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Climate Change Risk Assessment for Thailand's Tourism Sector

Research Report

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About this report:

This report forms part of the wider collaboration between the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and the Office of Natural Resources and Environmental Policy and Planning (ONEP) who currently implement the project "Risk based National Adaptation Plan" (Risk-NAP). The 2018 draft NAP defined the tourism sector as one of six priority sectors for Climate Change Adaptation in Thailand. The report presents one output under the project 'Mainstreaming Climate Change Adaptation into the Tourism Sector in Thailand', which is financed by the International Climate Initiative (IKI) of the German Federal Ministry for the Environment Nature Conservation and Nuclear Safety (BMU). One of the objectives was to identify potential climate change related risks to the Thai tourism sector, understanding data availability and recommending next steps the Thai tourism sector to address climate risks.

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Executive Summary

Objective

The Thai Government has identified tourism as one of six priority sectors to implement climate change adaptation. To strengthen Thailand's adaptive capacity, the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) together with the Office of Natural Resources and Environmental Policy and Planning (ONEP) is working on integrating climate change into sectoral plans and policy instruments. This Tourism Climate Change Risk Assessment (CCRA) aims to identify existing and future climate change risks for the Thai tourism sector. The results will form part of Thailand's climate change response strategies and support the implementation of the country's wider National Adaptation Plan (NAP). Building on this CCRA report, an analysis of the policy framework will be undertaken in order to identify opportunities for mainstreaming climate change into tourism related policies and planning processes.

Framework and approach

Building on the Intergovernmental Panel on Climate Change's risk framework, the proposed six-step framework applied in this CCRA of Thailand's tourism sector conceptualises climate risk as the interaction of hazards, vulnerability, and exposure. It situates these within the Thailand tourism system that is shaped by demand and supply, tourism strategy and policy, and wider socio-economic trends, infrastructure and land use planning. The steps are:

1. Analysis of the tourism system, including socio-economic trends;
2. Climate hazards, including observed trends and projected changes;
3. Tourism risks, including a compilation of past climate events
4. Suggested risk metrics for tourism;
5. Future climate risks for tourism, integrating evidence to prioritise focus for adaptation planning;
6. Policy recommendations, translating findings into policy, partnerships and other instruments.

This report provides two methodological chapters. First, a generic overview of key questions, data sources, and tools available is presented. This is followed by a description of the approach taken specifically for assessing climate risk for tourism in Thailand. This includes a broad review of relevant Thai and international literature, analysis of key tourism trends, extraction of data on climatic trends (past and projected), and stakeholder input by means of workshops, consultations, and surveys.

Thailand's tourism system

Continuous and substantial growth in tourism dominates the Thai tourism system. This has several implications. One is that tourism is increasingly important for the Thai economy, making it more pertinent to develop proactive risk management. Second, intensive growth is leading to pressure points in various destinations and issues of carrying capacity have emerged. Third, tourism can be a tool for regional development, and this could disperse exposure away from hazardous zones (e.g. in coastal zones). Dispersal is a key element of the Government's tourism strategy, but if increasing climate change impacts are not considered in the development process of new tourism regions/ destinations this strategy could increase the vulnerability of those places, and increase risks for tourists and locals.

Wider trends of a growing middle class are likely to foster domestic tourism, and decrease dependence on international tourism. This could reduce vulnerability if domestic tourists are more familiar with their travel environment. Overall, growth will increase exposure due to rising visitor numbers in key destinations. The demographic trend of ageing societies may require additional risk management, as older people are more sensitive to rapid climatic changes and slower to respond during disasters. High Internet access and better digital communication are tools to address vulnerability and ensure good communication in case of a crisis.

Thailand's 2nd National Tourism Development Plan seeks to improve the sustainability of tourism, presenting an opportunity to integrate climate risks. In addition to mitigation measures (i.e. low-carbon tourism), it is increasingly important to manage water resources efficiently and contribute to the integrity of ecosystems. In particular, the protection of marine resources is of high strategic importance to tourism.

Climate hazards

This CCRA drew on data from the World Bank Climate Change Knowledge Portal and relevant academic literature. Temperature as a key driver of tourist comfort has increased by about 1°C in Thailand between 1951 and 2016. Regional variations exist, for example with the number of hot days having increased more in the Central, North, and Northeast regions, and the number of hot nights becoming more pronounced in the Central and South regions. Mean annual temperatures are projected to increase by 1.3 to 1.6°C by mid-century and 1.7 to 3.4°C by late-century, depending on the climate scenario. Compared with 1986-2005, the number of hot days over 35˚C is expected to increase by 19-22 in the next 20 years and 31-43 by mid-century. Also, the number of nights requiring air conditioning is increasing substantially.

Observations from 1955 to 2014 show that, while precipitation has become less frequent in most parts of Thailand, rain events have become more intense. Seasonal shifts show a volume decrease between May and October, and an increase between November and April. Increased intensity of rainfall events has led to severe flooding and landslides. Precipitation projections show much more uncertainty than for temperature, but generally indicate an increase in rainfall (relatively more for June to October). Given fewer precipitation days, the length of dry periods has increased, raising the potential for drought. The 2016 drought led to severe water shortages on tourism islands (e.g. Koh Samui). Climate models indicate that a future decline in water availability would be experienced during the dry season (particularly during April and May), while an increase of water availability is expected during the wet season.

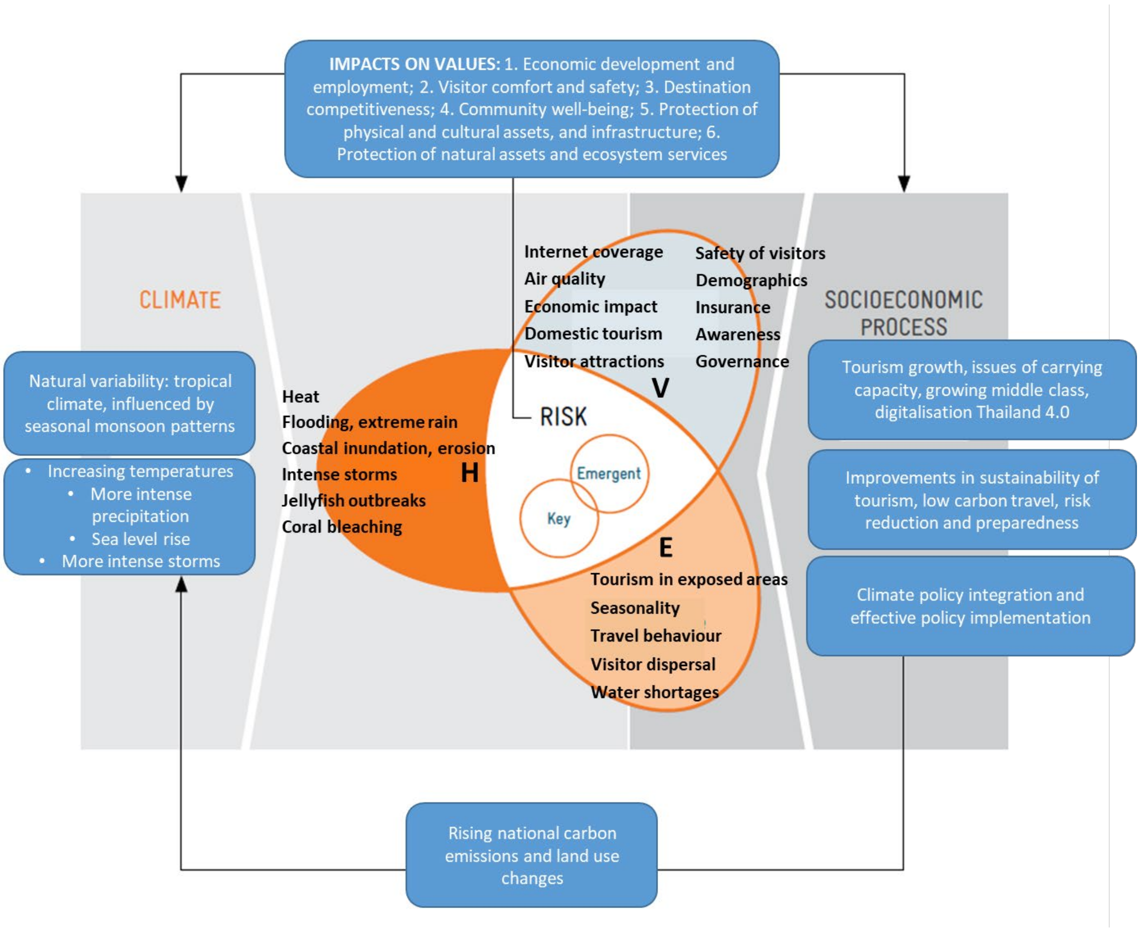
Key coastal climate-related changes include a significant increase in sea surface temperatures. The country experienced major coral bleaching events since 1991, with severe coral bleaching taking place in 1995, 1998, and 2010. Prolonged ocean warming caused a global coral bleaching event that started in 2014 and extended well into 2017, and also affected Thailand. In addition to bleaching, substantial extent of ocean acidification raises the possibility of far-reaching marine ecosystem change in the decades ahead.

Coastal regions are affected by rising sea levels. The Gulf of Thailand has seen increases by about 3 to 5 mm per year in the period between 1993 and 2008; about 3 to 5 times the rate of global sea level rise in Thailand. Several estimates exist for future sea level rise, which is likely to be in the order of 0.45 m to 1.2 m by 2100 depending on the scenario and model. These projections are of concern for tourism, in particular beach tourism. A recent study found that out of 51 zones that contain sandy beaches in Thailand, between 8 and 23 will disappear for the low and high emission scenarios, respectively. The tropical cyclone activity over the western North and South Pacific are anticipated to change in a warmer world. Several studies in the western North Pacific project a decrease in tropical storm frequency, but an increase in higher intensity storms, which will increase associated risks for Thailand.

Observed and future tourism risk

Tourism stakeholders in Thailand are aware of a wide range of climate hazards and impacts that have affected tourism in the past. In particular, tourism activity has been negatively impacted upon by hydrological events such as heavy rainfall, flooding, and landslides. Flooding has also constrained accessibility to some tourist destinations and has caused damage at cultural heritage sites. Tropical storms have led to infrastructure damage and in some cases resulted in tourist fatalities. Coral bleaching events have been identified as major risks for marine tourism operators and destinations that depend on healthy marine environments. Heatwaves were seen as detrimental, especially in regions that are popular for their cooler climate (i.e. the North). Higher temperatures also exacerbate the heath impacts through air pollution, a pressing problem not only in urban environments but also in the North due to forest burning.

A range of tourism relevant indicators were identified to measure and monitor the three dimensions of climate risk, namely the climate hazard itself, aspects of exposure, and vulnerability. These are to be seen in relation to the impacts they cause on the values or outcomes that tourism brings to Thailand. These values include the economic benefits from tourism, but also destination competitiveness, visitor comfort and safety, community well-being, and protection of physical, natural and cultural assets. The Executive Summary Figure 1 summarises the proposed metrics, embedded in the wider risk framework.



Executive Summary Figure 1 Overview of framework and key drivers of climate risk for tourism in Thailand.

Building on the insights provided above, five key risks for Thailand tourism have been identified.

- Increased likelihood of **extreme precipitation events will lead to more flooding**, especially in the North, Northeast, and Central regions of Thailand. In the absence of adequate adaptation measures, this can damage tourism infrastructure, assets and cultural heritage, and cause issues of transport access. More intense flooding can reduce the economic benefits of tourism and affect visitor comfort or safety. Impacts on community wellbeing are likely.
- **Hotter temperatures will reduce visitor comfort**, and potentially health, and may reduce destination competitiveness. Greater need for air conditioning will also increase business costs, and lead to maladaptive effects in terms of increased carbon emissions. In combination with air pollution, heatwaves could have a significant impact on tourism.
- **Warmer water temperatures and acidification make coral bleaching events increasingly likely and impactful**. This has major implications for those destinations that depend on marine tourism, as both the natural asset and competitiveness decline, and as a result the economic benefits from tourism. This would potentially affect community well-being.
- **Increased risk of drought will put pressure on tourism businesses** to become more water efficient and maintain economic benefits from tourism, without increasing water conflicts with other sectors and the community (i.e. undermining well-being). Operational costs for water supply are likely to increase.
- **Sea level rise and beach erosion** will affect destination competitiveness. Declines in economic benefits are possible as a result.

The CCRA concludes with ten recommendations in relation to knowledge and data gaps, potential adaptation options, and policy mainstreaming:

1. Rapidly improve the sustainability of tourism generally to reduce pressure on social and environmental systems. This will increase adaptive capacity to future climate risks.
2. Work with other Government agencies to identify unsustainable practices that increase the exposure and vulnerability of tourism, and advocate for changes in policy and practice.
3. Identify partnerships (across government, with private sector, and other organisations) to carve out win-win opportunities for climate risk management and adaptation.
4. Explore finance mechanisms for climate change adaptation and address data gaps on the business case of particular adaptation measures. Long time frames should be considered.
5. Invest in robust tourism statistics on regional visitation patterns by both international and domestic visitors.
6. A survey of tourists with regards to their perceptions of safety and comfort (e.g. air pollution, heat-wave) will help determine critical thresholds.
7. Ensure that tourism strategies (e.g. diversification, dispersal) take into account changes in climate risk and product/destination competitiveness.
8. Develop a destination-based risk assessment to illustrate how tourism planning and policy need to incorporate projected changes in climate risk at a local level.
9. Building on this CCRA, invest into further work on identifying, assessing and costing a portfolio of adaptation pathways and measures.
10. When communicating to tourism stakeholders, frame climate adaptation as being part of ‘good practice’, long-term planning and business competitiveness, rather than it being an additional and separate task.

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1. Introduction

This chapter explains the background and objectives of this project. This will be followed by an overview of existing risk assessment frameworks, in general and specifically for tourism. The framework used for this present risk assessment of Thailand’s tourism sector will be introduced.

1.1. Background and objectives

This Climate Change Risk Assessment (CCRA) was commissioned to systematically identify climate change risks for the Thai tourism sector and identify information gaps. The results feed in to Thailand’s climate change response strategies and support the implementation of the country’s wider National Adaptation Plan (NAP). Tourism is one of six priority sectors that have been identified in a nation-wide vulnerability analysis to plan and implement climate change adaptation efforts.

To strengthen Thailand’s capacity to adapt to climate change risks, the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) (GMBH) together with the Office of Natural Resources and Environmental Policy and Planning (ONEP) is currently implementing the project “Risk based National Adaptation Plan” (Risk-NAP). Of particular importance is the integration of climate risks into sectoral plans and policy instruments, ideally by identifying opportunities for mainstreaming climate change into existing or new policies. Identifying suitable entry points will for enhancing tourism policy with climate change considerations will enable decision-makers to adequately consider climate risk in policy-making processes. To achieve this, ONEP and GIZ initially engaged with three priority sectors for adaptation identified in the draft NAP. Tourism is one of these sectors.

In the course of developing the first NAP, several mainstreaming activities have already been organized in collaboration with the tourism sector. These involved technical contributions from experts within the tourism sector to the NAP document and a stakeholder workshop. The latter led to the initial development of a tourism sector climate change impact chain – a tool that helps to identify key hazards and intermediate impacts from climate drivers on in a participatory and engaging manner to increase the understanding of (cross-)sectoral climate change risks. In addition, the earlier work with the tourism sector took stock of existing activities and knowledge and helped raise awareness and assess needs and challenges to climate change adaptation with public and private sector stakeholders. Perspectives on climate risk and adaptation in tourism are being examined in piloting projects at the subnational level (in Chiang Rai Province and at the Andaman coast) implemented with support of the Risk-NAP project.

This CCRA built on this previous work and involved a range of stakeholders, including representatives from:

- Ministry of Tourism and Sports (MoTS)
- Department of Tourism (DoT)
- Office of Natural Resources and Environmental Policy and Planning (ONEP)
- Tourism Council of Thailand
- Tourism Authority of Thailand (TAT)
- Designated Areas for Sustainable Tourism Administration (DASTA)

The objectives of this CCRA were to identify potential climate change related risks to the Thai tourism sector and understand data availability and gaps with regards to a quantification of such risks. Recommendations on next steps regarding CCRA for the Thai tourism sector will be provided.

1.2. Risk assessment frameworks

This CCRA undertaken for the tourism sector in Thailand builds on the risk framework from the Intergovernmental Panel on Climate Change 5th Assessment Report (IPCC, 2014). The framework conceptualises climate risk as the interaction of hazards, vulnerability and exposure (Figure 1). The risk is a potential of negative outcomes; the impact is when these occur, for example due to extreme climatic events – either natural or influenced by human activity. Importantly, risk is moderated by various socio-economic drivers and processes that determine the exposure of elements in a system (e.g. groups of people, assets, or species) and their propensity to be affected.

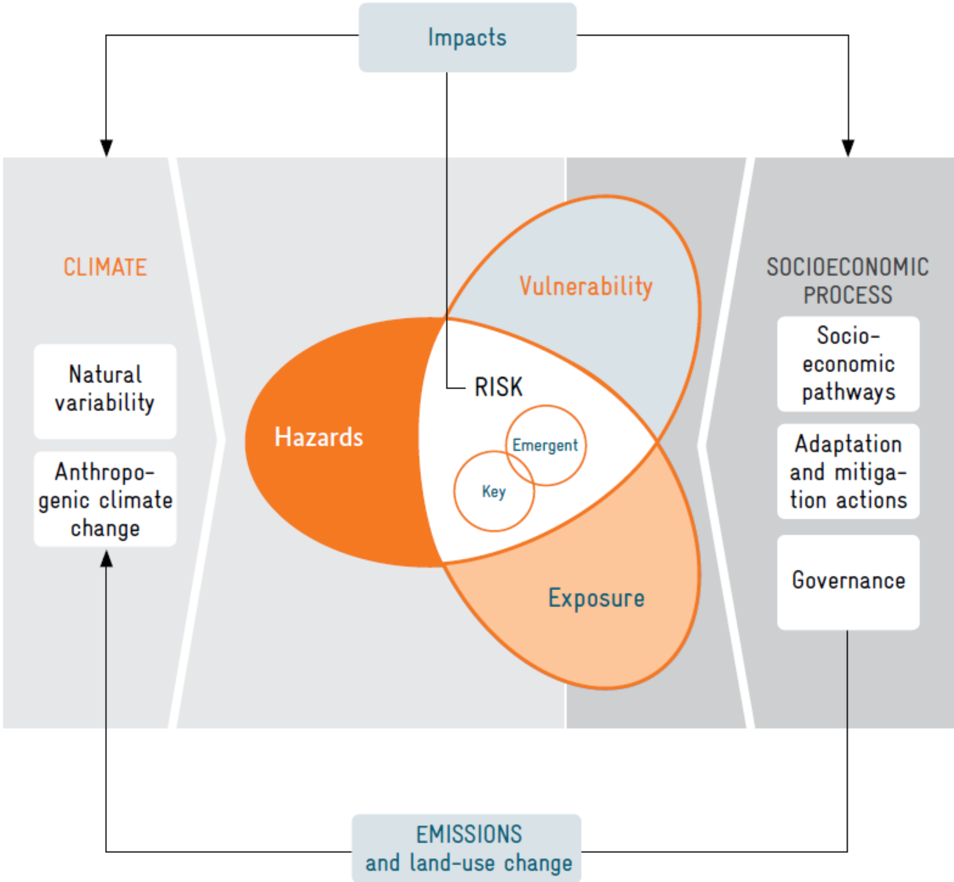


Figure 1 Risk framework from the IPCC 5th Assessment Report (2014).

This project focuses on understanding climate risks of tourism in Thailand with an aim of enhancing adaptive capacity, in particular through well-informed, targeted and integrated policymaking. Importantly, however, socio-economic factors are also at the core of future emission pathways that influence the extent to which natural climate variability will be exacerbated or modified by anthropogenic emissions. As such, it is imperative to keep emission reduction goals in mind when addressing climate risk, impacts and adaptation. Table 1 summarises the key terms that are integral to the above risk framework.

Table 1 Definitions of the key IPCC concepts that form part of a risk assessment (GIZ & EURAC, 2017).

Concept	Definition
Risk	The potential for consequences [= impacts] where something of value is at stake and where the outcome is uncertain (...). Risk results from the interaction of vulnerability, exposure, and hazard (...).
Hazard	The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources. In [the IPCC] report, the term hazard usually refers to climate-related physical events or trends or their physical impacts.
Exposure	The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.
Vulnerability	The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.
Adaptation	The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects.
Mitigation	A human intervention to reduce the sources or enhance the sinks of greenhouse gases (GHGs).

Several approaches and tools exist that help assess the risk to a particular region or sector. The Centre for Environmental Cooperation (CEC, 2017) in North America, for example, developed a Marine Protected Area Rapid Vulnerability Assessment Tool that involves five steps. Just like other tools, the basic starting point is to screen climate risks by considering past climatic events and stakeholders' experiences with present-day climate variability. In their CoastAdapt tool, NCCARF (2017) proposed to begin with questions such as:

- Have these occurred in the past in your area of interest?
- Do you have any existing risk management strategy in place to tackle this hazard?
- Do you have any residual (existing) risk from this hazard?
- What is the likely future direction of the hazard?
- Does this hazard has the potential to become problematic for you in future?
- Which geographical area/sector/assets/ecosystems can be impacted?

A climate signal can cause a hazard or set off a chain of hazards (or intermediate impacts) that ultimately – and depending on exposure and vulnerability – constitute a risk. The literature provides a range of examples that demonstrate the chain of impacts that are triggered by particular climate drivers. Research in the health sector, for example, demonstrates that changes in regional and local climate variability and weather (e.g. higher temperatures, increased precipitation) change intermediate factors, such as air pollution, pollen production, microbial contamination and distribution, and crop yield. These in turn, then pose risks to health, for example in relation to heat-related illnesses, allergic diseases, infectious diseases, and malnutrition (Haines et al., 2006).

For the New Zealand context, Becken and Wilson (2016) developed a detailed taxonomy of weather situations that impact tourism operators both directly and indirectly, illustrating a diverse and complex chain of causes and effects. Tourism businesses often use a combination of climate parameters to make operational decisions. To understand the impact of precipitation, for example, businesses need to know if it occurs in combination with wind, low visibility or cold temperatures; whether rainfall is prolonged and heavy, and whether there is a risk of flooding. Flood related closure of bridges on key access routes pose a major problem for businesses in destinations that are not directly affected by a particular weather event.

In their vulnerability sourcebook, GIZ and EURAC (2017) use the concept of impact chains to illustrate the domino effect that adverse climate signals can trigger. For example, they show that there are multiple impacts on smallholder farmers caused by too high temperatures and precipitation. The impacts of the initial climatic hazards combine to an intermediate impact of insufficient water availability. These are then moderated by aspects of exposure (e.g. how many farmers are there) and vulnerability (e.g. poor soils, lack of know how), combining to levels of risk. In the above example, the ultimate risk is the problem of water scarcity for farmers.

In a participatory process, GIZ has developed a preliminary impact chain for tourism in Thailand. Figure 2 visualises the cascading effects of changes in temperature, sea surface temperatures, ocean acidification, sea level rise and changes in precipitation. Risks are best understood by segmenting tourism into relevant elements. In this case, the impact chain differentiates between activities, destinations, and public and private services (e.g. utilities). These represent ‘elements of exposure’ for which climate risk might differ.

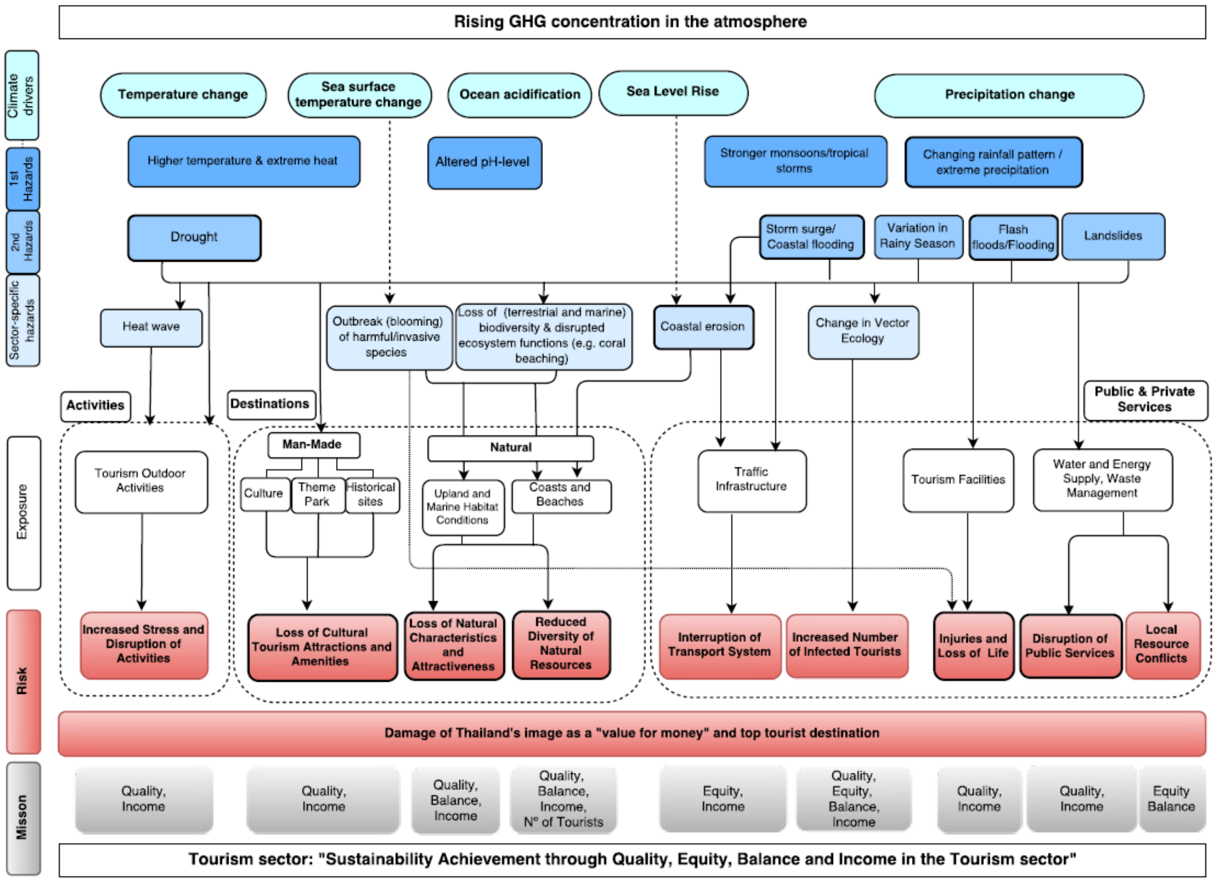


Figure 2 Tourism climate impact chain (GIZ, 2017).

1.3. Tourism-specific frameworks

Tourism is increasingly recognised as a priority sector in national climate change strategies (Simpson et al., 2008). Recent analysis by Scott and Gössling (2018) revealed that 82 of the 182 Nationally Determined Contributions (NDCs) that were submitted to the UNFCCC mentioned tourism. Yet, the extent of detailed vulnerability or risk assessments is limited. Notwithstanding this gap, the literature provides few frameworks specifically for climate risks in tourism. Existing frameworks identify that the 'tourism system' consists of a range of elements and processes, all of which need to inform a differentiated risk assessment. In other words, tourism is not a homogenous sector.

1.3.1. Disaggregating the 'tourism system'

In her climate change adaptation tool for coastal tourism, Becken (2016) proposed five sub-types of coastal tourism, all of which are impacted differently by a range of climate hazards. The five types are:

- Beach tourism
- Coral-reef based tourism
- Coastline tourism (including relevant infrastructure)
- Nature-based tourism (e.g. wetlands, mangroves)
- Cruise ship tourism

Elsewhere, in Chiang Rai, Thailand, experts distinguished natural versus man-made tourist attractions and those that operate year-round or seasonally, noting different exposures and vulnerabilities for these categories (Thailand Development Research Institute, 2018). In their assessment of international tourism and climate change, Scott et al. (2012) disaggregated the tourism system into tourists (i.e. the demand side), operators (the supply side) and destinations (the geographic context, which also forms part of the tourism supply). Figure 3 visualises the different impact pathways of changes in the environmental and climatic systems on tourism. The importance of socio-economic drivers is highlighted, in particular the existence and extent of climate policy and planning.

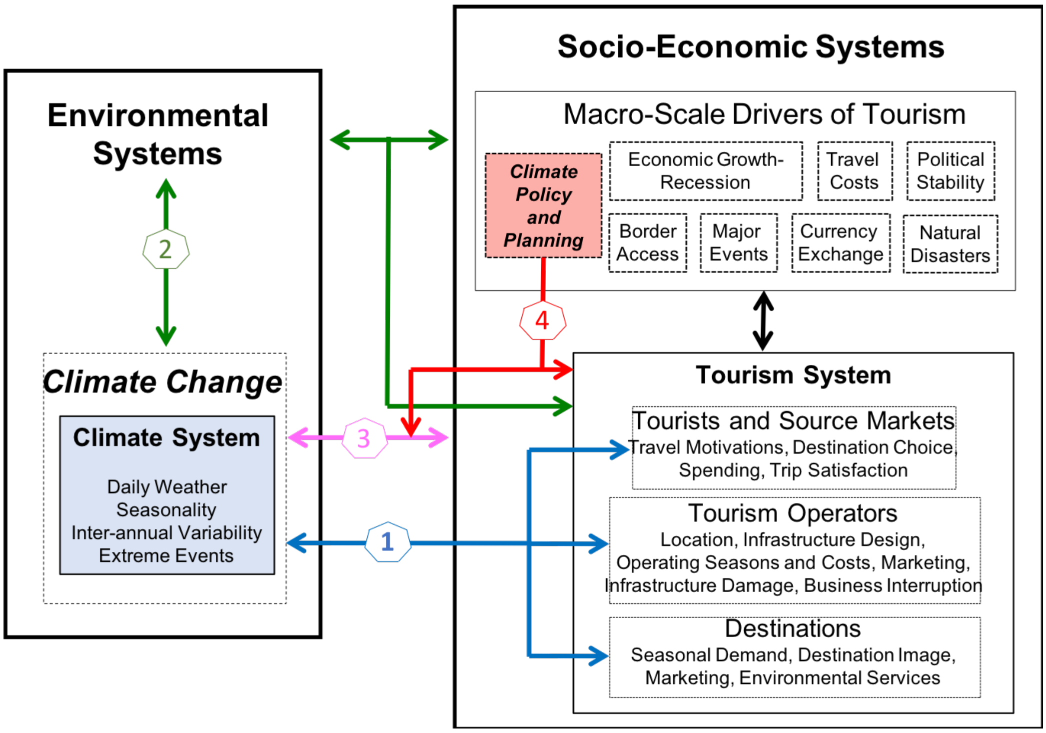


Figure 3 Different impact pathways for how climate change can affect international tourism (Source: Adapted from Scott et al., 2012).

1.3.2. Identifying suitable tourism metrics for measurement

Understanding past and future changes relies to a large extent on the measurement of key indicators. Identifying suitable metrics that are informative, meaningful, reliable, achievable (i.e. data availability and quality) and easy to interpret is not a trivial task. There is limited literature on metrics that allow to monitor changes that are relevant for tourism and climate change.

The Saint Lucia climate change impact assessment (Environmental Solutions Limited, 2015) selected a range of climatic parameters as relevant for tourism. These were: changes in average, minimum and maximum temperatures, as well as changes in the number of very hot days and cool nights. Very hot days were defined as the number of days hotter than the hottest 10% of days. Cool nights were those that had temperatures cooler than the coldest 10% of nights in the present climate. In addition, changes in mean rainfall (in mm) were projected, alongside extreme rainfall events. The latter were measured as the proportion of rainfall in heavy events, as well as the maximum 1-day and 5-day rainfall volumes. Finally, the assessment used the range of indicators to assess the nature of lasting weather conditions, for example the number of consecutive dry/ wet days and the total number of wet-days in a year. Indicators of wind speed and sea level rise completed the assessment. Further indicators from Belize are presented in Textbox 1.

A global analysis of tourism risk to climate change undertaken by Scott et al. (2019) used 27 indicators to construct a Climate Change Vulnerability Index for Tourism (CVIT). These indicators represented various types of domestic and international risks, and also included aspects of the tourism system itself and its adaptive capacity. The objective of developing a composite climate change vulnerability index for tourism was to foster discussion, enable investment and support decisions and facilitate better integration of tourism into other existing global vulnerability indices. The 27 selected indicators were aggregated into six index dimensions:

(1) tourism assets (five indicators): degradation or loss of natural and cultural heritage assets that attract tourists; damage to tourism infrastructure and destination communities;
(2) tourism operating costs (five indicators): impacts on climate sensitive tourism operators, increasing costs and affecting competitiveness;
(3) tourism demand (six indicators): impacts on domestic and international markets and economic growth, including increasing costs of transportation to reach destination countries (e.g. due to carbon policies);
(4) host country deterrents (three indicators): impacts that deter destination choice of international tourists such as extreme events or disasters, health and security risks;
(5) tourism sector adaptive capacity (five indicators): in-country capacity of tourism to adapt to climate change;
(6) host country adaptive capacity (three indicators): capacity of the destination country to adapt to climate change and maintain tourism assets, but also upkeep infrastructure and socio-political conditions suitable for hosting international tourists.

In addition to directly relevant indicators, Chinvanno’s (2013) highlighted the importance of considering a broader set of drivers of change. Examining Krabi, Thailand, multiple factors were found to affect the hydrological system and risk of future water conflict. In particular, tourism promotion/ marketing was highlighted as an economic driver that results in increased numbers of visitation, leading to higher water demand by tourism. Given trends of shorter rainy seasons and reduced precipitation this was seen to exacerbate water scarcity and competition over water resources, especially in the context of increasing demand for biofuel production and palm oil plantation. Chinvanno’s work confirms the importance of taking a system-wide approach to capture complex interactions.

Textbox 1: Vulnerability assessment for tourism in Belize, Caribbean

Source: Climate and Development Knowledge Network, 2014

A tourism-specific vulnerability assessment in Belize defined a set of indicators for exposure and sensitivity to climate change. The indicators were estimated for three periods of time, namely 2010, 2030-2039, and 2090-99. A Likert-type scale ranging from very low to very high was used to quantify change. Least vulnerable areas were identified (Figure 4).

Exposure:

- Sea surface temperature: measured through the difference between current sea surface temperatures, or projected SST, and the long-term mean SST
- Air temperature: % of scenarios that predict a 3˚C increase in temperature
- Hurricane intensity: average wind speed (mph)
- Sea level rise: metres above current sea level

Sensitivity

- Area of coral reef: Kilometre square of coral reef presence
- Reef health: Coral bleaching watch ranking
- Area of mangrove: Kilometre square of mangrove presence
- No. of hotels
- Tourism attractions

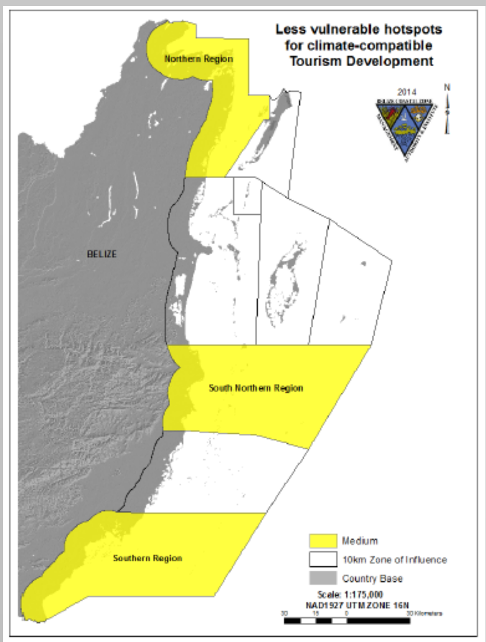


Figure 4 Vulnerability map for Belize

1.3.3. <u>What values are at risk?</u>

Understanding and measuring risk also necessitates defining 'risk to what'. The impact chain developed for Thai tourism (Figure 2) implicates that the overall concern is "damage of Thailand's image as value for money and top tourist destination”, which has implications for quality of income and its distribution, and the “sustainability achievement through quality, equality, balance and income in the tourism sector.”

