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# Climate Change Trends and Its Impact on Tourism Resources in Mu Ko Surin Marine National Park, Thailand

Onanong Cheablam[a] & Rajendra P. Shrestha[a]

[a] Natural Resources Management, School of Environment, Resources and Development, Asian Institute of Technology, PO Box 4, Klong Luang, Pathuthani 12120, Thailand

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# Climate Change Trends and Its Impact on Tourism Resources in Mu Ko Surin Marine National Park, Thailand

**Onanong Cheablam*** **and Rajendra P. Shrestha**
Natural Resources Management, School of Environment, Resources and Development, Asian Institute of Technology, PO Box 4, Klong Luang, Pathuthani 12120, Thailand

*The objective of this paper is to investigate the current and potential future impacts of climate change on tourism resources and tourism activities in Mu Ko Surin National Park. The research method for this paper involved the collection of information from interviews with key informants, non-participant observation, and secondary data. The results found that the park has experienced changes in climate, including increasing temperatures, changes in precipitation, rising sea surface temperature, and sea-level rise. The impact of increasing temperature can lead to mass coral bleaching. The beach was shown to have eroded at a rate of about 0.38 m per year. However, water resources are still sufficient for tourism activities. The impacts of climate change have led to coral reefs and fish being less attractive and reduced in quantity, some snorkeling and diving sites being closed. Therefore, for sustainable tourism management, adaptation action should take place in this area.*

**Key words:** climate change, coral bleaching, tourism resources, tourism activity, marine national park

## Introduction

Mu Ko Surin National Park is one of the Marine National Parks located in the Andaman Sea, in the eastern adjunct of the Indian Ocean. Today, the island is part of Phangnga Province, Thailand (Figure 1). The Park has two main islands: Ko Surin Nuea (North Island) and Ko Surin Tai (South Island). Around the two main islands are three smaller islands, namely Pachumba, Torinla, and Stork Island (Department of National Park, Wildlife and Plant Conservation [DNP], 2011). These smaller islands are most suitable for, snorkeling, SCUBA diving, and swimming especially on the site of the

*Email: conanong64@gmail.com

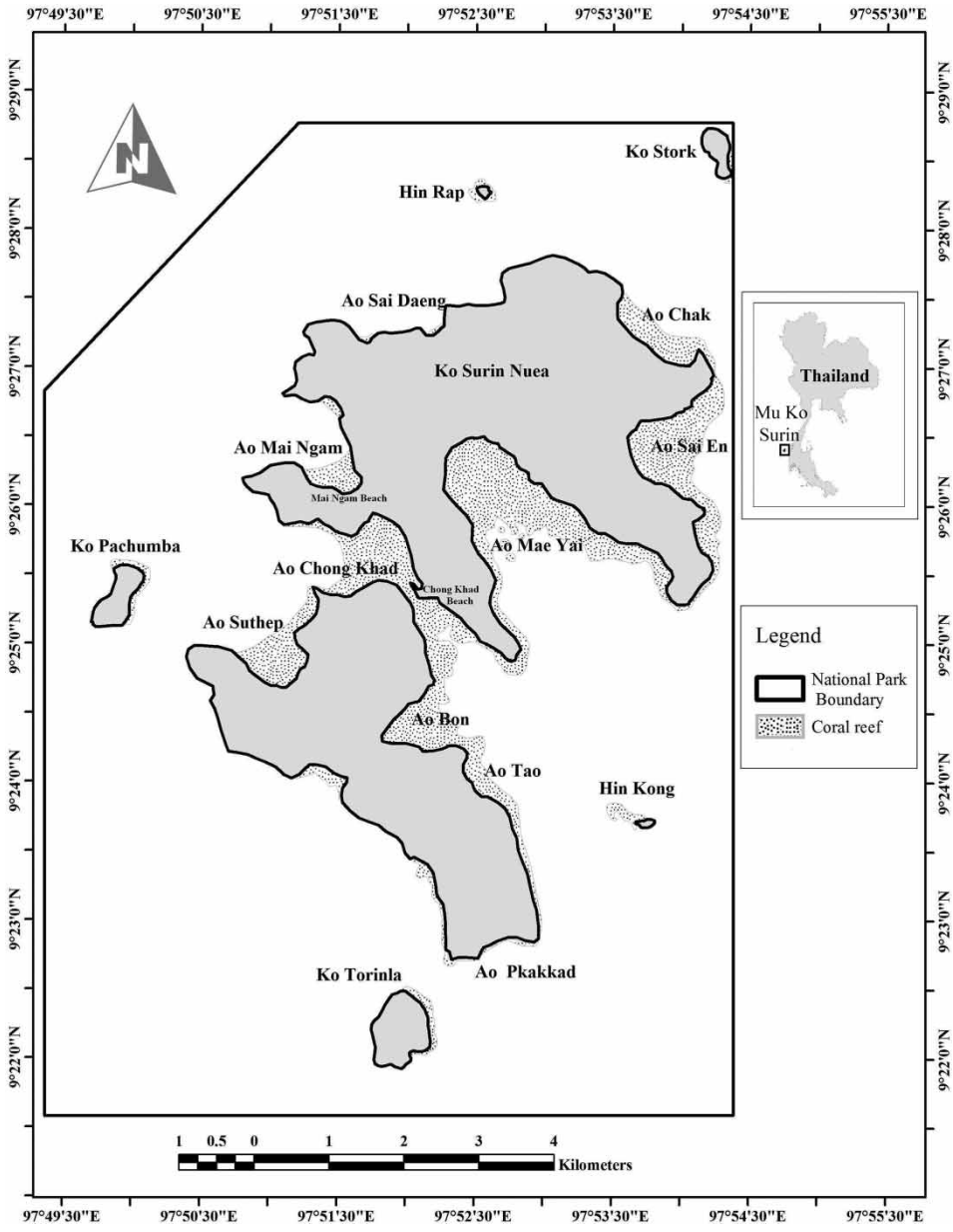


**Figure 1** Location Map of Mu Ko Surin Marine National Park, Thailand.

two exposed pinnacles. Mu Ko Surin is a popular destination for snorkeling and SCUBA diving (DNP, 2011). The terrestrial area of the island is covered by the dense forests and clean water, which enhance nature-based tourism activities such as hiking and camping (DNP, 2011; Worachananant, Carter, Hockings, & Reopanichkul, 2008). Mu Ko Surin consists not only of natural resources, but also has cultural resources; Moken (sea gypsies), who

depend on marine resources for their life. Due to the diversity of natural and cultural resources, Mu Ko Surin was registered as a site of Asian Heritage (ASEAN Heritage Parks, 2012). In the rainy season, between May and October, the Park is closed because of the heavy monsoon (DNP, 2011).

