.

The average yields of rain-fed rice are about 2.5–2.8 tonnes per hectare. In the past, villagers used to harvest 3–3.5 tonnes per hectare, but now they get less, possibly because they sell a lot of cattle dung and do not use many fertilizers or pesticides. When they do use fertilizer, it is generally only nitrogen (46-00-00, NPK) and applied 10 days after they sow the seed and again 20–25 days after transplanting.

The table below shows the seasonal calendar for rice:

Table 8.1: Seasonal calendar for rain-fed rice cultivation around Beung Kiat Ngong

Main Activity	Jan	Feb	Mar	Apr	May				June				July				August				September				October				November				December				Remark
					W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	
Land Preparation							X	X	X	X																											20-30 Days
To sow rice seed											X	X	X																								20 Days
Rice Transplanting														X	X	X	X	X																			30-35 Days
Rice Caring																			X	X	X	X	X	X	X	X	X										50-55 Days
Blossom																												X	X								15 Days
Mature																														X	X	X					20 Days
Harvest and Store																																	X	X	X	X	30 Days
Rice field fallow																																					
Rice Maturation Period																																					

The critical period when water is required is in the early wet season, between May to July, when the land is being prepared, the seed is being sown and the rice is being transplanted. Variations in the onset of the monsoon may delay rice planting, and periods without rain of longer than about 10 days in June to August may cause damage to the rice crop through water shortage. The occurrence of floods and storm events in September and October may also damage the maturing rice, and prolonged flood may cause complete loss of the crop.

The Mekong ARCC study on the climate change vulnerability of agricultural crops in different provinces included a CAM assessment of lowland rain-fed rice in Champasak province(ICEM, 2013). This is shown in Annex. The assessment notes that farming systems for both small holder and commercial plantations will face radical changes in terms of climate suitability in their production systems. **The livelihoods of smallholders working principally with rain-fed farming systems will be highly vulnerable to climate change**, and farmers will have to cope with increased incidences of extreme climatic events.

Irrigated rice is cultivated by about 20% of the farmers in the province and will face a critical period of high temperatures towards the end of the dry season. Only 50 ha out of the 1,387 ha of paddy around Beung Kiat Ngong is irrigated. Lowland rain-fed rice will also face increased temperatures especially at the beginning of the rainy season, when the rice seedlings are developing. The daily maximum temperature during the rainy season is above optimal for rice. The crop yield model for rain-fed rice indicates a decrease of 5.6%in annual yield. This means that in the future the crop yield will range from 2.36 – 2.64 tonnes/ha. Extreme events, especially storms and flooding, will also increase in frequency and intensity and these can completely damage and destroy the crop before harvest.

The communities have reported an increase in the incidence of Golden Apple snails which is the main rice pest, although from the analysis above this invasion does not appear to be driven by climate change. They do not report incidence of rice borers, though the black-headed rice borer is known to live in the sedges. It is known that the egg hatching period for *Chilo polychrysus* decreases when temperature rises between 30and 35°C. The optimum temperature for hatching lies between 23 and33°C. Above this temperature the larvae dies within the eggs. They also require 90–100% relative humidity (RH), and below 70% RH hatching is impaired. The rate of larval development depends on the temperature, increasing between 17 and 35°C. Between 29 and 35°C they only require four instars for full development compared to five or six at lower temperatures. This means that the rice borers may develop more rapidly and become more of a problem with increased temperatures, up to a threshold of about 35°C(Pathak, 1994).

8.2 Irrigated rice production

There are 50 ha of irrigated rice around Beung Kiat Ngong. This is used as a second crop and the rice is planted immediately after the harvest of the rain-fed crop.

In Phapho and Phakha, where there are 10 ha of irrigated rice each, villagers collect water during the wet season from a stream in a small dam. They pump the water to their field using a hand tractor. In Phalai where 30 ha of land are irrigated, they impound the water in a medium-sized dam in Houay Ta Uang and they use bigger pumping systems through a canal to the rice fields.

The dry season rice cultivation calendar is as follows:

Table. 8.2: Seasonal character for irrigated rice cultivation around Beung Kiat Ngong

Main Activity	Jan				Feb				March				April				May		June	July	Aug	Sep	Oct	Nov		Dec				Remark
	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4	W1	W2						W3	W4	W1	W2	W3	W4	
Land Preparation																										X	X			15 Days
To sow rice seed																											X	X	X	20-22 Days
Rice Transplanting	X	X	X	X																										25-30 Days
Rice Caring					X	X	X	X	X	X	X																			45-50 Days
Blossom												X	x																	15 Days
Mature														X	X															15 Days
Havest and Store																X	X													15-20 Days
Rice Maturation Period																														

The main vulnerability issue here for irrigated rice is the significant increase in temperatures during the dry season, at times over the critical thresholds for maximum temperatures for rice. Coupled with requirements for water up until the end of March, and the overall reduction in water availability during the dry season, this would make **irrigated rice highly vulnerable**, with expected decreases in yield as climate change progresses.

8.3 Fishing

There are two main methods of catching fish in the wetlands of Beung Kiat Ngong, depending on the season. In the wet season, the fishermen use fish hooks and fish nets (cast and gill nets) in the extended inundated areas of the wetland. In the dry season, especially towards the end when all the fish are concentrated in the pools and remaining open water ponds, fishermen use pumps or buckets to empty these pools and open bodies of water, lowering the water levels so that they can catch all the fish in that pool. A small pool may yield 3-5 kg of fish, but a larger pond may yield 50 kg or more.

Eels tend to be caught at the beginning of the rainy season when they are emerging from their holes, and in the late wet season when they are beginning to burrow into the mud.

The vulnerability analysis of the different fish species in Beung Kiat Ngong indicates that most of the main fish species, especially black fish (e.g. snakeheads) show a fairly low vulnerability to climate change. They may even benefit from the higher rainfall and increased extent of inundation in the wet season.

The white fish coming in from the larger rivers for spawning and nursery grounds in the wetlands will also benefit from the greater size of the inundated area. Since they will return to the main rivers at the end of the dry season, they will not experience the lower water availability in the dry season, though they may be exposed to other climate change stresses and other threats in the main river. These have not been considered here.

The main impact of climate change on the fishing activities in Beung Kiat Ngong has less to do with the stresses imposed by the changing climate on the fish themselves, and more to do with the increased accessibility and concentration of the black fish in ponds and pools at the end of the dry season, making them easier to catch. This will tend to reduce the overall population size, and eventually, after seasons of increased catch in the dry season, will lead to reduced overall catch.

Thus whilst **the fish themselves show low vulnerability to climate change, subsistence fishing livelihood may have an increased medium vulnerability** as a result of increased fishing pressure in the dry season. Adaptation responses may therefore consider strengthening local fish conservation rules for fishing during the dry season.

8.4 Drinking water

Generally drinking water availability from dug or tube wells has not yet been a problem in Beung Kiat Ngong. However, during the dry season, the availability of drinking water may become an issue in many of the villages as the groundwater table sinks. In Phalai this has not been a problem, but in most of the other villages, e.g. in Kiat Ngong, the ground water level is reported to be seven m below the surface in April. They also report that in some dry years they may have to wait overnight for the wells to recharge.

Another issue has been the quality of the ground water from tube wells in Kiat Ngong, where a number of the tube wells that were sunk in the last few years were discovered to have levels of arsenic that are too high for human consumption. Water is now only drunk from those wells where the arsenic levels are safe.

With climate change, with drier and hotter dry seasons, it is likely that drinking water availability at the end of the dry season (April and May) will become increasingly problematic. This is likely to be compounded by increasing populations in these communities and increased cattle numbers**. It is considered that these communities are highly vulnerable to the impacts of drier and hotter dry seasons, particularly in terms of drinking water availability.**

8.5 Livestock

Smallholder livestock production with cattle and buffalo is an important local livelihood. There appears to be a trend of increasing cattle numbers corresponding to decreasing buffalo herds. The elephant population has experienced a rapid fall in numbers, and the only remaining substantial herd is in Kiat Ngong. The number of grazing units has been estimated at 4,228, made up of 991 for buffalo, 2,661 for cattle and 13 for elephants.

The seasonal pattern of livestock activities revolves around rice cultivation. During the dry season buffalo and cattle are allowed to roam loose around the wetland and forest area between December and May, i.e. after the rice harvest up until planting of the next crop. During the wet season through to harvest, livestock are kept in compounds or tethered to keep them from the rice fields.