The Samoa Tourism Authority (2012) developed a similar impact chain for their National Tourism Climate Change Adaptation Strategy (2012-2017). Figure 5 shows that the socio-economic outcomes at risk from climate change include loss of jobs and income, and knock on effects to other parts of the economy.

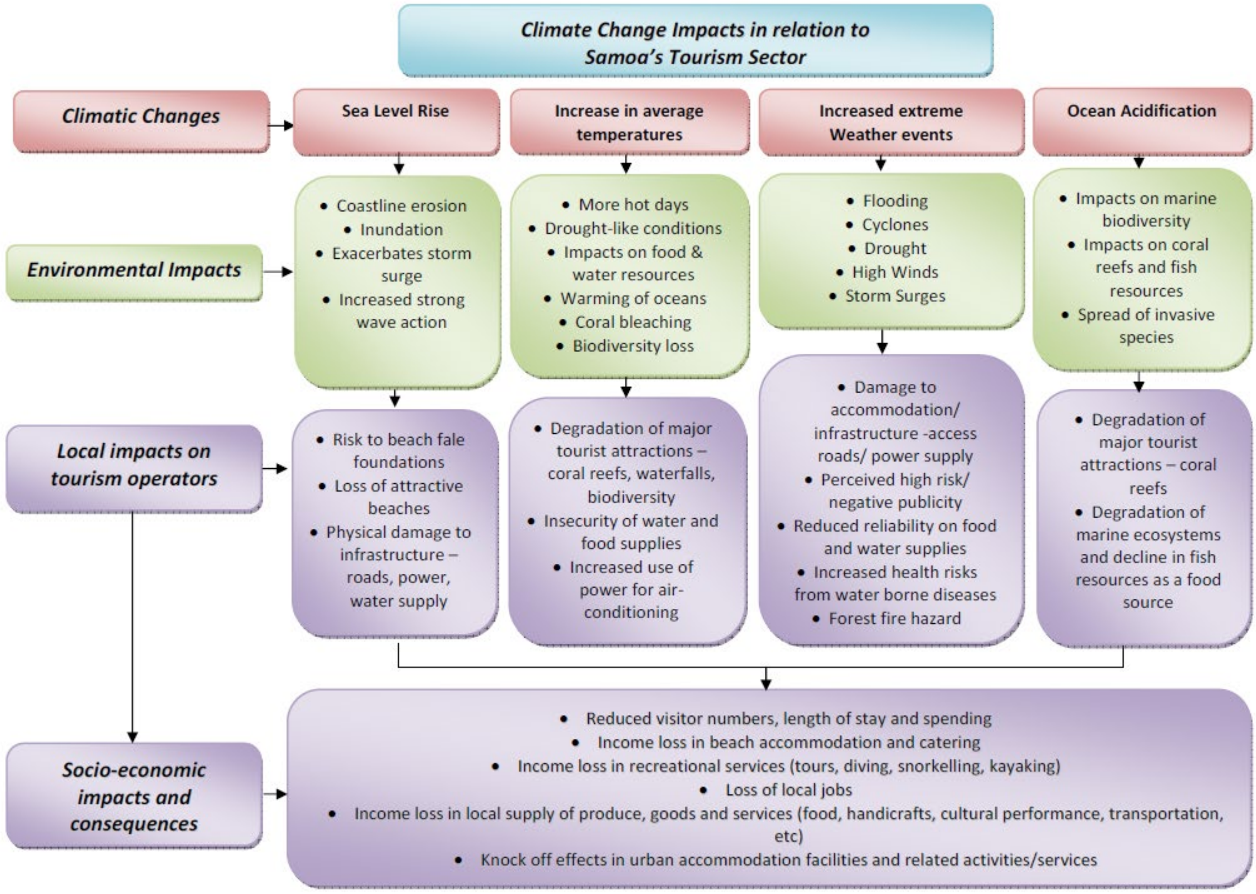


Figure 5 Impact chain for tourism in Samoa (Source: Samoa Tourism Authority, 2012).

1.4. Framework used for Thailand’s tourism sector

This CCRA follows the logic and terminology presented in the IPCC AR5 (2014), but also ensures that risk assessment aligns with broader approaches to developing adaptation options and strengthening resilience. Jopp et al.’s (2013) Regional Tourism Adaptation Framework Model involves the following four steps:

1. Define the tourism system
2. Establish risks and opportunities
3. Determine adaptive capacity
4. Adaptation process

The review of both general and tourism-specific frameworks has helped to develop a robust framework for this particular CCRA of the Thai tourism sector. It brings together accepted approaches and terminologies, and is fit-for-purpose for this present task. A six-step framework helped operationalise the IPCC approach for the tourism context. Figure 6 summarises the sequential steps involved in the CCRA.

1.4.1. *Socio-economic trends and tourism system*

Understanding the tourism system, and the wider socio-economic system in which it is embedded, is the first step towards a meaningful tourism risk assessment. This step responds to the well-established fact that risk is context and place specific. It is therefore necessary to identify types of destinations in Thailand that face similar climate risks (i.e. combination of a range of climatic and environmental parameters). Second, it may be important to distinguish different types of products (e.g. urban tourism) or market segments (e.g. Chinese visitors, ecotourists etc.). Understanding tourism's critical infrastructure and services, as well as relevant tourism trends is of great importance to assess future climate risks.

1.4.2. *Climate hazards – past and future*

Step 2 involves obtaining an understanding of existing climatic hazards in Thailand, and how these will change under different climate scenarios. Due to the diverse geography in Thailand, the climate hazards and projected trends are likely to differ for different regions.

1.4.3. *Tourism risks and metrics*

Step 3 focuses on understanding present-day climate variability and risks for tourism. In other words, what types of climate hazards are relevant to tourism and how can they be measured? It is important to bear in mind that new risks might emerge that are not captured by understanding past or present risks.

Step 4 specifically seeks to identify key indicators or metrics that are of particular relevance for monitoring climate risks for tourism.

1.4.4. *Future climate risks for tourism*

Building on the insights from past and present impacts of climate variability on tourism, Step 5 then involves overlaying climate projections and other socio-economic trends to assess future risks stemming from these macro drivers. In some cases, it will be challenging to differentiate climate and non-climate drivers. For example, sea level rise and increased storm intensity will increase the likelihood of degradation of tourism product from storm damage and loss of near-shore infrastructure. However, these risks also increase due to growing coastal development and potentially reduced opportunity to obtain insurance. Thus, this step considers context specific elements and trends of exposure and vulnerability, in addition to the more generic socio-economic trends.

Conceptually, the assessments of exposure and vulnerability are closely intertwined with trends in climatic and socio-economic macro-drivers, and the combination of all of these determines the overall risk to tourism. For example, promoting gastronomy tourism might lead to a diversification of livelihoods and reduce vulnerability. However, if agricultural products are exposed to climatic hazards and adaptive capacity is low, then this diversification could increase risk. In practice, it is difficult to distinguish whether a driver operates at a macro scale or whether it shapes vulnerability locally. To fully understand exposure and vulnerability factors that shape risk it is necessary to move to a local level assessment.

1.4.5. *Policy recommendations*

Step 6 translates the findings from the risk assessment into recommendations for policy. These may include new regulations, incentives, partnership arrangements, finance mechanisms and other instruments.

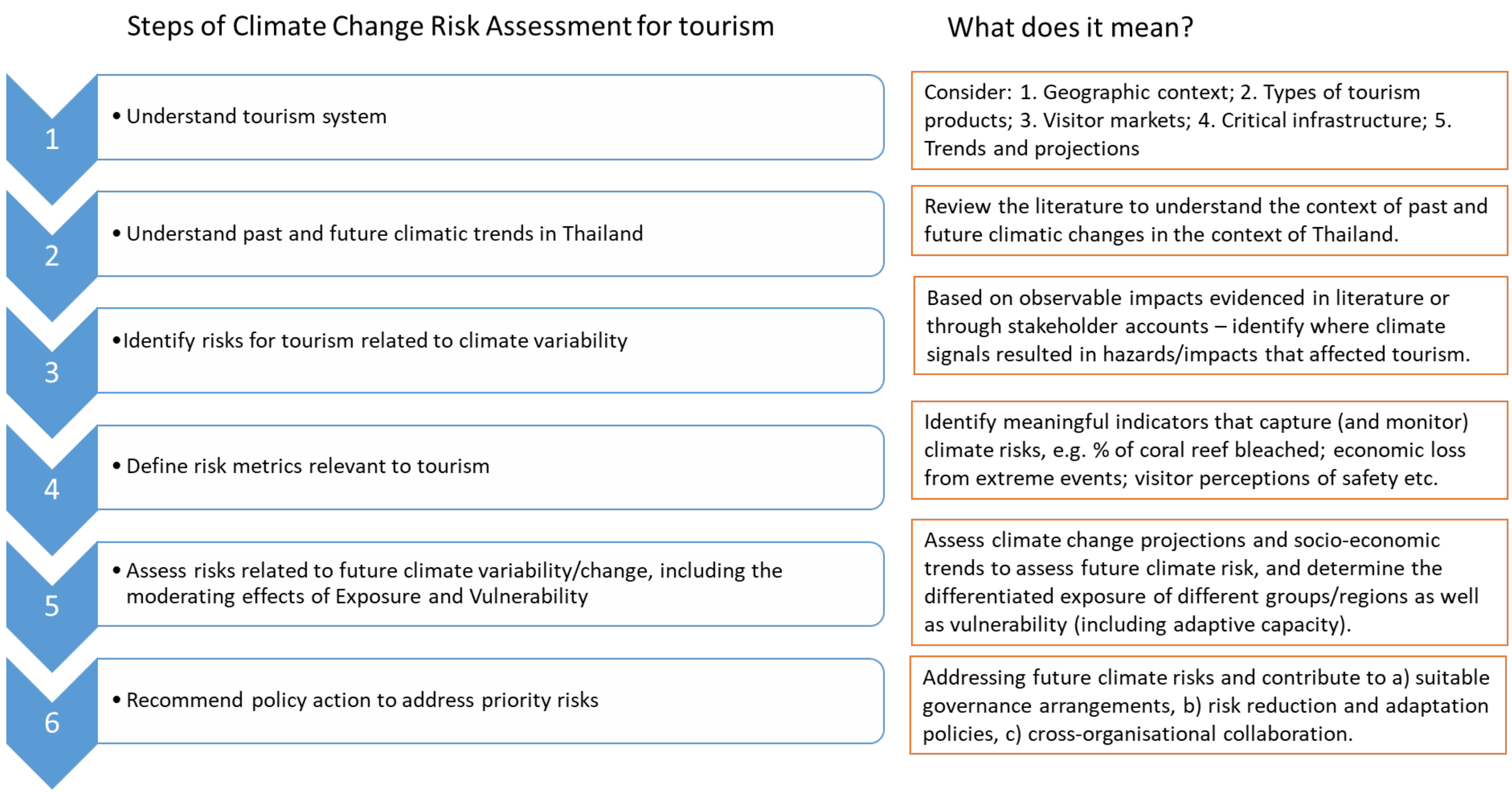


Figure 6 Six-step framework proposed for the CCRA of the Thai tourism sector.

2. General methodological considerations

Chapter 2 provides a 'how to' overview of conducting a risk assessment for tourism. Specifically, it will discuss:

- 2.1 First considerations – what scale, who should be involved?
- 2.2 What data are required – for example in relation to climate hazards and the tourism system?
- 2.3. Tools – what tools are available for different situations?

2.1. First considerations

2.1.1. What scale is appropriate?

Risk assessments are useful at different scales. By its nature, a national level assessment is more generic. It relies on national averages for key climate drivers (e.g. projections of mean temperature for the whole of Thailand) and high-level factors that determine risk. Examples include population growth or patterns of internal migration (e.g. urbanization), tourism growth numbers and shifts in key markets, and changes to the use of technology as part of the visitor experience or matching demand and supply.

Asking a set of 'W'-questions helps determine the most appropriate scale and focus. Figure 7 visualizes how a national-level assessment can inform sub-sequent, context-specific destination assessments. Local assessments are able to accommodate factors, such as micro climate hazards, the local geography, economic structure, community characteristics and types of tourism. Importantly lower scale assessments can consider the specific nature of drivers of exposure and vulnerability. For example, understanding the destination-specific portfolio of tourism products (e.g. coastal or rainforest) and types of visitors (e.g. backpackers or high-end visitors) allows understanding vulnerabilities and developing detailed risk profiles.

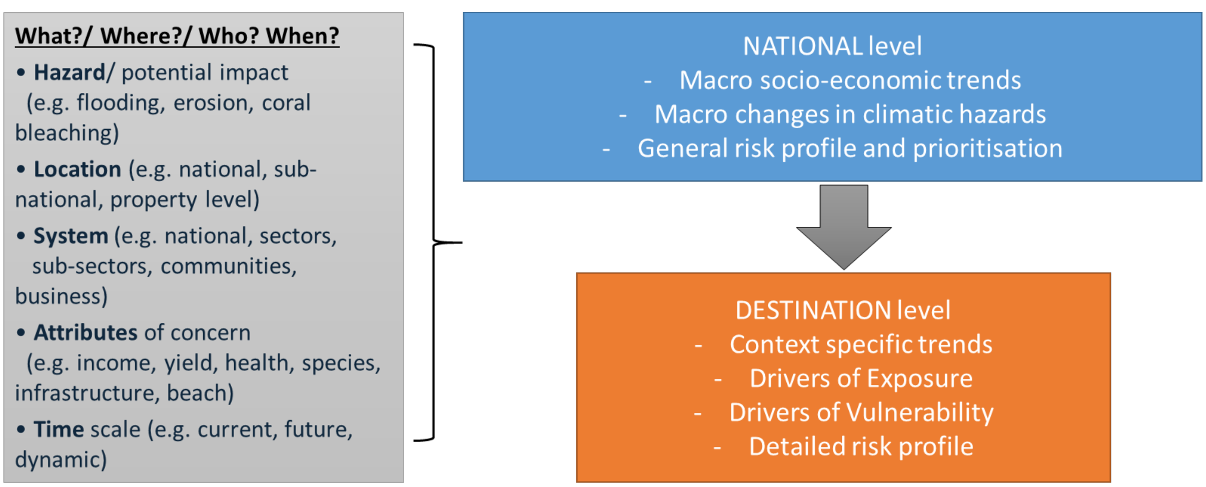


Figure 7 National level risk assessment inform more specific destination level assessments for tourism.

2.1.2. *What organisations should be involved?*

There are different types of roles and tasks involved in undertaking climate risk assessments. Identifying these can be guided by the questions below and by understanding the motivations behind the CCRA (Table 2).

1) Who is responsible for managing direct tourism risks? If climate change impacts are likely to undermine tourism economic development this should be of interest to a wide range of tourism organisations, including those linked to policy, marketing and management. The national tourism board would have a stake when key attractions are likely to be affected and marketing strategies need to be redesigned. Organisations involved in tourism training should be included as well.
2) Who is involved in managing intermediate impacts? Agencies responsible for the health of ecosystems (e.g. National Park) and land use planning are involved in managing or preventing a wide range of climate change impacts, such as those related to flooding, landslide, coastal erosion, and urban planning and zoning. Disaster risk management agencies are also heavily involved and usually take the lead on risks related to extreme and catastrophic events. Partnerships are of critical importance.
3) Who has the expertise to undertake the assessment? Expertise might sit in-house of the above organisations, or it may be recruited from outside. Providers of climate risk assessment know-how come from Universities, consulting firms or other players (e.g. international organisations or development corporations), or should be trained within relevant organisations.

Importantly, all of the above types of organisations or stakeholders are likely to play some part in the CCRA. Assessing climate risk for tourism is a collaborative effort and relies on the diverse input from multiple areas, including also the tourism industry that is frontline in dealing with climate impacts, but also the customers. Collaboration is necessary to understand, map and assess the risks, and it is of critical importance for the planning and implementation of future risk management measures.

Table 2 What are the motivations for undertaking a climate change risk assessment?

Why?	Tourism example
Define hazard magnitude	Tourism stakeholders in Thailand are well aware of the risk of flooding but they lack detailed information on where the risk is greatest, and where it poses a threat to the safety of visitors and communities.
Inform decision-making	The development of new destinations or products benefits from an understanding of future climatic conditions. For example, building design and landscaping become increasingly important due to an increasing number of hot days.
Develop policies	Policies could relate specifically to tourism (e.g. hotel standards) or other areas relevant for tourism. For example, National Parks might be closed to allow ecosystems to recover.
Raise awareness	There is an ongoing need to increase awareness and knowledge about climate change impacts tourism in Thailand, both amongst public sector officials or industry members.
Prioritise adaptation action	Investing in adaptation is costly, and robust information on adaptation priorities and expected success rates is important. Investing into water recycling, for example, could addresses the increasing risk of drought in water stressed destinations.
Monitor risks and adaptation	Monitoring the effectiveness of adaptation measures is important to continuously improve risk management, as well as help identify new risks that could affect tourism.

2.2. What kind of data are required?

A risk assessment relies on data. Data can be quantitative and qualitative, but ideally, they cover the spectrum of observed and future climate hazards, socio-economic and tourism trends. It might be useful for stakeholders who are preparing a CCRA to identify some high-level communication messages on climate change. These would then be followed by a detailed assessment of global and national climate trends and projections, which can subsequently be integrated with socio-economic data to describe future risks.

2.2.1. Global climate data

Future climate projections produced by global climate models (GCMs) are typically presented in the form of different scenarios that represent the uncertainty in GHG emissions and the response of the climate system. The IPCC Fifth Assessment Report (AR5) used Representative Concentration Pathways (RCPs) to describe different GHG emissions pathways and resulting (cumulative) atmospheric concentrations through to 2100. The RCPs include a rapid emission reduction scenario (RCP2.6, with atmospheric concentrations of CO_2 of 420 parts per million), two intermediate scenarios (RCP4.5 and RCP6.0), with concentrations between 540 and 660 ppm, and one high GHG emission scenario (RCP8.5). The RCP 4.5 scenario is consistent with the successful achievement of country pledges to the Paris Climate Agreement. RCP 8.5 represents a continuation of the current emissions trajectory (or business-as-usual) and results in CO_2 concentrations of 940ppm. To illustrate the difference between the low-emission RCP2.6 and the high-emission RCP8.5 scenario, Figure 7 shows global projections for both pathways, using three parameters of interest: surface temperature, precipitation and sea level rise. All of these parameters are also driving climate change in Thailand (see below).

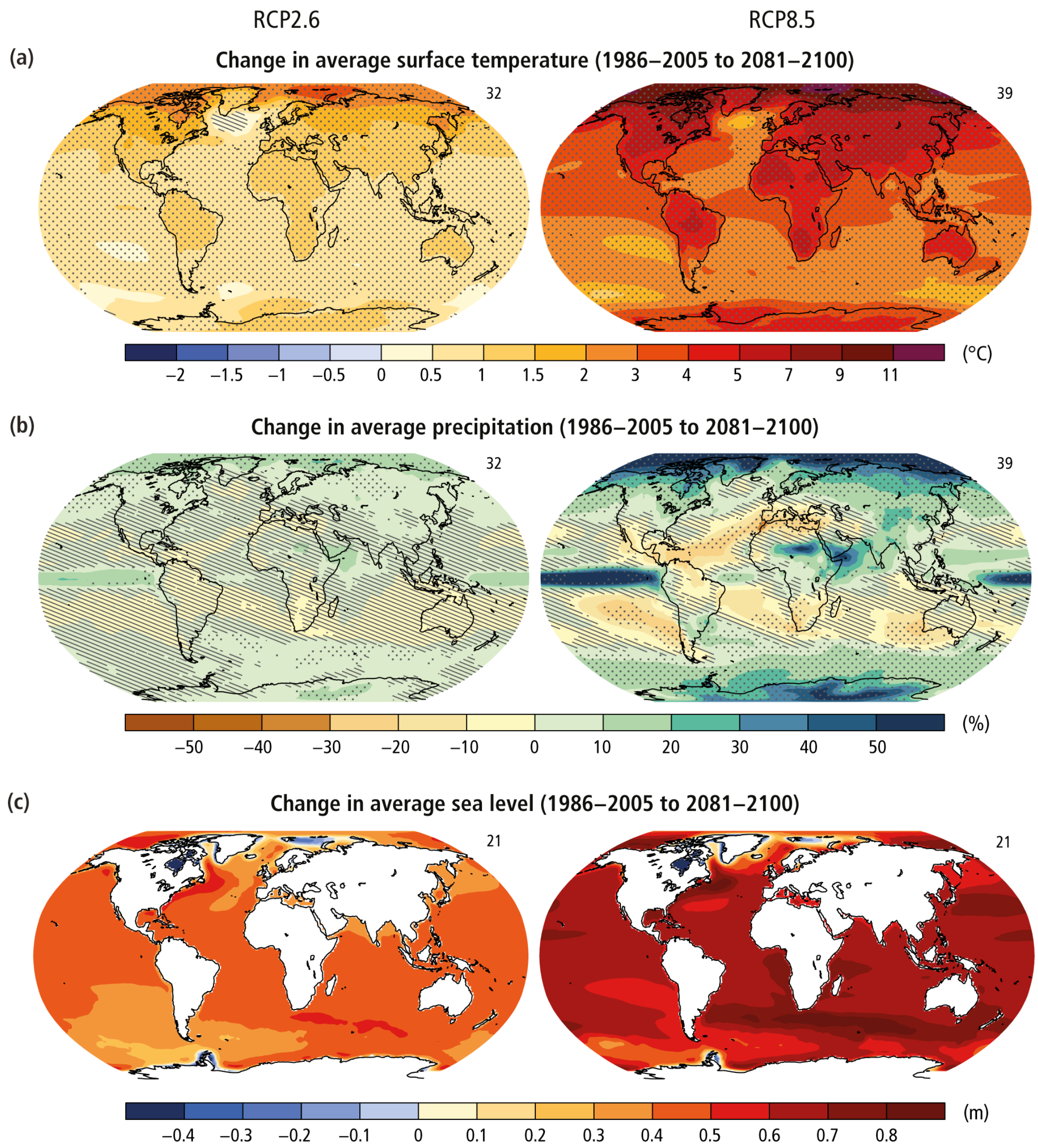


Figure 8 Projected temperature, precipitation and sea level for two emission scenarios (Source: IPCC, 2014).

Importantly, some atmospheric CO_2 measuring stations recorded a value of 410 ppm in January 2019, meaning that is very unlikely that the RCP 2.6 trajectory will still be met (NOAA, 2019). Indeed, global emission reduction commitments (as pledged by countries under the UNFCCC's Paris Agreement) are currently not ambitious enough to achieve RCP 2.6. Raftery et al. (2017) estimate the probability of achieving RCP 2.6 and the policy goal to limit global warming to 'well below' +2°C at less than 5%. Therefore, the risk assessment in this report will consider the RCP 4.5 (successful Paris Agreement) and RCP 8.5 (business-as-usual) emission trajectories.

2.2.2. Climate data for Thailand

Country-specific projections usually draw on global climate data models (or general circulation models (GCMs)). These are used to produce downscaled models to provide higher resolution outputs. There are three common approaches for downscaling GCMs: (i) GCM output combined with historical observations; (ii) statistical downscaling; and (iii) regional climate models. All of these approaches have their advantages and downsides. Regional climate models (RCMs), for example, can provide a higher resolution and can capture many regional features (including geographic and climatic), which GCMs cannot. However, RCMs are reliant on boundary conditions from GCMs (e.g., sea surface temperatures, changes in pressure patterns) and cannot correct potential errors in these boundary conditions; also, because they are commonly only run on a few GCMs projection.

Several climate change impact assessments have been undertaken in Thailand at varying scales. The climate change projections used in these studies differ due to the GCMs utilized and the downscaling techniques used. For example, the Southeast Asia Regional Centre START CC's work synthesized the key climate change trends for Thailand to enable better understanding of climate scenario data for the country (Chinvanno, 2010). The study used both statistical and dynamic downscaling, with several GCMs, to develop high-resolution climate scenarios provided through a Climate Change Data Distribution System (available for free for research). The SEACLID/CORDEX Southeast Asia program has similarly downscaled a number of CMIP5-GCMs for the Southeast Asia Region and disseminates high resolution regional climate change scenarios freely via their data portal. This program is aimed at strengthening numerical regional climate modeling and climate research capacities.

The World Bank Climate Change Knowledge Portal (WB-CCKP) provides an online platform for access to comprehensive global, regional, and country scale climate data (observed trends and future projections) that are developed to help decision makers understand the projections of future climate change and development related impacts. The portal provides projections from 35 GCMs that participated in the Coupled Model Inter-comparison Project, Phase 5 (CMIP5) and were used by the IPCC Fifth Assessment Report. Data are presented at a 1°x1° global grid spacing, which is illustrated over Thailand in Figure 9. Portal users can select an ensemble of all 35 GCMs, which is the best practise recommended by the climate science community. Alternatively, users may draw on individual GCMs, which may be of interest to compare to previous studies.

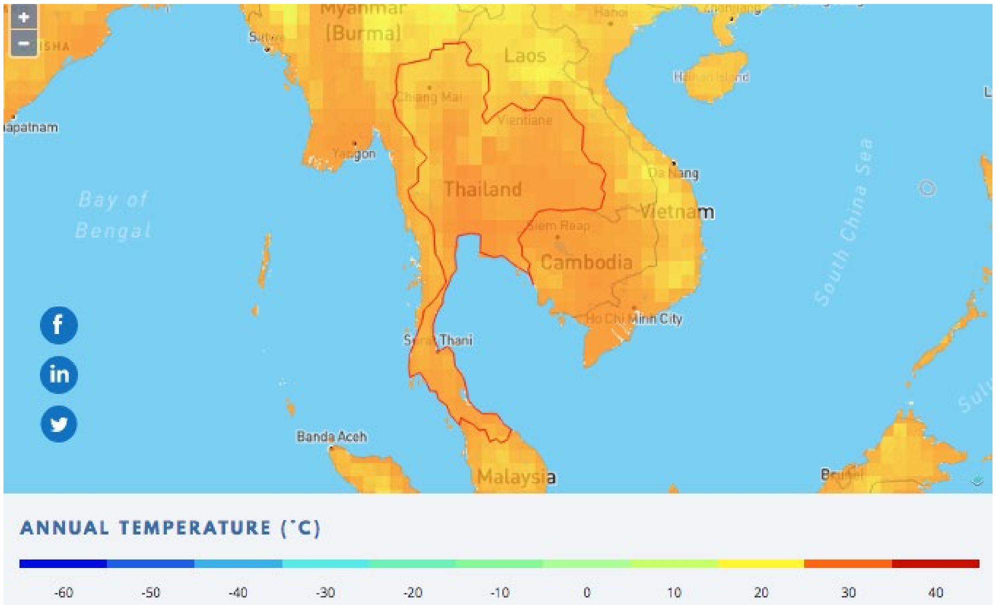


Figure 9 Spatial Resolution of World Bank Climate Change Knowledge Portal Temperature Data for Thailand for 1961-1990 (Source: World Bank Climate Change Knowledge Portal, 2019).

Portal users can select national average data or data from a grid cell closest to a specific area of interest. Historical data will go back as far as climate station data will reliably allow. Climate futures are provided for early- (2020-39), mid- (2040-59) and late-century (2080-99), with a reference period (1986-2005). The portal also provides several indicators that are useful for understanding key impacts of interest, such as extreme daytime temperature, nighttime temperatures, cooling degree days, extreme or maximum precipitation, length of dry periods and drought index. Importantly, data from the portal are provided freely under a Creative Commons Attribution 4.0 International License to access, download, and share with third parties. The climate change projections obtained from the WB-CCKP for Thailand are discussed in Chapter 5.

In order to produce global climate change projections and make relevant information more accessible a range of organisations developed online platforms (Table 3). These platforms are open source and researchers, policy makers, and other interest groups can extract information to assess projected risks, raise awareness and develop adaptation policies or measures.

Table 3 Online tools and sources for climate change related data for Thailand

Source	Content *(language EN/ THAI)*	Link
Thai Meteorological Department (TMD)	TMD provides a range of climate and weather statistics ranging back to the year 1951. *(EN/ THAI)*	www.tmd.go.th/en/
Southeast Regional Climate Downscaling (SEACLID/CORDEX) Program	SEACLID/CORDEX generated a range of downscaled climate change projections for Southeast Asia. For Thailand they downscaled the MPI-ESM-MR and EC Earth (GCMs, part of CMIP5) to a RegCM4 model for the two pathways RCP 4.5 and RCP8.5. The datasets are open-source. *(EN)*	www.ukm.edu.my/seaclid-cordex/#
Thailand Flood Monitoring System, Geo-Informatics and Space Technology Development Agency (GISTDA)	Thailand's Flood Monitoring System is an online tool enabling the user to retrieve automatically generated flood maps, based on historic flood data. GISTDA also provides a range of services, including detailed marine and GIS maps based on satellite data, which can be of importance to develop detailed flood and drought maps. *(EN/ THAI)*	http://flood.gistda.or.th/indexEN.html
Global Flood Analyzer, World Resources Institute (WRI)	WRI provides a tool that displays projected floods for different countries, estimating potential damage, affected GDP, and affected population. These get calculated according to a timeframe and the level of flood protection (resilience) that can be determined by the user. *(EN)*	https://floods.wri.org/#/country/226/Thailand
Global Flood Map	The Global Flood Map is an interactive map that shows the increase in global sea levels to assess areas affected by floods or inundations. *(EN)*	http://globalfloodmap.org
Southeast Asian SysTem for Analysis, Research, and Training network	SEA-START is part of the global START network and provides a platform to enhance data quality for potential impacts from environmental changes, including climate change, for the Southeast Asia region. On their website a range of climate change impact related publications. *(EN)*	www.start.chula.ac.th/start/ (Host: Chulalongkorn University)
Office of Natural Resources and Environmental Policy and Planning (ONEP)	ONEP, under the Ministry of Natural Resources and Environment, is Thailand's official focal point mandated to represent the country in international climate change negotiations and lead Thailand's climate change related planning processes. ONEP provides information about climate change related acts, policies, and plans. *(THAI)*	www.onep.go.th

2.2.3. Tourism data

Tourism data stem from the United Nations World Tourism Organisation (UNWTO) through the tourism barometer or the compendium of tourism statistics. Key indicators include number of arrivals, purpose of visit and expenditure. In addition, the Government of Thailand provides two main tourism databases.

1. TAT Intelligence Centre, administered by Tourism Authority of Thailand and accessible via https://intelligencecenter.tat.or.th. Data are available from 1995. Databases provided in English cover only international passengers to Thailand (port of entry), international tourist arrivals to Thailand 2018 -2019, international tourism receipts, and market profile by country. More date are available in Thai, for example on domestic tourism, licensed accommodations and attractions ('Things to do') in each city (total of 77 provinces). Each city's average hotel occupancy rate can be monitored on a monthly basis through this site (Figure 10), and this could be used to measure dispersal of tourists around Thailand. There is also a complete collection of current tourism policies and marketing strategies.

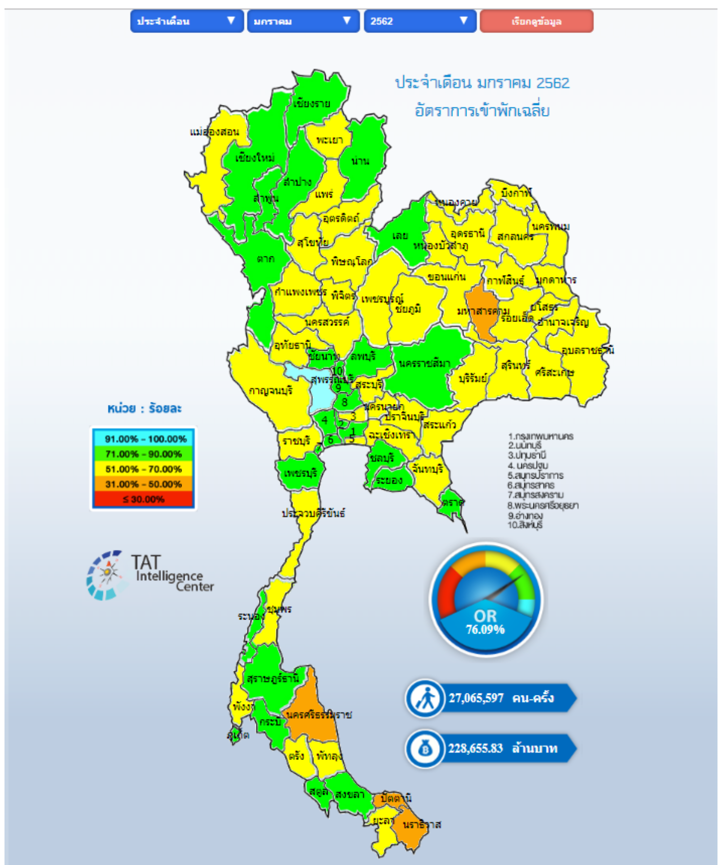


Figure 10 Screenshots of the TAT Intelligence Centre occupancy rates. Note: red means low occupancy rate (less than 30%) (Source: Tourism Authority of Thailand).

2. Thailand Tourism Intelligence Centre, administered by Ministry of Tourism and Sports (MOTS) and available on: https://thailandtic.com/th/page/item/index/id/2. However, data are presented differently on

MOTS and TAT sites. Figures 11 and 12 provide examples of how domestic tourism and the dispersal of tourists around Thailand are presented on each the MOTS and TAT platforms.