According to Scott, Gössling, and Hall (2012) and IPCC (2007a), the impacts of climate change led to damage of the natural resources, particularly in the coastal tourism and nature-based tourism. In addition, climate change impacts on destinations are closely entwined with tourist behavior (Gössling, Scott, Hall, Ceron, & Dubois, 2012). Hence, Mu Ko Surin National Park, which comprises smaller islands further from the mainland, and which is a hotspot among tourists, is vulnerable in the face of climate change, which affects the diversity of the island's shallow coral reefs. The coral reefs within the national park have been known for their great scenic quality, which help generate tourist activities (DNP, 2011). However, Mu Ko Surin National Park is still being disturbed by global climate change, which becomes evident in coral bleaching, as has been recorded since 1991 (Department of Marine and Coastal Resources [DMCR], 2010). Moreover, the trend of sea surface temperature (SST) – the main factor for coral survival in the Eastern Andaman – will continue to increase. By 2050, the SST is expected to exceed the coral's temperature tolerance (Hoegh-Guldberg, 1999). As a result of the impact of climate change on tourism, Thailand's gross domestic product will be significantly affected, because the tourism industry is the main source of the country's economy (Tourism Authority of Thailand [TAT], 2010).

Climate change impact is already influencing decision-making in the tourism destinations and all destinations will need to adapt to the risks and opportunities (Scott et al. 2012; World Tourism Organization [UNWTO], 2010). Although the number of publications on tourism and climate change has increased substantially since in 1986 (Becken, 2013) and climate change is expected to have a substantial impact in Thailand (Faculty of Environment and Resource Studies, 2008), a few studies have been conducted on the issue of climate change impacts on tourism in Thailand. In order to understand and increase awareness about the problem, both for the present and the future, this research attempts to fill the gap of climate change impact on tourism in marine destinations by showing the climate change trends and climate change impact on tourism resources and activities. The specific objectives of this research are to investigate the current and potential future impacts of climate change on tourism resources and tourism activity that are important for tourism at Mu Ko Surin National Park.

## *Trends of Climate Change on Small Islands*

The assessment carried out by the three Working Groups of the International Panel on Climate Change (IPCC) showed some future impact projections of climate change in Asia and in small island regions and some regions where it is more likely (more than 66%) to be impacted by global climate change (IPCC, 2007a). The Third Assessment Report in 2001 and the Fourth Assessment Report in 2007 of the studies carried out by the IPCC disclosed that small islands have the characteristics of being vulnerable to impacts from climate change, such as rising sea level, increasing temperature, and enhancement of extreme weather-related events, especially that most small islands have low adaptive capacity (IPCC, 2007b).

The evidence and projected scenarios observed by IPCC on global climate change showed that the global ocean temperature has risen by 0.10°C from the surface to a depth of 700 m between 1961 and 2003 (IPCC, 2007c). In the Indian Ocean, for example, the surface warming trend during the period from 1970 to 1999 had increased significantly where in some regions it exceeded 0.2°C per decade. In addition, the seasonal surface air temperature projection for the three 30-year periods relative to the baseline period from 1961 to 1990 showed that all regions would experience increased surface air temperatures, especially in the Mediterranean region where the air temperature would increase by 7.07°C between 2070 and 2099 (IPCC, 2007b).

The trends of extreme rainfall are generally less clear for each region than those of extreme temperatures (IPCC, 2007b). The result of the projected rainfall would usually indicate a trend of increased daily rainfall intensity and frequency. However, the number of storms had increased since the 1970s, particularly the greatest increases had been observed in the North Pacific, Indian, and South-West Pacific Oceans (IPCC, 2007b).

In addition, the effect of sea-level rise could lead to a reduction in island size, especially in the Pacific Ocean, although at the same time few islands are still resilient (IPCC, 2007b). At the end of the twenty-first century, the projected global average sea-level rise could be within the range of 0.19–0.58 m, with an average rate of $1.8 \pm 0.5$ mm/yr during the twenty-first century (IPCC, 2007c).

## *Trends of the Climate Change Impact on Park Tourism*

Physical resources that define the foundation of most tourism and recreation activities in parks can be affected by climate change, because tourism activities dependent on nature, such as ecotourism, are extremely influenced by climate. As a result of the changes in the length and quality of tourism and recreation, the reduced operating seasons due to changes in the climate, would have considerable implications for visitation and related aspects of park management (Jones & Scott, 2006).

WWF (2010) has also illustrated that under climate change, some species in many protected areas may disappear altogether in their current form. In addition, 29 of the protected areas around the world would be impacted by global climate change, which include the Backwater National Wildlife in USA, Gandhi National Park in India, Mount Kilimanjaro National Park in Tanzania, the Aldabra Atoll in the Indian Ocean (WWF, 2010), and Langtang National Park in Nepal (Nepal, 2011). Furthermore, the impact of climate change will also be felt in many areas. For example, the result of a study of Canada's national parks indicated that protected areas will suffer the loss of tundra and increase in temperate forests that will occur in over half of the protected areas (Laurance, 1998). Increased drought and aridity in South African protected areas could lead to huge losses of biodiversity (Turpie, Winkler, Spalding-Fetcher, & Midgley, 2002). In addition, tourism-related challenges for park management are the challenges relating to conservation and park management that are related to tourism in national parks. The recreational opportunities and visitation patterns will be changed by climate change. The length of operating seasons and the quality of tourism experiences are recreation dimensions that are highly sensitive to climatic change (Jones & Scott, 2006).