There are two main husbandry issues for cattle and buffalo. In the dry season when they roam free there is often not enough vegetation for them to eat, especially at the end of the dry season, and water availability is clearly an issue at this time. Also after flooding events there may not be adequate food available, because the grass and shrubs may have died. Fodder planting or collection for the livestock is not normally practiced in the communities. Poor nutrition tend to make the animals more susceptible to diseases such as foot and mouth disease (FMD).For example, there was an outbreak of FMD in Phapho and Kele in February and March 2009. Other threats include storms and lightning, which are reported to have killed cattle and buffalo in Phommaleu, Kele and Phakha.

The Mekong ARCC studies on climate change impacts on livestock (ICEM, 2013) notes that generally, cattle and buffalo are relatively thermotolerant and are capable of adapting to longer term temperature changes through regulating their body temperatures, through evaporative heat loss. The *Bos indicus* breeds are generally more tolerant, and are comfortable up to 38°C, but require adequate water supply and shade.

The study considered Khammouane as a “hotspot” province in Lao PDR and noted that while stocking densities are quite high with 4,228 grazing units in 14 km^2 of agricultural land (i.e. about 400 grazing units/km^2),this does not include the large expanse of wetland which is also used by the livestock. The study notes that small holder cattle/buffalo systems are most vulnerable to increasing temperatures, and the very high temperatures expected in the dry season coupled with the lack of suitable fodder will reduce growth rate, reproductive performance and increase susceptibility to disease. It also recognizes the shortage of fodder as a result of floods. **Overall, small holder livestock production is considered to be highly vulnerable to climate change, with particular stress during the dry season.**

8.6 Malva nuts (*Mak chong)*

Malva nuts are one of the most valuable NTFPs available to the communities living around Beung Kiat Ngong. Although the tree is a forest species and not a wetland species, its importance for local livelihoods is such that a vulnerability assessment has been carried out on the species.

Scaphium macropodum is a large straight tree up to 45 m tall with diameter at breast height (DBH) around 80 cm. Its leaves vary in shape and size according to age. It flowers in January and early February and fruits form in March to May. The fruits are brown and surrounded by a membranous wing up to 20 cm long and split open when it reaches the ground.

The tree has a very restricted distribution in small pockets of low evergreen forest in southern Laos, growing mainly on rocks and shallow soils. It does not survive well outside of the forest and effective cultivation in plantations is not easy.

It is a strongly *masting* species, which means that every three to four years it will produce an abundance of flowers and fruits. The mast years have a much greater production of seed than other years. Villagers report that there may be some connection between rainfall in January which keeps the flowers fresh for increased pollination, and honey bees are recognized as being important for pollination. Climate and rainfall patterns are said to determine the volume and quality of the fruits(Pinto, 2003).

In the FAO database on agroforestry crops, the ecology of a similar species, *Sterculia foetida*, indicates that it can survive in a wide temperature range from 16 to 36°C, with optimal temperatures between 18 and 32°C. The preferred rainfall range is between 900–2000 mm per year. It prefers well drained, heavy to medium heavy soils, with a preferred pH between 6 and 7.5.

The CAM matrix for Malva nuts is found in the Annex. The analysis shows that the species is highly vulnerable to increases in temperature, especially in the flowering season(January and February) when maximum temperatures will rise from 30–33°C to 32–35°C. Increased temperature may affect the flowering in several ways, e.g. through inhibiting the formation of the flowers and through reducing populations of honey bees known to be important for pollination. The impact will be felt in terms of reduced fruit production and perhaps reduced frequency of mast years dependent upon favourable climatic conditions.

Local people also maintain that fruiting is dependent upon having some rainfall during the flowering period. Climate change projections indicate that there is likely to be less rainfall in January and February, which could further reduce the size of the harvest and the frequency of masting years.

The projected increase in temperature towards the end of the dry season when the fruit sets and the nuts are harvested(with maximum daily temperatures rising from 34–36°C to 36–38°C), may adversely affect fruit setting and fall.

The increases in rainfall during the wet season, along with the projected increases in storms and flooding, are less likely to be of significance to Malva nuts since the trees are likely to be protected from storms in the forest and are above the level of the probable floods.

The summary matrix for *Scaphium macropodum*is shown below:

Table 8.3: Summary vulnerability assessment for *Scaphium macropodum,* Malva nuts, Mak chong

Threat	Exposure	Sensitivity	Impact Level	Adaptive capacity	Vulnerability
Increase in temperature in January/February (*Mak Chong* flowering)	H	H	H	L	H
Irregular distribution of rainfall during dry season	H	H	H	L	H
Increase in temperature especially at end of dry season (during fruiting, harvest)	H	H	H	L	H
Increase in rainfall during wet season	H	L	M	H	M
Increase jn frequency and intensity of storms	L	L	L	H	L
Increased risk of flooding	VL	VL	VL	H	L

9 Conclusions

9.1 Summary vulnerabilities of the different components of Beung Kiat Ngong wetlands

The following table (Table 9.1) summarizes the vulnerability assessments of the different components of the wetland ecosystem of Beung Kiat Ngong and the dependent livelihood activities of the eight core villages surrounding the wetlands. It is clear that whilst the overall wetlands and ecosystem component species have relatively moderate or even low vulnerability to climate change, the livelihood components on which the people depend appear to be much more vulnerable, apart perhaps from the fisheries livelihoods.

Table 9.1: Main climate change threats, impacts and overall vulnerabilities of the Beung Kiat Ngong wetlands

Wetland components	Main climate threats	Vulnerability
Overall wetland habitats of Beung Kiat Ngong	Increase in temperature and reduced rainfall during dry season, leading to the contraction of the wetted area, but to some extent compensated for by increased rainfall and inundation in wet season. Peatland, if it dries out during dry season, may release acid sulphate soils. Climate change may lead to some minor redistribution of habitats within wetland area.	M
Sedges	Resilient plant species, with vegetative reproduction, that can easily adjust to increased dryness during the dry season and inundation during the wet season	L
Sesbania sesban	Wide range of tolerance to heat, inundation and drought. Additional pressure from harvest if other wetland plants are stressed due to climate change.	L
Mimosa pigra	Very tolerant invasive species, observed on the edges of the wetland. Climate change is likely to increase its invasiveness over other shrub species.	L
Barringtonia acutangula	Flooded forest tree very resilient to prolonged flooding, growing at the edges of deeper parts of the wetland. Able to withstand periods of increased temperatures and drought. Increased temperatures may inhibit flowering and fruiting during wet season.	M
Black fish	Resilient to poor water quality and increased temperatures. Will benefit from increased inundated area due to spread of fish population and access to food sources.	L
White fish	During the wet season when they are in the wetlands, they will benefit from the larger flooded area and access to breeding sites and food sources. Their higher vulnerability results from their sensitivity to poor water quality and temperature, as well as unknown stresses in the main river during the dry	M

	season.	
Eels	As with black fish, eels are highly resilient and can move overland to avoid adverse conditions. They can survive drought by burying themselves in the mud, and growing strongly when conditions improve. They will benefit from the expanded inundated area during the wet season.	L
Snails	Both native and Golden Apple snails are tolerant to higher temperatures, and can aestivate in the mud or bottom of pools during the dry season. They will be able to take advantage of the increased distribution of eggs and hatchlings during the wet season. It is unlikely that the competitiveness of the Golden Apple snail will be increased by climate change.	L
Frogs	Lower rainfall in the dry season, the contraction of suitable habitats and the heightened risk of being hunted during the dry season, will increase pressure on the frog species.	M
Turtles	High temperatures during the breeding season may skew gender balance in turtle populations, as only females will be hatched. Irregular rainfall in the dry season and shrinkage of wetted areas will increase access and hunting pressure.	VH
Livelihood activities		
Rain-fed rice	Increased temperatures will reduce yield of rain-fed rice. Floods and storms before harvest may destroy the crops. There may be an increased threat from pests such as Golden Apple snails and rice borers.	H
Irrigated rice	Increased temperatures will reduce the yield of irrigated rice. Water availability in mid-dry season may be problematic.	H
Fishing	Black fish (throughout the year) and white fish (during wet season) show low vulnerability to climate change and may benefit from floods. But the shrinkage of pools and ponds during dry season may increase access and fishing pressure on black fish.	L
Drinking water	Increased temperature and drier dry seasons will reduce availability of drinking water by the end of dry season. Increased human and cattle populations will add further pressure on dry season drinking water availability.	H
Livestock	Increased temperatures and lack of suitable fodder during the dry season will decrease productivity and reproductive health of livestock, and may increase their susceptibility to disease. Fodder availability after flood events may also be a problem.	H