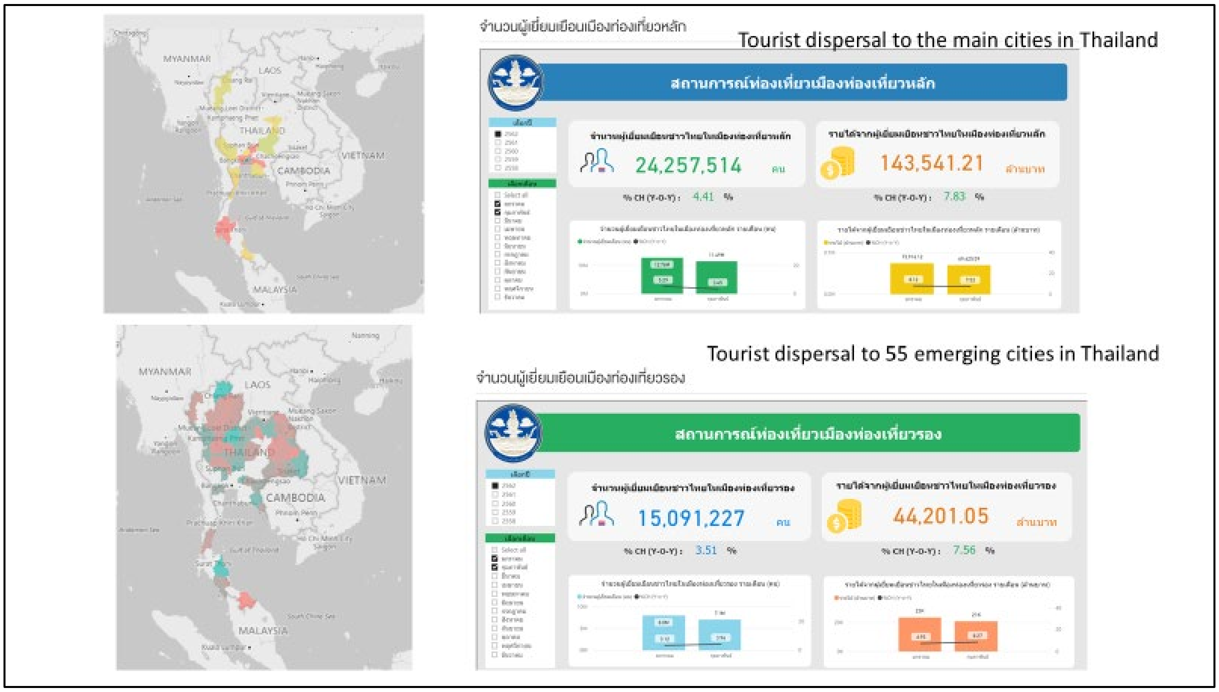


Figure 11 Dispersal of tourists in Thailand, according to the MOTS platform (Source: [https://www.thailandtic.com/th/content/category/detail/id/16/iid/46).](https://www.thailandtic.com/th/content/category/detail/id/16/iid/46)

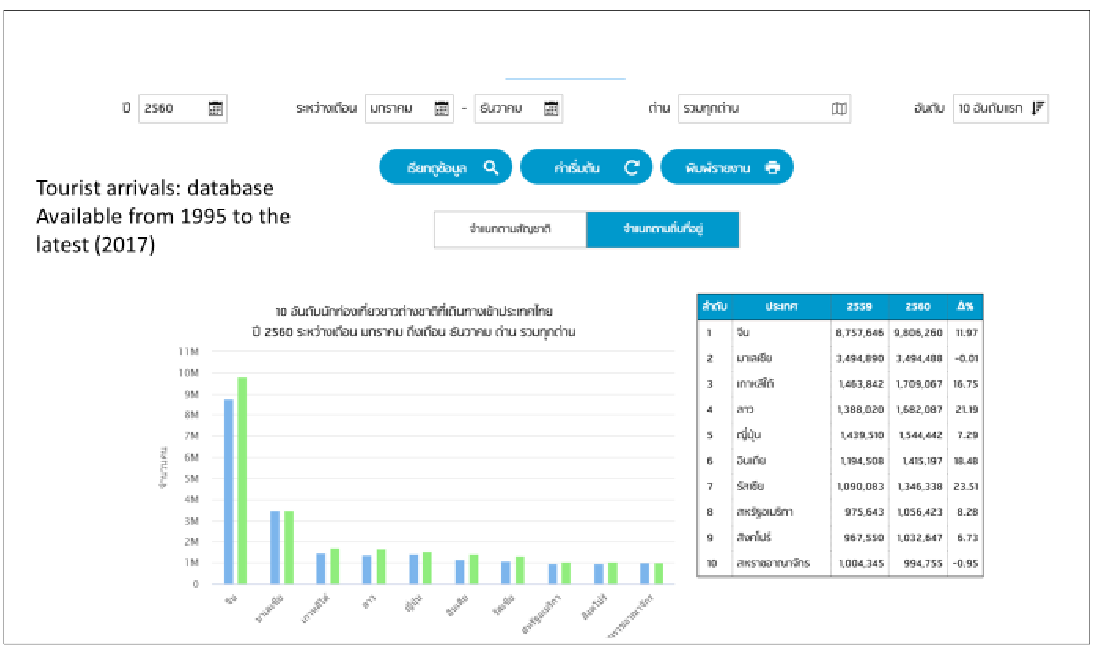


Figure 12 Dispersal of tourist according to TAT platform (Source: https://intelligencecentre.tat.or.th/articles/11851).

2.3. Tools and Approaches

The preparation of a CCRA requires consideration of the most suitable tools and approaches needed to generate data relevant for the objectives of the assessment. As discussed in section 2.1, there are several factors shaping the design of the risk assessment. To ease identifying the 'appropriate' approach, stakeholders can build up (use or modify) a range of existing tools and approaches. The subsequent section provides a brief summary of commonly used approaches and methodologies in risk assessments, whereas most risk assessments use a range of complementary methods.

Approaches and methodologies can be categorised as 'bottom-up' or 'top-down' (Figure 13), depending on the level of focus and data sources used. Commonly, 'bottom-up' approaches build on participatory methods and field research ('on-the-ground'-data) and tend to focus on ecological and socio-economic factors. 'Top-down' approaches, on the other hand often rely more on technical expertise (theoretical and desk-based) and tend to focus on physical impacts. Top-down approaches may also involve scenario analysis or economic modelling. Often, risk assessments will combine bottom-up (e.g. stakeholder consultations and community mapping exercises) and top-down approaches (e.g. different emission trajectories for impact projections).

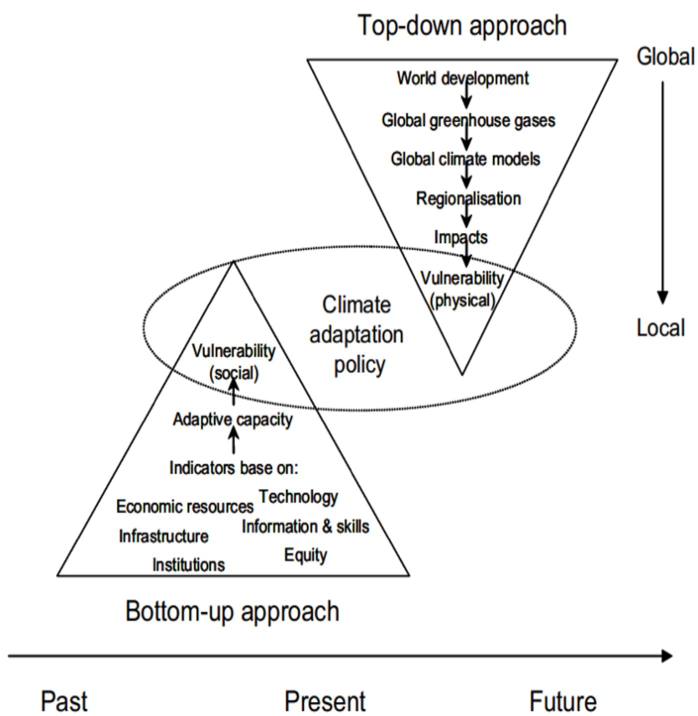


Figure 13 'Bottom-up' and 'Top-down' approaches used to inform climate adaptation policy (Source: Dessai and Hulme, 2004).

2.3.1. <u>High level planning</u>

CCRAs can be utilised to support high-level and long-term strategic planning of the tourism sector. This planning process can, for example, involve the integration of information about climate change risks into national tourism development plans or enhance regional planning and product development. High level planning commonly draws on assessing and exploring socio-economic trends (e.g. shifts in visitor mix or demography) to explore different but plausible future development pathways (scenarios).

It will become important to consider projected future climate change impacts in tourism development (alongside other natural hazards and risks pre-existent in the country/ region). This can enable high-level decision makers to mitigate potential risks in their planning phase rather than reacting to them after negative impacts evolve. For example, a country may develop new railway and road infrastructure to disperse visitor flows and promote exploring new destinations. If the country plans the location of the new transportation infrastructure without considering potential flood risks or erosion, the future occurrence of disruptions or damage of the transportation system can be disproportionally higher than if climate change projections would have informed the planning processes.

A prominent case in which climate change scenarios were used to identify adaptation options to enhance infrastructure to cope with future flood risks is the Thames Barrier in and around London (Textbox 2).

Textbox 2: Scenario-based risk assessment informed construction of Thames Barriers in London, UK

Source: Environment Agency, 2012

In 2012, the Environment Agency of the UK government published the Thames Estuary 2100 plan. To develop the plan a wide range of studies have been undertaken to gain a thorough understanding of how flood risks are managed presently, and the options and actions required to manage tidal flooding through the 2100s century. The assessment reviewed projected long-term impacts of climate change under different emission trajectories and to different planning horizons (from 2010 to 2034, 2035 to 2049, and from 2050 to 2100). Based on these assessments the plan provides indicative projected risks and recommendations for each area of the Thames Estuary. This analysis allowed an understanding of what potential risks arise for the city of London in case of global failure to reduce greenhouse gas emissions and to identify thresholds of required investments to enhance flood barriers in line with a changing climate and incrementally increasing risks.

Scenario planning relies on expert discussions and/or computer models. Key risks and impacts are identified through reviewing existing data and verifying them through expert interviews or vice-versa. The US National Park Service (2013) developed a handbook for practitioners to apply scenario-based planning for national park management. They propose a five-phased approach that takes three or more months to complete, and involves preliminary research, planning meetings, workshops, a series of strategy meetings, and monitoring.

2.3.2. Risk matrix

Risk is the combination of several factors. Prominently, risk is defined by the likelihood of an event occurring and by the extent of its impact, should it materialise. The impact itself is moderated by underlying factors of exposure and vulnerability. To determine and compare the impact of different types of risk, several earlier risk assessments have used a risk matrix (e.g. see CEC (2017), NESP Earth Systems and Climate Change Hub (2018), the Resort Municipality of Whistler (2016), and Becken et al. (2018)) composed of two dimensions:

- 'Consequence': the severity of an impact; on a three or five-level scale (high, medium and low).
- 'Likelihood': the probability with which an impact will occur. The scale involves five levels, namely: almost certain, likely, possible, unlikely, and rare.

To better grasp the two dimensions, NESP Earth Systems and Climate Change Hub (2018) suggested leaning on IUCN and IPCC definitions to assess impact severity and likelihood. More specifically, the IUCN 'scale' provides narratives to allow experts to assess the magnitude of an impact ranging from catastrophic to negligible, across a five-level scale. Additionally, the IPCC scale for assessing likelihood separates five different bands, all expressed by probabilities. For example, the likelihood of an impact happening with 'almost certainty' is expressed as being larger than 10%.

The integration of both dimensions, namely consequence and likelihood, provides an initial risk assessment (Table 4). Events that are almost certain and have a high consequence are associated with an extreme risk. Risk matrices can be developed at all levels, including at the national level to obtain an overview of key risks. They can also be used in local level assessments, for example as part of a stakeholder workshop in which potential impacts are collectively derived and then scored.

Table 4 Risk score = Consequence * Likelihood

Likelihood	**Consequence**		
	Low	*Medium*	*High*
Rare	Low	Low	Moderate
Unlikely	Low	Moderate	Moderate
Possible	Moderate	Moderate	High
Likely	Moderate	High	Extreme
Almost certain	High	Extreme	Extreme

2.3.3. Mapping (GIS or other)

Mapping of observed and projected impacts (e.g. future scenarios) is a common approach in climate risk assessments. Maps can draw on satellite and remote sensing data, climate change models, visualise results of indicator-based approaches, or can be developed in a participatory manner. Geographic Information Systems (GIS) are a methodology to prepare digital maps from these different data sources. GIS-based approaches often overlay different maps (layers of investigation) and enable communication of risks to a wide range of an audience. Figure 14 shows how a hazard map (visualising drought-prone areas) is overlaid with a vulnerability map to develop a risk map for an island in Indonesia.

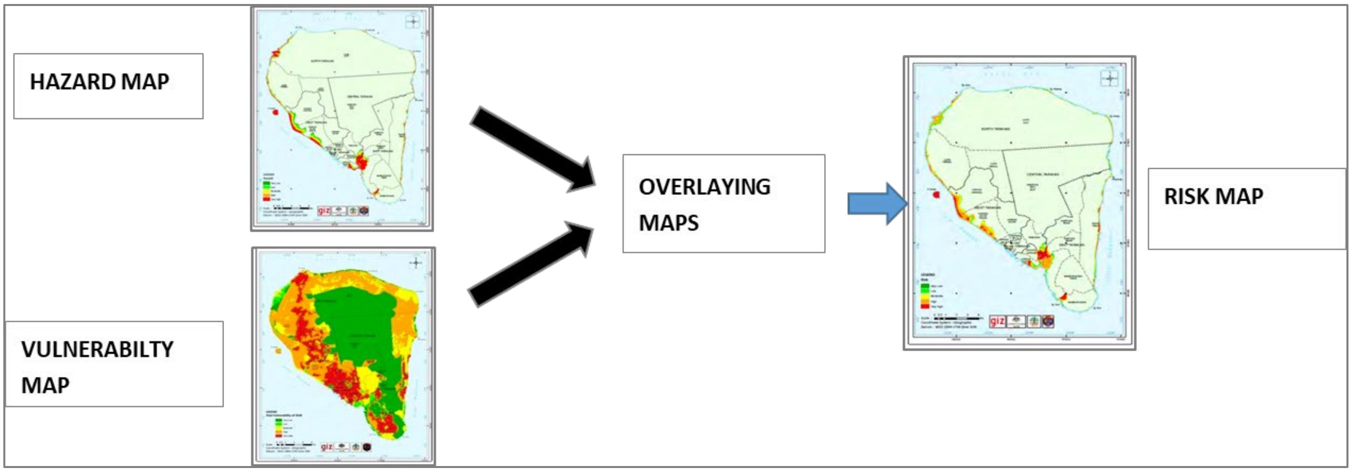


Figure 14 Hazard, vulnerability, and risk maps (Source: adapted from RCCAP and Indonesian Ministry of Environment, 2012).

2.3.4. <u>Indicator based</u>

Indicator-based risk assessments utilise a range of proxy-indicators to quantify outputs in perspective to a predetermined scale (e.g. high risk =1; low risk =0). This is a widely used methodology, commonly used for international indices and rankings of countries in perspective to living standards, ease of doing business, and human development. The most renowned international index for climate change is the Climate Risk Index, which is published by German Watch annually and displayed as a ranking and in map format.

Textbox 3: Water Risk Monetizer

Source: Ecolab (Source: https://en-nz.ecolab.com/sustainability/water-risk-monetizer)

The Water Risk Monetizer, developed by Ecolab and Trucost, is a publicly available and open-source tool to inform business decisions related to water-related risks in financial terms based on readily available information about water use, water costs, revenue, and production projections at individual facility and enterprise levels. The user can choose different water scarcity scenarios and a projected available water and associated cost increases will be generated. This tool has been used by hotels in various destinations.

2.3.5. Participatory methods

The majority of climate change risk assessments are participatory. Depending on the political and/or sectoral level of the assessment, a range of stakeholders will be involved in the process of collecting, and maybe interpreting, data. These often include experts, decision makers, officials, sector representatives, business man/ women, or community members. Most common forms of stakeholder engagement are surveys, interviews, workshops, focus group discussions, or mapping exercises. Table 5 showcases a range of potential participatory methodologies that can be used in climate change risk assessments.

The involvement of different stakeholders can have significant advantages. The stakeholders often represent a rich source of context specific knowledge, in some communities' oral story telling or songs are preserving memories about previous disasters and response strategies over centuries (e.g. Mercer et al., 2007). Also, public officials, sector representatives, and other key stakeholders often have insights and knowledge that cannot be found through literature reviews, particularly if language barriers are existent. Another benefit is that stakeholder engagement enables empowerment, and this is particularly important for groups or minorities that often have no voice or limited opportunity to provide input. Empowerment also increases the sense of ownership.

Table 5 Overview of selected participatory methodologies

Method	Approach
Climate Risk Mapping	Stakeholders (e.g. experts or community members) identify areas that were historically (previous events) impacted, e.g. by floods or coral bleaching, or which they perceive as being particularly vulnerable or exposed (e.g. because of many weak building structures are located close to the shoreline).
Historic transect	The facilitators asked stakeholders (e.g. a local hotel owner or community) to show him/her which places in the area have historically been affected by (climate change related) hazards, such as coastal erosion, or floods.
Climate hazard ranking	Stakeholders rank climate change hazards in line with their perception about how likely (likelihood) these hazards will cause impacts and how severe the impact will be (level of consequence). This can be combined with ranking the preferred adaptation action to cope with each hazard.
Historic and future timelines	Stakeholders describe historic experiences with certain hazards (capture dates and magnitude) and their response strategies (how did they cope with the hazards). This can provide some insights about trends, as well as map adaptation actions that are already being implemented. In a next step future climate scenarios and trends can be jointly discussed as well as potential alternative response strategies (adaptation options).

3. Approach taken for this National-Level Risk Assessment

Building on the six-step framework presented earlier (Figure 5), this section discusses the specific methods used to produce a CCRA for Thailand's tourism sector. Broadly, the approach builds on CEC's (2017) recommendation to undertake a risk assessment in a collaborative manner that involves a wide range of experts, decision makers and stakeholders. By doing so the input will be more varied and richer, but at the same time, the assessment serves the purpose of creating a common understanding, empowering people and building capacity.

3.1. Literature review of relevant climate impacts

To identify the range and severity of past climatic events, an extensive literature review was undertaken. The review began with a generic internet search to identify prominent reports or research papers, and this was then followed by further search based on the reference lists of these primary outputs. In other words, a method similar to the snowballing technique was implemented. The literature review focused on:

- Research on climatic events in Thailand
- Geographically differentiated climate hazards and risks;
- Climate projections for Thailand
- Climate impacts on tourism
- Types of metrics used in climate assessments in Thailand;
- Other relevant literature that provides insights into macro trends and the tourism system

In addition to understanding how climate change will manifest in Thailand, examining the tourism system was necessary to establish a baseline for understanding climate-tourism interactions and dependencies. More specifically, it allows the assessment of climatic hazards in a more focused manner. For example, much of tourism in Thailand occurs in coastal areas, meaning that marine impacts are of great relevance for tourism.

A considerable amount of literature was available in English language. Often, these sources referred to key findings from research reports written in Thai, for example in relation to the results generated in climate modelling exercises (e.g. number of days > 35 degrees). In these cases, the original sources are also referenced here, even though the original version in Thai was not read. In some cases, the Thai members of the team helped to translate text or extract key messages.

3.2. Tourism climate impact statements and risk matrix

Building on the above literature review on climatic changes in Thailand, and also drawing on the international literature on climate change and tourism (e.g. Becken & Hay, 2012; Jopp et al., 2010; Jopp et al., 2013; Rutty & Scott, 2016; Scott et al., 2008; Simpson et al., 2008), a series of climate risk statements for Thai tourism could be developed. These were further checked against input from key stakeholders who have knoeledge of previous climate events that affected tourism (e.g. DoT, ONEP, GIZ).

Following the approach of the Queensland Tourism Climate Change Response Plan (Becken et al., 2018), statements were proposed that linked a potential climate hazard with an impact and risk to particular elements of the tourism system (see also Table 4 earlier). These statements, shown in the middle circle in Figure 15, were then presented to stakeholders in an exercise of risk prioritisation. We presented verbal descriptors for the magnitude of impact, offering three levels of impact, namely high, medium and low. Participants assessed probability using the descriptors: Almost certain, likely, possible, unlikely and rare.

Figure 15 Linking climate hazards and macro drivers to specific tourism risks and impacts to enable a process of prioritisation and risk management, including climate change adaptation.

3.3. Stakeholder participation

3.3.1. Workshop

A stakeholder workshop in February was held to communicate the purpose of the project but also to collect information and input from a wide range of stakeholders. Table 6 summarizes the representatives from the various organisations. The stakeholders participated in several tasks that informed this CCRA (see Photo 1).

1. Previous impacts: Participants were asked to break out into groups to discuss experiences and cases of weather events affecting tourism in the past. Specific questions related to a) What happened?, b) Where did it happen? (place on a map) c) How did it affect tourism? And d) What was done?
2. Risk Matrix: In groups of three, participants had to rank hazards (based on their previous experience) by likelihood of occurrence and severity of impact. More specifically, they were asked to discuss the impact statements prepared before the workshop, rank them, and include additional hazards that were not on the list. The risk prioritization task using a risk matrix followed the method described earlier and also applied in CEC (2017), NESP Earth Systems and Climate Change Hub (2018), the Resort Municipality of Whistler (2016), and Becken et al. (2018).
3. Benefits of tourism: Group discussion on what Thailand seeks to achieve from tourism development, and how climate change could undermine the achievement of these goals. Participants were also invited to consider what needs to be in place to manage risks?

Table 6 Participants at the 7-8 February workshop in Bangkok

Organization	**Number of participants**
Climate Change Management and Coordination Division, ONEP	10
Biodiversity Management Division, ONEP	1
Division of Tourism Professional Development, DOT	1
Management System Development Group, DOT	2
Division of Attraction Development, DOT	6
Office of Secretary, DOT	1
Tourism Service Development Division, DOT	2
Division of Tourism Business and Guide Registration, DOT	2
Division of Tourism and Sports Economics, Office of the Permanent Secretary, Tourism and Sports	1
Strategy and Planning Division, Office of the Permanent Secretary, Tourism and Sports	2
Department of Water Resource	1
Department of Public Works and Town & Country Planning (DPT)	1
Department of National Parks, Wildlife and Plant Conservation (DNP)	1
Department of Disaster Prevention and Mitigation (DDPM)	2
Office of the National Economic and Social Development Council (NESDB)	2
Thailand Development Research Institute (TDRI)	4
Thailand Greenhouse Gas Management Organization (TGO)	2
Designated Areas for Sustainable Tourism Administration (DASTA)	1
Tourism Authority of Thailand (TAT)	2
Tourism Council of Thailand (TCT)	1
Association of Thai Travel Agents (ATTA)	1
Perfect Link Consulting Group Co. Ltd.	2
Professional Tourist Guides Association of Thailand	1
Naresuan University	1
Pacific Asia Travel Association (PATA)	2
Thailand Community based Tourism Institute (CBT-I)	1
the Project for Promoting Sustainability in Future Cities of Thailand (TFCP)	2
Department of Agricultural Extension	2
Fine Arts Department	1
Faculty of Economics, Thammasat University	2
Southeast Asia START (SEA START)	1
Total	61

In addition, a stakeholder workshop and training on the 4 June helped to collect feedback on proposed tourism indicators that help monitor climate risk.

Photo 1 Mapping previous climatic events – stakeholder exercise (8 Feb 2019).

3.3.2. Stakeholder surveys

Insights were gained from a survey of tourist accommodation providers in two provinces, namely Krabi and Surat Thani. Here, 193 valid surveys were conducted with accommodation owners-managers in Koh Tao (n=112; representing a 56% coverage) and Koh Phi Phi (n=81; representing a 67.5% coverage), based on self-completion questionnaires. The work forms part of a doctoral thesis by one of the team members (Janto S. Hess) and preliminary results were used as part of this CCRA. The study aims to investigate the potential recognition of climate change (and associated risks) in strategic investment decisions by accommodation suppliers in a small island context.

3.4. Assessing exposure and vulnerability

The risk prioritization using the two dimensions of consequence/impact and likelihood is an important step towards prioritizing risks. When stakeholders rate these dimensions they implicitly consider the various inputs that form risk. In particular, they will think about specific climate hazards and their probability of occurrence. They will also think about particular communities or elements-at-risk, and imagine how severely these might be affected. For example, the risk of coastal inundation will be juxtaposed with the stakeholder's knowledge of coastal infrastructure, villages, tourism activity and the extent to which they might be affected. The rating does not demand that the participant makes these considerations explicit; rather it represents a holistic assessment that integrates these factors in a thought process.

However, it is important to understand the underlying drivers of risk and impact more explicitly. As outlined earlier, the level of risk is shaped by the exposure and vulnerability of a system/unit at stake (e.g. a tourism destination). Therefore, following the overall assessment of the 'likelihood' and 'consequence' of a particular risk, was important to examine the key 'modifiers'. For example, the timeframe of a hazard (e.g., acute or incremental; reoccurring frequently or infrequently), trends (e.g., declining or accelerating), scale (e.g. local or national), or other compounding factors increase or decrease risk (for more detail see the approach described in NESP Earth Systems and Climate Change Hub, 2018). In particular, the vulnerability of the system/unit depends on its adaptive capacity.

This current assessment draws on existing tourism data/statistics and understanding to make some informed decisions on macro trends (e.g. growth, shift in markets, type of products) and drivers that affect exposures and vulnerabilities. At a later stage, and for a more context-specific, local risk assessment, it would be useful to conduct interviews with key informants who can provide more detail on the drivers of exposure and vulnerability in a particular destination.

4. The Thai Tourism System

Thailand has become one of the most frequently visited and popular tourism destinations in Southeast Asia. The “Land of Smiles” attracts visitors with its excellent food, a welcoming society, a year-round favourable climate, and a diverse landscape of beaches, islands, and mountains. The country created a total of 147 national parks, including 22 national marine parks. These attractions, in combination with strategic marketing campaigns and easy access through relaxed visa regulations, have led to sustained tourism growth since the 1990s. Tourism has seen a 485% increase between 1997 and 2017, reaching more than 35 million visitors in 2017. In 2017, the tourism sector provided 15.5% (5,834,000 jobs) of total employment in Thailand and contributed with (USD 95.0bn) to 21.2% of the country’s GDP (World Travel and Tourism Council, 2018).

The climate risks to Thailand’s tourism system are driven by socio-economic, climatic, and geographic factors, and Figure 16 below provides an overview of Thailand’s tourism system. The economic importance of tourism indicates that climate change induced risks to tourism represents a risk to the whole country.

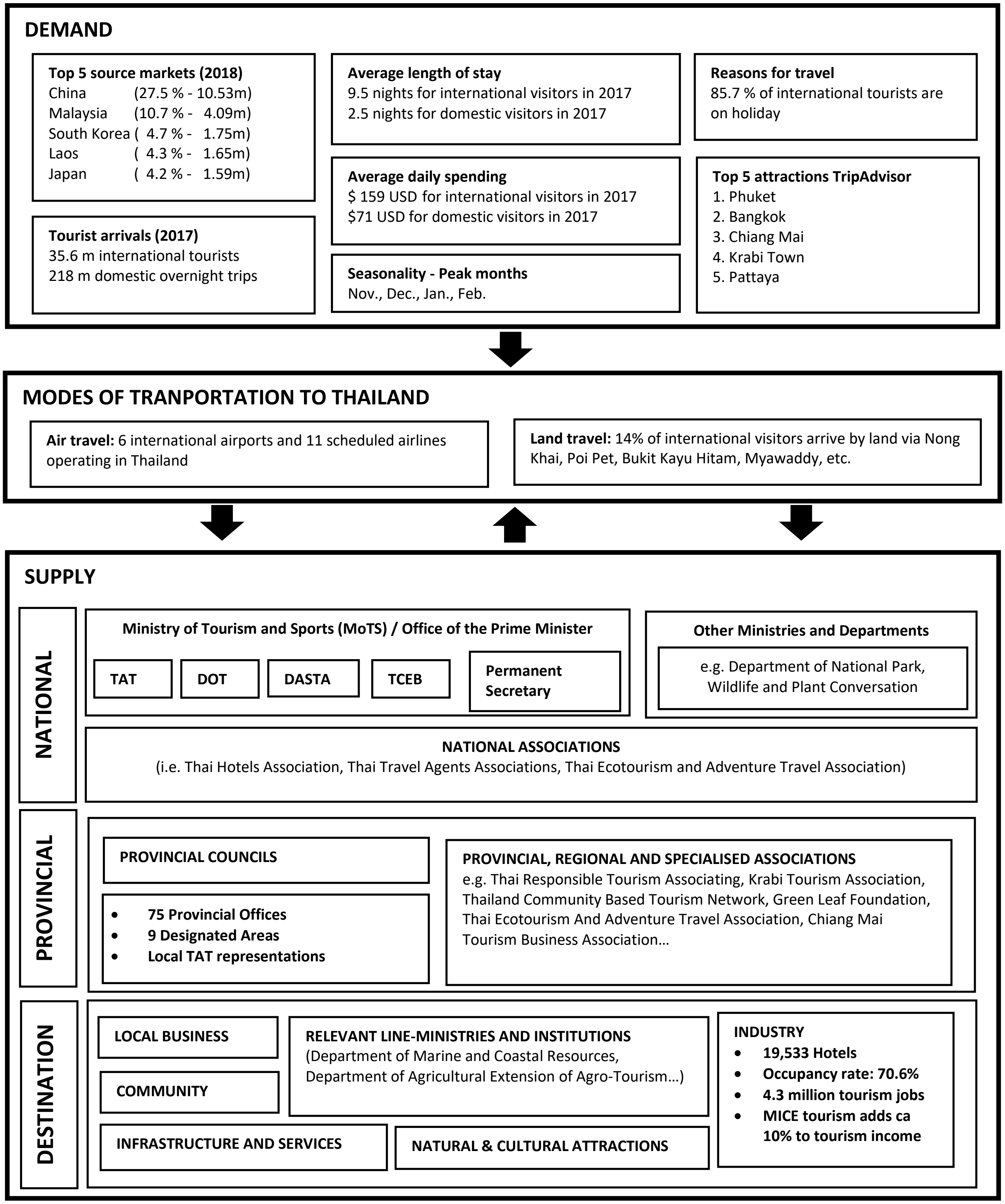


Figure 16 The Thai Tourism System (Source: design adopted from Tam (2019) and Klint et al. (2012).

4.1. Geographic Profile

The geographic features of the Kingdom of Thailand, with an extensive coastline, are a main reason why the country is repeatedly listed as being among the most vulnerable country's to climate change globally. Thailand is located in Southeast Asia and shares land borders with Laos, Malaysia, Myanmar, and Cambodia (see Figure 17). Its long-stretched land mass comprises 513,000 km^2 and is adjacent to two oceans, the Indian Ocean (Andaman sea) and the Gulf of Thailand. The elevation of the country ranges from predominantly flat central areas, e.g. the Chao Phraya river basin, to some Plateaus in the north-east, and some highlands in the northwest of Thailand, with mountains up to 2,565 m above sea level (Nations Encyclopedia, 2018).

The long-stretch of the country from north to south and a total of 936 islands spattered on its terrain leads to an extensive coastline of 3,219 km (Nations Encyclopedia, 2018). This coastline and islands with attractive beaches are a main tourism magnet of the country. A total of 25 river basin systems, including 254 sub-basins, pervade Thailand's mainland, of which the Chao Phraya and Mekong River systems are the major ones. The Chao Phraya River system define much of northern and central Thailand's geography and covers, with its tributaries, around 35 % of the nation's land. These low-lying areas are prone to flooding during the monsoon season. On the contrary the northern parts of the Chao Phraya river basin, as well as the northeastern region of Thailand tend to experience drought during the hot season.

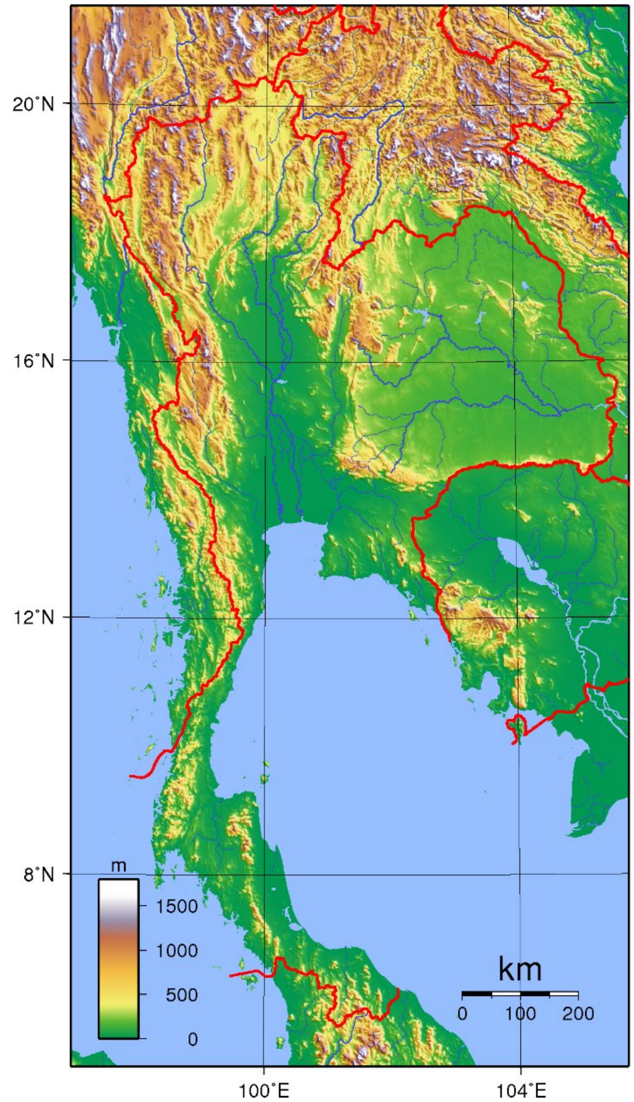


Figure 17 Topographic map of Thailand (Source: Created with GMT from publicly released GLOBE data by Sadalmelik, 2007 [https://commons.wikimedia.org/wiki/File:Thailand_Topography.png]).

4.2. Socio-economic Trends in Thailand

Socio-economic trends in a country can exacerbate the exposure of a tourism system to climate change threats (e.g. increasing densely populated urban areas along the coastline) or increase the adaptive capacity (e.g. if more financial resources are being made available to invest in adaptation measures). The ability of the industry to cope with climate change pressures is influenced by the level of education, poverty rates, religion and belief systems (e.g. fatalism), building standards and infrastructure, quality of healthcare and hospital coverage, as well as how well natural resources are preserved and managed (e.g. snorkelling in marine protected areas).

With over 69 million inhabitants, Thailand was ranked the 20th most populous country around the globe (The World Factbook, 2016). Roughly two thirds of the population live in rural areas and one third are inhabitant in urban spaces, including 15 million people that live in the Bangkok Metropolitan Region (BMR) (National Statistical Office, 2016) (Figure 18). The concentration of the population in few urban areas influenced investment dynamics with most industries being located, or having their headquarters, in the BMR. The associated infrastructure development (including touristic infrastructure) in Bangkok led to a large area of sealed surfaces, which increases vulnerability to climate change, for example through hindering rainwater from draining or trapping the heat.

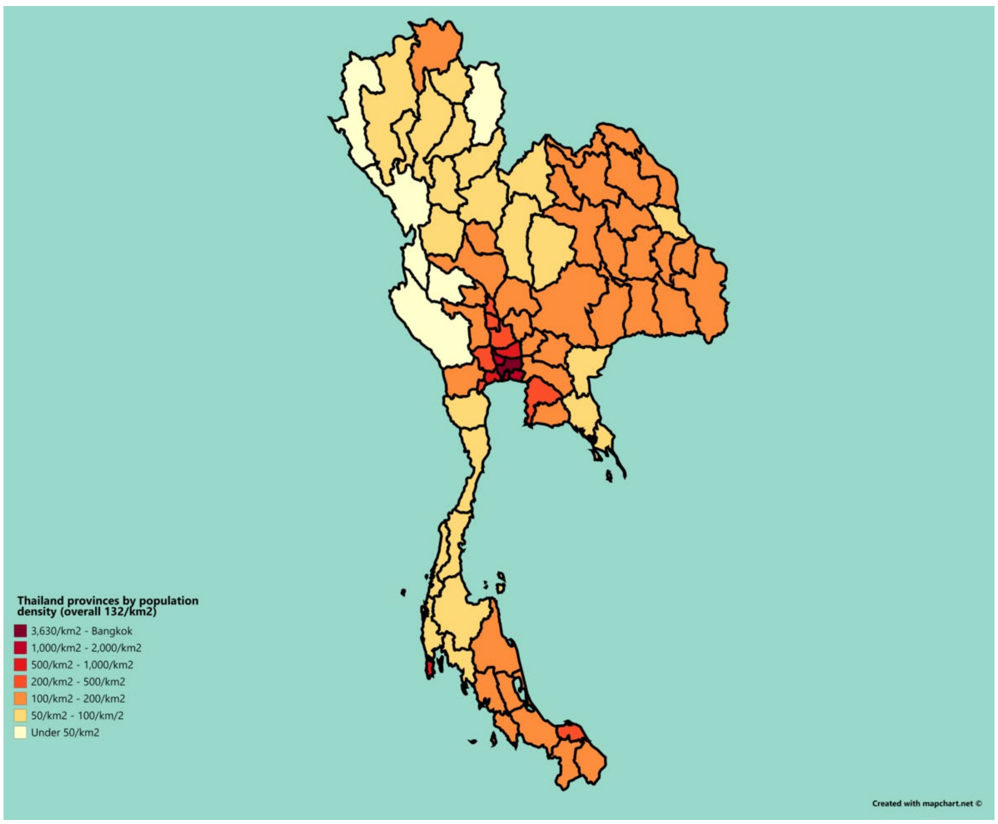


Figure 18 Population density of provinces in Thailand (2017) (Source: Wikimedia Commons, https://commons.wikimedia.org/wiki/File:Thailand_provinces_by_population_density.png).

The majority of the nation are Buddhist (94.6 %) and stem from the Thai ethnic group (97.6 %) (CIA, n.d.), whereas a minority of Muslims (around 4.3 %) reside mainly in southern Thailand (CIA, n.d.). The Buddhist philosophy of Karma (collecting good deeds) is often associated with the image of the ‘welcoming society’ (land of smiles) towards international visitors. Whilst Thailand’s overall literacy rate is high with 92.9 % in 2015, it ranks second-lowest among Asian countries in English language proficiency (World Bank, 2019).