In Thailand, protected areas which include both the national parks and wildlife sanctuaries are located in 32 areas which are situated

in climate change hotspots (Greenpeace Southeast Asia, 2006). Moreover, Boonprakob and Santisirisomboon (1996) stated that the ecosystems within the protected areas may change in terms of types like the subtropical mist forest could be replaced by a tropical dry forest.

Overall, national parks and protected areas might experience diminished capability to operate some tourism activities, particularly the parks in the tropical latitude, because of frequent hotter days, fewer cold days, more rainfall, more cyclones, excessive coral bleaching, and so on. On the other hand, parks in temperate latitudes may receive more visitors due to longer operating seasons with warmer spring and fall seasons.

## Data Collection, Sources and Methods

The research method for this study involved the collection of information from both secondary and primary sources. The details of the data collection methods are as follows:

### *Primary Data*

*Observation*. Non-participant observation was conducted to gain more insights into the physical features of the tourist destinations, such as the status of corals, beaches, facilities, transportation networks, and the overall scenario of tourism. In addition, the performance of the natural resources and environmental management efforts in Mu Ko Surin, in terms of addressing beach erosion and coral bleaching, was also investigated.

*Key informant interviews*. The key informants considered for this research were the stakeholders involved in the tourism sector in Phangnga Province. In addition, Mu Ko Surin National Park's officer and academic persons who expert on coral reefs and climate change in Thailand were indept-interviewed for this study. Interviews with key informants were conducted to gain more information about historical bleaching, impact of climate change, and adaptation measures. The key informants were tourism stakeholders in Kuraburi district considered as knowledgeable persons who could provide information about the impacts of climate change on tourism. The key informants and numbers are shown in Table 1.

The interviews were intended to obtain in-depth information from the relevant individuals with specific knowledge, particularly on the effect of climate change on tourism activities, coral bleaching, frequency of precipitation, etc., which are related to climate change. Open-ended questions were used to facilitate the analysis in this study.

### *Secondary Data*

Secondary data were gathered or extracted from various sources such as journal articles, project reports, official records, and Internet websites (Table 2). Furthermore, the data related to climate were collected from relevant sources and analyzed to strengthen the information provided by the key informants.

## Results and Discussion

### *Climate Change Trends*

*Changing air temperature*. According to IPCC (2007a), the air temperature in the Indian Ocean has increased and will increase continually by 0.51–0.98°C during the period from 2010 to 2039 and 1.05° to 3.77°C

**Table 1** List of Key Informants Interviewed

| Target key informants | No. of key informants |
|---|---|
| • National park officer | 1 |
| • Experts on coral reef and climate change | 2 |
| • Accommodation/restaurant staff | 3 |
| • Tour operators | 3 |
| • Local people (persons engaged in tourism-related activities, community-based tourism group leaders) | 2 |
| • Transportation staff | 3 |
| • Destination organizers/officers, namely TAT and TAO officers | 2 |
| Total | 16 |

between 2070 and 2099. Similarly, observed changes in the mean temperature recorded in Phangnga Province at Takua Pa Station were 27.62°C in 1991–2000 and 27.66°C in 2001–2010. Although the mean air temperature has risen only slightly (Figure 2), the

**Table 2** Sources of Secondary Data

| Data | Sources of data |
|---|---|
| Air temperature between 1981 and 2010 | Meteorological Department (2010) |
| Precipitation between 1981 and 2010 | Meteorological Department (2010) |
| Sea level between 2001and 2007 | Marine Department (2010) |
| The projected temperature and precipitation patterns between 1980 and 2099 | |
| The temperature and precipitation were projected using the PRECIS regional climate model and the future climate trend was based on the initial data from the ECHAM4 Global Circulation Model under SRES A2 and B2 GHG scenarios. The change in the future climate is compared with the decade in the 1980s | SEA-START (2011) |
| SSTs between 2010 and 2011 | ReefBase: A Global Information System for Coral Reefs (2011) Retrieved from http://www.reefbase.org |
| Wave height between 1991 and 2010 | Meteorological Department (2010) |

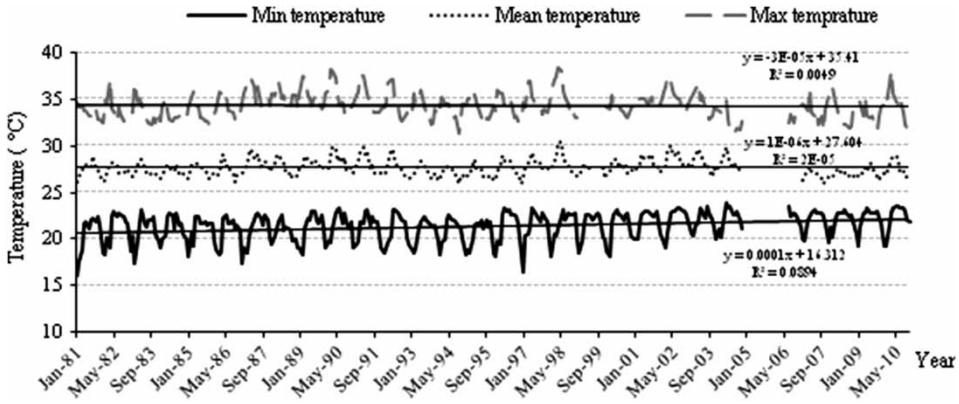


**Figure 2** Air Temperature in Phangnga Province between 1981 and 2010.
*Note*: Data for 2005 and 2006 not available from Meteorological Department.
*Source*: Meteorological Department (2010).

minimum temperature was significantly higher compared with the temperature over the three decades. In 1981–2009, the average minimum temperature was 16°C, but in 2001–2010 the average minimum temperature was 19°C. Therefore, the trend of temperature in the study area could likewise increase accordingly. As a result of the higher minimum temperature, there were fewer cold days, a finding that corresponds to the results of Vongvisessomjai (2010) and Faculty of Environment and Resource Studies (2008) which showed that in the past the annual mean minimum and mean maximum surface temperatures over southern Thailand followed an increasing trend.