Malva nuts	The flowering of Malva nut trees are likely to be affected by high temperatures and lower rainfall in January and February. Increase in temperature at the end of dry season may affect fruiting. Climate change effects on pollinating bees may also be a problem.	H

9.2 Overall vulnerability combined with non-climate threats

The non-climate threats to the sustainability of Beung Kiat Ngong listed in section 4.5 have been listed in Table 9.2 and the linkages with the impacts of climate change have been considered. These are also shown in Table 9.2. In general, the non-climate threats of overharvesting of natural resources, encroachment of agricultural land and tree cutting would appear to be far more pressing and damaging to the integrity of the wetlands than climate change by itself. The invasion by alien species such as the Golden Apple snail and *Mimosa pigra* are also causing significant changes. However the stresses of climate change on the habitats and their component vegetation may compound the human-induced pressure on the wetlands. The other most significant pressures that are compounded by climate change are indicated in colour.

In Beung Kiat Ngong, in comparison to Xe Champhone for example, there is less pressure on the wetlands through abstraction of water for dry season irrigation, so the pressure of reduced water availability for the wetlands in the dry season is not a problem as yet. However, with climate change, adaptive responses in agricultural practices may also make this aspect more significant.

Table 9.2: Climate change linkage of non-climate threats to the wetlands and wetland resources in Beung Kiat Ngong

Non-climate change threats to wetlands	Trends and pressures	Implications with climate change
Peat extraction for fertilizer	Now largely stopped, peat extraction changes the character of Beung Kiat Ngong from one form of wetland (swamp or bog) to another (open water ponds).	Peat formation is recognized as a carbon sink. Its removal releases carbon dioxide back into circulation, adding to greenhouse gases that cause climate change.
Unsustainable harvest of aquatic resources such as fish and wildlife, and of NTFPs such as Malva nuts	Increases the pressure on the wetland resources, reducing the biodiversity and viability of populations, making the wetlands as a whole less resilient	A less resilient wetland will not function as effectively in its ecosystem services, including carbon sequestration. Stresses from climate change will be compounded by those from unsustainable use.
Changes in numbers of cattle and buffalo	It appears that there is an increase in cattle and decrease in buffalo numbers. Cattle tend to feed around the edges of the wetland rather than inside the floating grasslands. Pressure will be put on the edge vegetation, and the ecological contributions of large herbivores in the grasslands will be reduced.	The edges of the wetland area will experience the most climate change stress, drying out more quickly and with potential for higher floods. The vegetation at the habitat edges is where changes will be observed, and the cattle grazing pressure will be highest at the edges of the Beung Kiat Ngong, so there may be a

Non-climate change threats to wetlands	Trends and pressures	Implications with climate change
		synergistic effect. Lack of grazing pressure within the wet grasslands may change species composition and increase the risk of fire in dry season.
Agricultural practices	More intensive use of fertilizers and agricultural chemicals, leading to build–up of contaminants.	Potential chemical stress on some species may be worsened by climate stress.
Tree-cutting	General trend will reduce the structure of flooded forest habitat.	Increases storm pressure on remaining trees.
Illegal encroachment of forest and wetland areas	Encroachment for agriculture on wetland areas.	With climate change, more land may be exposed during the dry season and become suitable for agriculture, leading to further increases in trend.
Fire	Fire in grassland and shrubland during the dry season, often started on purpose e.g. for hunting, is a natural process and may be beneficial for the wetland ecosystem, but not if fire coverage is comprehensive.	Increasing temperatures and evapotranspiration in the dry season will tend to dry out the grassland vegetation to a greater extent, increasing the risk of fire. Climate change may make fire more of a threat to the ecosystem rather than assomething beneficial.
Escapes of invasive and non-native fish species, such as Tilapia from aquaculture ponds	Tilapia is already found in the Beung Kiat Ngong ecosystem, so further escapes are unlikely to make this problem worse.	Tilapia is probably marginally more vulnerable than the black fish species to the stresses of climate change, so climate change is unlikely to make this threat worse.
Invasion by alien species	Two invasives are currently becoming a problem: Golden Apple Snail and *Mimosa pigra*. The snail is already beginning to supplant the native *Pila* species. *Mimosa pigra* has been observed on the edges of the wetland.	Golden Apple snail and *Pila* are probably as resilient as each other to climate change, but the Golden Apple snail is more aggressive and, despite predation by Open Bill storks, is spreading widely. It may be spread even more due toincreased floods. *Mimosa pigra*shows low vulnerability to climate change and is likely to take advantage of floods to spread rapidly over the next few years into the Beung Kiat Ngong wetlands, taking over shrubland habitats.
Inadequate human and financial resources to implement regulations and management plans		Climate change funding may contribute towards better and more resilient management for the wetlands.
Inadequate assessment of the social and	Tourism makes a recognized livelihood contribution, especially	Climate change may cause long term changes and variations in

Non-climate change threats to wetlands	Trends and pressures	Implications with climate change
environmental impacts of tourism on wetland areas and communities	in Kiat Ngong. Degradation of the wetland and ongoing loss of biodiversity will reduce its attraction for tourists.	the habitat and vegetation, but this will not be as significant as other pressures.
Upgrading of existing roads and infrastructure	Existing infrastructure in Beung Kiat Ngong consists of dirt roads around the wetland, which are in poor state in the wet season. Culverts and bridges are small. There is no major irrigation scheme.	Any road upgrading should ensure adequate cross drainage and correct sizing of bridges and culverts to ensure adequate passage of flash floods, which will get worse under climate change.
Construction of hydropower projects in the catchments	There are hydropower projects planned and under construction on the Xe Pian river and on the Sekong, but not in the immediate catchment of the Beung Kiat Ngong.	This is unlikely to have a compounding effect along with climate change, on Beung Kiat Ngong.

Key: Orange = highly significant pressure, Yellow = significant pressure

9.3 Adaptation planning and development of a management plan

Looking ahead to adaptation planning, the main conclusion from this assessment is that the wetland ecosystem is less vulnerable than its livelihood components, but that climate change brings an additional stress to the overall wetland ecosystem.

There are already indications that the wetland is experiencing stress due to non-climate change factors such as unsustainable harvesting of natural resources, encroachment by agriculture and invasion by alien species. The indications that the wetland ecosystem is stressed is evident from the report by Timmins and Duckworth (2014) which shows the dramatic decline in bird species compared to previous surveys, and the increase in invasives.

At present there does not appear to be much stress in terms of abstraction of water for dry season irrigation, so the availability of water during both wet and dry seasons does not yet appear to be problematic. If this were the case then the vulnerability of the overall habitat would be higher and would require water allocation management. This is perhaps in contrast to the wetlands at Xe Champhone where water for dry season irrigation is more important.

The wetlands at Beung Kiat Ngong appear to be dynamically resilient to the main pressures of higher temperatures and reduced rainfall during the dry season, counterbalanced by more rainfall and inundation during the wet season. The resilience of the wetlands will undoubtedly be increased by better management measures on the natural resources, especially on very vulnerable species such as turtles; ensuring more sustainable off-take of the natural resources; restrictions on encroachment and tree felling; and measures to counter the invasion of Golden Apple snail and *Mimosa pigra.*

It is perhaps the livelihood components that require greater attention from a purely climate change perspective, because with stronger and more resilient rice production, livestock farming and drinking water supply, there will be less dependence upon the wetland's natural resources, which would be used to compensate for production losses in the other subsistence sectors. The comparison between the natural ecosystem and its resources, with agriculture and livestock systems is interesting because natural systems appear to be generally less vulnerable than the livelihood systems. However certain components of natural systems on which people depend(e.g. turtles and Malva nuts) are amongst the most vulnerable, and these may require special adaptation measures.