Thailand is categorised as an emerging economy, with a GDP of $455.22 billion in 2017. Between 1985 and 1996 (until the Asian financial crisis in 1997), Thailand experienced a period of high economic growth with an average growth of approximately 12% per year. The current growth rates since 2010 fluctuated between 0.8% and 7.5%. Average GNI per capita amounted to $5,911 in 2017 (see Table 7). This continuous growth and development facilitate a growing middle class and, consequently an increasing number of domestic travellers. Importantly, and highly relevant for considerations of risks associated with tourism, there is another trend influencing the characteristics of domestic travellers. Thailand is an ageing society with the lowest population growth rate (0.3% per annum) and the second lowest total fertility rate (1.5) in Southeast Asia (UNESCAP, 2016). This is in line with a wider global tourism trend of increasing numbers of older travellers ('golden agers'). Whilst this market segment has a higher propensity to spend, they may also require special arrangements to care for health and safety.

The service sector contributes over half (55.6 %) to the country's GDP, compared with the industrial sector with 36.2 % (2017 est.) and the agricultural sector with 8.2 % (CIA, n.d.). The service sector has the highest growth rates in Thailand's economic structure, with the growth being largely fuelled by an expanding tourism industry. Possibly an important enabling factor of this growth is Thailand's excellent Internet coverage throughout all industrialised areas and tourism destinations. Thailand is ranked sixth out of all Asian countries in terms of the fastest internet speed available (Thai Tech, 2015).

Table 7 Basic socio-economic statistics of Thailand between 2010 and 2018 (World Bank, 2019)

	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Growth rate (%)	7.51	0.84	7.24	2.73	0.91	2.94	3.24	3.9
GDP (current US$ billion)	341.11	370.82	397,56	420.53	406.52	399.24	407.03	455.22
GDP/ capita (current US$)	5,075	5,491	5,860	6,171	5,942	5,815	5,911	N/A
GNI/ capita, Atlas method (US$)	4,580	4,950	5,520	5,730	5,750	5,690	5,640	5,960
Population (in million)	67.21	67.53	67.84	68.14	68.42	68.65	68.86	69.04

Considering this general socio-economic background, it is apparent that the following trends are relevant for a tourism CCRA:

- Increased development in locations exposed to climate or other environmental hazards;
- High population density in few coastal and urban areas, exacerbated by seasonally high visitor volumes;
- Relatively growing economic importance of the service sector, including tourism;
- Thailand has an aging society and growing middle class, which leads to more domestic travellers;
- Good Internet coverage and speed.

The above trends have the potential to shape the values or benefits that Thailand can generate through tourism, in particular, considering that the country's economic development and employment are increasingly driven by tourism. International tourism is of importance due to its ability to generate export earnings. However, this growth comes with an increasing level of tourism activity in exposed zones, for example coasts.

It also adds pressure on the environment, which undermines the resilience of ecosystems to respond to climate change. Thus, over-reliance on tourism for the national economy represents a risk when the competitiveness of the destination is likely to be eroded by climate change impacts. Examples include declines of coral reefs and other ecosystems, growing problems of air pollution, and uncomfortable weather conditions for visitors in popular destinations (see Rutty & Scott, 2016). The latter is particularly problematic for an aging cohort of travellers and those who visit specifically for purposes of medical treatment.

Improving technological infrastructure, in particular the Internet, provides additional adaptive capacity when systems are used to, for example, provide better information to the tourism industry and visitors, including early warnings of extreme weather events, but also other communication related to behaviours and adaptation measures (e.g. how to keep cool, or how to save water). The low English language proficiency could potentially lead to difficulties during disaster communication and recovery efforts.

4.3. Tourism infrastructure and geographic distribution

4.3.1. Concentration versus dispersal

Visitor flows in Thailand are unevenly distributed, with a predominant preference of tourists for the 'beach and sun' tourism segment, offered by Thailand's island and coastlines in the south of the country. In 2015, the majority of tourists (77% of total arrivals) visited the southern region, while only 1.4 million (5%) visited the northern region (Ministry of Tourism and Sports, 2017). Apart from the coasts, Bangkok attracts a large number of visitors and was identified as being the most visited city in the world for three consecutive years (trailed by London and Paris) (Talty, 2018). Similarly, some cities renowned for their cultural highlights, such as Ayutthaya, Sukhothai, and Chiang Mai, attract a large number of visitors. This shows a concentration of visitors at tourism hotspots putting particular pressure on the resource base of selected areas.

The visitor flows are also influenced by the quality of tourism infrastructure, such as transportation networks or the range of offered accommodations and services. In total, Thailand has 4,127 km (2017) of railways and 101 airports (in 2013), out of which 63 have paved runways (CIA, n.d.). Out of these airports, six accommodate inter-continental flights (Figure 19). These shape the accessibility of international travel in favour of the existing hot spots, and disincentivising travel to the North-East of Thailand. With ever-increasing visitor numbers, this concentration of tourism is challenging the carrying capacities and the local infrastructure of some destinations. This already leads to negative cultural and environmental impacts. In light of climate change, this concentration of tourism in exposed geographical locations is increasing vulnerability.

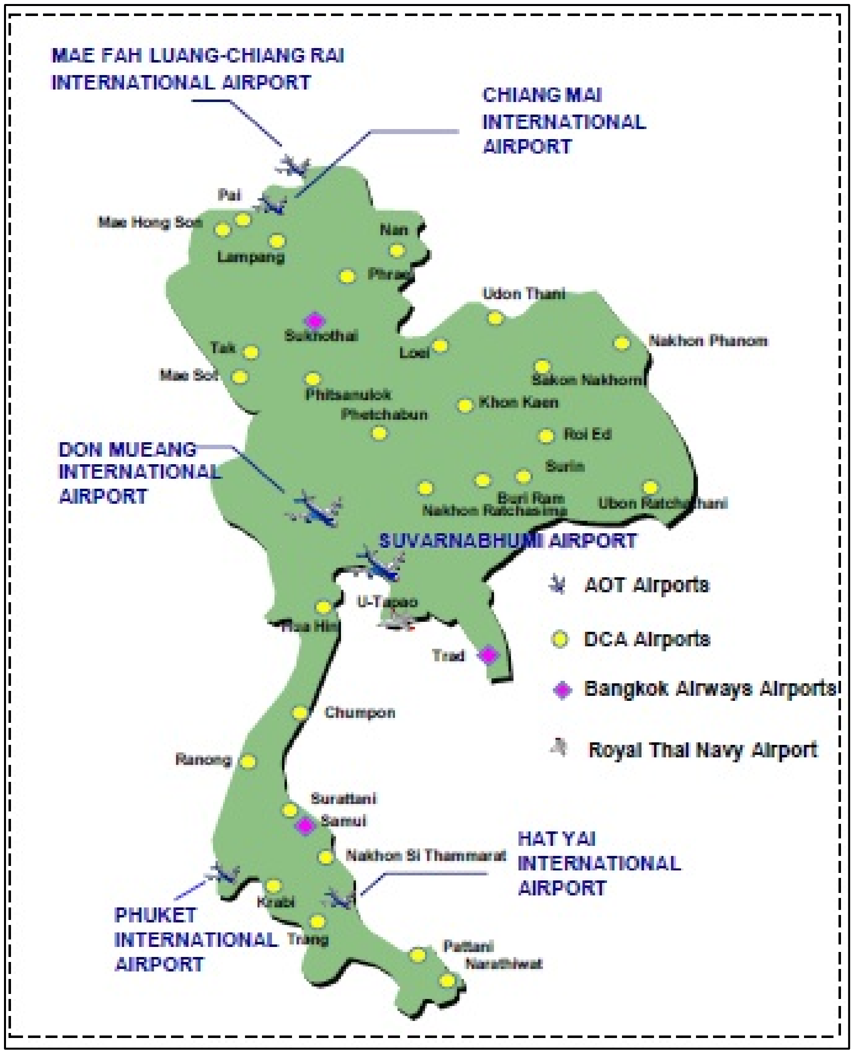


Figure 19 Map of international airports (Source: AOT, 2016)

The high number of visitors puts significant pressure on the ecosystems. Studies of reef ecosystems, for example, have shown that the increasing numbers of snorkelers and divers inevitably disturb and damage marine plants and animals (e.g. Wongthong & Harvey, 2014; Hoeksema et al., 2013). It is apparent that already weakened marine ecosystems, including corals, are more vulnerable to climate change impacts. Other impacts of high tourism concentrations in hotspots include: excessive water demand (which can increase the vulnerability of the destinations during climate-induced dry periods), increased congestion (which could amplify risks for any kind of sudden extreme weather event such as floods), and increases in the need for tourism infrastructure to be built in risk prone locations (e.g. hotels on low-lying beaches).

4.3.2. <u>Development patterns and risk</u>

The current development patterns in many shoreline destinations are likely to increase exposure to climate change hazards. Particularly islands face higher risks from climate change hazards, which are amplified through the siting of the tourism infrastructure and growth paradigms. Photo 2 below shows two of

Thailand's highly visited tourism islands, namely Koh Phi Phi Don (on the Andaman Coast) and Koh Tao (in the Gulf of Thailand). It is apparent from the pictures that the location of the tourism infrastructure will determine the level of exposure to climate hazards, such as sea level rise, extreme rain events, or tropical storms leading to coastal erosion. Koh Phi Phi Don has a total area of 12.25 km^2 and has an unusual topography as the island is split in two parts that are connected by a narrow flat sandy strip. This topography led to the development of nearly the entire infrastructure (village, accommodations, restaurants, etc.) of the island on the sandy strip that connects the two hilly limestone islands, as well as gives access to the beaches of Ton Sai Bay and Loh Dalum Bay.

The exposure of the low-lying sandy strip to ocean swells was tragically exemplified during the Tsunami in 2004. During the event, nearly the entire tourism infrastructure on the strip was damaged. The up to 6m high waves led to severe damage and a loss of around 70% of all prior available guest rooms on the island (Calgaro et al., 2009). The island received approximately 1.2 million visitors annually prior the Tsunami (Dodds, 2010). The reconstruction of the infrastructure was undertaken rapidly in the same location where the previous accommodations were sited. In addition, new accommodations and infrastructure was being developed and the total number of accommodation businesses more than doubled with an estimated 10,000 guests visiting the Phi Phi Islands per day during high season (Department of Public Works and Town and Country Planning, 2005) (GoKohPhiPhi, 2007). The (re-)development pattern on the island significantly increases the exposure of the infrastructure to climate change hazards.

Tourism infrastructure on Koh Tao, on the other hand, is located both at sea level and on higher elevated areas. The island has an area of 21 km^2 and consists of granitic hills that are up to 379m above sea level. While the tourism infrastructure on Koh Tao is potentially less exposed to climate hazards, such as coastal erosion, the islands main tourism segment, namely dive tourism, is arguably more exposed to increases of average sea water temperatures, coral bleaching, and ocean acidification, than the 'mass tourism' segment Koh Phi Phi Don targets.

Both islands share, however, that their small size and location of being relatively isolated (far from the mainland) makes them highly dependent on their limited fresh water reserves. With increasing visitor numbers and local populations (of permanent residents and seasonal workers), the likelihood of facing negative impacts (i.e. the risk) from climate induced dry periods (or droughts) increases.

Photo 2 Pictures of Koh Phi Phi Don (Andaman Coast) and Koh Tao (Gulf of Thailand).

The above cases exemplify how development patterns of tourism infrastructure, tourism segments, and the growth of visitor numbers shape the vulnerability of specific locations of Thailand to climate change impacts. These factors should be incorporated in future tourism development planning in order to reduce risks and to manage, rather than respond to trends and hazards.

4.4. Types of tourism and trends

4.4.1. International tourism

Inbound tourism to Thailand has increased, particular due to growing arrivals from East Asia and the Pacific (mainly China). Figure 20 shows inbound tourism trends for the last five years.

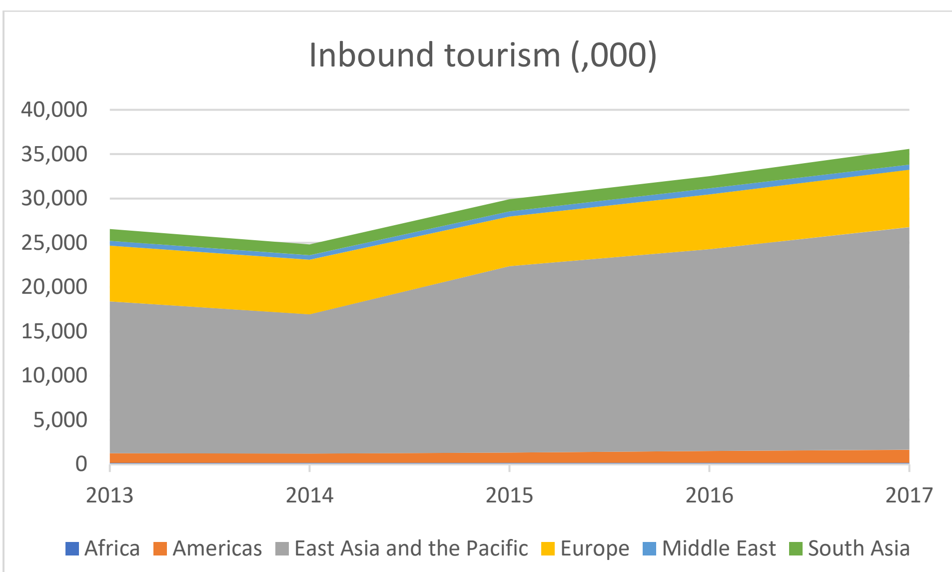


Figure 20 International arrivals to Thailand by region of origin (Source: UNWTO, 2018).

The majority (namely 88%) of visitors to Thailand come for holiday reasons, whilst about 9% visit for business (Figure 21). Of all visitors, 85% arrive by plane, with 14% getting to Thailand by road and 1.4% on the water. UNWTO statistics also reveal that three quarters of international tourists (74.3%) travel independently, with the remainder being part of a package tour. The number of package tourists has remained relatively stable, whereas other forms of travel have increased. It is not clear whether package tourists are more or less vulnerable to climate change impacts than free independent travellers. The literature indicates that those booking package tours tend to be more risk adverse (meaning they might change destination easier if they have a negative perception); on the other hand they travel in a more predictable and manageable manner and should be accompanied by a knowledgeable tour guide. The latter would make them relatively less vulnerable.

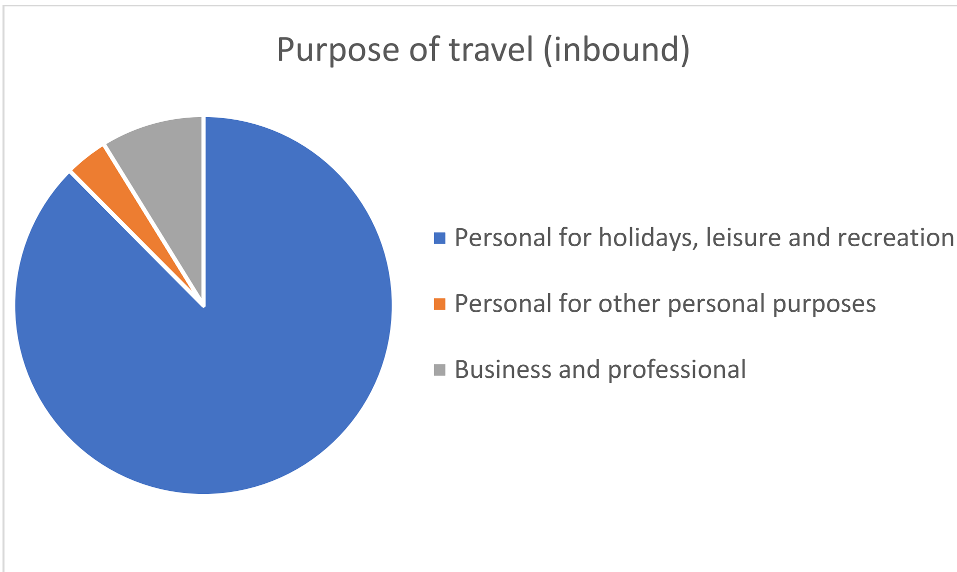


Figure 21 Purpose of travel of international visitors to Thailand in 2013 (Source: UNWTO, 2018).

Considering growth in tourism, international expenditure has increased to a level of $62 billion in 2017 (Figure 22). However, spend per person saw some decline in recent years, with a sudden increase again in 2017. Considerations of expenditure per visitor are of critical importance when moving from a volume-driven approach to one that is more focused on value.

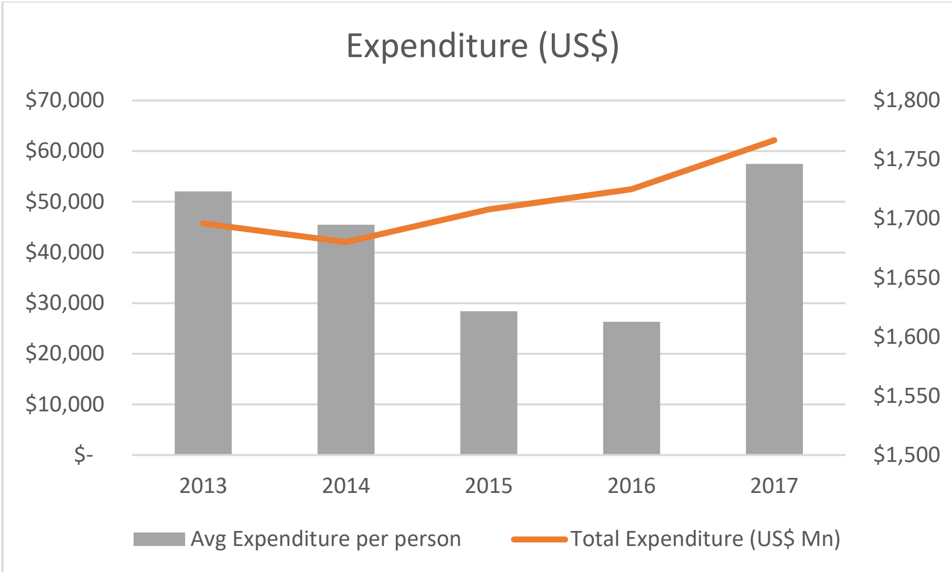


Figure 22 Expenditure by international visitors to Thailand (Source: UNWTO, 2018).

4.4.2. Domestic tourism

As in most countries, domestic tourism far outweighs international tourism in terms of volume. Figure 23 shows the extent of domestic tourism activity over the last five years, relative to international arrivals. Total numbers reached 218 million, with the larger contribution being from domestic overnight visitors (57.6%).

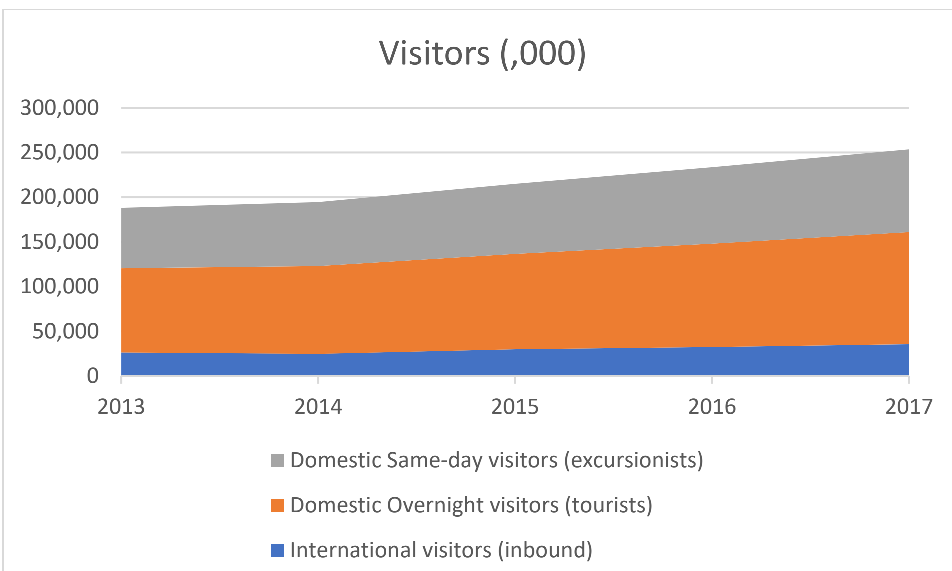


Figure 23 Growth in domestic visitation in Thailand (Source: UNWTO, 2018).

One major difference between domestic and international tourists is their length of stay. Figure 24 shows a comparison of the average number of nights spent on a trip for these two market segments. Importantly, for both groups, the trip length has slightly decreased in recent years. This undermines a value-based approach where longer trips generate higher yield.

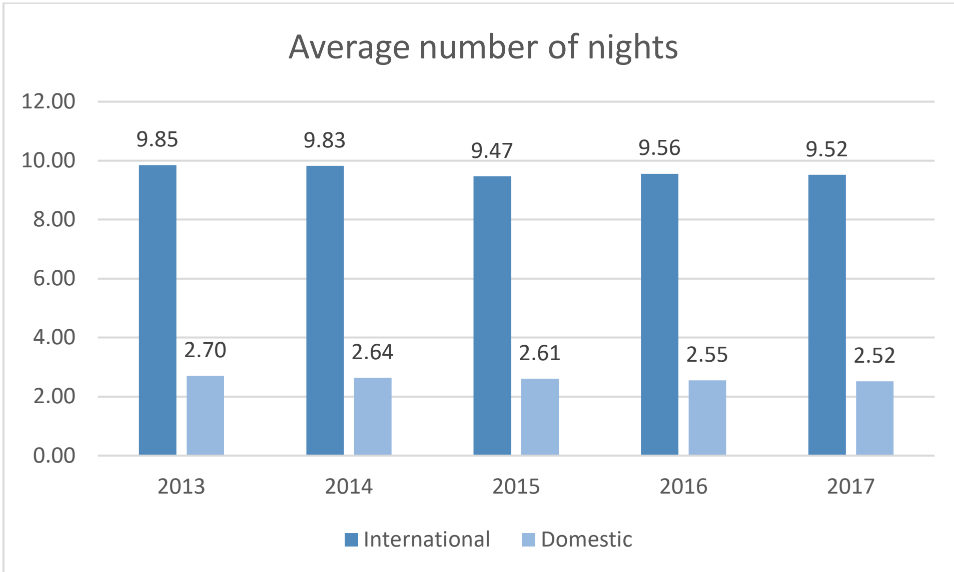


Figure 24 Length of trip by international and domestic visitors in Thailand (Source: UNWTO, 2018).

In line with shorter stays, domestic visitors also spend less per trip in Thailand. They also chose different types of activities, regions and products, which manifests in a lower daily spend compared with international tourists. Figure 25 presents daily expenditure by international and domestic segments. It is understandable that a substantial focus is on international tourism due to its higher expenditure and ability to generate export earnings. However, when the volume is considered as well, domestic tourism becomes a defining force for most regions in Thailand. As elsewhere in the world, the value of domestic tourism is grossly underestimated. In terms of vulnerability, domestic tourists are more likely to be familiar with hazards and necessary context of emergency situations and are likely to be more effective in their (protective) responses. This includes the ability to speak the local language, understand relevant communication channels, and skills to interpret the geography and climatic drivers.

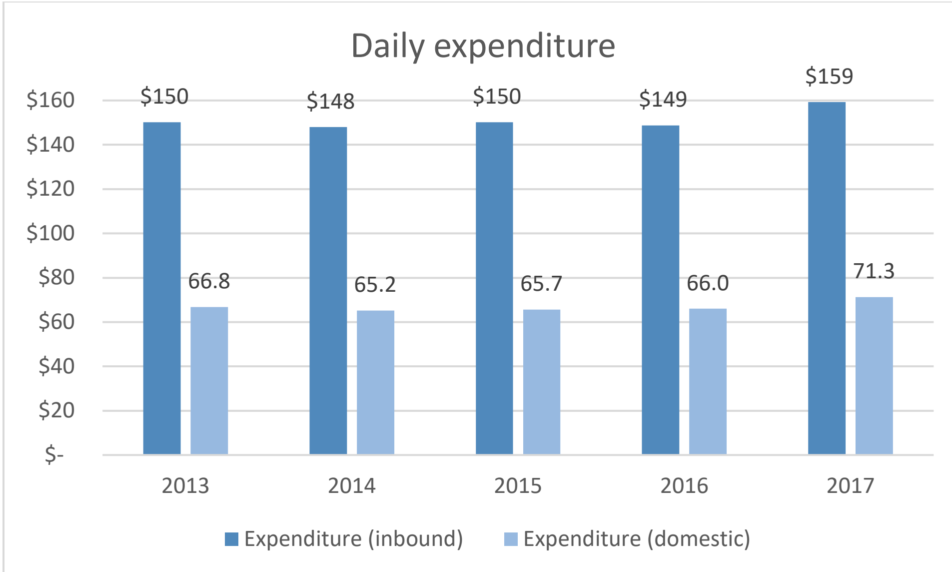


Figure 25 Daily expenditure by international and domestic visitors in Thailand (Source: UNWTO, 2018).

4.4.3. <u>Strategy and anticipated trends</u>

Future resilience to climate change of Thailand's tourism sector will be influenced by the government's strategies and plans to deal with anticipated trends. Developing and implementing regulatory frameworks, including a wide range of instruments (e.g. incentives) is an important step to future-proof tourism. The current guiding document is the 2nd National Tourism Development Plan (2017-2021). The plan outlines the government's vision for future development, which states that by 2036:

> *"Thailand will be a world leading quality destination, through balanced development while leveraging Thainess to contribute significantly to the country's socio-economic development and wealth distribution inclusively and sustainably". (Ministry of Tourism and Sports, 2017, p. 13)*

To reach this vision, five strategies were developed (see also Textbox 3), namely:

(i) Development of tourism attractions, products and services including the encouragement of sustainability, environmental friendly, and Thainess integrity of attractions;

(ii) Development and improvement of supporting infrastructure and amenities without inflicting negative impact to the local communities and environment;

(iii) Development of tourism human capital's potential and the development of tourism consciousness among Thai citizens;

(iv) Creation of balance between tourist target groups through targeted marketing that embraces Thainess and creation of confidence among tourists; and

(v) Organization of collaboration and integration among public sectors, private sectors and general public in tourism development and management including international cooperation.

Textbox 3: Thailand's 2nd National Tourism Development Plan

Source: Ministry of Tourism and Sports, 2017

To ensure ability to monitor progress, the 5-year strategic objectives are accompanied by key performance indicators (Figure 26). These objectives and indicators show that climate change is not yet sufficiently mainstreamed into tourism development planning processes in Thailand. The current strategies do not address this gap sufficiently and future revisions would need to incorporate climate relevant factors, ideally cutting across all five strategies, and not just in the sustainability focused objective.

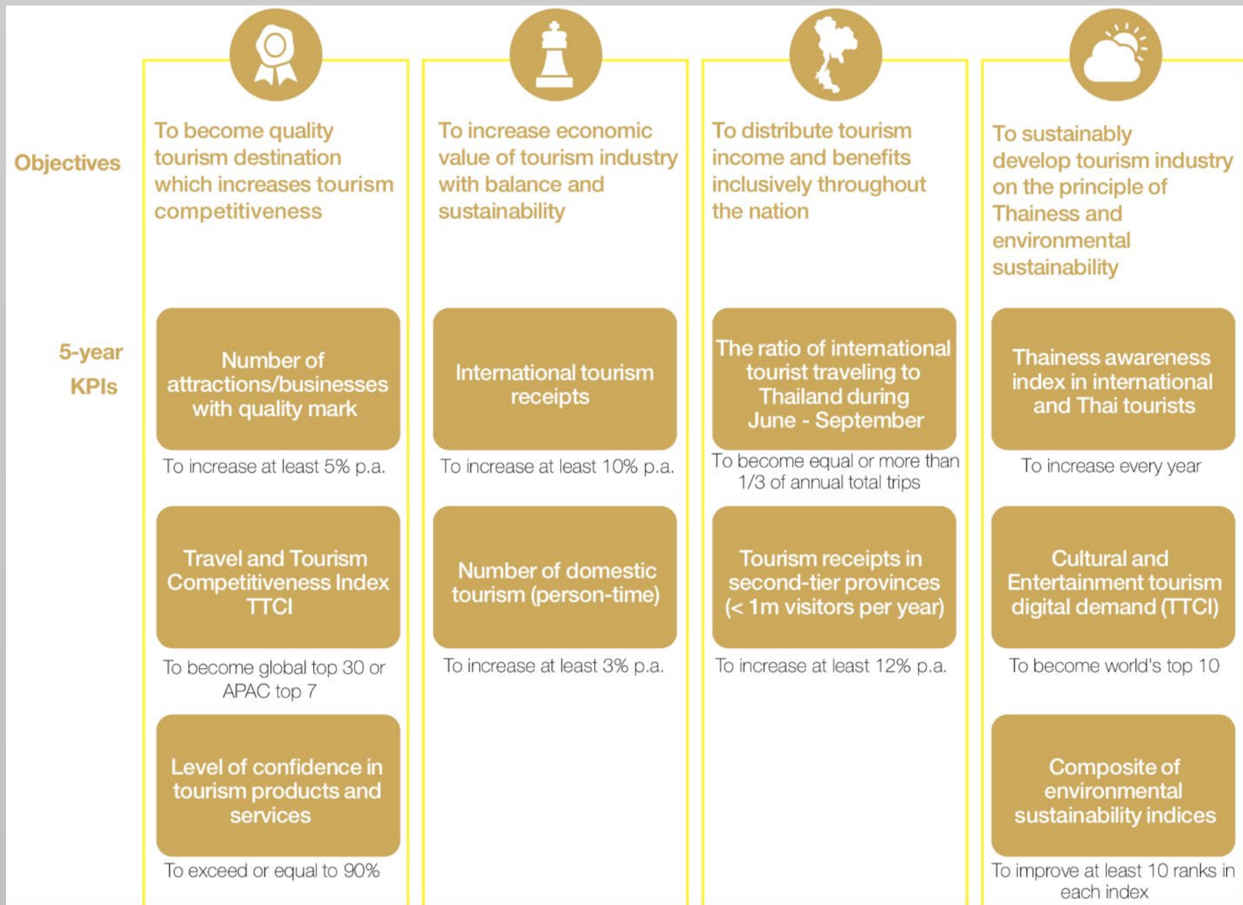


Figure 26 Thailand's tourism's 5-year strategic objectives and targets (Source: MOTS, 2017, p. 18).

In-line with this new development plan, the government promotes a diversification of visitor flows through the development of 55 secondary cities to proactively manage increasing visitor numbers and create a more balanced distribution of tourists. The Tourism Authority of Thailand (TAT) launched domestic activities to invite tourists to "Visit a Secondary City: Must Try, Must Love and Must Care" by focusing on promoting low-carbon tourism in the secondary destinations as well as promoting and creating awareness of eco-friendly tourism. Figure 27 shows the location of these 55 secondary destinations (on a provincial level), which already hosted 2,288,164 international tourists in the first half of 2018 (TAT Intelligence Centre (TATIC), 2019). The top five source markets were Lao PDR (513,046), China (235,573), United Kingdom (110,942), Germany (103,912), and France (84,380).

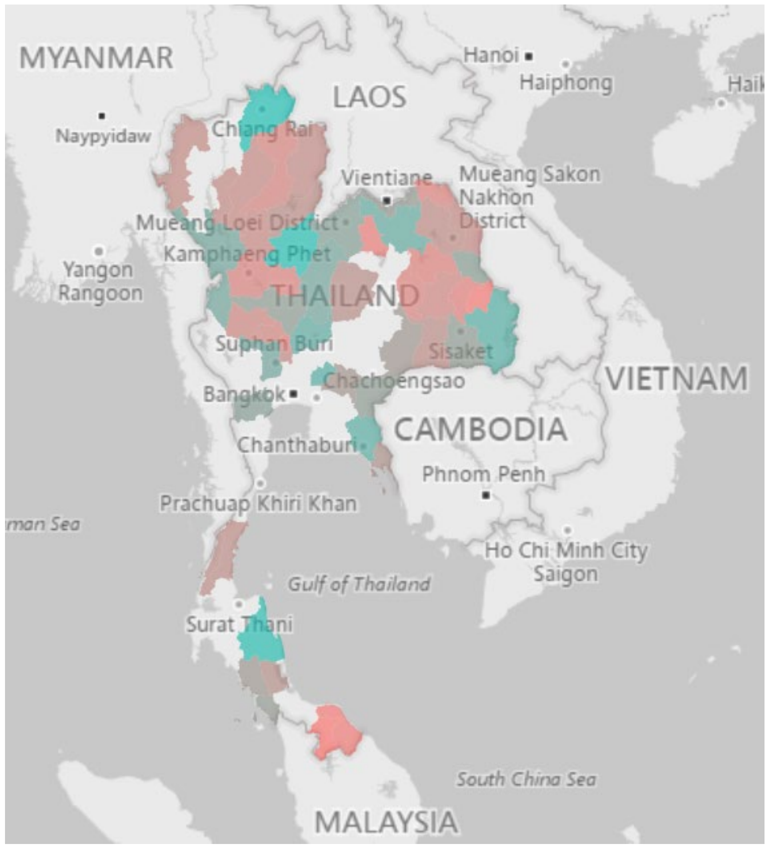


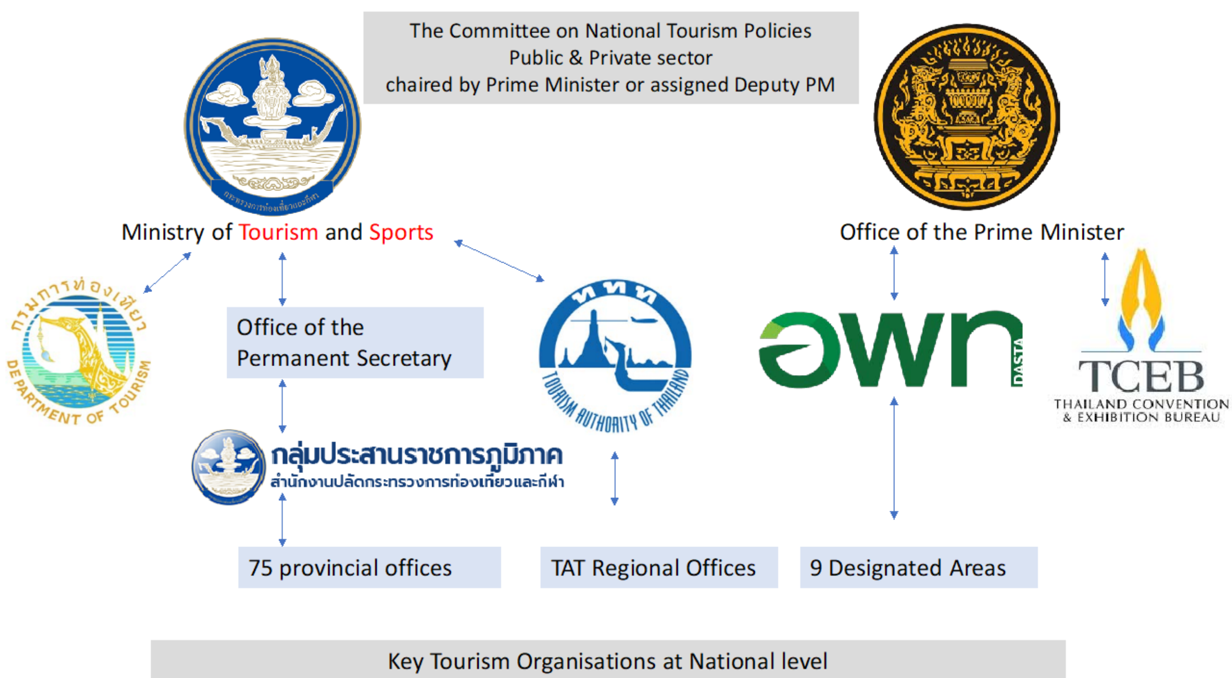
Figure 27 Secondary (N= 55) Destinations on a provincial level (Source: TAT Intelligence Centre, 2019).