Moreover, the Southeast Asian System for Analysis, Research and Training (SEA-START) Regional Center also projected the climate change in Phangnga Province using the PRECIS model (SEA-START, 2011). The result showed that in a 30-year period, the temperature will increase, and Phangnga Province will experience hotter days, with the air temperature above 33°C during 2070–2099 for more than 200 days a year (Table 3). Thus, in the future, Phangnga Province, where the study area is situated, would experience fewer cold days, cold nights would also become less frequent, while hot days and hot nights would be more frequent.

Although the rainfall trend is still not clear, it appears that the amount of rain will increase in each year in the future. Moreover, it is likely that there will be more events of heavy rain, but the amount of rainfall could not be established. The analysis shows that Thailand's section of the Andaman Sea, and the Indian Ocean of Thailand, would experience increased sea surface and air temperatures. The environment would be affected as the temperature gets higher and there would be more hot days, fewer cold days, and more intense precipitation. Thus, such climate change could be one of the most important environmental issues, and should be addressed, as it is affecting the tourism industry in these areas. These findings correspond to the results of IPCC (2007a) which indicated that in the Indian Ocean region, the air temperature would increase by 1.05–3.77°C between 2070 and 2099.

**Table 3** Past and Projected Changes in Temperature and Precipitation Between 1980 and 2099 in Phangnga Province by the PRECIS Model

| Data | 1980–2009 | 2010–2039 | 2040–2069 | 2070–2099 |
|---|---|---|---|---|
| Mean temperature (°C) | 27.83 | 28.30 | 29.35 | 30.77 |
| Cold day (<16°C) (day/year) | 0.00 | 0.00 | 0.00 | 0.00 |
| Hot day (≥33°C) (day/year) | 4.23 | 13.70 | 74.87 | 207.57 |
| Rainfall day (day/year) | 155.72 | 150.59 | 150.00 | 155.14 |
| Annual rainfall (mm/year) | 2,263.44 | 2,243.17 | 2,454.25 | 2,583.73 |
| Heavy rain (35.01 mm −90 mm) (day/year) | 8.14 | 9.83 | 12.03 | 15.10 |

*Source:* SEA-START (2011).

*Changes in precipitation.* The rainfall pattern in Mu Ko Surin National Park is influenced by the southwest monsoon. Rainfall recorded over three decades in Phangnga Province shows slight increases (Figure 3). The average annual rainfall recorded in Thakau Pa Station from 1981 to 1990 was 3,244 mm and 3,615 mm between 2001 and 2010. The highest monthly rainfall was observed in September, especially in 2007 when there was extreme rainfall of 1,104 mm, resulting in more intense precipitation events, while the lowest monthly rainfall was in February. The result implies that Mu Ko Surin National Park is exposed to the threats of precipitation change.

*Changes in the sea surface temperature.* Over the period from 2001 to 2010, the SST rose while the oceans were warming. The SST data in Mu Ko Surin National Park provided by ReefBase (http://www.reefbase.org) showed that the SST at Mu Ko Surin National Park has increased, especially in 2010, and that the SST has risen to more than 31°C continually in five-month periods (Figure 4).

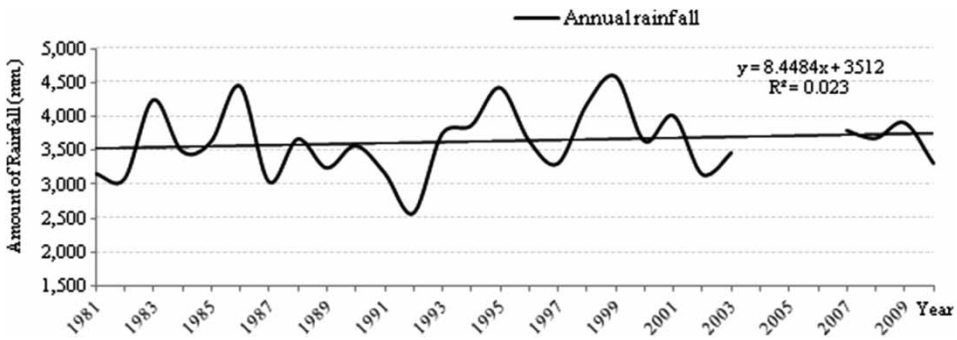


**Figure 3** Annual Rainfall in Phangnga Province at Takua Pa Station between 1981 and 2010.
*Note:* Data Except 2005 and 2006.
*Source*: Meteorological Department (2010).

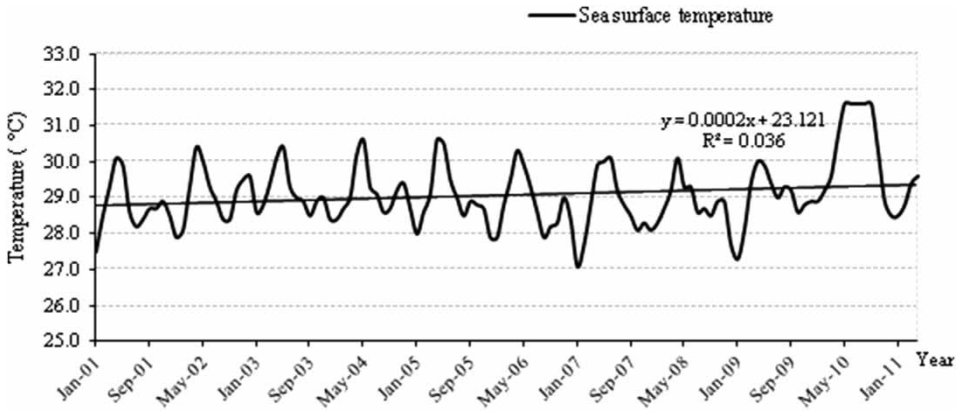


**Figure 4** SST at Mu Ko Surin National Park Between 2001 and 2010.
*Source:* ReefBase (2011).

Since 1910, the annual and seasonal ocean surface temperatures have increased between 0.6°C and 1.0°C throughout a large part of the South Pacific. Moreover, in the Indian Ocean, the analyses showed that the warming trend ranged from 0°C to 0.5°C per decade during the 1971–2004 period (IPCC, 2007a). According to IPCC (2007a), climate change impact like temperature increase can lead to the value of corals and ecosystem services being damaged. Rising of the SST is an important condition that leads to coral bleaching (Baker, Peter, & Bernhard, 2008).