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11 Annexes of all the CAM matrices

Overall vulnerability assessment for the wetlands as a whole

System – Beung Kiat Ngong

1. **Overall wetland system-**
2. **Includes – open water pools, floating grass mats, islands, peatland, flooded forest, rice fields**

Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
Change and shift in regular climate	*written description of how the threat relates to the asset*	*refer to table*			*Written explanation of what the impact is, and why it was scored (high, med, low)*	*refer to table*	
Increase of temperature especially at end of dry season	• Increase in temperature of up to 3°C increases evapotranspiration and decreases availability of water in the wetland in the dry season	H[6]	H[7]	H	• Shrinkage of wetted grasslands and peatlands in the dry season • Wetted area will tend to shrink in dry season • Increase in fire risk in grassland, leading to less forests • Increase in temperature in the open water ponds, may decrease the oxygen content of the ponds and may lead to fish kills	H[8]	M
Irregular distribution of rainfall in dry season	• In January, Feb, March and April, there is less rainfall (-6%) • Increased evapotranspiration • Rainfall in late dry season	H[9]	H[10]	H	• If there is less rain in January – April, the effects of increased evapotranspiration and shrinkage of the wetted will area will increase • Shallower and edges of the wetland will tend to dry out faster	H[11]	M

[6] The system is a mosaic of open water, grasslands and flooded forest with mixed exposure to high temperatures, some shading.
[7] Peat land area is unique in Laos, if it dries out it will be lost. Large wetlands in Laos are also rare.
[8] The mosaic of the wetland allows for flexibility in adapting to changes each year, grassland especially is able to reestablish itself. But note that peatland may have less adaptive capacity, especially if it dries out for too long.
[9] The rainfall in dry season does not do much to affect the extent of the wetland, but the lower rainfall in January to April, and higher temperatures increase the evapotranspiration.
[10] The shallower parts of the wetland and edges will be sensitive changes in evapotranspiration and falling soil moisture content.
[11] Wetland ecosystem cannot do very much to adapt to reduction in dry season rainfall, but shows strong resilience when the rains come and the wetlands are wetted again.

	increases by about 11% in May						
Increase in rainfall in wet season	• 10% increase overall in wet season from May to October	VH[12]	L[13]	H	• Flooded area will increase in size, more open water • Some areas will become deeper – if grassland area, it may be the grassland will not survive • Large trees will survive, in the long term young trees will not grow in the deeper area • Some shift in the distribution of different habitats, but not a major shift	H[14][15]	M
Change and shift in events							
Increased frequency and intensity of storms	▪ One more heavy rainfall event per year ▪ Intensity of heaviest storm increases from 120 to 144mm	H[16]	L[17]	M	• Storm events will only have temporary effect upon the wetland • Some damage to trees	H[18]	M
Increased risk of flooding	• During August the maximum monthly rainfall is likely to increase from 398 to 425 mm • Wet season volume of water will generally be higher and during a high rainfall year the risk of flooding will increase • Historically, flooding occurs	M[19]	L[20]	M	• There maybe some damage to vegetation on higher ground and islands around the wetland	H[21]	M

[12]Wetland area is fully exposed to increases in rainfall in wet season.
[13]Wetland ecosystem will benefit from more water.
[14]Wetland ecosystems can adapt well to increases in wet season rainfall, with shifts in distribution of vegetation and habitats.
[15]The water levels in Beung Kiat Ngong are to some extent regulated by the topography, and back flows from the Xe Kampho.
[16]Exposure of wetland to storm cannot be avoided, but increase in storms is not very great.
[17]Wetland ecosystems are not very sensitive to damage from storm events.
[18]Wetland ecosystem is naturally resilient to storms, and will recover quickly.
[19]Increased frequency of flooding will happen only slightly.
[20]Wetland ecosystem is not very sensitive to short flooding events (less than two weeks).
[21]Good resilience and recovery from flood damage

	once in 10 years; this may increase in frequency slightly • Flooding may also result from back flows from the Xe Kampho river						

System – Beung Kiat Ngong

Barringtonia acutangula

It can establish itself in areas with only brief exposure to drying, or where current is strong. It is commonly found in lower areas of the channel with brief exposure and rocky substrate. Flowering and fruiting occurs throughout the year. It responds to drought and increased temperature by shedding leaves to reduce evapotranspiration. When underwater, leaves are retained and photosynthesis continues.

Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
Change and shift in regular climate	*written description of how the threat relates to the asset*	*refer to table*			*Written explanation of what the impact is, and why it was scored (high, med, low)*	*refer to table*	
Increase of temperature especially at end of dry season	• Increase in temperature of up to 3°C increases evapotranspiration and decreases availability of water in the wetland in the dry season	M[22]	M[23]	M	• Increase in temperature and drought during dry season may increase leaf fall as response • Growth during dry season may be reduced further	H[24]	M

[22]Within a flooded forest area, the exposure to increased temperature is moderated both by the water and the shade from other forest trees.
[23]Increases in temperature in the dry season will increase the area drying out and therefore exposed.
[24]The mosaic of the wetland allows for flexibility in adapting to changes each year, grassland especially is able to reestablish itself. But note that peatland may have less adaptive capacity, especially if it dries out for too long.

Irregular distribution of rainfall in dry season	• In January, February, March and April, there is less rainfall (-6%) • Increased evapotranspiration • Rainfall in late dry season increases by about 11% in May	M[25]	MM M[26]	M	• The areas exposed during the dry season are likely to increase allowing other species that are less tolerant to deep inundation to move in	L[27]	M
Increase of temperature during wet season	• Increase in wet season temperatures with maximum temperatures up to 35°C	M	H[28]	M	• Flowering in wet season may be inhibited by higher temperatures, leading to lower fruiting and reproduction	M	M
Increase in rainfall in wet season	• 10% increase overall during wet season from May to October	VH[29]	L[30]	H	• Flooded area will increase in size, • Some areas will become deeper; this will favour survival of Barringtonia • Large trees will survive, in the long term young trees will not set in the deeper area • Some shift in the distribution of different habitats, but not a major shift	H[31]	M
Change and shift in events							
Increased frequency and intensity of	▪ One more heavy	H[32]	L[33]	M	• Some damage to trees – loss of branches	M[34]	M

[25]The rain falling in dry season does not do much to affect the extent of the wetland, but serves to reduce the evapotranspiration.
[26]*Barringtonia* is less sensitive to dry season rainfall.
[27]*Barringtonia* is adapted to grow well in areas where other trees cannot survive and so may become marginally less competitive in those areas that dry out in the dry season .
[28]Increases in temperature in early wet season may affect flowering.
[29]Wetland area is fully exposed to increases in rainfall in wet season.
[30]Wetland ecosystem will benefit from more water.
[31]Wetland ecosystems can adapt well to increases in wet season rainfall, with shifts in distribution of vegetation and habitats.
[32]Exposure of wetland to storm cannot be avoided, but increase in storms is not very great.
[33]Wetland ecosystems are not very sensitive to damage from storm events.
[34]Wetland ecosystem is naturally resilient to storms, and will recover quickly.

storms	rainfall event per year ▪ Intensity of heaviest storm increases from 120 to 144mm				and trees falling		
Increased risk of flooding	• During August the maximum monthly rainfall likely to increase from 398 to 425 mm • Wet season volume of water will generally be higher and during a high rainfall year the risk of flood will increase • Historically, flooding occurs once in 10 years; this may increase in frequency slightly • Flooding may also result from back flows from the Xe Kampho river	M[35]	L[36]	M	• Barringtonia extremely well adapted to flooding conditions, which will favour its survival	VH[37]	L

[35]Increased frequency of flooding will happen only slightly
[36]Wetland ecosystem not very sensitive to short flood events (less than two weeks)
[37]*Barringtonia* well adapted to flooding conditions with good resilience and recovery from flood damage

System – Beung Kiat Ngong wetland habitat

1. **Malva nuts – *Mak Chong* (*Scaphium macropodum*) Sterculiaceae**

Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
Change and shift in regular climate	*written description of how the threat relates to the asset*		*refer to table*		*Written explanation of what the impact is, and why it was scored (high, med, low)*	*refer to table*	
Increase in temperature in January/February (*Mak Chong* flowering)	• Current temperature in January – February shows rise from 30 to 33°C. This will increase from 32 – 35°C. • Daily maximum temperatures would rise from 34 – 37 to 36 – 40 °C • These are on the borderline of absolute tolerance levels of similar species • Increase in temperature likely to be mitigated by presence of Mak Chong in the forest	H[38]	H[39][40]	H	• Flowering in January/February may be impaired by increases in temperatures • Increase in temperature may reduce the populations of honey bees that are an important pollinator • Impact will be felt in terms of reduced fruit production and perhaps reduced frequency of masting years dependent upon the occurrence of favourable climatic conditions (lower temperatures and January rainfall)	L[41]	H