In addition to the development of secondary destinations, DASTA promotes community-based tourism alongside, creative tourism, and low carbon destinations as part of their key strategy towards more sustainability. They implemented these alternative management models and approaches in selected/ designated destinations as learning sites. The development of new tourism products (especially targeting local communities without adequate tourism infrastructure) and diversification of visitor flows to alternative destinations poses the risks to increase the vulnerability of the locals and destinations to climate change impacts if these hazards are not taken into account early on in the process. However, it likewise provides the opportunity to facilitate development processes in a climate resilient manner, e.g. to provide building regulations and development zoning plans that consider potential hazards, integrate up-to-date sustainable building design, water efficiency measures, and to enable an uptake of risk-transfer mechanisms (insurances).

Thailand's is striving to become more technology and innovation driven as a nation in their development trajectory. In order to facilitate such a process, the current government introduced the concept of 'Thailand 4.0' as a paradigm towards boosting the quality of life. Thailand 4.0 targets, through different support programs, 10 key economic sectors and provides US$1 billion for research through 12,290 new PhD positions. The realisation of the Thailand 4.0 aspirations appears challenging and requires more advancements in the field of improving language skills, promoting farmers' capacity building processes to take up new technologies, and fostering critical thinking to trigger innovation and creativity (Jones & Pimdee, 2017).

4.5. Tourism sector – institutional arrangements

The tourism sector in Thailand is composed of a wide range of government and private sector organisations. Within the public sector, the Prime Minister chairs the Committee on National Tourism Policies. Figure 28 visualises the structure of Government organisations and their vertical integration. The existence of multiple regional representations is of critical importance as vulnerability assessments and adaptation measures, whilst driven by national policy and programs (including funding), are most likely being implemented at the regional and local levels.



Note: MOTS is responsible for both tourism and sports, there is also department of sports

Figure 28 Overview of public sector tourism organisations.

Each of the Organisations shown in Figure 28 above have a designated role and responsibilities. Figure 29 summarises these for Designated Areas for Sustainable Tourism Administration (DASTA), TAT, and MOTS.

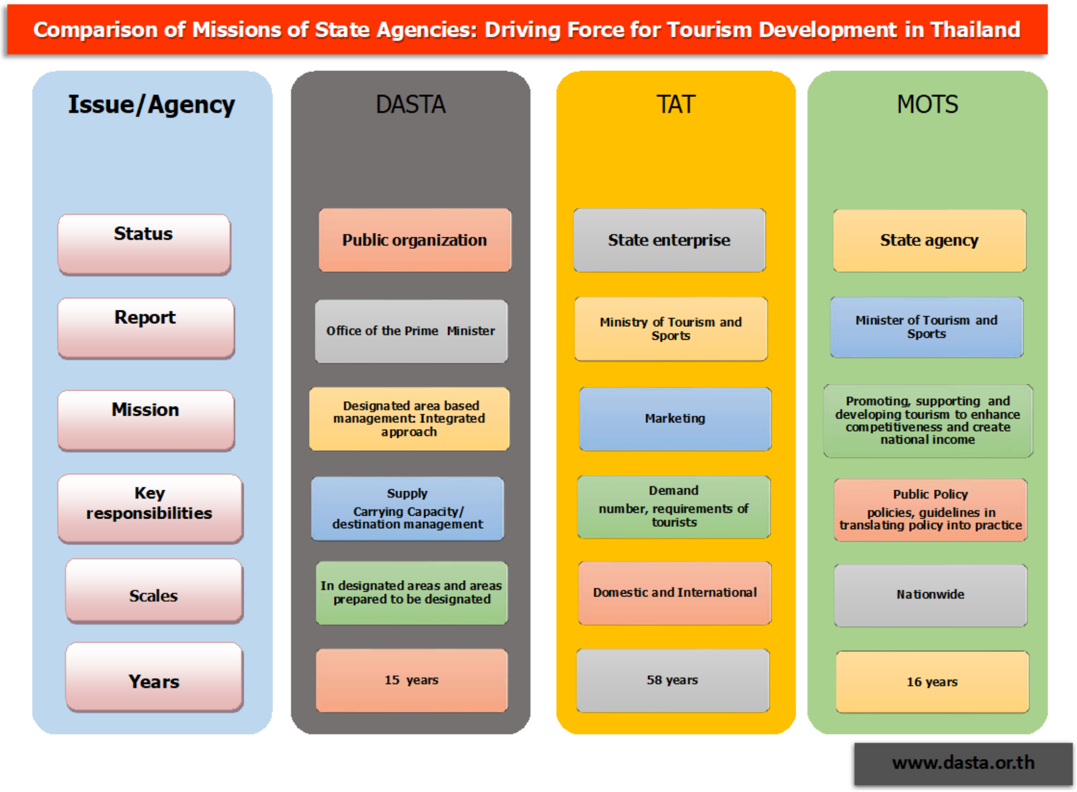


Figure 29 Roles and responsibilities of key public sector tourism agencies (Source: DASTA).

In terms of addressing climate change and tourism, the above organisations or agencies are likely to have different types of involvements. These will be discussed in a separate report on mainstreaming climate change into tourism policy making. In addition to tourism agencies, climate change policy 'for tourism' is also likely to occur in non-tourism agencies, for example those related to land/nature management or disaster risk reduction.

Public sector activities need to be supported and complemented by private sector stakeholders and organisations. Relevant umbrella bodies include: Association of Domestic Travel (ADT), Association of Thai Travel Agents (ATTA), Thai Hotels Association (THA) and the Thai Ecotourism and Adventure Travel Association (TEATA).

At an international level, ASEAN (Tourism Competitiveness Committee, Sustainable and Inclusive Tourism Development Committee, Tourism Resourcing, and Monitoring and Evaluation Committee, Tourism Professional Monitoring Committee) plays an important role of leadership and guidance.

5. Climate Change Trends and Projections in Thailand

The interface between climate and tourism is multifaceted and complex. Climate has direct and significant effects on tourism operators, destinations and tourists, influencing destination assets, competitiveness and tourist demand patterns worldwide. Climate is an important resource for tourism in Thailand, which enjoys an attractive tropical climate. Thailand's climate change risks are shaped by its climatic characteristics and geography, particularly its extensive coastline and the low-lying Chao Phraya River Basin. As indicated in Chapters 1 and 4, the implications of a changing climate and its impacts on environmental and socio-economic systems for the tourism sector are anticipated to be far-reaching.

This chapter provides an overview of climate futures projected from a range of global GHG emission scenarios set out in the IPCC 5th assessment report (Stocker et al., 2013), including the successful achievement of the Paris Climate Agreement (RCP 4.5) and a Business-as-Usual trajectory of continued emission growth (RCP 8.5). Consistent with best-practice, the climate change projections provided are derived from an ensemble of 35 leading global climate models (GCMs) approved by the IPCC to participate in the fifth phase of the Climate Model Inter-comparison Project (CMIP-5). The climate change projection data are made available through the World Bank Climate Change Knowledge Portal. Additional regional studies that provide further insight into important aspects of observed and future climate changes are also included. Further information on the historical climate and climate change projection data used in this Chapter are provided in Chapter 2.

The chapter first presents an overview of Thailand's climate and then focuses on three areas of change that are most important to possible impacts on the tourism sector:

- 5.1 Overview of climate
- 5.2 Temperature (averages and extremes);
- 5.3 Precipitation (averages and extremes – including flooding and drought); and
- 5.4 Coastal (sea temperatures, sea level, and tropical cyclones).

5.1. Overview of climate in Thailand

Thailand enjoys a tropical climate, which is influenced by seasonal monsoon patterns. The average annual temperature is 26.3°C in the north and 27.5°C in the southern and coastal areas that have a strong maritime climate influence. Monthly average temperatures are lowest in December and January at just under 24°C, but exceed 26°C from March until October (see Figure 31). March to June is the hottest period of the year, when maximum temperatures usually reach 40°C or more in large areas of the country. The onset of the rainy season begins to reduce temperatures, starting around mid-May.

Average annual rainfall throughout the country ranges from approximately 1,200 to 4,500 mm. Most areas of the country receive 1,200 to 1,600 mm per year, but some areas on the windward side, particularly Trat province in the Eastern Part and Ranong province in the Southern Thailand West Coast, receive more than 4,500 mm a year. Precipitation peaks in the months of August and September in most regions (see Figure 30).

The climate of Thailand is strongly influenced by monsoon winds. The southwest monsoon (May to October) brings warm, moist air from the Indian Ocean towards Thailand, causing abundant rainfall over much of the country, but particularly in higher elevation mountainous regions. The northeast monsoon (October to February) brings to cooler, drier air from China to most of Thailand, but particularly influencing the Northern and North-Eastern regions.

From a tourist comfort perspective, these variations create three different seasons: (i) the warm-low rainfall season from November to February; (ii) the hot-low rainfall season from March to April; and (ii) the rainy season from May to October.

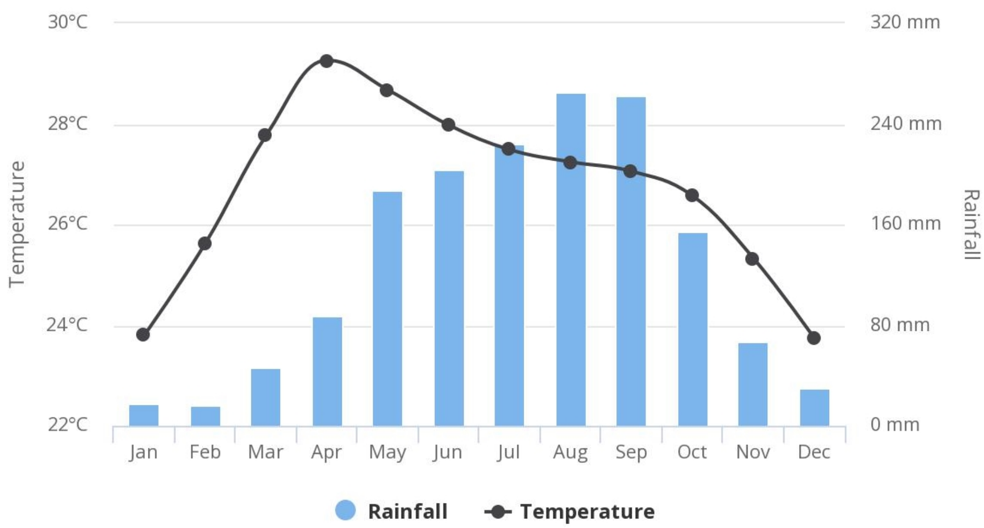


Figure 30 Average Monthly Temperature and Rainfall Thailand (1991-2016) (Source: World Bank 2019).

Thailand possesses five different climate zones based on the Köppen-Geiger climate classification system (see Figure 31). The country's central to northern climate is classified as hot and tropical (Aw climate), with a dry period and the average temperature of all months above 18°C. The southern part of the country has a more tropical humid climate (Af, Am). There are also small areas of temperature climate in the far north (Cwa, Cwb). During the winter months, outbreaks of cold air from China occasionally reduces temperatures in these regions to near or below 0°C. At different times of the year each of these regions provide climate resources sought by international tourists for comfortable beach and sightseeing holidays to escaping uncomfortable summer urban heat-islands of major cities.

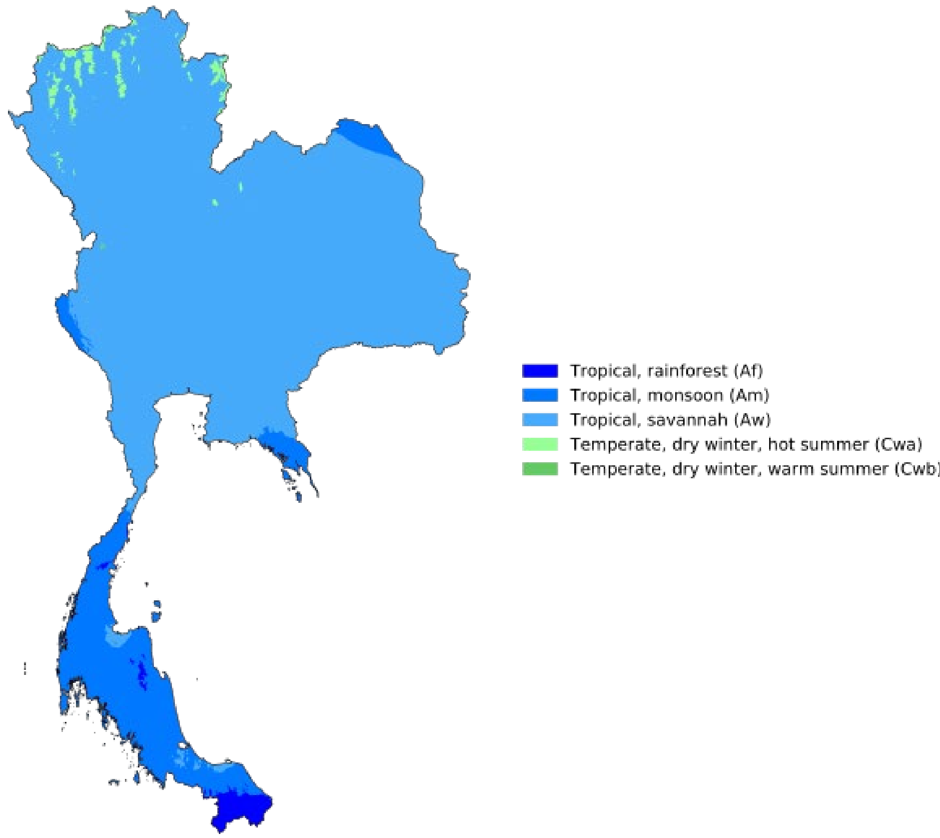


Figure 31 Köppen-Geiger climate classification for Thailand (1980-2016) (Source: Beck et al., 2018).

5.2. Temperature

5.2.1. Observed trends

According to the Thailand Meteorological Department (2011), average annual temperatures have increased by 0.95°C between 1955 and 2009. Data available through the World Bank (2019) portal reveal a very similar trend of 1°C warming over most parts of Thailand between 1951 and 2016. Consistent with global patterns, Limjirakan and Limsakul (2012) found that the observed warming trend was strongest in daily minimum temperatures (Tmin = +1.04°C versus Tmax = 0.96°C and Tmean 0.92°C). Their study found slightly larger increases in Tmax and Tmean in Eastern Thailand, and the most prominent increase in night-time temperature occurring in Central and South regions.

The frequency of extreme temperatures has also increased since 1951, especially in the coastal regions and major cities of the country. Trends in widely used thermal comfort indicators, such as hot days over 35°C and warm nights over 25°C, reveal substantial increases that are highly relevant to the tourism sector, both in terms of tourist comfort but also energy demand for air conditioning. A study by Limjirakan & Limsakul (2012) found the number of hot days has increased in the Central, North and Northeast regions (Figure 32). The increase in the number of hot nights has been much more pronounced and most prominent in the Central and South regions.

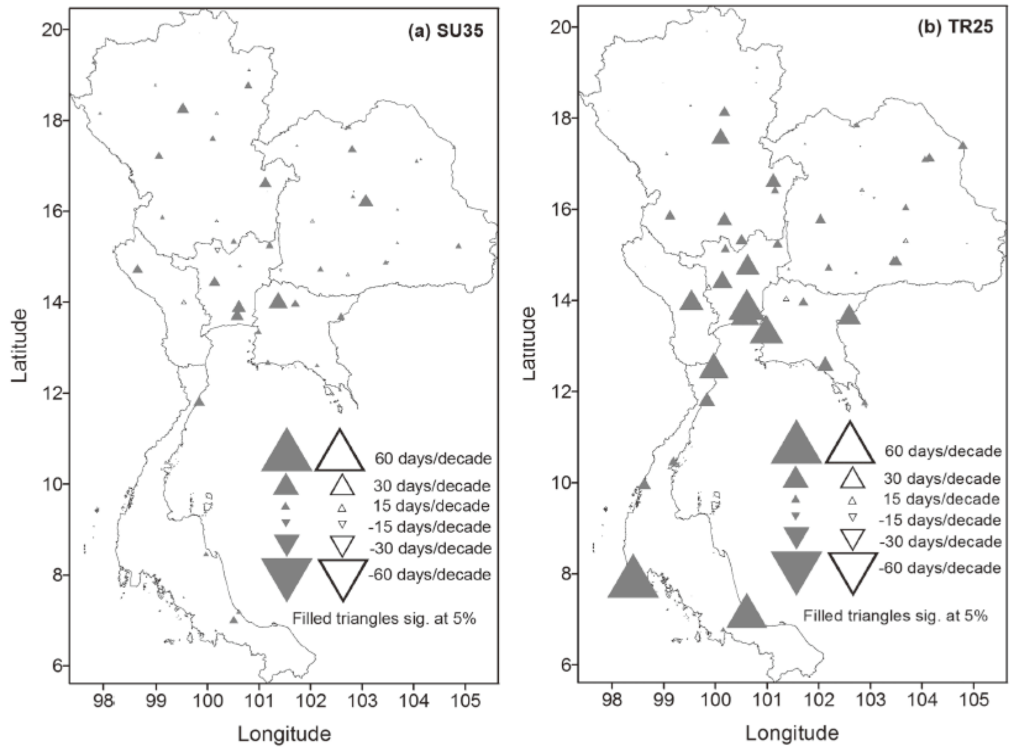
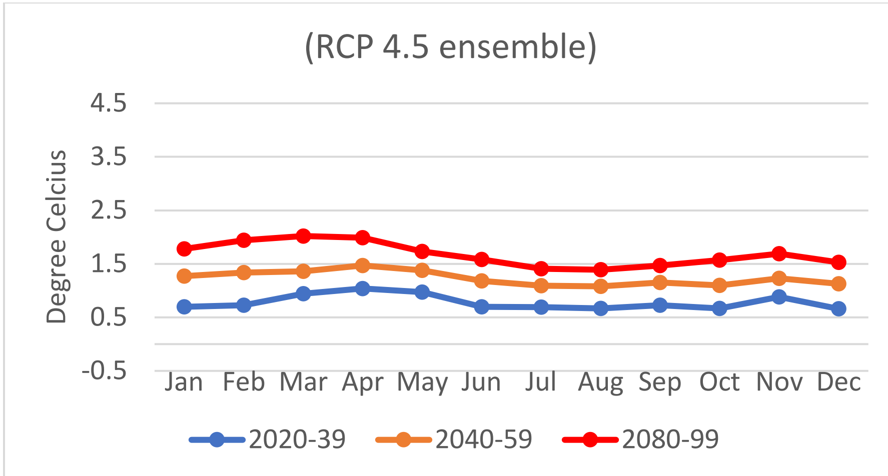


Figure 32 Decadal trends in (a) hot days (over 35°C) and (b) warm nights (over 25°C) 1970 to 2009 (***Source: Limjirakan & Limsakul, 2012).***

5.2.2. Projected future change

Based on the 35 model ensemble projections provided by the World Bank (2019), depending on future emission trajectories, mean annual temperatures across Thailand are projected to increase by 1.3 to 1.6°C by mid-century and 1.7 to 3.4°C by late-century (compared with 1986-2005) (Figure 33). The projected rate of warming is relatively consistent across seasons, but is greater in the Northern, interior regions of the country than in the Southern, coastal regions.



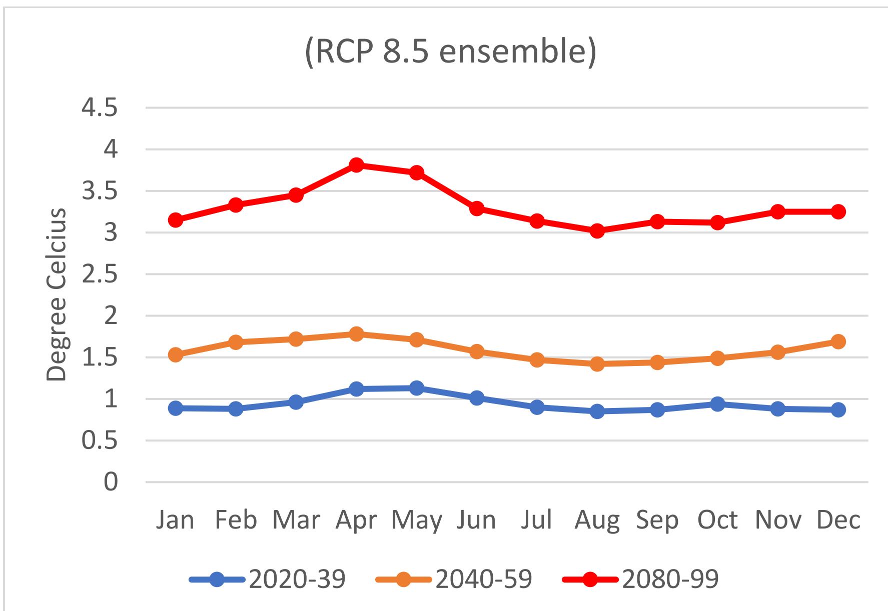


Figure 33 Projected Monthly Temperature Change (compared to 1986-2005) (Source: World Bank, 2019).

Table 8 summarizes the projected changes in future temperatures that are very important for tourist comfort and health. Compared with 1986-2005, the number of hot days over 35˚C are expected to increase by 19-22 in the next 20 years, 31-43 by mid-century, and 45-108 by late-century. Similar patterns are observed for days greater than 40˚ and heat index days (when the combined effects of temperature and humidity make it feel like 35˚). The important difference between a successful Paris Agreement versus a Business-as-Usual emission trajectory is visible by mid-century and very pronounced in late-century, when the increase in extreme temperature indicators are all more than double in the high emission scenario.

Table 8 Projected Change in Heat Stress Indicators (compared to 1986-2005)

Number of Days	2020-39		2040-69		2080-99	
	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5
Summer Days >25C	6	7	9	11	12	17
Tropical Nights >20C	15	18	26	34	35	61
Hot Days >35C	19	22	31	43	45	108
Hot Days >40C	8	10	11	17	15	41
Heat Index Days 35C	19	19	37	53	70	194
Warm Spell Duration	12	17	27	44	48	131

Figure 34 shows that the increase in heat index days is greatest in the Southern regions of the country. Similar spatial patterns are projected for hot days (greater than 35˚C and 40˚C).

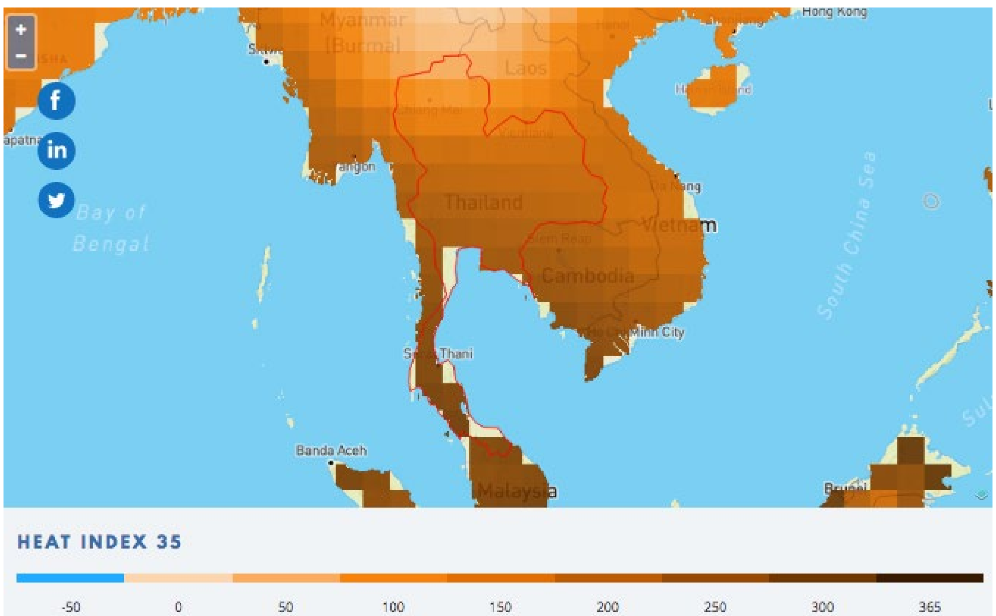


Figure 34 Projected Change in Heat Index Days for 2080-99 (compared to 1986-2005) (Source: World Bank, 2019).

The increase in tropical nights (>20C) is also highly important to tourist comfort and future space cooling needs in accommodations. The number of nights requiring air conditioning is expected to increase by 26-34 nights by mid-century and up to 35-61 in late-century. This substantial increase in air conditioning requirements for day and night comfort in hotels and other accommodations is demonstrated in Figure 35, which shows very rapid growth in cooling degree days under the high emission scenario (RCP 8.5) in particular.

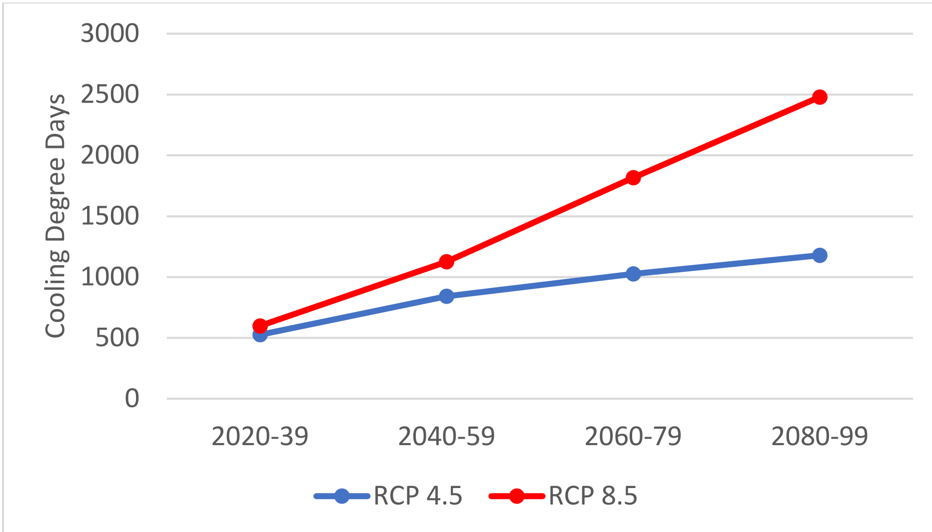


Figure 35 Projected Change Cooling Degree Days[1] (compared to 1986-2005).

The continuing increase in temperatures and decrease in cool days also has implications for destinations in the North of Thailand that are popular for offering more comfortable cooler conditions. The duration of the cool days (temperature < 16° C) in the North and Northeast are projected to shorten after mid-century from currently 2 - 2.5 months to 1 - 2.5 months (Limsakul et al., 2011). Textbox 4 further examines what the decrease in cooler conditions could mean for destinations in Chiang Rai Province. Summer heat escape tourism is likely to be an expanding tourism market in southeast Asia, with the China Tourism Academy (2018) assessing destination potential and several Chinese cities now marketing the 'refreshing summer climate' with daytime temperatures of 22°C.

[1] Heating degree days and cooling degree days are used extensively in calculations relating to building energy consumption. A degree day compares the mean (the average of the high and low) outdoor temperatures recorded for a location to a standard temperature (e.g. 65° Fahrenheit (F) in the United States). The more extreme the outside temperature, the higher the number of degree days. A high number of degree days generally results in higher levels of energy use for space heating or cooling. Cooling degree days (CDD) are a measure of how hot the temperature was on a given day or during a period of days. A day with a mean temperature of 80°F has 15 CDD. If the next day has a mean temperature of 83°F, it has 18 CDD. The total CDD for the two days is 33 CDD.

Textbox 4: Chiang Rai winter temperatures and destination attractiveness

Source: Thailand Development Research Institute (2018)

Chiang Rai province is the northernmost province of Thailand. It is characterized by highlands and hilly terrain with an average elevation of 1,500 – 2,000 meters above the sea level, which creates a distinctive natural scenery. The weather is cooler than the rest of Thailand, with an average annual temperature of 25°C and average annual daily minimum of 15.1°C. The cool season runs from October to February with temperatures of around 21°C during the daytime but the night temperatures can be as low as 8°C. Average annual precipitation amounts to 1747.5 mm, peaking in August and being lowest in December. Peak tourism demand in Chiang Rai is in December and January, when it is cooler and drier (Figure 37).

A study by the Thailand Development Research Institute (2018) examined the relative importance of climatic and other factors (unique culture and tradition, natural characteristics of the tourist attractions, festival/event, convenience in accessing the tourist attractions and cost) for visitors to Chiang Rai. Natural attractions and the climate were found to be the key attractors, indicating that as climate change causes warmer temperature and a shorter winter/cooler season there could be an impact on the tourists' decision whether to visit the region. Chiang Rai will still remain relatively cooler than the rest of Thailand under future climate scenarios, so tourists may still be attracted to the relief from higher temperatures in other parts of the country and major cities in particular.

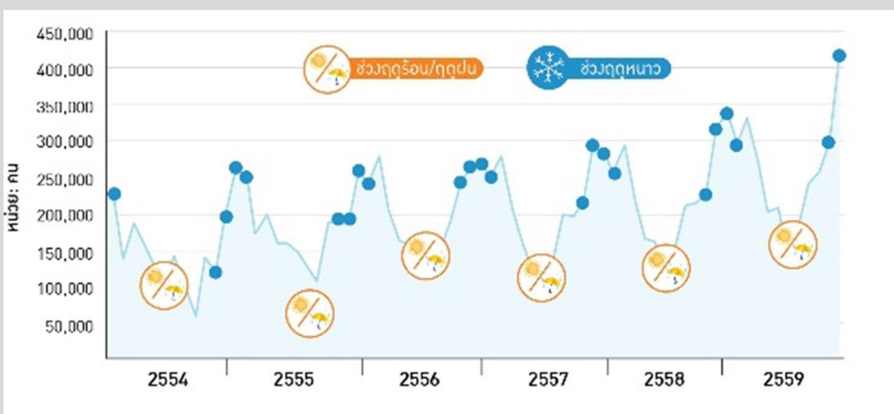


Figure 36 Seasonal Visitation to Chiang Rai

5.3. Precipitation changes

5.3.1. Observed trends

Analysis of long-term climate station data from 1955 to 2014 by Limsakul and Singhruck (2016) found that while precipitation has become less frequent in most parts of Thailand, with a reduction in the occurrence of consecutive wet days, precipitation events have become more intense. Indices that measure the amount of precipitation during wet day events and maximum single-day precipitation amounts indicate a trend toward more intense precipitation events that contribute an increasing share of annual precipitation (Figure 37). There also appear to be regional shifts in the volume of rainfall, with increasing rainfall in the Gulf region, the lower Chao Phraya basin area, and Northeastern Thailand. In addition, observed trends indicate seasonal differences in precipitation changes, with a volume decrease between May and October, and an increase between November and April.

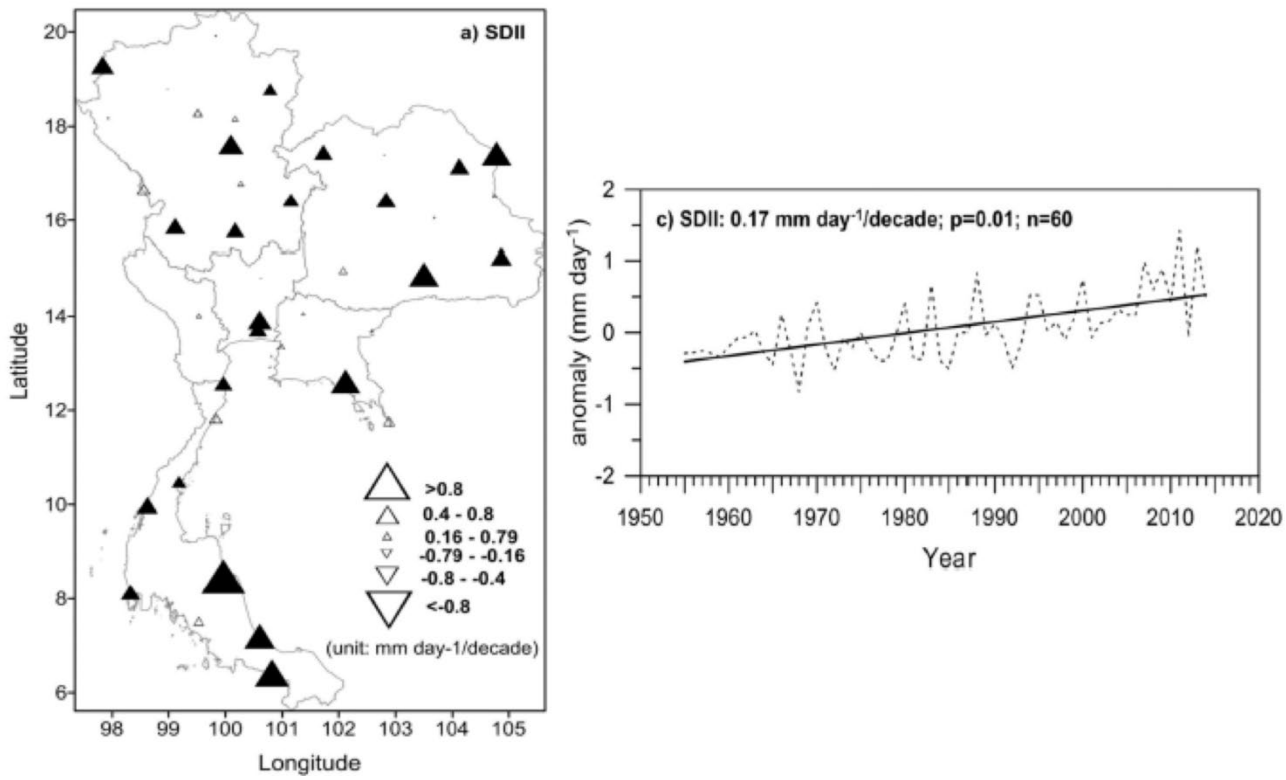


Figure 37 Regional Trends in Simple Daily Intensity Index (SDII) from 1955 to 2014 (Source: Limsakul & Singhruck, 2016). Note: Upward-pointing triangles show increasing trends, while the downward-pointing triangles indicate decreasing trends.

An important consequence of these observed changes in precipitation patterns is the increased frequency and severity of floods, as experienced in many parts of Thailand. In combination with deforestation, more intense precipitation events can cause serious landslides and flooding of lowland areas. In 2011, flooding and mudslides affected a large area in North Thailand, including the tourist regions of Chiang Mai, Chiang Rai, Phayao, and Mae Hong Song Provinces. The 2011 Chao Phraya River flood is estimated to have caused over US$45 billion damage (Mahsud et al., 2016) and impacted 76 of Thailand's 77 provinces, including an estimated 10.56 million rais of land (1.69 million hectares). Figure 38 shows the extent of flooding in 2011. Promchote et al. (2016) analysed the 2011 situation and concluded that the flooding was due to an unusual combination of factors, including exceptionally high rainfall in the pre-monsoon season in that year, leading to record-high soil moisture. In addition, elevated sea levels in the Gulf of Thailand prevented adequate drainage, exacerbating other water management challenges.