*Changes in the sea level.* The sandy beaches of Mu Ko Surin National Park include areas that are highly subject to destructive processes due to sea-level rise; the islands are particularly susceptible to coastal erosion. Observed sea-level rise in most parts of the Indian Ocean has paralleled that of the global trend. The IPCC projects that in the next century, the global average sea level will rise by 0.18–0.59 m, and sea-level rise spans from 9 to 88 cm in the global sea level by 2100, due to thermal expansion of seawater and melting of mountain glaciers and small ice caps (IPCC, 2001).

Sea level in the Andaman Sea of Thailand reaches the highest level in June and the lowest level in February. Observations of the mean sea level at Kuraburi Station by the Marine Department between 2001 and 2006 indicated that the average mean sea levels from 2001 to 2003 and 2004 to 2006 were 2.14 m and 2.21 m, respectively, implying that the average mean sea level rose at a rate of about 2.6 mm per year (Figure 5).

*Changes in wave height.* The observed wave heights at Takua Pa Station by the Meteorological Department (2010) show that wave heights have progressively increased during last decades, at a rate of 0.028 m per year (Figure 6). The average wave height during the monsoon season (May to October) has increased at a rate of 0.035 m per year in 2000–2010. The wave height has also risen at a rate of 0.021 m per year during the tourism season from November to April. The analysis of the data on wave heights conducted by the Meteorological Department (2010) in two decades showed that the condition of the sea has changed.

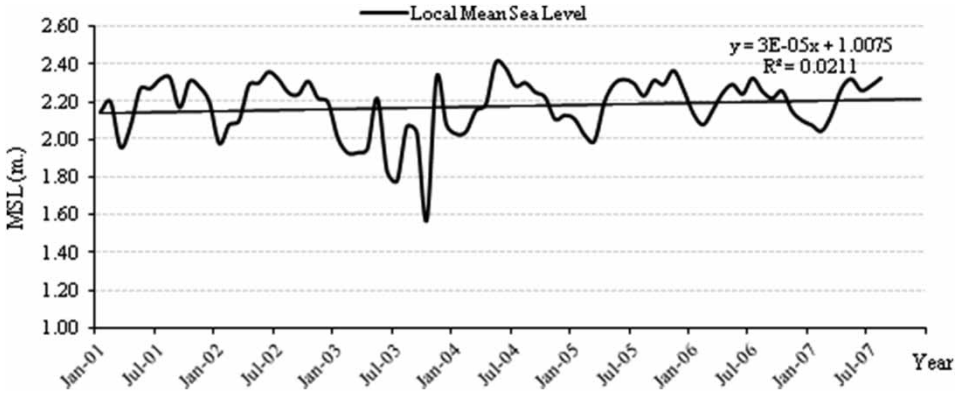


**Figure 5** Monthly Mean Sea Level at Kuraburi, Phangnga Province During 2001–2007. *Source:* Marine Department (2010).

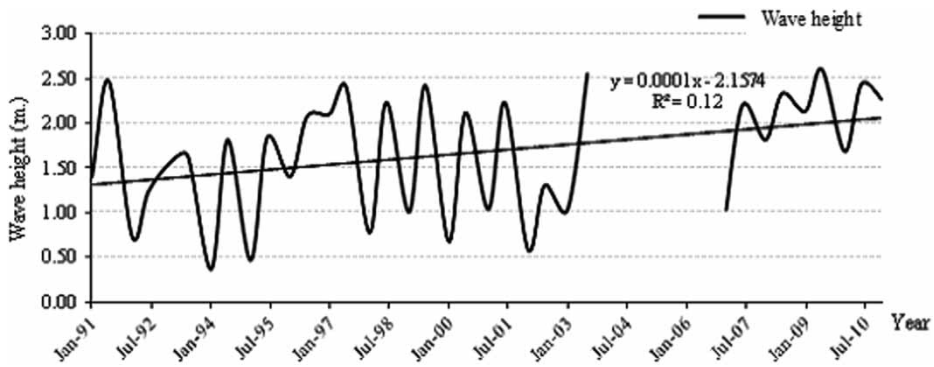


**Figure 6** Mean Monthly Wave Height in Phangnga Province Between 1991 and 2010. *Source:* Meteorological Department (2010).

More particularly, during the monsoon season (August), the sea state has been more severe than in the past decades, readily changing from moderate to rough. However, in December and January, which is the tourism season, the sea state could change from slight to moderate based on the wave height.

## *Impact of Climate Change on Tourism Resources*

Climate change can affect biodiversity and the ecosystem in many ways. Climate change has already contributed to observed changes in the tourism resources in Mu Ko Surin National Park, as discussed below.

*Coral bleaching.* Coral reefs in the Andaman Sea and the Gulf of Thailand were more seriously affected in 2010 than in previous years, as the sea temperature rose significantly, leading to severe coral bleaching. Corals in Mu Ko Surin National Park were also severely damaged as the sea temperature increased from 29°C to 30°C in March and in April–June to 31–32°C, which is beyond the

thermal limit of corals (30.1°C), considering that a temperature increase in only 1 or 2°C could cause coral "bleaching" (DMCR, 2010; Hoegh-Guldberg, 1999). The effect of sea temperatures beyond the thermal limit of corals, occurring over a long-term period (about three months), is bleached corals, especially the staghorn and table corals of the genus *Acropora*, which were the most damaged (Phuket Marine Biological Center, 2011). Moreover, along the flat reefs less than 10 m deep, the corals were also extensively bleached. When the sea temperature does not decrease, this leads to mortality of corals and some corals end up being covered with algae.

In addition, results of a survey conducted by Atsilarat and Soo-ampon and Department of Marine and Coastal Resources after a coral bleaching incident showed that in August and December 2010, the coral reefs were severely damaged. Coral mortality was more than 75%, especially in some tourist destinations such as in Ao Tao, Ko Pachumpa, Ko Torinla, Hin Kong, Ao Suthep, and in Ao Bon, where more than 90% of corals were either bleached or dead (Table 4). Since the coral reefs in Mu Ko Surin National Park were massively impacted by the bleaching event in 2010, the status of its coral reefs has changed enormously. Many coral reefs have been transformed from being in a healthy state to a very poor condition.