[38]Increased temperatures modified to some extent by forest cover
[39] Temperature range of species is quite sensitive, especially for flowers(near the absolute maximum)
[40]Increased temperatures may also affect the distribution and populations of honey bees, and so reduce the pollination
[41]Flowering of Malva nut trees is quite specific, with little adaptive capacity

Irregular distribution of rainfall in dry season	• Rainfall in dry season increases by about 11% but mostly occurs in May • In January, February, March and April, there is less rainfall • In January there is about 12% less rainfall, and 11% less in February	H[42]	H[43]	H	• If dry season rainfall prolongs the life of the flower and encourages pollination, then it is likely that less rainfall will reduce pollination and fruiting process • As above	L[44]	H
Increase of temperature especially at end of dry season (fruiting and harvest)	• Increase in temperature of up to 4°C • Mean maximum temperature increases from 34 – 36°C to 36 – 38°C • Daily maximum temperatures increases from 38 to 41°C to 40 to 44°C	H	H	H	• Fruit and seed development may speed up due to increase in temperature • If very hot, the viability of the seed may be reduced • The flesh of the fruit (which is harvested) may be different in quality	L	H
Increase in rainfall in wet season	• 10% increase overall in wet season from May to October	H[45]	L[46]	M	• Increase in rainfall unlikely to have significant impact upon growth of trees	H[47]	M
Change and shift in events							
Increased frequency and intensity of storms	▪ One more heavy rainfall event per year ▪ Intensity of heaviest	L	L	L	• Mak Chong trees relatively protected from storms because they are located in forest cover	H	L

[42] There is reduced rainfall and incidence of rain in January and February, by about 10%.
[43] Local opinion indicates that there is a connection between rainfall and duration of flowering, so sensitivity is likely to be high.
[44] There is little adaptive capacity for flowers to change in the short term.
[45] Increase in rainfall will provide more water during growing period.
[46] Growth of *Mak Chong* unlikely to be really affected by rise in water availability during growing season.
[47] *Mak Chong* will take advantage of increased rainfall, provided that the soils in which the trees are growing are well-drained.

	storm increases from 120 to 144mm				• But note that Mak Chong is taller than many other trees and may be more exposed to strong winds		
Increased risk of flooding	• In August the maximum monthly rainfall is likely to increase from 640 to 680 mm • Wet season volume of water will generally be higher and during a high rainfall year the risk of flood will increase • Historically, flooding occurs once in 10 years; this may increase in frequency slightly	VL	VL	VL	• Mak Chong tends to be located in the forest above the flood level and so will not be affected	H[48]	L

[48]If the area becomes regularly flooded new seeding will be inhibited

System – Beung Kiat Ngong wetland habitat
Freshwater turtles – *Malayemys subtrijuga* and *Hieremys annandalii*

Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
Change and shift in regular climate	*written description of how the threat relates to the asset*	*refer to table*			*Written explanation of what the impact is, and why it was scored (high, med, low)*	*refer to table*	
Increase of temperature especially at end of dry season	• Increase in temperature of up to 3°C increases evapotranspiration and decreases availability of water in the wetland in the dry season • During dry season mean maximum temperatures rise • January, from 31 to 32.5°C • February, from 33 to 35.1 °C • March, from 34.5 to 36°C • April, from 34.5 to 37.6°C	H	VH[49,50]	VH	• Increased temperatures can affect the sex ratio of the hatchlings: males tend to be produced between the temperatures of 28 – 30°C. Above (and below) these temperature range, mostly females will be produced. This results in skewed sex ratio in populations. • Hatchlings coming from eggs closer to the surface (i.e. exposed to higher temperatures) have been observed to swim slower and nearer the water surface	L[51,52]	VH
Irregular distribution of rainfall during dry season, including drought	• In January, February, March and April, there is	H	H	H	• Permanently inundated areas will become smaller in extent and permanent pools will	M	H

49 Nesting for both species starts in dry season. For *M. subtrijuga*, it starts in March/April, and for *H. annandalii* it starts in December/January and incubation lasts until beginning of wet season (June/July).
50 Eggs are deposited in excavated holes in the banks which are then covered back again.
51 Only relatively few (4 – 6) eggs are laid at one time.
52 Depth of nests can influence incubation temperature, but not clear if female chooses depth depending on environmental conditions.

	less rainfall (-6%) • Increased evapotranspiration • Rainfall in late dry season increases by about 11% in May				become shallower • Both of these factors will make the turtles easier to capture		
Increase in rainfall in wet season	• 10% increase overall in wet season from May to October	H	L	M	• Rapid wetting and inundation of the wetland from the start of the wet season will increase the habitat for the turtles • Collection of turtles will be more difficult in wet season because of access(waters are deeper)	H	M
Change and shift in events							
Increased frequency and intensity of storms	▪ One more heavy rainfall event per year ▪ Intensity of heaviest storm increases from 120 to 144mm	M	VL	L	• Storms should have little impact upon turtles, which can hide under water. • Flash flows down the small streams may increase turbidity, but this is unlikely to affect the turtles	H	L
Increased risk of flooding	• In August the maximum monthly rainfall is likely to increase from 640 to 680 mm • Wet season volume of water will generally be higher and during a high rainfall year the risk of flooding will increase • Historically flooding occurs once in 10 years; this may increase infrequency slightly	L	VL	L	• Floods will expand the habitat available to turtles temporarily, and increase in availability of food	VH	L

Mimosa Pigra

Species / assemblage	IUCN status	Exposure	Sensitivity				Potential impacts	Adaptive capacity				Vulner-ability	Vul.+ other threats
			Range	**Pop. size**	**Resilience**	**Overall**		**Ecolo gical**	**Biogeo-graphic connecti-vity?**	**Adapt quickly?**	**Overall**		
Mimosa pigra Spreads throughout wetland; not harvested for human use; rapidly grows with floods and dominates other species	--	High, rapid growth for this species while other plants decrease in tough conditions	Large	Large	High. Rapidly grows with high tolerance to tough conditions.	Low. It can survive under adverse conditio ns.	Spreads out in the wet season; high tolerance for dry conditions	High	Yes	Yes	High	**Low**	**Low**

Source: (ICEM, 2012)

CAM Matrices for fish species

1. *Channa striatus*

System component or assets	Threat	Intrepretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
		written description of how the threat relates to the system component		*refer to table*		*written explanation of what the impact is, and why it was scored (high, med, low)*	*refer to table*	*refer to table*
1. Channa striatus. A BLACK FISH FOUND IN A WIDE RANGE OF WETLAND ENVIRONMENTS INCLUDING, RICEFIELDS, RESERVOIRS, CANALS.	Increase in temperature	Increase in temperature for Gai Lai will be greatest in Jul & Aug; up to 18% increase. Maximum temperatires in the dry season will peak at 40oC with 36oC as the GCM average.	high	low	medium	Projected temperatures are well within the tolerable range for this species. Air breathing fish so DO levels unimportant. Populations may become more prolific in upland areas, currently below optimum for this species	very high	**low**
	Increase in precipitation	Monthly average rainfall will increase in the period Apr-Nov by 4-13%. October is projected to show the highest increase in rainfall.	medium	low	medium	incresaed precipitation should allow easier access to the floodplains and will benefit this species. Fish is tolerant of turbid waters	very high	low
	Decrease in precipitation	Rainfall will decrease in the dry season months of Dec-Mar by between 4-10%, with Feb showing the higest percentage reduction.	medium	high	medium	Reduced rainfall during the cold season months, coupled with increased temperatures will result in the faster drying of refuge areas, allowing for increased predation and hunting.	medium	**medium**
	Decrease in water availability	Although rainfall decreases in the period Dec-Mar, these are low rainfall months and therefore the volume of water lost from the system does not appear to be hugely significant.	medium	high	medium	Reduced water levels in dry season refuge areas, allowing for increased predation and hunting.	medium	medium
	increase in water availability	Increases in rainfall during the months from Apr-Nov, is more significant and will result in higher flows in the small rivers and streams of this province. E.g Projected rainfall for Aug in a typical year, is 429 mm.	high	low	medium	Fish will benefit from increased water availability, particularly in areas with floodplains and lowland rice grwoing areas.	very high	low
	Drought	The drought situation in the valleys of this region is not expected to change significantly during the time period studied.	low	medium	medium	No significant affect expected for this species	high	medium
	Flooding	Flooding will become increasingly common and some months may have as much as 900mm of rain per month, in some years. Incresaed rainfall in throughput the period Apr-Nov. will result in waterlogged soils and faster run off of rainwater.	high	very low	medium	Fish will benefit from increased water availability, particularly in areas with floodplains and lowland rice grwoing areas.	very high	low
	Storms and Flash floods	Maximum daily rainfall will increase slightly with as much as 150mm falling on some days, and 20 days a year with in excess of 80mm of rainfall.	high	very low	medium	Flash flooding may affect survival of juveniles in exposed areas.	medium	medium
	sea level rise	n/a	-	-	-	-		
	increasing salinity	n/a	-	-	-	-		