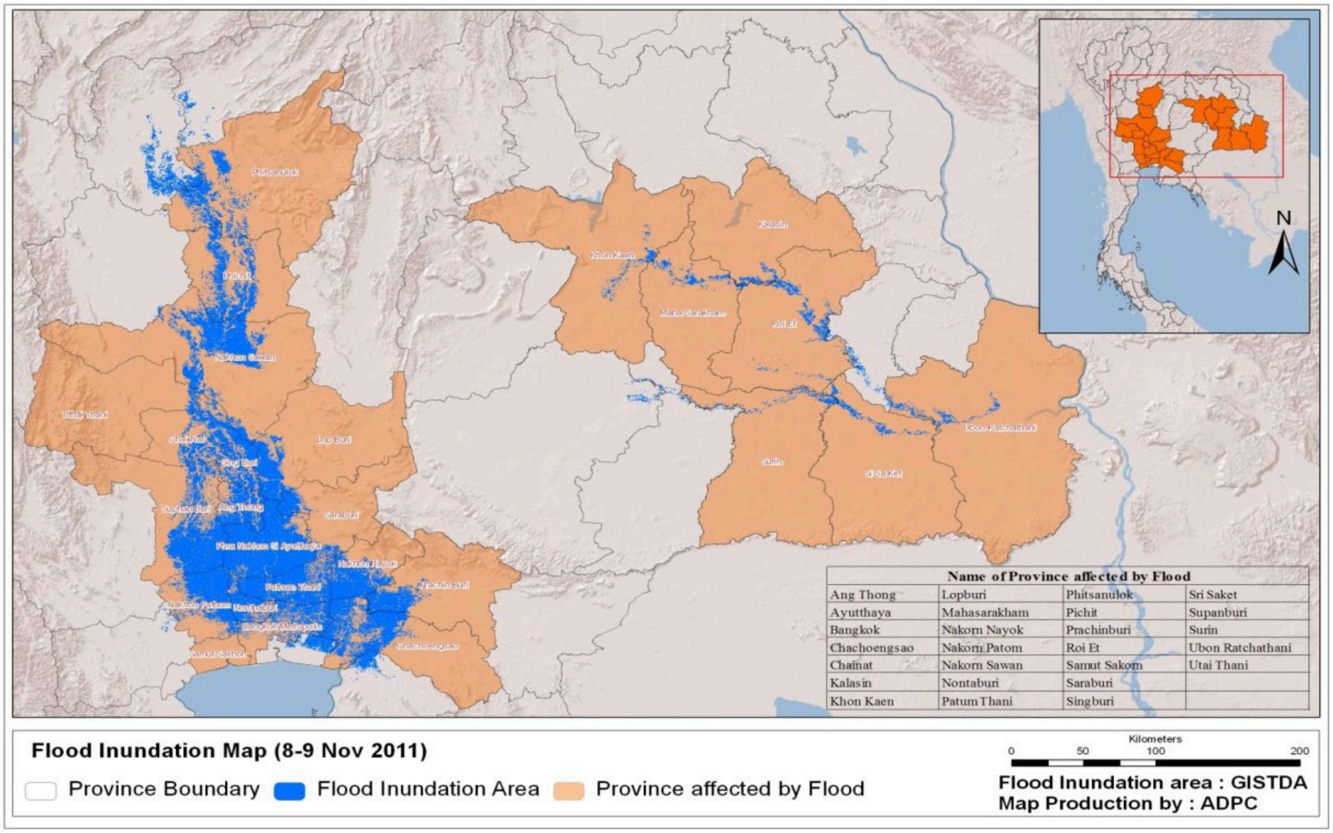


Figure 38 Flood inundation map (8-9 Nov 2011) (Source: Asia Disaster Preparedness Centre (ADPC), n.d.).

With fewer days with precipitation, the length of dry periods has increased, raising the potential for drought related impacts. Droughts are not a new phenomenon to the country, but the increasing severity and frequency poses growing risks to different economic sectors. In 2016, total drought related losses were estimated to be around US$3.4 billion or 0.85% of GDP (Bangkok Post, 2016a). The 2016 drought also led to severe water shortages on tourism islands. In Koh Samui, for example, the government ordered water rationing for tourism businesses and citizens as their water reservoirs were drying up (Bangkok Post, 2016b).

5.3.2. Projected future changes

Projections of mean annual precipitation from different global climate models show a range of changes for Thailand. Precipitation projections from global climate models show much more uncertainty than for temperature. Global climate model projections provided on the World Bank (2019) portal tend towards increases in all models, with a 20% variation in annual precipitation. Similarly, in the climate models analysed by Naruchaikusol (2016), the total volume of precipitation was projected to increase by the middle of the century. The World Bank (2019) ensemble projections for annual precipitation vary between +28% to +74% by late-century, depending on a low or high emission scenario. Seasonally, minor changes in precipitation are expected from November to April, with much greater increases projected for June through October (Figure

39). While fewer annual rain days can be beneficial to the tourism experience, increased precipitation during wet days is more impactful on the tourism experience. As a result, the net impact of any annual or seasonal change in precipitation on tourism perceptions of Thailand as a destination remains uncertain and likely of marginal consequence.

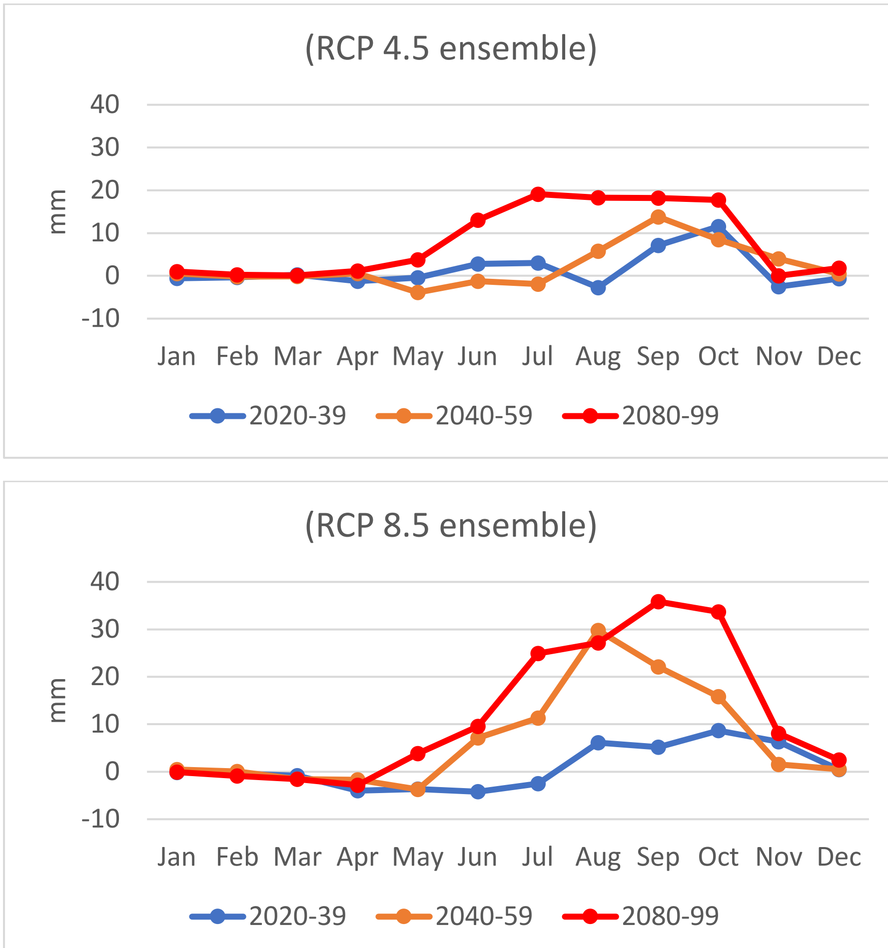


Figure 39 Projected Monthly Precipitation Change (compared to 1986-2005) (Source: World Bank, 2019).

Some studies point to regional patterns of annual precipitation change. The World Bank (2019) ensemble shows the least change in the Ranong area, while Limsakul et al. (2011) suggested total annual precipitation is likely to remain almost unchanged in Western Thailand. Chiang Rai Province in northern Thailand is projected to experience some of the largest relative increases in precipitation within the LMB with annual precipitation increasing by 9 to 18% (USAID, 2014).

In addition to total annual and seasonal precipitation changes, changes are also projected in extreme precipitation events and dry periods. Table 9 displays changes in the number of days with heavy rainfall (>20 and >50 mm) as well as the volume of water (in mm) during maximum 5-day rainfall events. Future water availability in Thailand has been assessed by Shrestha (2014) using the Hydrological Engineering Centre's Hydrologic Modelling System (HEC-HMS) and decadal climate projections from the UK Hadley Centre PRECIS regional climate model. Broadly, this assessment found that a decline in water availability would be experienced during the dry season (particularly during the hot season in April and May), while an increase of water availability is expected during the wet season. This increase in the wet season is accompanied by increased frequency and intensity of floods.). Other studies of the Yang River Basin system (Shrestha & Lohpaisankrit, 2016), the Ping River Basin (Sharma & Babel, 2013), and the Chao Phraya River (Ligaray et al., 2015), also project increased frequency and magnitude of flood events under a mix of future climate scenario models.

Table 9 Projected Change in Extreme Precipitation (compared to 1986-2005)

	2020-39		**2040-69**		**2080-99**	
	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5
Days with Rainfall >20mm	1.1	1.1	1.5	2.8	2.7	3.5
Days with Rainfall >50mm	0.2	0.2	0.3	0.4	0.5	1
Maximum 5-day rainfall (increase in mm)	10	8	14	18	19	39

5.4. Sea level rise and other coastal hazards

5.4.1. Observed trends

The global oceans are undergoing substantial change from GHG emissions. Similar to land-based temperature measurements, sea surface temperatures continue a multi-decade warming trend. The IPCC (Stocker et al., 2013) estimates that more than 90% of the additional energy accumulated from the enhanced greenhouse effect is stored in the oceans. As a result, over the last four decades of the 20th century, the upper layers of the oceans have warmed at a rate 50% faster than previously (Durack et al., 2014). Prolonged ocean warming caused a global coral bleaching event that started in 2014 and extended well into 2017. The global oceans have also absorbed much of the CO2 emissions from human activity, increasing ocean acidity by an estimated 30% (Friedrich et al., 2012). The current rate of ocean geochemical changes is unprecedented over the last 300 million years, raising the possibility of far-reaching marine ecosystem change in the decades ahead (Honisch et al., 2012).

A number of studies have been undertaken to examine the impact of changes in climate, sea surface temperatures, and sea level on Thailand's coastal zones and cities, particularly areas already prone to flooding and erosion (Wangt et al., 2014). Koad et al. (2012) found that sea surface temperatures at all study sites in the Gulf of Thailand had significantly increased from 1981 to 2011 and that mass coral bleaching events were likely to occur when there were sudden increases in sea surface temperatures over a short period or a small increase over a long period due to major El Niño or La Niña events roughly every 10 years. Thailand has been experiencing major coral bleaching events since 1991, with severe coral bleaching taking place in 1995, 1998 and 2010.

Sea level rise in areas of Thailand is pronounced. Sea levels in the Gulf of Thailand have risen by about 3 to 5 mm per year in the period between 1993 and 2008 (TRF, 2011), which is roughly 3 to 5 times the rate of global sea level rise estimated by Church et al. (2011). Sojisuporn et al. (2013) used data from 13 tide gauge stations in the Gulf of Thailand covering a period of 25 years (1985 – 2009) and measured an average increase of 5mm per year. Thammasart University Research and Consultancy Institute (2009) noted that the effects of sea level rise overlaid with land subsidence from groundwater extraction could lead to a 'net sea level rise' of 25 mm per year, for example in the wider Bangkok area or the river mouths in the Gulf of Thailand (Naeije et al., 2013). Using tidal gauge observations, Saramul and Ezer (2014) found large spatial variations in relative sea level rise rate, ranging from ~1 mm to ~20 mm per year, with the highest rate in the upper Gulf of Thailand near Bangkok, where local land subsidence due to groundwater extraction dominates the trend (Textbox 5). They also found indications that relative sea level rise rate increased significantly after the 2004 Sumatra–Andaman Earthquake, with less spatial differences than before the earthquake, but with high rates of ~20–30 mm per year almost everywhere.

An estimated 830 km of coastline are currently subject to coastal erosion, especially in the upper Gulf of Thailand area (Krainara, 2013). According to the Southeast Asia START Regional Center and World Wildlife Fund (2008), community members in villages on the Andaman Coast have already experienced land loss due to coastal erosion.

Textbox 5: Bangkok as the 'Venice of the East'

A number of media stories and other think tank reports have referred to Bangkok as the 'Venice of the East' (e.g., Deviller 2018) or the 'Atlantis of the Pacific' (e.g., Centre for Climate and Security 2012). These publications note that Bangkok is built on former marshland with an average elevation of about 1.5 m above sea level and that many of the canals that earned the city its nickname of Venice of the East, have been lost – increasing the vulnerability to flooding due to reduced drainage. Canals have been attractive features of Bangkok as a tourist destination and some still exist, for example Khlong Saen Saeb and Khlong Phadung Krung Kasem. Another area popular with visitors who wish to explore Bangkok's waterways is Thonburi, located on the west bank of the Chao Phraya River. A World Bank (2010) report indicates that 1 in 10 and 1 in 30-year flood events would flood 30% more of Bangkok with so called 'nuisance flooding' by mid-century.

Photo 3 Flooding in Bangkok (Source: https://phys.org/news/2018-09-sea-bangkok-struggles-afloat.html)

5.4.2. Projected future change

The global oceans are anticipated to undergo unprecedented change over the 21st century as a result of climate change. As sea surface temperatures continue to increase under all emission scenarios, the risk of coral bleaching intensifies. An important indicator for coral reefs is when they are expected to experience annual severe bleaching, which provides no time for corals to recover from recurrent bleaching. Under a high emission future, Van Hooidonk *et al*. (2013) estimated that a majority of coral reefs globally would experience annual severe bleaching by the mid-2050. Using higher-resolution projections (at a 4-km resolution), Van Hooidonk *et al*. (2016) compared local-scale variation in the onset of annual severe bleaching under low and high emission (RCP 4.5 and 8.5) scenarios. The global average year for the projected timing of annual severe bleaching was 2054 in the lower emission scenario (RCP4.5) and 2043 in the high emission (RCP 8.5) scenario. The onset year for coral reefs in Thailand was slightly later (2046) in the high emission scenario.

The world's coastlines would be transformed by sea level rise and associated accelerated erosion under a high emission scenario. The IPCC (2013) concluded that by the end of the century, global mean SLR (relative to 1986-2005) will be in the range of 26–55 cm in low emission scenario (RCP 2.6) to 52–98 cm in a high emission scenario (RCP 8.5). A subsequent survey of 90 experts on SLR from 18 countries estimated that a high emission future (RCP 8.5) would result in SLR of between 0.7 to 1.2 m by 2100 (Horton et al., 2014). A recent study using emission trajectories from the IPCC's new *Shared Socioeconomic Pathways* projects sea level rise of between 52 to 132cm by 2100 (Nauels et al., 2017*)*. Coastline recession caused by rising sea levels represents one of the most significant impacts for coastal tourism worldwide (Scott et al., 2012).

Importantly, SLR will not be uniform worldwide. Using ensemble-mean regional SLR data (1 degree latitude-longitude resolution) from 21 CMIP5 models, Ritphring et al. (2018) indicate that late-century SLR along the coastline of Thailand is expected to be 0.46 m for RCP4.5 and 0.61 m for RCP8.5 (relative to 1986 – 2005) (Figure 40). Local rates of sea level change may be higher as a result of land subsidence related to ground water withdrawal.

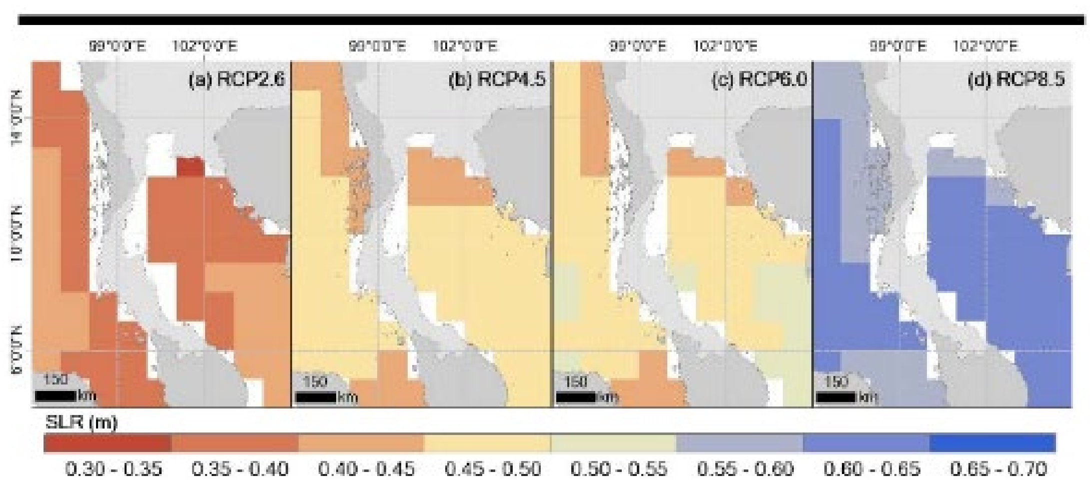


Figure 40 Project Rates of Sea Level Rise near Thailand by 2100 (Source: Ritphring et al. 2018).

A recent study shows that coastline recession is a major issue for Thailand's beaches. Compiling data on beaches in Thailand, Ritphring et al. (2018) assessed various sea level rise scenarios of the Coupled Model Intercomparison Project Phase 5 (CMIP5) in 2081–2100, relative to a reference period 1986–2005. Using the so-called Bruun rule, they found that the overall national beach loss rates were in the order of 45.8% for RCP2.6, 55.0% for RCP4.5, 56.9% for RCP6.0 and 71.8% for RCP8.5. Testing the RCP4.5 further, the projections ranged from 49.1% for MPI-ESM-LR to 73.4% for MIROC-ESM-CHEM. The findings are highly relevant for tourism as the authors estimate that out of 51 zones that contain sandy beaches, between 8 and 23 will disappear for the pathways of RCP2.6 and RCP8.5, respectively.

Tropical cyclones have not often impacted Thailand over the last 40 years, but in January of 2019 tropical storm Pabuk caused as many as 30,000 to 50,000 tourists to leave the popular resort island of Koh Samui, Koh Tao and Koh Phangan during the peak Christmas-New Year season (The Guardian, 2019). The tropical cyclone activity over the western North and South Pacific are anticipated to change in a warmer world. Several studies in the western North Pacific project a decrease in tropical storm frequency, but an increase in higher intensity storms (in particular categories 4 and 5 on the Saffir–Simpson scale) (Sugi et al., 2012, Wu et al., 2014). Nevertheless, some studies have shown contrasting future projections, with Zhang and Wang (2017) finding a shift toward stronger tropical storms, with no significant change of tropical storm frequency under a low emission (RCP 4.5) scenario, but a considerable decrease under a high emission (RCP 8.5) scenario. Wang et al. (2017) found an increase in tropical cyclone track density (June-September) over southern Vietnam under late-century RCP 4.5 and 8.5 scenarios, which may portend increased future impacts for Thailand.

6. Risks for Tourism from Past and Present Climate Variability

6.1. Observed impacts on tourism in Thailand

The Thai Department of Tourism (DoT) has reviewed past climate events and their impacts (Table 10). Prominent past examples included flooding (in particular the big flood in 2011) and tropical storms that affect coastal areas. Increasing risk of drought has also been noted by DoT. For example, reduced precipitation led to the drying up of waterfalls that are important tourist attractions.

Table 10 demonstrates that those impacts observed in Thailand align well with global research on tourism and climate change. Interestingly, the primary impact of climate change, namely increases in temperature, is not being seen as having led to major impacts on tourism so far. The literature (e.g. see Becken, 2013a; Rutty & Scott, 2016), however, indicates substantial impacts both as gradual warming (slow onset) or extreme events (i.e. heatwaves). It is possible that heat-related impacts are not recognised (yet) as tangible risks related to climate change and tourism in Thailand. The literature provides further insights into further challenges, for example the risk of water conflict, increased costs for operators, and heightened fire risk, and what adaptation measures could be put in place to manage the risk (see Chapter 8).

Table 10 Climate hazards and what they mean for tourism (Source: compiled by DoT staff)

Climate hazard	Specific event in Thailand	Observed impacts	Relevant tourism risks/impacts broadly identified in the literature
Warmer temperatures			• Altered seasonality (prolonged hot season heatwaves) and heat stress for tourists; more hot nights • Increased cooling costs for businesses • Increase in infectious and vector-borne diseases
Sea surface temperatures rise	Coral bleaching in the Gulf of Thailand (2018)	• Coral bleaching taskforce established	• Increased coral bleaching and marine decline • Aesthetics degraded in dive and snorkel destinations
	Andaman sea bleaching (2016)	• 10 beaches closed for recovery	
	Jellyfish, Sirinart National Park in Phuket province (Sep 2016)	• Explosion in jellyfish numbers (esp. Portuguese Man-of-War) affected beach activities	• Increased appearance of poisonous jelly fish
Changes in precipitation - Flooding	The Big Flood, Central part of Thailand (late 2011)	• Critical infrastructure and facilities affected (roads, airport etc.) • Historical tourist attractions (temples e.g. Wat Maha That) flooded (Ayutthaya province)	• Heavy rain leading to flash floods or flooding • Landslides affecting tourist assets and infrastructure • Changing rainfall patterns affecting seasonality of tourism
	Flash flood in Krabi province (August 2017)	• Tourist attraction (Emerald pool) was affected by flash flood	
Changes in precipitation - Drought	Drought in Lampang and Petchabun provinces (March 2016)	• Waterfalls (Phra sadet and Than Thip) dried up	• Reduced precipitation leading to water scarcity and drought; desertification • Impacts on natural ecosystems and resources • Increased wildfires threatening infrastructure and safety • Increase in freshwater costs and water conflict
Increased storm intensity	Tropical storm Pabuk storm in	• Tourists lost their lives	• Damage to build and natural infrastructure/ assets • Increased insurance costs/ loss of insurability

and/or frequency	several provinces (Nakhon Si Thammarat, Chumphon, - Surat Thani, - Phuket and Trang (31 Dec 2018 – 4 Jan 2019)	• Tourism activities, such as diving and agro-ecotourism, compromised • Damage to facilities, such as coastal road, airports, hotels and resorts • Impact on cultural destinations, such as Koh Li Bong community in Trang province (Muslim fishing community), Pak Nam Pak Phraya in Nakhon Si Thammarat province	• Reputational damage through media coverage • Reduced access (e.g. closed roads), flight disruptions • Safety of guests and staff • Disruptions to the supply chain • Health risks associated with stagnant water or wastewater • Coastal inundation and beach erosion
Sea level rise	Ban Khun Samut Chin in Samut Prakarn province	• Coastal erosion is causing damage to historical building (temple); damage also from inundation and storm surge	• Coastal lake or watercourse entrance instability • Higher impacts of storm surge and tidal inundation • Loss of or damage to coastal infrastructure
	Phala sub-district, Ban Chang district, Rayong province	• Tourist attractions (beach) are eroded and reduced	• Higher costs to protect and maintain waterfronts
	Bang Kra jao in Samut Prakarn province	• Saltwater intrusion affected agricultural areas (Agri-Cultural tourism attraction e.g. coconut palm sugar factory)	• Saltwater intrusion into groundwater and soils

6.2. Input from coastal tourism stakeholders

Preliminary data from a tourism business survey (Hess, 2019) provide insight into hazards and impacts already experienced by accommodation suppliers in selected islands of Thailand (Table 11). More specifically, out of a sample size of 193, a high percentage of business owners and managers expressed that they experienced strong or some negative impacts from climate change related hazards (in between 2014 and 2017). The most prominent observed impacts were: reduction of natural beauty, changing weather seasons, storm or wind damages, loss of biodiversity, and freshwater shortages. Future analysis could look at a comparison between impacts in different regions, and attempt to estimate the economic costs of climate change impacts.

Table 11 Observed negative impacts on accommodation businesses (N=193) during the last 3 years (pooled sample for hotels in Koh Tao and Koh Phi Phi)

	Accumulated		**Strong impact**		**Some impact**	
	Number	% of total	Number	% of total	Number	% of total
Perceived reduction of natural beauty	157	81.3	58	30.0	99	51.3
Changing weather seasons	152	78.7	35	18.1	117	60.6
Storm or winds damaged enterprise/ premises	146	75.6	40	20.7	106	54.9
Loss of biodiversity	136	70.5	44	22.8	92	47.7
Freshwater shortage	135	69.9	49	25.4	86	44.6
Flood (extreme rain events)	117	60.6	43	22.3	74	38.3
Coral bleaching	113	58.6	44	22.8	69	35.8
Long period of hot temperatures	92	47.7	16	8.3	76	39.4
Sea level rise	70	36.2	13	6.7	57	29.5
Coastal erosion	52	26.9	10	5.2	42	21.8

6.3. Impact mapping at stakeholder workshop

A stakeholder workshop formed an essential part of the consultations for this project. The purpose of this workshop was to both communicate the project and enhance the knowledge base for the CCRA. Participating stakeholders identified locations and observed climate impacts in tourism destinations around Thailand. Note, that the recollection of events by stakeholders is unlikely to be comprehensive (and it is not the purpose of this exercise to achieve a complete inventory of past impacts), but this exercise was nevertheless important to complement the literature research and events identified by DoT. All of these pieces of information inform the assessment of future risks. The input received from stakeholder falls within five types of hazards (Figure 41 and Table 12 further below):

- Air pollution (indirectly related to climate change in that higher temperatures exacerbate the health impacts)
- Heatwaves and higher temperatures
- Hydrological events (tsunami is included here as stakeholders put forward this geological hazard)

- Landslides (strongly related to strong precipitation events)
- Coral bleaching (related to higher temperatures)

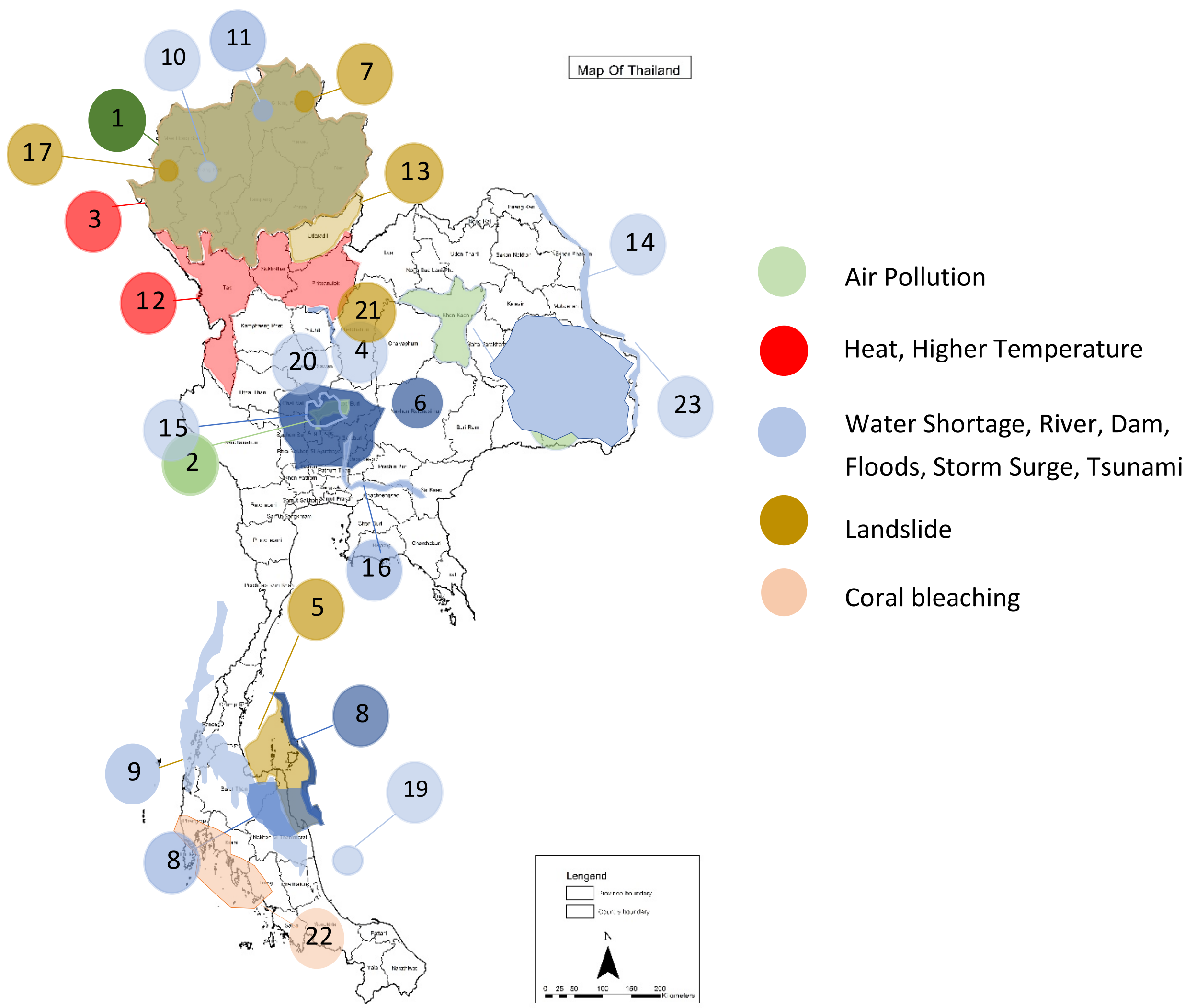


Figure 41 Stakeholders' recollection of past climate hazards and events relevant for tourism.

Several extreme events have occurred in recent years, including floods and landslides (in particular in the North), leading to considerable destruction, and the death of tourists. Most extreme events related to either excessive rainfall or lack of rain. Water shortages have put substantial limitations on tourism across several destinations in Thailand. In addition to economic costs (not quantified to date) from extreme rainfall events, reputational damage was identified by stakeholders.

The increasing temperatures in the North were seen as shortening the tourist season. The main motivation at present is to visit these regions (especially for domestic tourists) to escape hotter temperatures in the south. Note that the warming temperatures and decrease in cool days in Chiang Rai (see also Textbox 4) were discussed as one case study during the workshop and this might have influenced stakeholder recall in this particular exercise.

Air pollution is a big problem for tourism, in particular in the northern parts of Thailand where forests are burned for agricultural purposes. Air pollution is affecting Thai people as well as tourists (Pasukphun, 2018). There are established links between climate change and air quality. In the RCP8.5 scenario, for the South Asia region, the frequency of air pollution events will increase by between 20 and 120 days per year by mid-century, relative to today's frequency. Research shows that for particulate matter of less than 2.5 µm in diameter, it is likely that thresholds provided by the World Health Organization for 'safe air' will be breached almost daily (Kumar, et al., 2018). The issues around air pollution in urban areas are complemented by acute air quality problems in the North. These are measured through PM10. The level of PM10 has increased considerably since 2006, in particular in the nine regions Chiang Rai, Chiang Mai, Lampang, Lamphun, Mae Hong Son, Nan, Phrae, Phayao and Tak. Despite these concerns, open burning continues to be a common method of managing agricultural wastes.

Table 12 Specific detail on climatic events that affected tourism in Thailand (Source: stakeholder workshop, 7-8 February 2019, Bangkok). Note: minor edits were made but the information in this table essentially reflects the feedback from experts and their knowledge and assessment of past situations.

No.	Hazard	Impact on tourism	Action taken
1	Air pollution and smog in the North	Tourist avoid travelling to the North during the slash and burn period.	➢ Clean up pollution where possible ➢ Avoid smoking in the public ➢ Emergency response by wearing facemasks ➢ Prohibited burning in forest and agriculture areas ➢ Created firebreaks
2	PM 2.5 in Bangkok and metropolitan	Tourists are not comfortable to stay in Bangkok. Tourists are concerned about their health and hesitate to make visit outdoor attractions.	➢ Monitored PM 2.5, mainly from exhaust by passenger vehicles, trucks and public transport ➢ Prohibited burning agricultural plots ➢ Temporary close schools and universities ➢ Work-from-home measure were allowed especially for pregnant women and chronic-health- condition people
3	Shorter winter season in the Northern Thailand	Shorter peak season for tourism.	➢ Develop new tourist attractions
4	Aggressive invasion of floating water hyacinth due to warmer river water	Blocked water transportation. Reduced attractiveness of tourism, in particular cruising along the Chaopraya river	➢ Marine Department cleaned up the weeds

		with uniqueness of old living pattern.	
5	Landslide due to intensive and prolong rainfalls	Tourist destinations damaged and caused for more often repairing or re-construction	➢ Developed emergency response plan
6	Floods are more frequent in Central of Thailand Floods in Bangkok and central part of Thailand in 2011	Natural tourist destinations are damaged and loss of income from tourists. Tourists changed transport modes due to damaged infrastructures (air and land transport). Bad reputation for the country.	➢ Dredged canals and improved flood ways ➢ improved image by using testimonial ➢ Promoted secondary tourist cities ➢ Provided economic compensation i.e. loan with low interest
7	Landslide at Phu Chi Fa (mountain peak) in Chiang Rai	Infrastructures were damaged. Decreased confidence level of tourists (reputation)	➢ Announced Phu Chi Fa as a disaster-effected area ➢ Installed temporary steel bridge ➢ Fixed the road
8	PABUK storm in 2019	Tourism businesses were disrupted. Buildings and tourism properties were damaged. One tourist died, and other tourists avoided travelling to the affected areas.	➢ Warning activated + (by National Warning Center) ➢ Evacuation conducted and temporary evacuation sites were prepared ➢ Tourists adjusted travel plans ➢ Cleaned places and fixed houses ➢ Compensation and emergency relief were carried out
9	Tsunami in 2004 (img 9201), (img 9182)	Tourists died. Properties were damaged and destinations were destroyed. Tourism businesses were disrupted (loss of income). Buildings and offices were damaged. Eroded image of Thailand and tourist lost confidence.	➢ Managed dead bodies and provided assistances ➢ Cleaned tourist destinations ➢ Developed Tsunami warning system, constructed Tsunami warning towers, installed Tsunami *buoys* ➢ Organized Tsunami Remembrance Day
10	Dam's Water shortage in Chiang Mai	Number of tourists decreased. No water activities in dams.	➢ Developed water discharge tunnel
11	Floods in Tham Luang cave, Chiang Rai (Heavy rain and rainy season started earlier than previous years)	Enhanced attraction from foreigners to acknowledge more tourist destination in Chiang Rai.	➢ Set a safety standard as a pilot for other caves ➢ Identified open hours

		Uncertainty of high season for tourism.	
12	Higher Temperature in Sukhothai, Tak and Pitsanulok (> 42˚C)	Tourists were not comfortable staying out during high temperature.	➢ Extended service hours to extend after sunset
13	Landslide in Uttaradit	Roads were damaged. Tourists could not access the tourist destinations.	➢ Activated emergency response plan
14	Water Shortage in the Mekong River	Boat service business decreased. Could not provide in-land water transport.	➢ Created new activities i.e. activities in dry season (riverbank beaches)
15	Floods in Ayuthaya	Ancient archaeological remains were damaged.	➢ N/A
16	Storm surge along Thai Gulf Zone leading to coastal erosion	No beaches for tourists. Tour operators could not run business, loss of income.	➢ Constructed coastal erosion barriers ➢ Planted trees to prevent coastal erosion
17	Landslide in Mae Hong Son	Roads were blocked.	➢ N/A
18	Air pollution in Khon Kaen	Tourist avoided to stay in Khon Kaen and chose to stay in neighboring province, i.e. Udonthani, resulting in income loss for tourism businesses.	➢ Prohibited the agricultural burning of plots ➢ Adopted measures to decrease the use of diesel-based vehicles
19	Floods in Had Yai		➢ Built water reservoirs (Kaem Ling)
20	Water shortage in Borrapetch (Thailand's greatest fresh marsh)		➢ N/A
21	Landslides at Namkor-Namchun, Petchabun	Roads were damaged and tourists could not access the tourist destinations.	➢ -Activated emergency response plan
22	Coral bleaching around Andaman coast.	Less attractive to tourists to visit. Income loss for tourism supply chain in the areas.	➢ Closed islands for habitation/ use
23	Drought around north eastern of Thailand	Insufficient water usage for consumption and tourism businesses.	➢ Established Office of National Water Resources for integrated water management ➢ Artificial rain

6.4. Risk metrics

6.4.1. Values at risk

Any risk assessment needs to ask questions related to risk 'of what' and 'to what'. Building on the approach by the NESP Earth Systems and Climate Change Hub (2018), and based on the relevant literature (Becken, 2013b; Scott et al., 2008; Scott et al., 2012), the values at risk for Thai tourism could be captured by the following six dimensions, whereby the first three appeared most prominent in discussions with stakeholders.