Furthermore, as a result of the coral bleaching events in 2010, Thailand's Department of National Parks, Wildlife and Plant Conservation have closed five tourist destinations in Mu Ko Surin National Park and six marine national parks in the Gulf of Thailand and the Andaman Sea in January 2011. This was intended to allow the corals to recover from bleaching (DNP, 2011).

*Effect of coral bleaching on fishes.* Changes in fish distribution have been linked to changes in the use of coral reefs as their habitats. In addition, the status of corals is associated with shifts in fish densities. Dead corals cause habitat shifts in terms of density and population of fishes. Based on the results of the survey of the status of fish before and after coral bleaching, Atsilarat and Soo-ampon (2010) found that the densities of fish in tourist destinations decreased, particularly the population of butterfly fishes, the main tourist attraction because of their beautiful colors, had reduced dramatically. In addition, commercial fishes have also reduced, especially snappers. Moreover, changes in the status of corals could also lead to some situations where traditional fish species might be replaced by new species.

*Beach erosion.* During the past decades, Mu Ko Surin has experienced a rise in the mean sea level due to the low elevation and flat beach of Surin Island, which makes it particularly vulnerable to sea-level rise. Sea-level change has an important effect on coastal erosion (IPCC, 2007a), and according to Vongvisessomjai (2010), coastal erosion of the Gulf of Thailand has been a significant result of sea-level rise. Coastal areas can be eroded by sea-level rise in several ways, especially when wave action moves higher onto the beach; the sandy beaches will be greatly affected, especially in the monsoon season. Based on an interview with the Mu Ko Surin National Park Officer, who has been working in Mu Ko Surin for 8 years:

> In 8 years that I have worked in Mu Ku Surin, Mai Ngam Beach has eroded around 3 meters. In the past, Mai Ngam Beach has a long beach and there are many trees on the beach, but beach has eroded and tree has died now as stronger wave action and

**Table 4** Status of Coral Reefs in 2010 and Tourism in 2011

| Destination | % Live coral cover[a] | | % Mortality post-bleaching | Tourism[b] activities |
|---|---|---|---|---|
| | Pre-bleaching | Post-bleaching | | |
| Ko Stork | 35.00 | 21.10 | 78.90 | Allowed |
| Ao Chak | 50.00 | 22.22 | 77.78 | Not allowed |
| Ao Sai En | 83.61 | 18.18 | 81.82 | Allowed |
| Ao Mae Yai (North-inside) | 91.67 | 4.00 | 96.00 | Not allowed |
| Ao Mae Yai (North-outside) | 85.51 | 15.38 | 84.62 | Not allowed |
| Ao Krating | 79.17 | 10.20 | 89.80 | Allowed |
| Ao Por | 47.62 | 2.60 | 97.40 | Allowed |
| Ao Sai Deang | 34.70 | 24.20 | 75.80 | Allowed |
| Ao Suthep Noi | 65.52 | 9.71 | 90.29 | Allowed |
| Ao Bon | 70.59 | 9.90 | 90.10 | Allowed |
| Ao Tao | 88.37 | 4.63 | 95.37 | Not allowed |
| Ao Phakkad | 45.45 | 6.58 | 93.42 | Allowed |
| Ao Chokkhad | 50.00 | 15.38 | 84.62 | Allowed |
| Hin Kong | 85.07 | 9.09 | 90.91 | Allowed |
| Ko Pachumba | 65.52 | 1.40 | 98.60 | Not allowed |
| Ko Torinla NE | 96.00 | 6.80 | 93.20 | Not allowed |

[a]Phuket Marine Biological Center (2011).
[b]Field survey by researcher in 2011.



higher sea level. (Respondent K, National Park Officer)

Mai Ngam Beach has eroded by approximately 3 m in 8 years, which means that the beach has eroded at a rate of about 0.38 m per year. Moreover, the Chongkhad Beach has also eroded about 1.5 m, although it is not as severe as the Mai Ngam Beach. The erosion of these beaches has occurred continually, due to wave actions brought about by strong southwest monsoon winds. Similarly, sea-level rise has led to beach erosion in Bangladesh. Ali (1999) examined the erosion at 21 sandy beaches in Bangladesh and the result found that an average recession of 0.87 m occurs per 1 cm rise in the sea level. This means that the recession distance through erosion due to sea-level rise (SLR) is about 87 times the SLR.

*Landslide and its impact on forests*. Landslides often occur in the main island's forests both in Ko Surin Nuea and Ko Surin Tai. In the past decades, Mu Ko Surin National Park experienced about six landslides in several places. In addition,

forests have been damaged, especially the dominant trees that are important in the coastal ecosystem. According to Paolini, Villalba, and Grau (2005), increased precipitation over relatively long intervals results in frequent occurrence of landslides. Thus, based on the projection of the precipitation in Phangnga Province by the PRECIS Model (SEA-START, 2011), increased precipitation could induce frequent occurrence of landslides that would lead to vital environmental changes in Mu Ko Surin National Park.

Mangroves are important, as mangrove areas serve as nurseries for fish and other aquatic species. Moreover, mangrove forests also play a role as buffers, protecting the coasts from possible severe damages during storms. Nevertheless, a finding has shown that most mangrove forests in the Park such as those found in Ao Mai Ngam, Ao Mae Yai, and Ao Sai En have not been affected by storm and sea-level rise.

*Water resource*. Freshwater in Mu Ko Surin comes from three main sources, namely: Surin Nuea (near bungalows), Surin Tai (connecting to Ao Chongkhad), and Surin Tai (near the Moken village). Records seem to indicate that the water resources in Mu Ko Surin are sufficient and accessible for domestic use as well as also serving the needs of tourists, especially during the tourism season. Water from these sources is still in great quantities in spite of the fact that Mu Ko Surin was hit by the tsunami in 2004, and even in the midst of an increasing temperature.