Source: ICEM (2013) USAID Mekong ARCC Fisheries study

2. *Clarias batrachus*

System component or assets	Threat	Intrepretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
		written description of how the threat relates to the system component		*refer to table*		*written explanation of what the impact is, and why it was scored (high, med, low)*	*refer to table*	*refer to table*
3. Clarias batrachus NON MIGRATORY, BLACK FISH, IMPORTANT FOR FOOD SECURITY.	Increase in Temperature	Projected increases in temperature for MDK will extend well above this fish's preferred range, particularly in April, (39°C) GCM average). This may be more of a factor in exposed lowland areas, than in forested streams.	High	very low	medium	Known to be tolerant of warm water and wide temperature variations. Able to survive dry season in damp ponds despite high temperatures.	very high	low
	Increase in precipitation	Increased precipitation May-November (5-15% per month). may result in increased erosion and turdibity of water bodies.	high	very low	medium	C. batrachus able to tolerate very turbid waters although poorer water quality may affect growth and maturation.	high	medium
	Decrease in precipitation	Slight reduction in precipitation for MDK in the low rainfall period; Dec-Apr, mayresult in reduce flows in upland streams..	medium	low	low	Looks unlikley to affect dry season refuge areas, utilised by this fish.	high	low
	Decrease in water availability	Decreased water availability through reduced precipitation in period Dec-April.	medium	low	medium	Onr of the most mobile of the black fish species, able to migrate over wet surfaces, not needing innundation.	high	medium
	increase in water availability	Increases in water availability through increased precipitation in period May-Nov.	medium	very low	low	This fish likely to benefit from increased water availability	very high	low
	Drought	Increases in drought conditions in Dec, Apr, May & Jun	low	medium	medium	Looks unlikley to affect dry season refuge areas, utilised by this fish.	low	medium
	flooding	Increased water velocities and innundation of floodplains caused by flooding in period Aug - Oct.	medium	low	medium	Fish is very adaptable and can tilerate a wide range of water conditions	high	medium
	Storms and Flash floods	Increased number of days with greater than 100 mm of rainfall will result in increased indicence of flash flooding.	medium	medium	medium	Not expected to have significant impact on this species	high	medium
	sea level rise	N/a	-	-	-	-		
	increasing salinity	N/a	-	-	-	-		

Source: ICEM (2013) USAID Mekong ARCC Fisheries study

3. Trichogaster pectoralis

System component or assets	Threat	Intrepretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
		written description of how the threat relates to the system component		*refer to table*		*written explanation of what the impact is, and why it was scored (high, med, low)*	*refer to table*	*refer to table*
3. Trichogaster pectoralis NON MIGRATORY, SMALL BLACK FISH, IMPORTANT FOR FOOD SECURITY.	Increase in Temperature	Maximum temperatures Increases of up to 10% in the wet season. 5-7% during other seasons. Even higher relative changes in minimum temps 3-27%, highest in the cool season.	Very High	low	high	Known to be tolerant of warm water and wide temperature variations. (optimum 23-28oC)	high	medium
	Increase in precipitation	Increased precipitation in the period March-December, highest in the months of Aug & Sept and Oct. Highest perceptage increase in precipitation occurs in December (40%).	high	very low	medium	Generally beneficial but poorer water quality may affect growth and maturation.	high	medium
	Decrease in precipitation	Decreases in precipitation are projected to occur duing the months of Jan & Feb, (although these are low rainfall months they are not the driest months).	medium	low	low	Resilient'black fish' species able to survive low Reduced rainfall in jan & feb will result in poorer dry season refuge enviornments water conditions. Decrease in rainfall does not happen at the driest time of year.	high	low
	Decrease in water availability	Reduced soil water availability in period Feb-May and Aug & Sept. The dry season decrease may affect stream water flows.	medium	low	medium	Loss habitats and connectivity. Poorer water quality, less food, increased competition, increased fishing pressure. Increased stress. Migration behaviour affected. Compounded by temperature increase.	low	medium
	increase in water availability	No negative effect.	-	-	-			
	Drought	Droughts (>60% of years for 6 months) resulting in poorer water quality, increased fishing pressure in refuge areas. Negative effects compounded by temperature increase.	low	very low	low	Loss habitats and connectivity. Poorer water quality, less food, increased competition, increased fishing pressure. Increased stress. Compounded by temperature increase.	medium	medium
	flooding	No negative effects anticipated	-	-	-			
	Storms and Flash floods	Increase in the number of days with daily precipitation above 100 mm, from 7-10 days. Increase in the highest single daily precipitation; 160mm	medium	medium	medium	Not expected to have significant impact on this species	high	medium
	sea level rise	n/a	-	-	-	-		
	increasing salinity	n/a	-	-	-	-		

Source: ICEM (2013) USAID Mekong ARCC Fisheries study

4. *Oreochromis niloticus*

System component or assets	Threat	Intrepretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
		written description of how the threat relates to the system component		*refer to table*		*written explanation of what the impact is, and why it was scored (high, med, low)*	*refer to table*	*refer to table*
Oreochromis niloticus	Increase in temperature	At least 6% incresae in maximum temperatures, with as high as 16% in the Jul and 10% in Aug. Higehst prijected temp 460C Minimum temps increasing most during the cooler months 10% Dec, 8% Jan & Feb.	high	low	medium	This fish is not sensitive to low DO levels, associated with higher water temperatures. Increased evaporation rates will work result in pond levels dropping quickly in the cool and dry seasons.	high	**medium**
	Increase in precipitation	Increased precipitation from Mar- December, resulting in significant changes to monsoon month water flows in streams and rivers. Highest % increase in April 25%, (a low rainfall month)	medium	high	medium	This species can tolerate turbid water conditions. Increased precipitaion will improve some pond conditions for this fish.	high	medium
	Decrease in precipitation	Decreases in Jan & Feb will reduce dry season flows in rivers and streams, although these are low raifall months, so overall change in flows may not be significant	medium	low	medium	Reduced dry season rainfall will work together with Increased evaporation rates resulting in pond levels dropping more quickly in the dry seasons.	medium	medium
	Decrease in water availability	Reduced dry season flows in rivers and streams, although these are low rainfall months, so overall change in flows may not be significant	high	low	medium	Reduced water availability could affect the viability of culturing this species, although it is tolerant of very warm, low DO conditions	medium	**medium**
	Increase in water availability	Significant increases in wet season flows peaking in Aug with 703 mm	medium	high	medium	Increased water availability will enable farmers to maintain wtare levels for this fish.	high	medium
	Drought	No significant increase in drought conditions predicted.	low	low	low	Reduced water availability will not affect the viability of culturing this species.	high	**low**
	Flooding	Increased risk due to increases in precipitation, (see above)	high	low	medium	This fish will readily leave ponds that are flooded.	medium	**medium**
	Storms and Flash floods	Increase in days where more than 100cm of rain falls, (from 11 days a year to 14 days a year.	high	very low	medium	Ponds in hill areas and small valleys will be especially affected by these conditions	very low	**high**
	sea level rise	n/a						
	increasing salinity	n/a						

Source: ICEM (2013) USAID Mekong ARCC Fisheries study

Note: This assessment done for aquaculture rather than capture fishery.