1. Economic benefits (i.e. development and employment)
2. Visitor comfort and safety
3. Destination competitiveness
4. Community well-being
5. Protection of physical and cultural assets, and infrastructure
6. Protection of natural assets and ecosystem services

The above six values are *outcome measures*. They are already implicitly captured in many tourism policies and plans, and their systematic monitoring should be linked to climate action and risk management. Thus, when seeking to address specific climate risks it is therefore important to clarify which of these values is at risk. For example, reducing the risk of flooding could be mainly undertaken for the purpose of ensuring ongoing economic tourism development, or it could be implemented specifically to protect cultural assets. It is possible that the implementation of adaptation measures addresses multiple values in a complementary way, but it is also conceivable that there are trade-offs. The closure of National Parks for ecosystem recovery, for example, might compromise the goal/value of economic development.

6.4.2. Indicators to monitor climate risks

Monitoring climate risk is important. This requires a multi-dimensional approach to cover all the elements that shape risk (see also Figure 1, IPCC risk framework). The following three Tables have been developed by drawing on information presented in Chapters 4 (Thailand tourism system), Chapter 5 (Climate data) and Chapter 6 (Observed impacts of climate on tourism). These metrics are specifically suggested for the tourism context and represent the three dimensions of: i) hazards (Table 13), ii) exposure (Table 14); and iii) vulnerability (Table 15). For some indicators the data source has already been identified, whereas others require further investigation or potentially the development of a new data set.

It is noted that these indicators are a first suggestion only and require further consultation. Also, ONEP are working on a set of tourism-specific indicators as part of their NAP process. The indicators presented below may constitute additional input into ONEP's indicator selection.

Table 13 Indicators of climate hazards

Factor	Metric	Source	Note
Heat	• Tmean, Tmax, Tmin, • Hot days over 35˚C • Summer Days >25 ˚C • Tropical Nights >20 ˚C • Heat index days • Warm spell duration	World Bank	Can also be sourced locally and projected using downscaled models.
Flooding and 'bad weather', and drought	• Total precipitation mm • Days with Rainfall >20mm • Days with Rainfall >50mm • Maximum 5-day rainfall (increase in mm)	World Bank	Can also be sourced locally and projected using downscaled models.
Coastal inundation and erosion	• Sea level rise (mm) • % of beach loss	tbc	
Disaster risk from storms	• Changes in storm intensity	tbc	
Jellyfish outbreaks	• No. of visitors affected by jellyfish	tbc	
Coral bleaching	• % of coral reefs bleached	Tbc (Government program or CoralWatch citizen science)	Taskforce established by Department of Marine and Coastal Resources (DMCR) and Department of National Parks, Wildlife and Plant Conservation (DNP)

The dimension of exposure helps to describe and measure the elements that are at risk. Assessing exposure generates information the number and type of people, their livelihoods, infrastructure, or economic, social, or cultural assets that may be adversely affected by climate hazards. In addition, exposure also includes places and settings (e.g. touristic spots), species or ecosystems, environmental functions and resources (e.g. availability of freshwater) that could be impacted and need to be protected. Table 14 provides tourism specific indicators related to exposure.

Table 14 Indicators of tourism exposure

Factor	Metric	Source	Note
Tourism activity in exposed areas	• Population (and tourist) density in coastal areas • $ investment for tourism in coastal areas • Density of hotels in exposed areas (e.g. hotels per km2)	tbc	Could be differentiated by areas exposed to hazards, e.g. flood plains, shoreline, etc.
Seasonality	• Ratio of international tourists travelling to Thailand during June to September (flood hazard related), or April to May (heat stress related)	Indicator suggested in Thailand's 2nd National Tourism Development Plan	Reduced seasonal peaks decrease exposure of tourism and improve ability to manage due to less concentration (this could also be an indicator of vulnerability).
Travel behaviour (trip length)	• Length of stay (international and domestic)	Tourism statistics (UNWTO)	Longer stays reduce exposure if they lead to higher dispersal into less exposed regions. Could also be an indicator of vulnerability due to better familiarity with destination and greater economic benefits.
Visitor dispersal	• Tourism receipts in second tier provinces	Indicator suggested in Thailand's 2nd National Tourism Development Plan	Better dispersal increases the likelihood of visitors travelling to less exposed 'hot spots' (e.g. coastal areas, Bangkok). Could also be an indicator of vulnerability if greater dispersal erodes ability to manage.
Water shortages	• Water use in tourism businesses (litres)	tbc	Water scarcity affects level of service, but also increase potential resource conflict.

Vulnerability describes the propensity to be negatively affected, given certain hazards and exposure to them. The higher the sensitivity to harm and the lower the capacity to cope or adapt, the higher the vulnerability. For example, a tourism business depending on one single market (e.g. European backpackers) and product (e.g. diving tours) is highly vulnerable to any changes to these critical parameters. Diversifying the offer and appealing to broader visitor groups, in particular domestic travellers, increases the capacity to act in the face of adversity (e.g. a coral bleaching crisis) and draw on alternative incomes (e.g. guided tours or cooking classes) (Table 15).

Table 15 Indicators of tourism vulnerability

Factor	Metric	Source	Notes
Internet coverage	• % of population with Internet access	National statistics	Better Internet access reduces vulnerability.
Air quality	• Air Quality Index (AQI)	National monitoring	Better air quality reduces overall vulnerability to climate change.
Contribution of visitors to the Thai economy	• Visitor expenditure (international and domestic)	Tourism statistics	More expenditure reduces vulnerability due to improved development.
Domestic tourism activity	• Volume of domestic tourism	Indicator suggested in Thailand's 2nd National Tourism Development Plan	More domestic tourism is likely to relatively decrease vulnerability compared with international tourism.
High quality visitor attractions	• Attractions with quality mark and/or environmental certification	Indicator suggested in Thailand's 2nd National Tourism Development Plan	Higher share of quality businesses reduces vulnerability. Needs to be enhanced with environmental certification criteria.
Safety of visitors	• Number of tourist fatalities due to natural disasters	tbc	More fatalities are an expression of increasing vulnerability (as well as exposure and hazards).
Demographics of visitors	• Share of tourists aged over 65	tbc	Elder people are more vulnerable to heat stress.
Insurance coverage	• Number of insured businesses	tbc	Insured entrepreneurs are less vulnerable to climate change impacts as they recover quicker.
Climate change awareness	• % of tourism stakeholders with high awareness of climate change risks.	tbc (survey)	Higher awareness is likely to lead to enhanced protective action.
Governance	• Tourism policies include climate change (% of relevant policies that integrate climate)	tbc	The more climate change is mainstreamed the higher the chances of improving adaptive capacity.

The 4th of June stakeholder workshop confirmed a number of indictors that appeared to be of priority to stakeholders. Specifically, the following indicators stood out as being perceived as important (Photo 4):

- Changes in precipitation – Flooding
- Changes in precipitation – Drought

- Sea surface temperature rise
- Seasonality
- Tourism activity in exposed areas
- Safety of visitors
- Contribution of tourism to the Thai economy
- Coral bleaching
- Coastal erosion

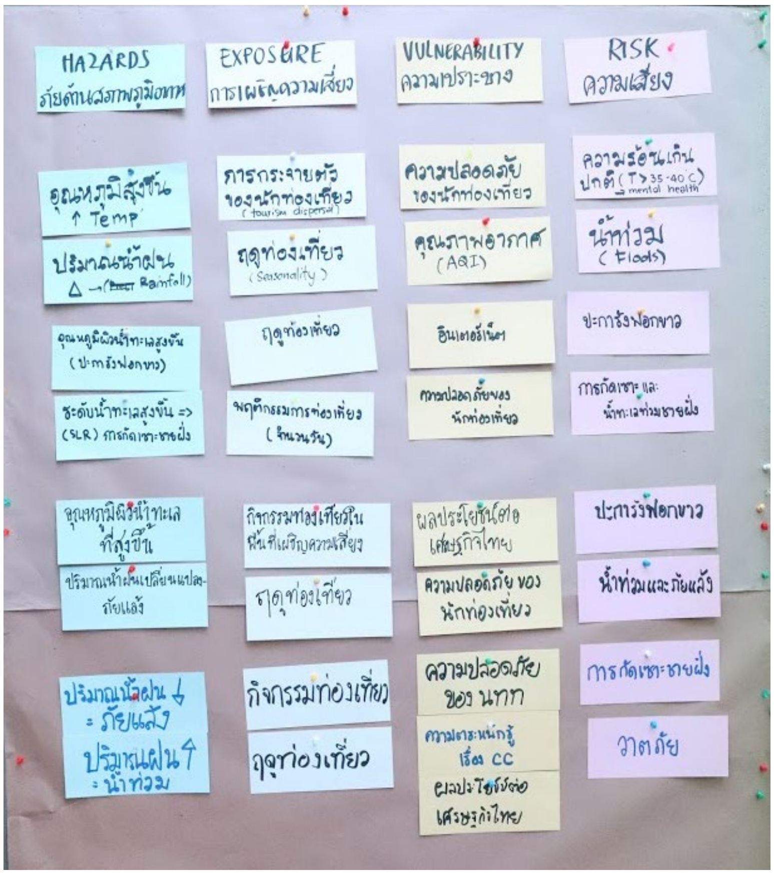


Photo 4 Stakeholders identified important indicators (Source: 4 June workshop).

7. Future Risks to Tourism from Climate Change

This chapter presents an assessment of future risks for tourism in Thailand due to climate change. Figure 42 summarises the key trends and metrics identified as relevant for the tourism system, building on the risk framework provided by the IPCC. The chapter first presents the findings from a risk prioritisation exercise undertaken at a stakeholder workshop (see Chapter 3 for method) and then integrates the findings from Chapters 4 to 6 to arrive at an overall assessment of risks and hot spots.

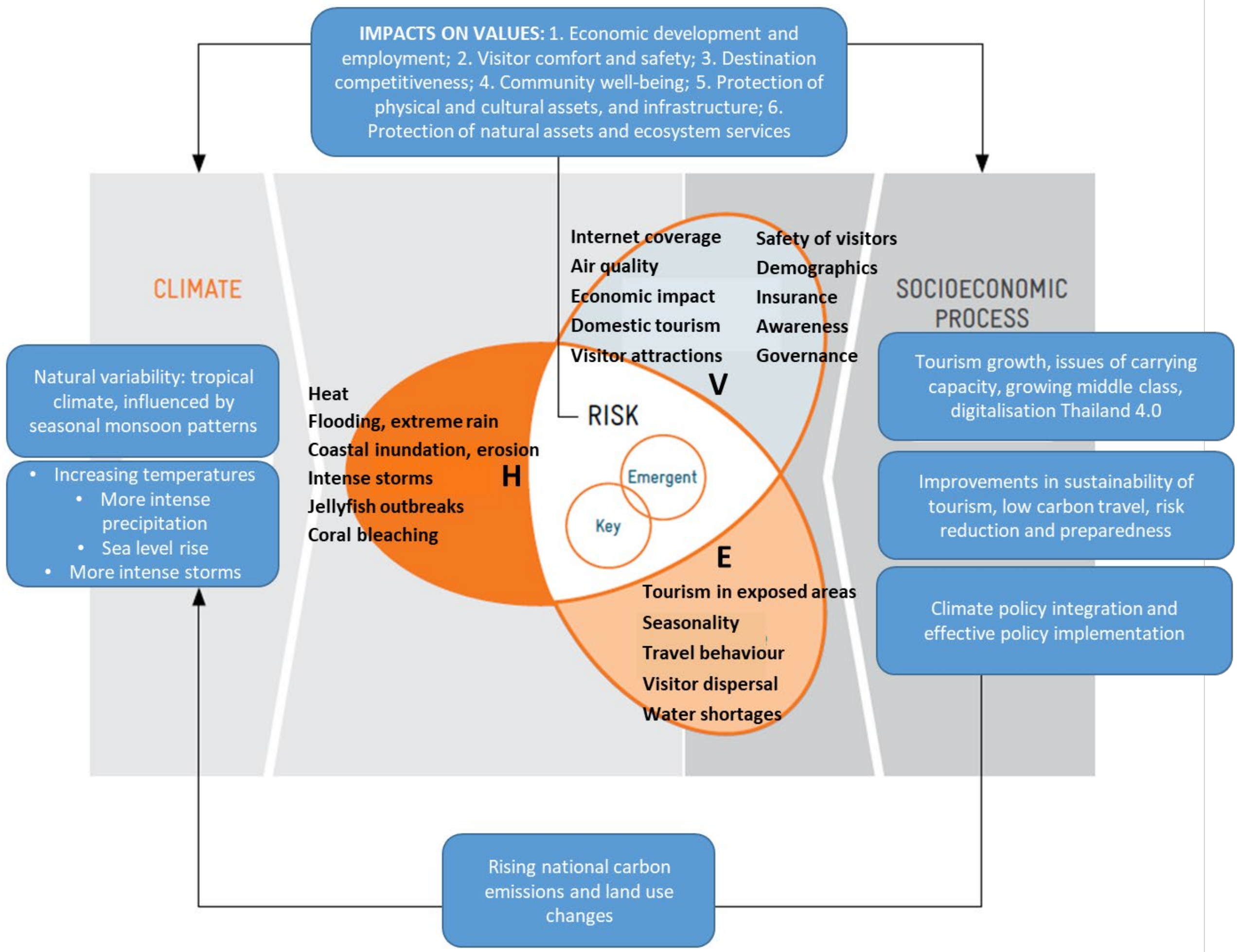


Figure 42 Risk framework enriched by tourism-specific insights for Thailand (Source: based on IPCC, 2014).

7.1. Risk matrix – future risks

In the February workshop, a series of climate risk statements for tourism were presented to stakeholders. These statements captured a particular hazard and potential intermediate impacts and risks. To provide a more conclusive and easy-to-understand narrative, some of the statements also make specific reference to 'elements-at-risk', i.e. parts of the tourism system that might be particularly exposed. Table 16 presents the statements and relates them to the tourism values that are at risk.

Table 16 Climate impact and risk statements for tourism

Statement	What values are at risk?
Increased temperature and heatwaves, resulting in discomfort and health risks for visitors. Higher operational costs.	• Economic benefits • Tourist safety and comfort
Reduced precipitation, shorter monsoon season and higher evaporation in some regions leading to drought or water shortage. Higher operational costs for operators in terms of water supply.	• Economic benefits • Community well-being
Biodiversity loss – loss of plant and animal species. Increased ocean temperature leading to loss of marine biodiversity. Impact on nature-based tour operators.	• Economic benefits • Protecting natural assets
Ocean acidification and rising sea temperatures pose risk to coral reefs by causing stress to the coral ecosystems. If the reef suffers damage or a reduction in size, operators have less resources to support their business.	• Economic benefits • Protecting natural assets
High temperatures and reduced precipitation increasing risk of forest fires, threatening infrastructure, community/ visitor safety and demand.	• Protecting assets and heritage • Community well-being • Tourist safety and comfort
Increased frequency of heavy precipitation in some regions leading to flooding or flash floods, damaging historic architectural and cultural assets, damage to tourism infrastructure and issues of access.	• Protecting assets and heritage • Community well-being
Extreme storm impacts on built assets, utilities, and transport infrastructure. Damage causing supply chain disruptions and increased costs, e.g. for insurance.	• Economic benefits • Protecting assets and heritage • Tourist safety and comfort
Shortening of the cold period (cold days T < 16° C) in the North and Northeast. This may reduce destination attractiveness as a cool 'winter retreat'.	• Destination competitiveness • Tourist safety and comfort
Sea level rises – loss of land and risk of inundation of tourism infrastructure and landscapes (beaches, dunes, mangroves). Exacerbated impacts of storm surges / spring tide, including in low-lying urban areas (e.g. Bangkok).	• Protecting assets and heritage • Destination competitiveness
Reputational damage from extreme weather events (i.e. safety perceptions, destination image), reduced demand.	• Destination competitiveness
Changes in consumer sentiment towards long-haul travel with possible decline in destination competitiveness.	• Destination competitiveness
Multiple climate hazards leading to reduced security and social unrest caused by climate impacts on food and water security, and public health. Reduced ability of tourism to provide good quality services and safety.	• Economic benefits • Destination competitiveness
Tourist health / comfort and negative publicity due to increases of tropical diseases, e.g. mosquito-borne diseases (e.g. Malaria, Dengue Fever).	• Tourist safety and comfort • Destination competitiveness

Participants rated the above statements according to likelihood and consequence (Figure 43). Stakeholders are most concerned about impacts on the marine environment (from acidification and coral bleaching). Flooding events, droughts, and sea level rise are all seen as very likely and associated with a significant impact. Heatwaves are also seen as likely, but the consequences are perceived to be less detrimental. Increasing damage from storm is seen as likely and causing damage to the tourism industry. Interestingly, the risk of reputational damage as well as impacts from increasing occurrence of diseases are not seen as priorities.

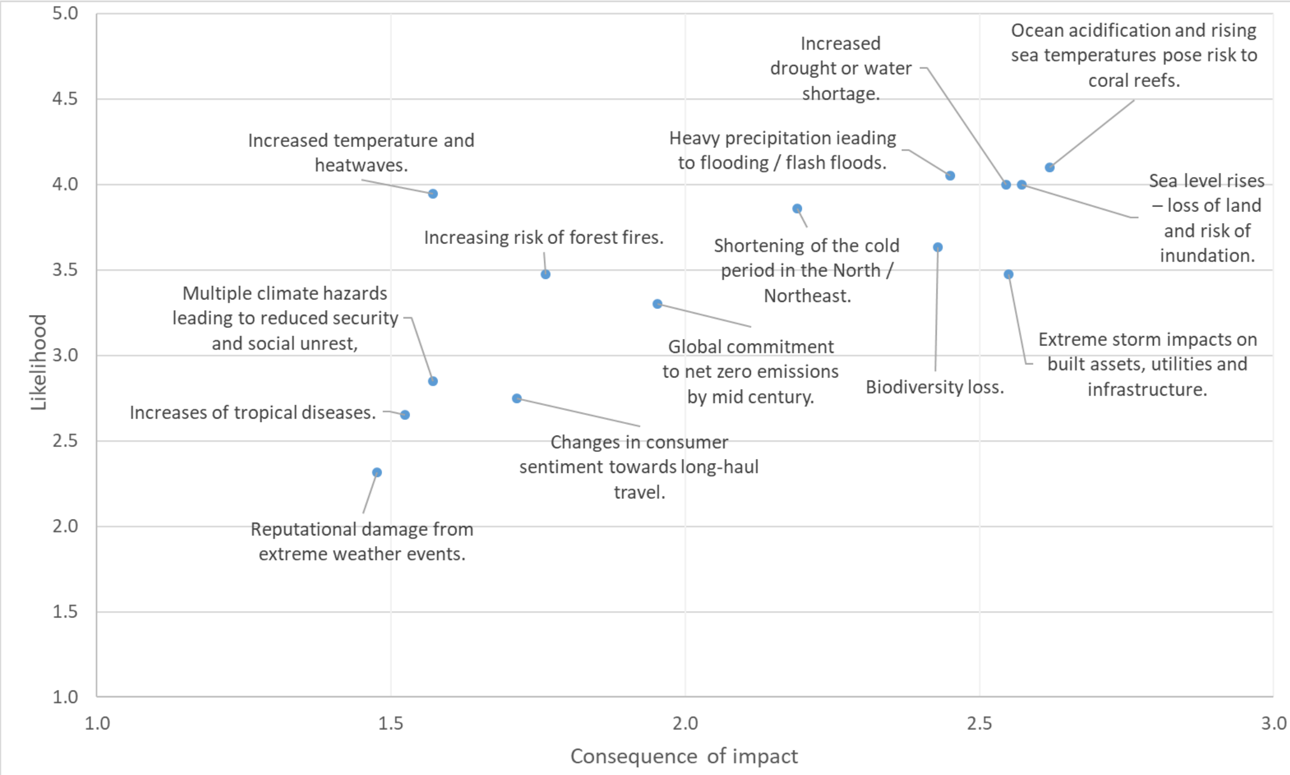


Figure 43 Risk matrix for key impacts of climate change affecting Thai tourism (stakeholder workshop).

7.2. Awareness of climate risk as an important factor

Tourism stakeholders in Thailand understand that climate change has the potential to undermine tourism development goals and specific benefits that tourism might bring. The following examples originate from a stakeholder workshop held in February (Photo 5). One of the key opportunities from tourism is development of infrastructure. In particular, transport infrastructure provides the necessary means for tourism to develop, but it also provides greater connectivity for locals. Transport infrastructure is recognised as being exposed to flooding, and stakeholders suggested to improve the regulations and specifications for managing flood risk of key routes relevant to tourism. Another example relates to the protection of cultural heritage (including intangible heritage), which is at risk from climate change (amongst other factors such as overcrowding). Better zoning, regulation and building management might be options to reduce the risk.

Photo 5 Stakeholder ideas on what aspect of tourism development is at risk and how it could be addressed?

7.3. Vulnerability

A global comparison (181 countries) of risk and vulnerability using 27 indicators by Scott et al. (2019) shows that Thailand is among the countries in the shaded upper-right quadrant of Figure 44, which represents countries with higher vulnerability and where tourism represents a significant proportion of the national economy (more than 15% GDP). Many of the other countries in this higher risk quadrant are Small Island Developing States as well as some other countries from the Southeast Asia tourism region.

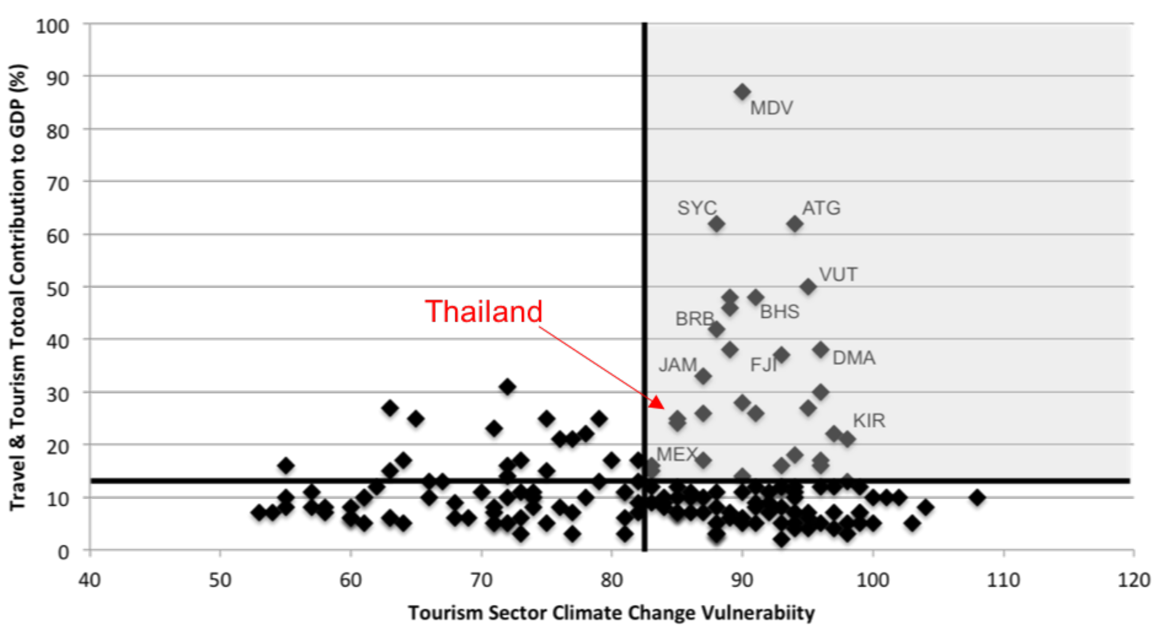


Figure 44 Global Climate Change Risk and Economic Importance of the Tourism Sector (Source: Adapted from Scott et al., 2019).

Figure 45 illustrates the dimensions of the index where Thailand's tourism was rated the most at risk, including country wide impacts that could deter tourism (e.g., weather related disasters, public health) and potential impacts on tourism demand (e.g., impacts on the broader economy affecting domestic and international arrivals, climate and other tourism assets). Thailand's tourism sector was rated as being in the highest risk quintile (top 20% of countries) for the following indicators: weather extremes, the proportion of leisure tourists (who are more apt to change travel plans than business or VFR travellers), and the projected impact of climate change on the domestic economy (GDP) and nearby countries. Thailand was also rated in the second highest risk quintile (top 40% of countries) with respect to: impacts on marine ecosystems, sea level rise, mitigation policy affecting energy costs, altered climate resources and international arrivals, climate change impacts on the economy (GDP) of its top 5 source markets, and public health impacts.

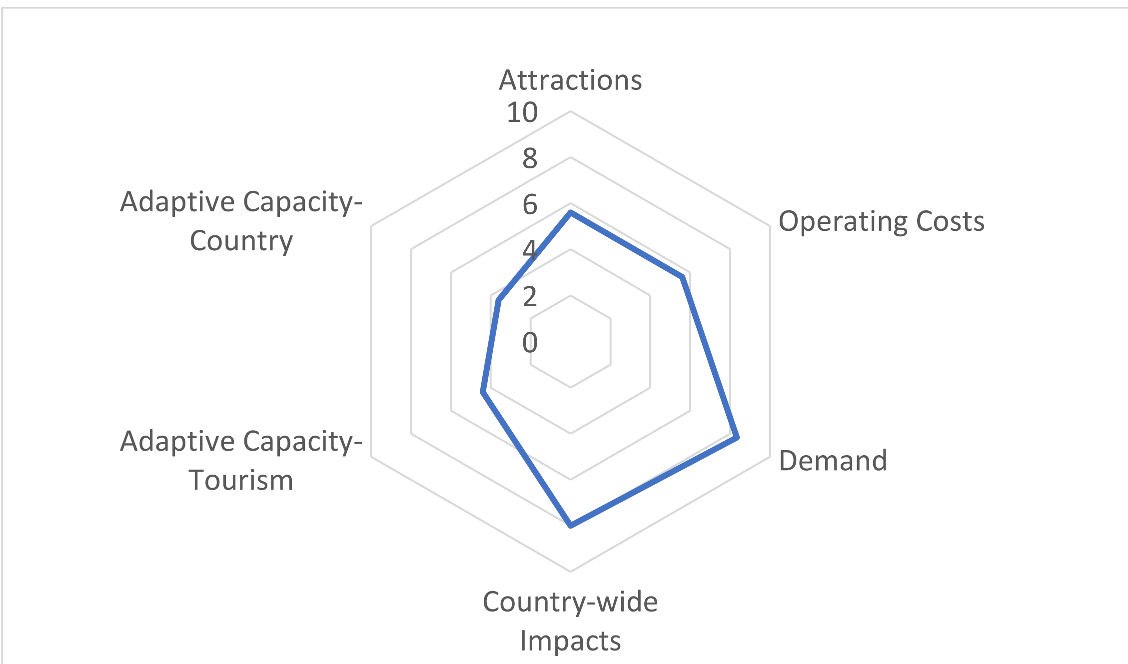


Figure 45 Thailand Tourism Climate Change Vulnerability Indicator Ratings (10=highest) (Source: Scott et al. 2019).

Figure 46 illustrates the relative risk ratings for 18 indicators associated with risks to tourism assets/attractions, operating costs, tourism demand and country level impacts that could impact tourism in Thailand. Rankings of 5 indicate that Thailand was in the most at-risk quintile (top 20%) relative to the 181 countries in the study. Thailand's highest risk factors included impacts associated with weather extremes and related disasters, exposure to highly adaptable international leisure tourism markets, and impact of climate change on the domestic economy/tourism spending. Some of these have already been recognised by stakeholders, but others require further exploration. For example, whether diversifying more strongly into business travel (as opposed to leisure) would be a suitable measure to reduce vulnerability.

The risk factors rated 'high' (top 21-40% of countries) included impacts on marine biodiversity, sea level rise impacts on beaches and coastal tourism infrastructure, future water stresses and costs, negative impact on international arrivals, climate change impact on economic growth in its top 5 markets, and health risks. Except for health risks, these have been captured in the CCRA presented here. Health risks are not featuring as a high priority amongst stakeholders, with the exception of jellyfish outbreaks. Further research into the exposure and vulnerability of particular tourist groups might be useful.

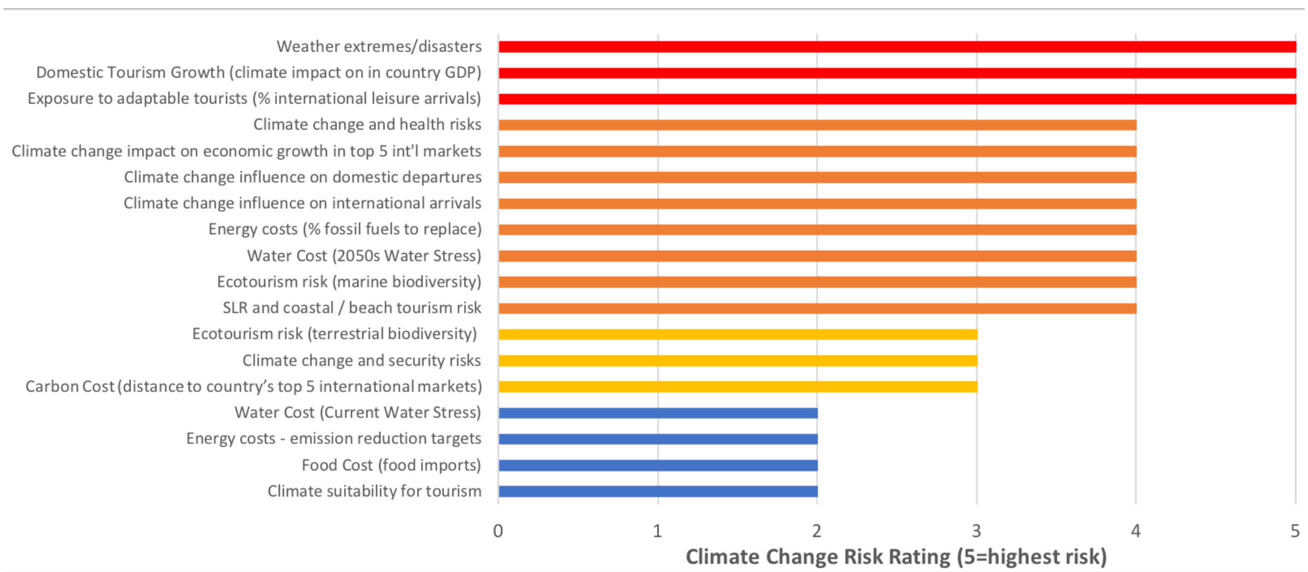


Figure 46 Specific risk ratings for Thailand (Source: Scott et al., 2019).

7.4. Risk assessment for macro-regions

7.4.1. National overview

Building on the insights provided above, five key future risks for Thailand tourism are evident.

1. Increased likelihood of **extreme precipitation events will lead to more flooding**, especially in the North, Northeast, and Central regions of Thailand. Unmitigated, this could lead to damage to tourism infrastructure and assets, and cause issues of transport access. More intense flooding can reduce the economic benefits of tourism and affect visitor comfort or even safety. Impacts on community wellbeing are likely, as well as damage to cultural heritage.
2. **Hotter temperatures will reduce visitor comfort**, and potentially health, and may reduce destination competitiveness. Greater need for air conditioning will also increase business costs, and lead to maladaptive effects in terms of increased carbon emissions. In combination with air pollution, heatwaves could have a significant impact on tourism.

3. **Warmer water temperatures and acidification make coral bleaching events increasingly likely and impactful**. This has major implications for those destinations that depend on marine tourism, as both the natural asset and competitiveness decline, and as a result the economic benefits from tourism. This would potentially affect community well-being.
4. **Increased risk of drought will put pressure on tourism businesses** to become more water efficient and maintain economic benefits from tourism, without increasing water conflicts with other sectors and the community (i.e. undermining well-being). Operational costs for water supply are likely to increase.
5. **Sea level rise and beach erosion** will affect destination competitiveness as the decline the natural resource on which coastal destinations are built. Declines in economic benefits are possible as a result.

Table 17 presents macro trends that are likely to shape climate risk for tourism in Thailand. This is followed by some more detail on regional risk factors.

Table 17 Summary of key drivers of risk

Dimension	Comment	Direction of trend
Climate hazards	Increasing temperatures (e.g. number of cool nights and heat index) indicate reduced thermal comfort.	Increases climate risk
	Increasing precipitation in more intense events leading to flooding and related impacts.	Increases climate risk
	Increasing risk of drought. Posing significant risks to destinations with limited freshwater resources, such as islands.	Increases climate risk
	Sea surface temperatures are increasing, leading to more frequent coral bleaching. In conjunction with ocean acidification the stress on marine ecosystems increases.	Increases climate risk
	Sea level rise and coastal erosion are projected to increase, affecting Thai beaches and coastlines.	Increases climate risk
	Storms may become more intense, increasing the likelihood of damage to the tourism system.	Increases climate risk
Exposure	Tourism is growing, leading to greater volumes to be managed and to be dispersed.	Exposure increases, but depends on extent and nature of dispersal.
	Investment into coastal development continues, leading to greater exposure of tourism.	Increases exposure.
	Efforts to decrease seasonality may alleviate exposure to unfavourable climatic conditions.	Could reduce exposure.

	Greater share of domestic tourism could lead to relatively less exposure.	Could reduce exposure.
	Reduction in water consumption by tourism businesses should reduce exposure.	Could reduce exposure.
Vulnerability	Declining air quality exacerbates comfort issues, especially in cities.	Increases climate risk.
	Greater economic contribution to the Thai economy could be used to strengthen adaptive capacity.	Could reduce vulnerability.
	Investment into high quality and climate proofed new attractions can build adaptive capacity. Focus on gastronomy tourism could reduce vulnerability but also increase exposure to new risks.	Could reduce vulnerability, but depends on attraction portfolio.
	More elderly visitors (including domestic) are more prone to be affected by adverse conditions.	Increases climate risk.
	Increasing knowledge and improving training will help adaptive capacity.	Could reduce vulnerability.
	Mainstreaming climate into policies and developing new partnerships could improve adaptive capacity.	Could reduce vulnerability.

7.4.2. North Thailand

Key climate hazards:

- Heat – in particular increasing heat index and reduced number of cool nights, which undermine destination competitiveness. Projections for Thailand indicate a warming by mid-century of 1.7 to 3.4°C by late-century with the rate of warming being relatively greater in the Northern and interior regions.
- Heavy precipitation – the climate models are less certain compared with temperature, but indication is that precipitation will increase, but rain will fall in fewer days. Hence, extreme rainfall events are more likely. In the past these have led to landslides and extensive flooding. Chiang Rai Province in northern Thailand is projected to experience some of the largest relative increases in precipitation.

Key aspects of exposure:

- Visitors who come during cooler winter months are exposed to a change in temperatures relative to the expectations of more comfortable conditions.
- Hotter temperatures exacerbate the problem of air pollution, which has been noted in relation to forest burn off and transportation.
- Businesses located in flood plains are exposed to water damage, but also those who depend on access that could be cut off due to flooding.

- Visitors who seek to participate in outdoor activities (e.g. trekking) are more exposed.

Key aspects of vulnerability:

- Elderly visitors who specifically seek thermal comfort might be more vulnerable.
- Free independent travellers to this region who come to undertake 'active holidays' (e.g. trekking) are likely to be healthier and less vulnerable to adverse conditions.

7.4.3. *North East Thailand*

Key climate hazards:

- Heat – in particular increasing heat index and reduced number of cool nights, which undermine destination competitiveness. Projections for Thailand indicate a warming by mid-century of 1.7 to 3.4°C by late-century with the rate of warming being relatively greater in the Northern and interior regions. Slightly higher increases in warming have been observed for the Eastern region, and the projected rate of warming is relatively greater in the Northern and Central parts of Thailand.
- Heavy precipitation – the climate models are less certain compared with temperature, but indication is that precipitation will increase, but rain will fall in fewer days. Hence, extreme rainfall events are more likely. In the past these have led to landslides and extensive flooding.

Key aspects of exposure:

- Businesses located in flood plains are exposed to water damage, but also those who depend on access that could be cut off due to flooding.
- Due to relatively lower visitation, the overall exposure of the region to changes in tourism activity is relatively less.

Key aspects of vulnerability:

- Visitors to North East Thailand are more likely to travel 'off the beaten track' and are potentially more familiar with local conditions and have higher coping ability.
- Businesses relying on a limited range of market segments are more vulnerable.