## *Impact of Climate Change on Tourism Activities*

As a result of coral bleaching impact, the tourism routes in Mu Ko Surin National Park had changed. After five destinations for snorkeling and diving were closed, the travel routes of the Park service for tourists have changed. Before the coral bleaching events in 2010, there were more destinations than during the post bleaching incidents. At present, travel trips for snorkeling and diving include fewer sites and fewer attractions, and in order to maximize tourism activities, the Park had to open new sites in Ao Subparod and Ao Bon to serve this preferred activity of tourists. Accordingly, it is expected that coral bleaching will affect tourists' travel behavior, because environmental quality indirectly influences the behavior of people (Gössling et al., 2012; Petrosillo et al., 2007). Moreover, the coral reef conditions, including both reef health and coral bleaching, are important in the experience and satisfaction of snorkeling tourists (Roman, Dearden, & Rollins, 2007).

Furthermore, as a result of beach erosion, tourist activities in the Park's beaches have been reduced. Sunbathing, relaxing, and camping are the activities which have been impacted by beach erosion. In addition, trees on the beach have also been affected by erosion that led to some dead trees that could no longer provide the necessary shade for beach goers. Moreover, in 2009, increased and prolonged precipitation events had caused landslides at the nature trail (Mai Ngam-Chongkhad), which is the main nature trail in Surin Island. As an impact of such landslides, the nature trails lose their attraction since they are no longer comfortable to walk on.

## *Impact of Climate Change on Tourism Businesses*

The park is among the best destination for snorkeling in Thailand (DNP, 2011). This activity is

also the main attraction of tourists. About 30,000 tourists travel each year to Mu Ko Surin National Park and create income for many tourism businesses and local people in the area (DNP, 2011). However, Thailand has been impacted by many critical events such as violent political protests and rallies of those with differing political views in 2008, which led to the Suwarnabhumi International Airport being closed. Also, in 2009 Thailand was affected by the hamburger crisis. As a result, the number of international tourists dropped. However, the number of tourists picked up in 2010 and 2011 (TAT, 2010). On the other hand, in 2011, the number of tourists in Mu Ko Surin National Park decreased by almost half the number of tourists as per the previous year (DNP, 2011). A major factor that has an impact on the number of visiting tourists is coral bleaching (DNP, 2011).

In the in-depth interview, the impact of climate change, such as higher temperature, more/less precipitation, more storms, and higher sea waves, leads to an effect on tourism business and operation, especially a higher sea temperature leads to coral bleaching. A tour guide illustrated that:

> As a result of coral bleaching and diving and snorkelling destinations being closed, this may be lead to travelers deciding not visit to Mu Ko Surin. (Respondent E, Inbound tour, Assistant Manager)

In order to better understand the impact of climate change, businesses in the tourism sector were asked to describe climate change impact in Phangnga Province. A tour guide illustrated that:

> I knew about climate change impact and coral bleaching in Mu Ko Surin for the first time when corals were whitened . . . most of coral has bleached in many destinations and about three months later it has covered by algae. (Respondent D, Inbound tour, Manager)

In the in-depth interviews, participants brought forward a wide range of aspects relating to climate change impact (Table 5), for example, change of temperature and rainfall, and uncertainty about weather and storms. Apart from these attributes, all tourism businesses mentioned "higher air temperature" than they had experienced in the past 10 years. Particularly, Respondent A who had worked in Kuraburi district for more than 10 years stated that:

> . . . air temperature in summer season is very poor, temperature is high and the hot weather is long lasting. (Respondent A, Three-star hotel, Owner)

General observation of temperature data was discussed in this paper and concluded that temperature patterns change with area, the minimum temperature was significantly higher compared with the temperature over the last three decades and the occurrence of extreme events is likely to increase in Phangnga Province. Hence, the perception of the tourism sector about the air temperature corresponds with the observed data.

### *The Possible Adaptation Measures in Mu Ko Surin National Park*

As the finding of the study revealed, the Park is being threatened by global warming, particularly the coral reefs which are the main tourism resources and the most important for many people. Such resources provide rich biodiversity, economically important values, and ecosystem services which are important to people, especially the local people who depend on these natural resources for their livelihoods.

**Table 5** The Impact of Climate Change on Operation Mentioned by Tourism Businesses

| | | Tourism businesses | | | |
|---|---|---|---|---|---|
| Climate change | Impact | Accommodation | Tour operation | Transportation | Souvenir seller |
| Warmer air temperature | • Change of tourism season in 2010<br>• Cooling cost as heat stress<br>• Water supply<br>• Loss of cost for planting | | | | |
| Warmer sea temperature | • Coral bleaching/ mortality<br>• Tourist has reduced/loss of income to more than half<br>• Changing of route for tourism is longer but less attraction<br>• Loss of beautiful fish<br>• Tourist destinations have been closed<br>• Loss of cost for fuel of boat due to route for tourism is longer | | | | |
| More precipitation | • Land slide | | | | |
| Sea-level rise | • Beach erosion<br>• Pier erosion | | | | |
| Higher sea wave | • Tourist sea sickness | | | | |

In this regard, focus should be placed on climate change adaptation to reduce such impacts. A Respondent L presented that:

> the Park is being threatened by global warming, particularly the coral reefs which are the main tourism resources and the most important for many people (Respondent L, Experts on coral reef and climate change)

As shown in the result of this study, the climate in Mu Ko Surin has undergone changes, such as increased temperature and precipitation, and strong storm surges. These extreme events have become more frequent, and are damaging natural resources, particularly the rising SST during the month of April. The potential impacts of climate change on natural resources, which are also tourism resources, could be in many ways. After the impact, Mu Ko Surin needed adaptation measures. However, the Thai government has no management plan to serve coral bleaching. Although Thailand has developed a strategic plan on climate change and is developing its ten-year climate change plan (National Strategic Plan on Climate Change 2008–2012), it has limited local plans to serve the unique impacts in each area. A Respondent K illustrated that:

> Thailand has not implemented the Coral Bleaching Response Plan like in some countries that experience coral bleaching events, Mu Ko Surin should consider raising awareness, capacity building, policy enforcement, research technique, information sharing, and technical adaptations … Great Barrier Reef, Australia is a great example for coral bleaching management and adaptation. (Respondent K, National Park Officer)