5. *Mastacembalus armatus* (for *Monopterus albus*)

System component or assets	Threat	Intrepretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
		written description of how the threat relates to the system component		*refer to table*		*written explanation of what the impact is, and why it was scored (high, med, low)*	*refer to table*	*refer to table*
Mastocembalus armatus	Increase in Temperature	At least 6% increase in maximum temperatures, with as high as 16% in the Jul and 10% in Aug. Higehst prijected temp 460C Minimum temps increasing most during the cooler months 10% Dec, 8% Jan & Feb. Minimum temps in wet season 5-6.5% increase over baseline.	high	low	medium	this species is tolerant of a very warm low DO conditions. The projected temperatures should not affect this fish very much. Its upland range may be expanded. Increased evaporation of dry season water bodies could affect survival of brood stocks.	high	medium
	Increase in precipitation	Increased precipitation from Mar- December, resulting in significant changes to monsoon month water flows in streams and rivers. Highest % increase in April 25%, (a low rainfall month)	medium	very low	low	As one of the black fish group, this species is adapted to live in wetland environments that fluctuate between flood and drought. Tolerant of turbid waters. Increases in precipitation are unlikely to affect this species in a negative way.	very high	low
	Decrease in precipitation	Decreases in Jan & Feb will reduce dry season flows in rivers and streams, although these are low raifall months, so overall change in flows may not be significant	medium	medium	medium	Small changes in precipitation during the dry season could affect water levels in dry season refuge areas and thereby affect the capacity of this fish to survive until the first rains.	medium	medium
	Decrease in water availability	Reduced dry season flows in rivers and streams, although these are low rainfall months, so overall change in flows may not be significant	low	medium	medium	Lower water levels in dry season refuge areas and thereby affect the capacity of this fish to survive until the first rains.	low	medium
	increase in water availability	Significant increases in wet season flows peaking in Aug with 703 mm	medium	very low	low	No negative effect foreseen	very high	low
	Drought	No significant increase in drought conditions predicted.	low	medium	medium	Harsher dry seasons could compromise this fish's capcity to survive in shallow wetlands, during the dry season	low	medium
	flooding	Increased risk due to increases in precipitation, (see above)	high	low	medium	No negative effect foreseen	very high	low
	Storms and Flash floods	Increase in days where more than 100cm of rain falls, (from 11 days a year to 14 days a year.	medium	low	medium	No negative effect foreseen	very high	low
	sea level rise	n/a						
	increasing salinity	n/a						

6. Golden Apple Snail, *Pomacea canaliculata*

Assessment is carried out for the vulnerability of the ecosystem towards the invasive species, not the species itself.

System component or assets	Threat	Intrepretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity (this is inverted for invasive species	Vulnerability of ecosystem,(not invasive species)
		written description of how the threat relates to the system component		*refer to table*		*written explanation of what the impact is, and why it was scored (high, med, low)*	*refer to table*	*refer to table*
3. Pomacea canaliculata. THE GOLDEN APPLE SNAIL. INVASIVE PEST OF RICEFIELDS	Increase in Temperature	Projected increases in temperature for Kieng Giang will extend well above this fish's preferred range. GCM max temperatures may reach as high as 42.	High	low	high	Temparture range tolerance 15.2- 36.6oC New upland areas will be colonised by theis animal	very 'low'	Very high
	Increase in precipitation	Increased precipitation May-November (5-15% per month). may result in increased erosion and turdibity.	high	very low	medium	GAS are not espcially sensitive to turbidity. Egg development happens above the water surface so not affected by water quality.	low'	medium
	Decrease in precipitation	Slight reduction in precipitation for KG in the low rainfall period; Dec-Apr, may result in reduced freshwater flows and higher coastal salinities.	medium	low	low	Capacity to survive the dry season in some water bodies, will be reduced.	high	low
	Decrease in water availability	Decreased freshwater availability through reduced precipitation in period Dec-April.	medium	low	low	Capacity to survive the dry season in some water bodies, will be reduced.	high	low
	increase in water availability	Increases in water availability through increased precipitation in period May-Nov.	high	low	medium	will allow the GAS to repopulate areas more quickly	very low	high
	Drought	Increases in drought conditions in Dec, Apr, May & Jun	low	very low	low	Capacity to survive the dry season in some water bodies, will be reduced.Increased harvesting for food.	medium	medium
	flooding	Increased incodence of flooding	high	very low	medium	GAS will benefot from increased flooding and floodied areas	very low	high
	Storms and Flash floods	Increased number of days with greater than 100 mm of rainfall.	medium	medium	medium	Not expected to have significant impact on this species	high	medium
	sea level rise	Sea level rise will result in some areas no longer being exposed, at low tide.	medium	very high	high	This species does not tolerate salinities above 6.8 ppt. So will be lost from some areas	high	medium
	increasing salinity	Increased salinities during the dry season, may result from reduced freshater flows.	medium	very high	high	This species does not tolerate salinities above 6.8 ppt. So will be under increased prsssure in some areas.	high	medium

			Range	**Pop. size**	**Resilience**	**Overall**		**Ecological**	**Bio-geographic connectivity?**	**Adapt quickly?**	**Overall**		
Amphibians													
***Hoplobatracus rugulosus* (Kop, frog)**	--	M, number of suitable ponds for breeding may decrease	Large	M	M	M	Potential breeding failure due to dry periods after some rains in early wet season; increased rainfall expected in May, although may be more erratic in June	Yes	Yes	Yes	M	**M**	**H,** High market demand for consumption
***Rana lateralis* (Kiat leuang)**	LC	M, Hot dry conditions can result in reduced soil moisture and affect local climate	M, Only found in certain wetlands in the south	M	M	M	Wetland habitat for the species is associated with forests. When there is less surrounding forests it may change soil moisture and local climate, thus impacting this species.	Yes	Yes?	Yes	M	**M**	**H,** Over-harvest, forest conversion (except sacred forests);forest has been converted to other uses

CAM Matrix for rain-fed rice

The following tables are obtained from Mekong ARCC study on Agriculture

21.1 LOWLAND RAINFED RICE

Threat/Opportunity	Interpretation of threat/Opportunity	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability	Change in production and link with other sector
Increase in temperature	Average maximum temperature will be above 35°C only in May. Maximum temperature will not reach 45°C. Increase of temperature will be between 6 to 12% during the growing period Early crop in May will face high temperatures with 50% of the daily maximum temperatures above 35°C. During the rest of the growth period the exposure is lower (less than 25% of the daily maximum temperature). Daily maximum temperature is above the comfort zone during the wet season, but 75% of days are below 35°C.	**Medium**	High[166]	High	Increase in temperature during the rainy season might affect rice growth during the different stages of the culture resulting in a lower yield.	Low[167]	High	

[166]Temperature exceeding 35°C at anthesis stage can induce sterility (Yoshida 1981). Increased temperature will reduce the number of grains (Sheehy et al. 2006). However, rice can grow in warm conditions up to 45°C (critical temperature at germination).

[167]External adaptive capacity is low, with lack of access to new varieties and extension services.

-Internal adaptive capacity is high, with capacity to grow in warm temperatures, critical temperature is 45°C at some growth stages, but with negative impact on yield

Source: ICEM (2013)

Threat/Opportunity	Interpretation of threat/Opportunity	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability	Change in production and link with other sector
Increase in precipitation	Increased rainfall of 5 to 18% during the crop period. Maximum monthly rainfall of 425 mm in August will still be within the acceptable range for rainfall. Extreme months in July or August can reach more than 600 mm of rainfall and might damage the rice crop.	**Medium**	Low[168]	Medium	Increase of rainfall will benefit the rice crop with fewer droughts. Only extreme events with high monthly rainfall will damage the rice.	Medium[169]	Medium	
Decrease in water availability	Decrease in water availability will not be significant, with a decrease between 2.5 to 0%	**Very Low**	High	Low	Low potential impact	Low	Low	
Drought (in rainy season, different from baseline)	Drought will be more frequent in April (before the rice crop) and in November (end of the crop) but the increase of frequency is not significant (4%)	**Very Low**	High[170]	Low	Not a significant impact with projected increase in rainfall.	Low[171]	Medium	Will affect negatively HH food security
Flooding	Higher rainfall during the wet season. Extreme events with more than 140 mm/day of rainfall will occur and more than 3 events with more than 100 mm/day.	**Low**	Medium	Low	Lowlands and fields close to wetlands and river might be more exposed to flooding in 2050. The damage depends also on the height and the duration of the flood.	Medium	Medium	

[168]Submergence of lowland rainfed rice due to important rainfall can affect rice yield. For example, 25% of submergence during the flowering stage can reduce yield by 21% (Yoshida 1981).