7.4.4. *Central Thailand*

Key climate hazards:

- Heat – in particular increasing heat index and reduced number of cool nights, which undermine destination competitiveness. Projections for Thailand indicate a warming by mid-century of 1.7 to 3.4°C by late-century with the rate of warming being relatively greater in the Northern and interior regions.
- Heavy precipitation – the climate models are less certain compared with temperature, but indication is that precipitation will increase, but rain will fall in fewer days. Hence, extreme rainfall events are more likely. In the past these have led to landslides and extensive flooding, particularly in the low-lying Chao Phraya River Basin, including Bangkok Metropolitan Area.

- Drought – the region has experienced previous periods of drought that affected tourism. The dry season could get drier, whereas the wet season gets wetter.

Key aspects of exposure:

- Tourism capital and assets, especially in the great Bangkok area, are highly exposed to flooding. This is also likely to affect cultural heritage (as evidenced in past experience).
- Visitors to Bangkok are particularly exposed due to the heat island effect.
- Hotter temperatures exacerbate the problem of air pollution, which is particularly evident in Bangkok.

Key aspects of vulnerability:

- Good Internet coverage ensures good flow of information in case of a disaster situation, or also to warn visitors of air quality or other health issues.
- Tourism businesses that consume more water are more vulnerable to water restrictions and shortages.
- Visitors to Bangkok with health issues are particularly vulnerable to a combination of poor air quality and hot temperatures.
- Businesses with no risk planning or insurance are more vulnerable to extreme events (e.g. flooding) than those who can afford disaster preparedness.

7.4.5. *South Thailand*

Key climate hazards:

- Increases in projected heat index are most pronounced in the South of Thailand.
- Coastal inundation is likely given projected trends of sea level rise.
- Beach erosion is a growing risk for beach-based tourism destinations.
- Coral bleaching – increasing occurrence of coral bleaching reduces destination attractiveness and may trigger more general degradation of marine ecosystems.
- More intense storms pose significant risk to tourism infrastructure in coastal areas, and safety of visitors and communities.

Key aspects of exposure:

- High density of population and tourism infrastructure in coastal areas increases exposure.
- Low distance to shoreline increases exposure to inundation, storm surge, storms, and beach erosion.

Key aspects of vulnerability:

- Lack of insurance and disaster preparedness hinders ability to recover after an event.
- Dependence on limited products and segments (e.g. diver tourism) increases vulnerability.
- Tourism businesses, particularly on islands with limited freshwater resources, that consume more water are more vulnerable to water restrictions and shortages.
- Coastal tourism possibly less vulnerable to heatwaves due to cooling effect of water.

8. Recommendations for Tourism Decision Makers

This chapter provides an outlook on how the findings from this national level CCRA can support the adaptation planning process of Thailand's tourism sector. The chapter summarises the key risks for Thailand tourism and what high level approaches might follow (8.1). It also presents an overview of existing knowledge and identified gaps (8.2). Thirdly, it introduces the concept of adaptation and presents some tools that help prioritise adaptation options (8.3). The recommendations are summarised in 8.4.

It is important to note that this CCRA provides the knowledge-base for further work by the consultancy team on Thailand's tourism sector policy environment. A more detailed stakeholder mapping exercise will follow, and this will help identify entry points into Thailand's regulatory framework for mainstreaming climate change adaptation. Both the CCRA and the policy analysis constitute integral elements of advancing Thailand's response to climate risks for tourism.

8.1. Prioritising action

Chapter 7 summarised five key risks for Thailand tourism, and addressing these is of strategic importance to ensure ongoing benefits and value generated from tourism activity. The risks were:

1. **Increased likelihood of extreme precipitation events will lead to more flooding;**
2. **Hotter temperatures will reduce visitor comfort;**
3. **Warmer water temperatures and acidification make coral bleaching events increasingly likely and impactful;**
4. **Increased risk of drought will put pressure on tourism businesses; and**
5. **Sea level rise and beach erosion will affect destination competitiveness as the decline the natural resource on which coastal destinations are built.**

In all cases, climate hazards exacerbate existing risks that are at least partially driven by human action, failures in management, or external costs imposed by other players. In other words, addressing non-climate risks is an important no-regret measure that will also help reduce the risks from future climate change. More specifically, risk of flooding and landslides can be reduced by improved land use management (e.g. limit deforestation, consider floodplains in the development process). Negative impacts of heatwaves can be moderated by working on reducing air pollution. Risk of coral bleaching and coral recovery is reduced by minimizing all other stressors affecting the marine ecosystem, for example water pollution. Maximising resource efficiency and avoiding all waste, especially in relation to water, will considerably reduce the risk of water shortages for tourism businesses. Finally, careful development of infrastructure in coastal zones will reduce risks of erosion and sea level rise. A general move towards greater sustainability of tourism will be highly beneficial for climate risk management and adaptation.

Second, and again valid for all five key risks, is an increasing need and opportunity to form partnerships. Tourism government organisations will increasingly work with other parts of government to ensure sustainable outcomes for Thailand as a country. Given tourism's growth this is of critical importance – simply to ensure no unwanted consequences of uncontrolled tourism growth. Examples of possible problems could be resource conflict over water, government resources spent on rescue missions for tourists, and increased pressure on national electricity grids from greater use of airconditioning in the tourism industry. Collaborations with key players will help manage such challenges and also carve out win-win opportunities. Public-private sector partnerships will also be increasingly important. An example might be a partnership with airlines around carbon offsetting and regeneration of natural ecosystems, or a partnership between leading hotels and water efficiency or disaster warning systems. Moreover, partnerships might involve local-level players (e.g. community groups), non-governmental organisations and knowledge partners.

Finally, all climate risks identified will require some form of financing to be addressed. In some instances, adaptation measures should eventually lead to a more efficient way of operating and save costs, but upfront investments are likely. An example would be to mainstream building designs (e.g. drawing on traditional architecture and design in Thailand) that ensure better ventilation and cooling and do not rely on air conditioning. Such designs would ultimately reduce operational costs. Research into the business case of adaptation measures (including return on investment and cost-benefit) would be helpful. Other measures might not require additional finance, but may result in a reduced income compared with business-as-usually practices of maximising return on a resource. An example is the closure of National parks, which is already used as a tool to ensure recovery of national systems. Such closures might lead to relatively less economic income from tourism in the short term but are likely to generate a greater net benefit in the long term.

To make informed decisions regarding the sustainability of tourism, partnerships and finance it is important to address some knowledge gaps, and consider the spectrum of adaptation options. These are explored in the following sections

8.2. Knowledge gaps

This CCRA revealed that there is substantial knowledge on climate change in tourism, both evident in the academic literature (international and Thailand specific) and organically amongst key stakeholders. The World Bank Data portal also allowed a national level examination of observed and projected climate trends. However, it was also found that more tourism-specific datasets are lacking, and more regional or local information needs to be identified, compiled or derived to produce meaningful destination assessments. A survey of tourists with regards to their perception of safety and comfort (e.g. air pollution, heatwave) would be beneficial to identify hot spots of concern. Furthermore, an economic analysis of the costs of previous and projected climate impacts would be useful.

The availability of reliable and robust data is key for future more specified risk assessments of Thailand's tourism sector at different scales, and for sub-sectors. Table 18 provides an overview of identified data sources and gaps in line with the proposed indicators in Chapter 6.4. This gap analysis serves as a basis for discussion amongst tourism stakeholders on what gaps could be addressed as a priority and with the highest benefit.

Table 18 Overview about existing knowledge and remaining gaps, in perspective to proposed indicators under chapter 6.4

Factor	Existing data	Gap
Heat	National level data from GCM, and downscaled projections	Higher resolution destination data to deliver local assessments/maps of increases in temperature
Flooding and 'bad weather', and drought	National level data from GCM, and downscaled projections	Localised flood and drought risk data/ maps on destination levels; integration with water scarcity maps by catchment.
Coastal inundation and erosion	National level data from GCM, and downscaled projections	Local level sea level rise projections and overlay with topography and geomorphology (i.e. coastal models).
Disaster risk from storms	National level data from GCM, and downscaled projections	Local level storm activity projections.
Jellyfish outbreaks	N/A	No statistics of jellyfish outbreak duration per coastal zone and affected tourists available.
Coral bleaching	Tbc (Government program or CoralWatch citizen science)	Monitoring program to be developed (by reef and considering different habitats and species composition)
Tourism activity in exposed areas	tbc	No local data on tourism flows and distribution, tourism activity (what and who) nor tourism infrastructure and investment.
Seasonality	Visitor statistics are available	Visitor statistics only at national level.
Travel behaviour (trip length)	Statistics are available	No information on where people stay and a complete location/map of all accommodation (densities)
Visitor dispersal	Some statistics are available	Detailed expenditure distribution by destination and commodity type (i.e. as in Tourism Satellite Account)
Water shortages	tbc	No data on resource monitoring (including water) by tourism businesses.
Internet coverage	National statistics available	Local-level statistics tbc
Air quality	Statistics available	Could be derived for destinations of interest.
Contribution of visitors to the Thai economy	Tourism statistics	See above on lack of detailed expenditure data.
Domestic tourism activity	Statistics are available	Limited additional information on domestic tourism activity (where, what, who)
High quality visitor attractions	Statistics are available	No central database on certified businesses.
Safety of visitors	tbc	No national (or broken down by destination) inventory on incidents involving visitors.
Demographics of visitors	tbc	No age distribution of visitors available.

Insurance coverage	tbc	No publicly available data on insurance coverage in tourism.
Climate change awareness	tbc (survey)	Would require a monitoring program (survey)
Governance	tbc	Unknown at this point and would require ongoing assessment.

The following actions could help address some of the gaps and add depth to this present CCRA:

1. Understanding key temporal and spatial dimensions of the tourism system

- A survey of visitors to Thailand (and ideally domestic tourists as well) designed to collect information on itineraries and activities is recommended. This information could be converted into 'tourist flows' and visitation maps (densities) to help tourism planning and risk management.
- The survey could also include other relevant questions on visitor experience to generate multiple benefits to tourism stakeholders, including strategic priorities (e.g. digitalisation of tourism, emerging products such as agritourism and community-based tourism).

2. Subnational level climate change risk assessments:

- Should be conducted for tourism hotspots at a regional or destination level. Potential scope of such assessments could cover Bangkok, Phang Nga Bay, Mu Ko Chumphon Archipelago, Mu Ko Chang National Park, Andaman Coast, or Gulf of Thailand.
- The assessment can provide more detailed insights into risk factors and factors shaping context-specific vulnerabilities and hazards.
- GIS maps could be used as a tool to display specific risk areas to tourism sector to raise awareness. This can be based on a quantified risk index utilising selected indicators proposed in chapter 6.4; and
- Participatory methods (e.g. focus groups) can also be considered to provide additional information from local stakeholders of relevance to the risk assessment.

3. Targeting one pilot destination as a case study site:

- One pilot destination (e.g. one of the 55 secondary destinations promoted to diversify visitor flows) could be selected for a targeted risk assessment and participatory identification of adaptation options.
- A climate change risk-informed development plan (e.g. with zoning, building standards, promotion of insurance coverage) can be developed.
- Demonstration of how tourism data can be integrated with other data (e.g. on National Park management or land use planning).
- The findings can be used to showcase this case study site as a good practice example that can be replicated among primary and secondary tourism destinations.
- Marketing and communications plan should be put in place. The objective of the plan is to communicate the milestones with tourism stakeholders. Marketing communication strategies should be derived to showcase this site as "Thailand Climate Resilient" pathway and/or Thailand responsible tourism/sustainable best practices.

Finally, and in addition to knowledge and data gaps, gaps exist in human resources and capacity. This present project is accompanied by training of tourism stakeholders, and a needs assessment is being developed. Capacity has to be built at the national and provincial levels, and amongst the business community.

8.3. Summary of recommendations

Building on the risk assessment presented in this report, and following on from the above suggestions for activities to address knowledge gaps, ten 10 key recommendations are made. These present 'ways forward' to progress the tourism sector in Thailand towards addressing climate risk. A more detailed adaptation plan or roadmap should follow these recommendations.

- Rapidly improve the sustainability of tourism generally to reduce pressure on social and environmental systems. This will increase adaptive capacity to future climate risks.
- Work with other Government agencies to identify unsustainable practices that increase the exposure and vulnerability of tourism, and advocate for changes in policy and practice.
- Identify partnerships (across government, with private sector, and other organisations) to carve out win-win opportunities for climate risk management and adaptation.
- Explore finance mechanisms for climate change adaptation and address data gaps on the business case of particular adaptation measures. Long time frames should be considered.
- Invest in robust tourism statistics on regional visitation patterns by both international and domestic visitors.
- A survey of tourists with regards to their perceptions of safety and comfort (e.g. air pollution, heat-wave) will help determine critical thresholds.
- Ensure that tourism strategies (e.g. diversification, dispersal) take into account changes in climate risk and product/destination competitiveness.
- Develop a destination-based risk assessment to illustrate how tourism planning and policy need to incorporate projected changes in climate risk at a local level.
- Building on this CCRA, invest into further work on identifying, assessing and costing a portfolio of adaptation pathways and measures.
- When communicating to tourism stakeholders, frame climate adaptation as being part of 'good practice', long-term planning and business competitiveness, rather than it being an additional and separate task.

9. References

Airports of Thailand (AOT) (2016). Airports in Thailand – Corporate Presentation. https://seekingalpha.com/article/4038726-airports-thailand-optimistic-long-term-prospects-concerns-near-term-valuations (accessed 23 April 2019).

Asia Disaster Preparedness Centre (ADPC) (n.d.). Flood inundation map (8-9 Nov 2011).

Bangkok Post (2016a). Relief as rain falls, but drought's aftermath to linger. Available (03/01/2019) http://www.bangkokpost.com/news/general/994313/relief-as-rain-falls-but-droughts-aftermath-to-linger

Bangkok Post (2016b). Severe water shortage on Koh Samui. Available (03/01/2019) https://www.bangkokpost.com/news/general/1107052/severe-water-shortage-on-koh-samui

Beck et al. (2018). Present and future Köppen-Geiger climate classification maps at 1-km resolution. Nature Scientific Data. DOI:10.1038/sdata.2018.214

Becken, S. (2013a). Tourism and Climate Change – an Evolving Knowledge Domain. Tourism Management Perspectives, 6, 53–62.

Becken, S. (2013b). Developing a framework for assessing resilience of tourism sub-systems to climatic factors. Annals of Tourism Research, 43, 506–528.

Becken, S. (2016). Climate change impacts on coastal tourism. Info Sheet 6. CoastAdapt, NCCARF. https://coastadapt.com.au/sites/default/files/factsheets/T312_7_Coastal_Tourism.pdf

Becken, S. & Hay, J.E. (2012). Climate change and tourism: from policy to practice. Routledge, New York.

Becken, S. & Wilson, J. (2016). Are tourism businesses' responses to weather variability a suitable precursor to climate change adaptation? Worldwide Hospitality and Tourism Themes (WHATT), 8(5), 578-592.

Becken, S., Montesalvo, N. & Whittlesea, E. (2018). Building a resilient tourism industry: Queensland Tourism Climate Change Response Plan. Brisbane, Australia. Available (20/03/19) www.qtic.com.au

Calgaro, E., Naruchaikusol, S. & Pongponrat, K. (2009). Comparative Destination Vulnerability Assessment for Kao Lak, Patong Beach and Phi Phi Don (Project Report). Bangkok: Stockholm Environment Institute.

Centre for Climate and Security (2012). Bangkok: The Atlantis of the Pacific? Available (03/03/2019) https://climateandsecurity.org/2012/09/12/is-bangkok-sinking/

China Tourism Academy (2018). Development report of summer heat escape tourism in China. (2018中国城市避暑旅游☒展☒告).

Chinvanno, S. (2010). Preparation of climate change scenarios for climate change impact assessment in Thailand. Southeast Asia Regional Centre START: Available (03/11/2018) http://startcc.iwlearn.org/project/copy4_of_hydro-agronomic-economic-model-for-mekong-river-basin-and-local-adaptation-in-thailand-model-development

Chinvanno, S. (2013). A holistic approach to climate change vulnerability and adaptation assessment: Pilot study in Thailand, Adaptation Knowledge Platform, Partner Report Series No. 4. Stockholm Environment Institute, Bangkok. Available (12/12/18) www.asiapacificadapt.net

Church, J.A., White, N.J., Konikow, L.F., Domingues, C.M., Cogley, J.G., Rignot, E., Gregory, J.M., van den Broeke, M.R., Monaghan, A., & Velicogna, I. (2011). Revisiting the Earth's sea-level and energy budgets from 1961 to 2008. Geophysical Research Letters. https://doi.org/10.1029/2011GL048794

CIA (n.d). The World Factbook — Central Intelligence Agency: Thailand [WWW Document]. Cent. Intell. Agency. Available (03/11/2018) https://www.cia.gov/library/publications/the-world-factbook/geos/th.html

Climate and Development Knowledge Network (2014). Analyzing Vulnerability of the Belize Coastal Tourism Sector. Available (20/02/19) https://cdkn.org/wp-content/uploads/2014/04/Vulnerability-assessment-report_final.pdf

Climatological Center (2010). Climate variability and Climate change Projection in Thailand. Thailand Meteorological Department, Technical Document No. 551-524- 01-2010. Available (03/01/2019) http://bit.ly/1YUvaFR

Commission for Environmental Cooperation (CEC) (2017). North American Marine Protected Area Rapid Vulnerability Assessment Tool. Montreal, Canada: Commission for Environmental Cooperation. 30 pp.

Department of Public Works and Town and Country Planning (2005). City Planning for Phi Phi Island, Krabi Province. Ministry of Interior, Bangkok.

Dessai, S. & Hulme, M. (2004). Does climate adaptation policy need probabilities? Climate Policy, 2(4), 107-128.

Dodds, R. (2010). Koh Phi Phi: Moving Towards or Away from Sustainability? Asia Pacific Journal of Tourism Research, 15, 251–265.

Durack, P.J., Gleckler, P. J., Landerer, F.W., & Taylor, K.E. (2014). Quantifying underestimates of long-term upper-ocean warming. Nature Climate Change, 4, 999-1005.

Environment Agency (2012). Thames Estuary 2100 Plan. London. Available (23 April 2019) https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/322061/LIT7540_43858f.pdf

Environmental Solutions Limited (2015). Volumes I and II: Impact Assessment and National Adaptation Strategy and Action Plan to address climate change in the tourism sector of Saint Lucia. Prepared for the Caribbean Community Climate Change Centre, Belize. The Government of Saint Lucia.

Friedrich, T., Timmermann, A., Abe-Ouchi, A., Bates, N., Chikamoto, M., Church, M., …Santana-Casiano, J. (2012). Detecting regional anthropogenic trends in ocean acidification against natural variability. Nature Climate Change, 2(3), 167-171.

GIZ & EURAC (2017). Risk Supplement to the Vulnerability Sourcebook. Guidance on how to apply the Vulnerability Sourcebook's approach with the new IPCC AR5 concept of climate risk. Bonn: GIZ.

GoKohPhiPhi (2007). Phi Phi fun facts and cool things to know. Available (4 March 2019) http://www.gokohphiphi.com/phi-phi.html.

Haines, A., Kovats, R.S., Campbell-Lendrum, D. & Corvalan, C. (2006). Climate change and human health: impacts, vulnerability, and mitigation. The Lancet, 367, 2101-2109.

Hess, J.S. (2014). Including Tourism Enterprises to Finance Climate Change Adaptation: Exploring the Potential in Small Island Developing States (Master thesis). University of East Anglia (UEA), Norwich.

Hoeksema, B. W., Scott, C. & True, J. D. (2013). Dietary shift in corallivorous snails following a major bleaching event at Koh Tao, Gulf of Thailand, Coral Reefs, 32: 423–428.

Hönisch, B., A. Ridgwell, D.N. Schmidt, E. Thomas, S.J. Gibbs, A. Sluijs, R. Zeebe, L., Kump, R.C., Martindale, S.E. Greene, W. Kiessling, J. Ries, J.C. Zachos, D.L. Royer, S. Barker, T.M. Marchitto, R. Moyer, C. Pelejero, P. Ziveri, G.L. Foster, & B. Williams (2012). The geological record of ocean acidification. Science, 335(6072), 1058-1063.

Hönisch, B., Ridgwell, A., Schmidt, D., Thomas, E., Gibbs, S., Sluijs, A., … Williams, B. (2012). The geological record of ocean acidification. Science, 335(6072), 1058-1063.

Jones, C., & Pimdee, P. (2017). Innovative ideas: Thailand 4.0 and the fourth industrial revolution. Asian International Journal of Social Sciences, 17(1), 4 – 32.

Jopp, R., DeLacy, T. & Mair, J. (2010). Developing a framework for regional destination adaptation to climate change, Current Issues in Tourism, 13(6), 591-605.

Jopp, R., DeLacy, T., Mair, J. & Fluker, M. (2013). Using a Regional Tourism Adaptation Framework to Determine Climate Change Adaptation Options for Victoria's Surf Coast, Asia Pacific Journal of Tourism Research, 18(1-2), 144-164.

Klint, L.M., Jian, M., Law, A. & DeLacy, T. (2012). Dive Tourism in Luganville, Vanuatu: Vulnerability to Climate Change. Tourism in Marine Environments, 8 (1/2), 91–109.

Koad, P. et al. (2012). Sea surface temperature trends in the Gulf of Thailand and the Andaman Sea. Oceans Conference. https://ieeexplore.ieee.org/document/6263509

Krainara, C. (2013). Global Warming Impact: Case Study of Coastal Erosion in Central Thailand and Impact Mitigation. Office of the National Economic and Social Development Board. (in Thai)

Kumar, R., Barth, M.C., Pfister, G.G., Monache, L.D., Lamarque, J.F., Archer-Nicholls, S., Tilmes, S., Ghude, S.D., Wiedinmyer, C., Naja, M., Walters, S. (2018). How Will Air Quality Change in South Asia by 2050? Journal of Geophysical Research, Atmospheres, 123(3).

Ligaray, M., Kim, H., Sthiannopkao, S., Lee, S., Cho, K.H & Kim, J.H. (2015). Assessment on Hydrologic Response by Climate Change in the Chao Phraya River Basin, Thailand. Water, 7, 6892-6909.

Limjirakan, S. & Limsakul, A. (2012). Observed Trends in Surface Air Temperatures and Their Extremes in Thailand from 1970 to 2009. Journal of the Meteorological Society of Japan, 90(5), 647−662,

Limsakul, A. and Singhruck, P. (2016). Long-term trends and variability of total and extreme precipitation in Thailand. Atmospheric Research, 169, 301-317.

Limsakul, A., A. Chidthaisong and K. Boonprakob (2011). Thailand's First Assessment Report on Climate Change 2011 (Working group I: Scientific Basis of Climate Change). THAI-GLOB, Thailand Research Fund. Available (01/12/18) http://bit.ly/1TwhLjL (in Thai)

Masud, M., Soni, P., Shrestha, S. & Tripathi, N. (2016). Changes in Climate Extremes over North Thailand, 1960–2099. Journal of Climatology, Article ID 4289454, 18 pages.

Mercer, J., Dominey-Howes, D., Kelman, I., Lloyd, K. (2007). The potential for combining indigenous and western knowledge in reducing vulnerability to environmental hazards in small island developing states, Environmental Hazards, 7:4, 245-256.

Ministry of Tourism and Sports (2017). The Second National Tourism Development Plan (2017–2021), Bangkok: Ministry of Tourism and Sports.

Ministry of Tourism and Sports (2018). Tourism Statistics. Available (20/03/18) http://www.mots.go.th/main.php?filename=index

MOAC (2012). Climate Change Strategy in Agriculture 2013 – 2016. (in Thai)

Naruchaikusol, S. (2016). Climate Change in Thailand. TransRe Fact Sheet. Issue No. 2, June 2016.

National Statistical Office (2016). TNSO: The National Statistical Office, Kingdom Of Thailand [WWW Document]. Available (24/03/18) http://web.nso.go.th/index1.htm

Nations Encyclopedia, (2018). Thailand [WWW Document]. Available (23/03/18) http://www.nationsencyclopedia.com/geography/Slovenia-to-Zimbabwe-Cumulative-Index/Thailand.html

Nauels, A., Rogelj, J., Schleussner, C.F., Meinshausen, M. & Mengel, M. (2017). Linking sea level rise and socioeconomic indicators under the Shared Socioeconomic Pathways. Environmental Research Letters, 12(11), 114002. Bibcode:2017ERL....12k4002N. doi:10.1088/1748-9326/aa92b6.

NCCARF (2017). Guidance on undertaking a first-pass risk screening. Available (12/03/19) https://coastadapt.com.au/sites/default/files/factsheets/T3M4_1_1st_pass_risk_assessment_0.pdf

NESP Earth Systems and Climate Change Hub (2018). Climate change and the Shark Bay World Heritage Area: foundations for a climate change adaptation strategy and action plan, Earth Systems and Climate Change Hub Report No. 7, NESP Earth Systems and Climate Change Hub, Australia.

Nicholls, R.J., Hanson, S.E., Lowe, J.A., Warrick, R.A., Lu, X., Long, A.J. and Carter, T.R. (2011). Constructing Sea-Level Scenarios for Impact and Adaptation Assessment of Coastal Area: A Guidance Document. Supporting Material, Intergovernmental Panel on Climate Change Task Group on Data and Scenario Support for Impact and Climate Analysis (TGICA), 47 pp.

NOAA (2019). Trends in Atmospheric Carbon Dioxide. Available (12/03/19) https://www.esrl.noaa.gov/gmd/ccgg/trends/

Pasukphun, N. (2018). Environmental health burden of open burning in northern Thailand: a review. PSRU Journal of Science and Technology, 3(3), 11-28.

Promchote, P., Wang, S. & Johnson, P.G. (2016). The 2011 Great Flood in Thailand: Climate Diagnostics and Implications from Climate Change. J. Climate, 29, 367–379.

Raftery, A., Zimmer, A., Frierson, D., Startz, R., Liu, P. (2017) Less than 2C warming by 2100 unlikely. Nature Climate Change, 7, 637-641.

RCCAP and Indonesian Ministry of Environment (2012) Framework of Climate Change Risk Assessment: Overview Climate Change Risk Assessment in Indonesia. Available (23.04.2019) http://www.rccap.org/wp-content/uploads/2017/04/Indo-WS-D1-3_Framework_ClimateChange_Risk_Assessment_Indonesia.pdf.

Ritphring, S.; Somphong, C.; Udo, K., and Kazama, S., (2018). Projections of future beach loss due to sea level rise for sandy beaches along Thailand's coastlines. In: Shim, J.-S.; Chun, I., and Lim, H.S. (eds.), Proceedings from the International Coastal Symposium (ICS) 2018 (Busan, Republic of Korea). Journal of Coastal Research, Special Issue No. 85, pp. 541–545. Coconut Creek (Florida), ISSN 0749-0208

Rutty, M. & Scott, D. (2016). Comparison of Climate Preferences for Domestic and International Beach Holidays: A Case Study of Canadian Travelers. Atmosphere, 7(2), 30 - 42.

Samoa Tourism Authority (2012). National Tourism Climate Change Adaptation Strategy for Samoa (2012-2017). Apia.

Saramul, S. & Ezer. T. (2014). Spatial variations of sea level along the coast of Thailand: Impacts of extreme land subsidence, earthquakes and the seasonal monsoon. Global and Planetary Change, 122, 70–81.

Scott, D., & Gössling, S. (2018). Tourism and climate change mitigation: Embracing the Paris Agreement – Pathways to decarbonization. Brussels: European Travel Commission.

Scott, D., Amelung, B., Becken, S., Ceron, J.P., Dubois, G., Gössling, S., Peeters, P. & Simpson, M. (2008). Climate Change and Tourism: Responding to Global Challenges. Madrid/Paris: United Nations World Tourism Organisation and United Nations Environment Programme.

Scott, D., Gössling, S. & Hall, M. (2012a). International tourism and climate change. WIREs Climate Change, 3, 213-232.

Scott, D., Hall, C.M., Gössling, S. (2012b). Tourism and climate change: impacts, adaptation and mitigation, Contemporary geographies of leisure, tourism and mobility. Routledge: London, New York.

Scott, D., Hall, C.M., Gössling, S. (2019-in press) A Global Climate Change Vulnerability Index for the Tourism Sector. *Annals of Tourism Research*.

Sharma, D. & Babel, MS. (2013). Application of downscaled precipitation for hydrological climate change impact assessment in the upper Ping River Basin of Thailand', Climate Dynamics, 41(9-10), 2589-2602.

Shrestha, A. (2014). Assessment of water availability under climate change scenarios in Thailand, Journal of Earth Science Climate Change, 5:184.

Shrestha, S. & Lohpaisankrit, W. (2016). Flood hazard assessment under climate change scenarios in the Yang River Basin, Thailand, International Journal of Sustainable Built Environment, October 2016: Article in Press

Shrestha, S. (2014). Chapter 2: Assessment of Water Availability under Climate Change Scenarios in Thailand, Climate Change Impacts and Adaptation in Water Resources and Water Use Sectors: Case studies from Southeast Asia, Springer Water

Simpson, M.C., Gössling, S., Scott, D., Gladin, E., Hall, C.M. (2008). Climate Change Adaptation and Mitigation in the Tourism Sector: Frameworks, Tools and Practices. UNEP, University of Oxford, UNWTO, WMO, Paris.

Sojisuporn, P., Sangmanee, C. & Wattayakorn, G. (2013). Recent estimate of sea-level rise in the Gulf of Thailand. Maejo Int. J. Sci. Technol.2013, 7(Special Issue), 106-113. Available (14/05/19) www.mijst.mju.ac.th

Southeast Asia START Regional Center and World Wildlife Fund (2008). Climate change impacts in Krabi province, Thailand: A study of environmental, social and economic challenge. Available at: http://startcc.iwlearn. org/doc/Doc_eng_11.pdf

Stocker, T.F., D. Qin, G.-K. Plattner, L.V. Alexander, S.K. Allen, N.L. Bindoff, F.-M. Bréon, J.A. Church, U. Cubasch, S. Emori, P. Forster, P. Friedlingstein, N. Gillett, J.M. Gregory, D.L. Hartmann, E. Jansen, B. Kirtman, R. Knutti, K., Krishna Kumar, P. Lemke, J. Marotzke, V. Masson-Delmotte, G.A. Meehl, I.I. Mokhov, S. Piao, V. Ramaswamy, D., Randall, M. Rhein, M. Rojas, C. Sabine, D. Shindell, L.D. Talley, D.G. Vaughan and S.-P. Xie, 2013: Technical Summary. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Sugi, M., H. Murakami, and J. Yoshimura (2012). On the mechanism of tropical cyclone frequency changes due to global warming. *J. Meteor. Soc. Japan*, 90A, 397–408.

Talty, A. (2018). Bangkok Is The Most Visited City In The World. Available (04.02.2019) https://www.forbes.com/sites/alexandratalty/2018/09/25/bangkok-is-named-most-visited-city-in-the-world-again/#29ab07be4071.

Tam, S. (2019). Sounding the alarm: Is the Sri Lankan tourism sector prepared for climate change? A thesis presented to the University of Waterloo in fulfilment of the thesis requirement for the degree of Master of Arts in Geography and Environmental Management. Waterloo, Ontario, Canada.

TAT Intelligence Centre, (2019). Thailand Tourism Intelligence Centre. Available (17 April 2019) https://www.thailandtic.com/th/content/category/detail/id/16/iid/51.

Thai Tech (2015). Thailand ranks 6th in Asian Internet speeds. Available (19/02/19) https://tech.thaivisa.com/thailand-internet-speeds-asia/10942/

Thailand Development Research Institute (2018). Assessment of Mainstreaming Climate Change Adaptation into Policy and Plan for 4 Pilot Sites in Thailand. Inception Report. Submitted to SEA START RC and GIZ, Bangkok.

Thailand Meteorological Department (2011). Rainfall and Severe Flooding over Thailand in 2011. Climatological Center, Meteorological development Bureau. (in Thai)

Thammasart University Research and Consultancy Institute (2009). Final Report: Analysis of Sea Level Rise Impact to Land Use of Coastal Areas in Thailand. (in Thai)

The Guardian (2019). Thailand: tourists flee as Tropical Storm Pabuk set to bring seven-metre waves. Available (20/04/19) https://www.theguardian.com/world/2019/jan/03/thailand-tourists-flee-as-tropical-storm-pabuk-set-to-bring-seven-metre-waves

The Resort Municipality of Whistler (2016). Community Energy & Climate Action Plan. Available (20/11/18) www.whistler.ca

The World Factbook (2016). Available (10/01/19) http://web.nso.go.th/index1.htm

TRF (2011). IPCC &TARC Report: State of Knowledge on the World and Thailand's Climate Change. T-GLOUB, Thailand Research Fund. (in Thai)

UNESCAP (2016). Asia-Pacific Population Journal. Available (25/01/19) https://www.unescap.org/sites/default/files/publications/APPJ%20Vol.%2032%20No.1.pdf

US National Park Service (2013). Using Scenarios to Explore Climate Change: A Handbook for Practitioners. Climate Change Response Program. Available (20/03/19) https://www.nps.gov/subjects/climatechange/upload/CCScenariosHandbookJuly2013.pdf

USAID (2014). Mekong Adaptation and Resilience to Climate Change. Available (10/05/18) https://www.iucn.org/es/node/19117 van Hooidonk et al (2016). Local-scale projections of coral reef futures and implications of the Paris Agreement. Available (20/01/19) https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5175274/#b5

van Hooidonk R., Maynard J. A. & Planes S. (2013). Temporary refugia for coral reefs in a warming world. Nature Climate Change, 3, 1–4.

Wang, C., Liang, J., Hodges, K. (2017). Projections of tropical cyclones affecting Vietnam under climate change: downscaled HadGEM2-ES using PRECIS 2.1. *Quarterly Journal of the Royal Meteorological Society.* doi.org/10.1002/qj.3046

Wangt, Y., He, B., Herath, S., Basnayake, S. & Huang, W. (2014). Climate Change Scenarios Analysis in Coastal Region of Thailand. Journal of Coastal Research: Special Issue 68 - Climate Change Impacts on Surface Water Systems: pp. 160 – 167

Weather Online (2018). Climate of the World: Thailand | weatheronline.co.uk [WWW Document]. URL https://www.weatheronline.co.uk/reports/climate/Thailand.htm (accessed 3.13.18).

Wongthong, P. & Harvey, N. (2014). Integrated coastal management and sustainable tourism: A case study of the reef-based SCUBA dive industry from Thailand, Ocean & Coastal Management, 95: 138-146.

World Bank (2010). Climate Risks and Adaptation in Asian Coastal Megacities: A Synthesis Report. Available (20/03/19) https://siteresources.worldbank.org/EASTASIAPACIFICEXT/Resources/226300-1287600424406/coastal_megacities_fullreport.pdf

World Bank (2019). Country Profile: Thailand [WWW Document]. URL Available (27/01/19) http://databank.worldbank.org/data/views/reports/reportwidget.aspx?Report_Name=CountryProfile&Id=b450fd57&tbar=y&dd=y&inf=n&zm=n&country=THA (accessed 1.09.19).

World Bank (ongoing). World Bank Climate Change Knowledge Portal. Available (20/03/19) https://www.google.com/search?q=world+bank+portal+thailand+climte+change&rlz=1C1GGRV_enAU766AU766&oq=world+bank&aqs=chrome.0.69i59j69i57j69i60l3j0.2873j0j9&sourceid=chrome&ie=UTF-8

World Tourism Organization (2018). Compendium of Tourism Statistics dataset [Electronic], UNWTO, Madrid, data updated on 11/12/2018.

World Travel and Tourism Council (WTTC) (2018). Travel & Tourism Economic Impact 2017: Thailand. London: World Travel and Tourism Council.

Wu, L. et al., (2014). Simulations of the present and late-twenty-first-century western North Pacific tropical cyclone activity using a regional model. *J. Climate*, 27, 3405–3424.

Zhang, C. & Wang, Y. (2017) Projected Future Changes of Tropical Cyclone Activity over the Western North and South Pacific in a 20-km-Mesh Regional Climate Model. Journal of Climate. doi.org/10.1175/JCLI-D-16-0597.1