The results of this study point out that Mu Ko Surin would be affected by climate change, particularly due to the increased sea temperature in the future. Therefore, adaptation action should take place in this area. As for adaptation action in Mu Ko Surin, based on the study findings and in discussion with Mu Ko Surin National Park managers and stakeholders could recommend and suggest guidelines for best-practice future climate change adaptive management five themes:

1 Coral bleaching preparedness and management
   - Coral bleaching monitoring/assessment
   - Coral recovery and conservation
   - Improvement of the ability to predict bleaching risk
   - Measurement of the extent of bleaching
   - Controlling outbreaks of pests (e.g. crown of thorns starfish)
   - Decreasing the impact from tourism activities affecting the reefs
   - Enhancement of awareness about bleaching situation and its impacts on tourist, local community, business operators, and anyone who benefits from coral reefs.
2 Natural tourism resources management
   - Erosion control of beach (soft engineering and environmental conservation measures and avoiding hard structures).
   - Tree planting in landslide area.
   - Strict enforcement of the laws and regulations of the national park, especially, fishery activities that lead to coral reef damage and water pollution from boat tourism.
3 Coral reef adaptation research and management plan
   - Climate change adaptation research
   - Coral bleaching response plan
   - Climate change adaptation plan
4 Technical adaptations

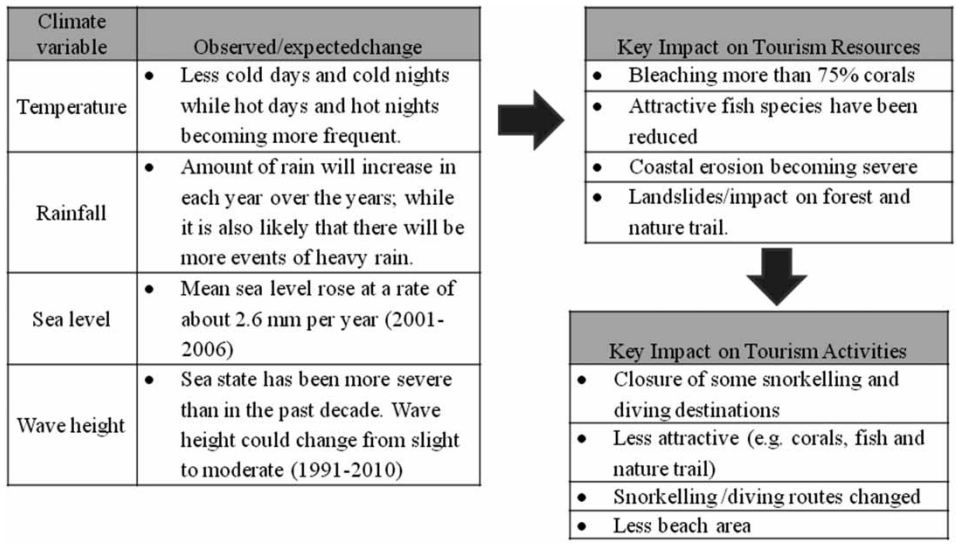


**Figure 7** The Impact of Climate Change on Tourism Resources and Activities.

- Suitable technique adaptations of Mu Ko Surin for reducing coral bleaching and climate change impact (e.g. Australia used awnings or umbrella-like structures on buoys to shade corals and spraying cooler water from deeper areas onto the ocean surface at peak heat times to cool surface waters.)

5 Tourism destination and activity changes
- Closing tourist destinations where coral reefs have been extremely damaged.
- Changing and reducing tourist activities that depend on coral reef to beach and forest. For example, sun bathing, swimming, and walking on nature trails.
- Building or supplemental artificial reefs in suitable areas instead of natural coral reef areas for tourism activity.

However, Mu Ko Surin National Park should rapidly implement plans for climate change impacts, as climate change has an extreme impact on tourism's natural resources.

## Conclusions

This study highlighted the observed changes in climate, including cases of increasing temperatures, changes in precipitation, rising SST, sea-level rise, and increasing wave height, that lead to increased climate variability. Based on the results of previous studies, the projected change in precipitation has increased slightly while the frequency of heavy precipitation events has also increased.

The most prominent impact of climate change, particularly of the sea temperature rise, on the main tourism resources in Mu Ko Surin National Park, is on the coral reefs. All corals in the Park's tourist destinations had been affected due to coral bleaching, where in each destination there were dead corals, and coral bleaching occurred in more than 75% of the coral reefs. Moreover, the population of fishes has also been reduced after the incidents of coral bleaching. In view of the huge quantity of dead corals due to coral

bleaching, Thailand's Department of National Parks and Wildlife and Plant Conservation closed five tourist destinations in Mu Ko Surin National Park in January 2011: Ko Pachumba, Ko Torinla, Ao Chak, Ao Tao, and Ao Mae Yai. In addition, sandy beaches have eroded due to sea-level rise and strong waves, especially in the monsoon season. Specifically, in the past eight years, Mai Ngam Beach, a popular tourist destination, eroded at the rate of about 0.38 m per year. Moreover, increased precipitation leads to landslides in Ko Surin Nuea and Ko Surin Tai, including the severe landslide in 2009 at the Mai Ngam-Chokkhad nature trail, which resulted in the loss of attraction of the trail for tourists. Although many of the Park's tourism resources, such as coral reefs, fishes, beaches, and forests have been impacted by climate change, its water resources are still sufficient and clean enough to be used for tourism activities. Therefore, the impact of climate change on tourism resources and activities could be summarized as follows (Figure 7).

Mu Ko Surin National Park, which is a popular destination for marine tourism, has suffered much due to the impact of climate change. Tourism resources have changed, especially the coral reefs, which had been more severely affected than the other resources, leading to changes in travel routes. Since it has been predicted that SSTs will continue to rise, the frequency of heavy precipitation is on the increase, and sea-level rise will persist, therefore there will be considerable degradation of the tourism resources and tourism activity in the Park. This could lead to unsustainable tourism, whereby there are continued losses in terms of tourism revenues as well as incomes of people who depend on tourism activities for their livelihoods.

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