[169]External adaptive capacity is low with international and government research capacity to develop submergence-resistant varieties, using intermediate plant height (instead of dwarf varieties), but difficulties in reaching small-scale farmers. However, the internal adaptive capacity is high, with traditional lowland rainfed rice more adapted to submergence compared to HYV rice

[170]Dry spells in the rainy season can affect rice yield and abnormal rainfall patterns can generate water stress in rainfed systems

[171] Difficult access to drought-resistant varieties

Threat/Opportunity	Interpretation of threat/Opportunity	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability	Change in production and link with other sector
Flash floods	Extreme events with more than 140 mm/day of rainfall will occur and more than 3 events with more than 100 mm/day.	**Medium**	Medium	Medium	However this threat is extremely variable, depending on local topography, soil type, and land cover. In Champasak Province, the topographic profile is not prone to flash floods.	Low [172]	Medium	Will affect negatively HH food security
Storms	Extreme events with more than 140 mm/day of rainfall will occur and more than 3 events with more than 100 mm/day.	**High**	Medium [173]	High	Rainy season rice can be submerged following increase of rainfall; and a prolonged submergence will reduce yield.	Medium [174]	High	Will affect negatively HH food security
Increase in atmospheric CO2	Increased CO2 atmospheric concentration will modify rice crop growth and ultimately increase yield.	**High**	Low [175]	Medium	Low due to other limiting factors.	High [176]	Medium	Improve HH food security

[172] Rice crop will be damaged by submergence and physical debris transported by the flash flood
External capacity is low. It will require local improvement or adjustment of flash flood protection systems

[173] Rainy season rice can be submerged following increase of rainfall and a prolonged submergence will reduce yield, with traditional varieties more resistant and resilient to this climatic event

[174] It depends on the rice varieties planted, and whether they are tolerant to submersion or not

[175] Increased CO2 level will increase rice yield (Krishnan 2007), however it depends on other limiting factors such as nitrogen fertilization. We considered the sensitivity as low since upland rice is usually grown with limited inputs and therefore the response to CO2 will be limited

[176] Internal and external capacity are high and farmers can benefit from the increase of CO2 concentration by using adequatefertilization and rice field management and increase their rice yield

CAM matrix for small holder cattle and buffalo livestock system

The following tables are obtained from the Mekong ARCC study on Livestock, ICEM (2013)

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
Smallholder cattle/buffalo 'keeping': *Bos indicus*, draft cattle, buffalo	Increase in temperature	**Increase of ~5% and 10% in max. temperatures potentially reaching highs of 42-43°C, relative increase in minimum T of similar proportions.**	M	L[13]	M	The effect on the individual will be difficult to detect, but across herds may be significant. The effects of a gradual increase will be limited as stock are already accustomed to high temperatures. **Breed:** increasing T has limited impact on productivity of *Bos indicus* breeds and buffalo, particularly in the case of low-input asset/draft systems. Extreme temperatures ('snaps') may have direct impacts on animal value, productivity and resilience to disease. **Housing:** stock are rarely housed, though may have access to stalls and usually shade. **Feed:** changes in pasture and forage quality and availability may affect land carrying capacity and stock condition affecting growth rates, reproductive performance and disease resilience potentially in either a positive or negative manner. **Animal health:** stock are rarely vaccinated and/or dewormed and are raised in minimal biosecurity systems. Low stocking densities reduce risk of disease spread. T increase effects on pathogen viability and prevalence will alter disease risks, most likely reducing risk. Empirical data is needed. The likelihood and severity of extreme temperature periods is currently unknown, however, more frequent or more extreme 'snaps' will have greater impact than gradual changes in T.	M	M

[13] Temperatures above 38°C can negatively impact productivity in *Bos indicus* (milk production, and likely growth, but wide variation based on the individual, no available information on draft) but are strongly influenced by past experience. May affect pathogen viability and stock resilience to disease challenges. Effects on cropping systems may alter value and use due to their role and feeding systems (grazing with some cut and carry)

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
						Value: stock are high investment and an important form of wealth storage, their ability to provide traction may be reduced by increased T. **Adaptive capacity:** stock are relatively tolerant. Wholesale changes in husbandry are culturally and economically unlikely. Local AH and extension services are likely relatively good where accessible, remote areas are likely underserved and, despite stock value, cattle keepers typically rarely seek support.		
	Increase in precipitation	**Longer, wetter wet season increase of ~5-18% (on a medium base: ~10-25mm per month).**	L	L[14]	L	**Breed:** high tolerance. **Housing:** limited effect given, typically, shelter is available (under human houses, trees). **Feed:** will likely increase availability and quality of grazing areas and forages. **Animal health:** stock are rarely vaccinated and raised in low biosecurity systems, however, density is low. May affect disease risks, increased mud may increase the likelihood of disease spread through fomites - risk assessments would need to be conducted. **Value:** stock are high investment and an important form of wealth storage, condition may be improved increasing value and capacity to work.	H	L

[14] Effects on feed availability and quality. Effects on cropping systems may become important in terms of value and use of animals, may affect availability of crop residues as supplementary feeds.

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
						Adaptive capacity: stock are relatively tolerant, though increased disease risks may have high impacts. Low density systems reduce risk of disease outbreaks despite limited application of AH measures, increased movement and mixing will heighten risks. Wholesale changes in husbandry are unlikely in the short-medium term. Local AH and extension services are likely relatively good where accessible, remote areas are likely underserved and, despite stock value, cattle keepers typically rarely seek support.		
	Decrease in precipitation	**Shorter dry season possibly with greater variability (from a low base: 1-5mm in Jan and Feb - Feb most significant drop from 20 to 15mm).**	M	M[15]	M	**Breed:** high tolerance, but may already be stressed. **Housing:** limited effect. **Feed:** stock may be undernourished, especially at the end of the dry season/early rainy season, reduced dry season precipitation may exacerbate this problem. **Animal health:** reduced stock condition may increase disease risk. May lose wallowing areas, increasing the above T increase physiological impacts by limiting stock ability to cool themselves. **Value:** stock are high investment and an important form of wealth storage, loss of condition, were this to occur, will effect value and ability to work. **Adaptive capacity:** stock are relatively tolerant but may already be stressed. Wholesale changes in husbandry are unlikely in the short-medium term. Local AH and extension services are likely relatively good where accessible, remote areas are likely	M	M

[15] Effect on availability and quality of grazing areas and forages. Effects on cropping systems may become important in terms of value and use of animals, may affect availability of crop residues as supplementary feeds particularly during extreme dry (drought). May reduce stock ability to reduce body temperature through wallowing.

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
						underserved and, despite stock value, cattle keepers typically rarely seek support.		
	Increase/decrease in water availability	**Variation of approximately 1% increase or decrease in soil water availability. Insignificant.**	VL	L[16]	L	Change in soil water availability is negligible. **Breed:** negligible effect. **Housing:** N/A. **Feed:** negligible. **Animal health:** negligible. **Value:** negligible. **Adaptive capacity:** negligible change, N/A.	H	L
	Drought	**Reduced frequency of droughts.**	L	L[17]	L	Reduced frequency of droughts. Positive impact, reduced vulnerability.	VH	L

[16] Effects on availability and quality of grazing areas. Effects on cropping systems may become important in terms of value and use of animals, may affect availability of crop residues as supplementary feeds. May affect stock ability to reduce body temperature through wallowing.

[17] Positive effects.

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
	Storms/flash flooding	**Increases maximum daily precipitation (associated with storms, heightened risk of flash flooding).**	M	H[18]	H	**Breed:** no effect. **Housing:** some use of housing, stalls or commonly kept beneath human homes, direct losses of infrastructure through flash floods may have short-term impacts on stock and HH wealth, more significantly. **Feed:** possible loss of forage plots. **Animal health:** direct losses, little impact on disease. **Value:** stock are high investment and an important form of wealth storage, losses will have a very significant impact on HHs. **Adaptive capacity:** little can be done if exposed to flash flooding, stock may be offered greater protection due to their value. Relocation only method of ensuring safety and unlikely to be feasible for most HHs employing these stock.	L	H

[18] Direct losses among those exposed to flash flooding.

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