CAPACITY BUILDING MODEL FOR LOCAL GOVERNMENTAL AGENCIES ON SUSTAINABLE TOURISM DEVELOPMENT ADAPTING TO CLIMATE CHANGE

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โมเดลการเสริมสร้างสมรรถนะขององค์การบริหารส่วนท้องถิ่นในการปรับตัวต่อการเปลี่ยนแปลงสภาพภูมิอากาศเพื่อการพัฒนาการท่องเที่ยวอย่างยั่งยืน

นางสาววรรณวิชนี ถนอมชาติ

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Field of Study	Environment, Development and Sustainability
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วรรณวิชนี ถนอมชาติ: โมเดลการเสริมสร้างสมรรถนะของ องค์การบริหารส่วนท้องถิ่น ในการปรับตัวต่อการเปลี่ยนแปลงสภาพภูมิอากาศเพื่อการพัฒนาการท่องเที่ยวอย่างยั่งยืน . (CAPACITY BUILDING MODEL FOR LOCAL GOVERNMENTAL AGENCIES ON SUSTAINABLE TOURISM DEVELOPMENT ADAPTING TO CLIMATE CHANGE) อ. ที่ปรึกษาวิทยานิพนธ์หลัก: อ. ดร.แสงจันทร์ ลิ้มจิรกาล, 124 หน้า.

ปัญหาการขาดการจัดการทรัพยากรน้ำที่เหมาะสมและการขาดแคลนน้ำอาจมีสาเหตุมาจากการเปลี่ยนแปลงสภาพภูมิอากาศได้ส่งผลกระทบต่อการพัฒนาการท่องเที่ยวอย่างยั่งยืนในประเทศไทย องค์การบริหารส่วนท้องถิ่นเป็นหน่วยงานหลักสำคัญที่มีบทบาทและหน้าที่โดยตรงในการจัดการกับปัญหาดังกล่าว การเสริมสร้างสมรรถนะขององค์การบริหารส่วนท้องถิ่นเพื่อจัดการปัญหาการจัดการทรัพยากรน้ำและการขาดแคลนน้ำรวมถึงผลกระทบที่อาจเกิดขึ้นจะเป็นประโยชน์ต่อภาคการท่องเที่ยวและชุมชนด้วย การศึกษาโมเดลการเสริมสร้างสมรรถนะขององค์การบริหารส่วนท้องถิ่นในการปรับตัวต่อการเปลี่ยนแปลงสภาพภูมิอากาศเพื่อการพัฒนาการท่องเที่ยวอย่างยั่งยืนจึงได้ดำเนินการศึกษาที่เกาะช้าง จังหวัดตราด ประเทศไทย โดยมีวัตถุประสงค์เพื่อศึกษาผลกระทบของการเปลี่ยนแปลงสภาพภูมิอากาศต่อทรัพยากรน้ำซึ่งอาจมีผลกระทบต่อธุรกิจการท่องเที่ยว เพื่อประเมินสมรรถนะขององค์การบริหารส่วนท้องถิ่นในการจัดการผลกระทบที่เกิดขึ้น และเพื่อนำเสนอโมเดลในการเสริมสร้างสมรรถนะสำหรับองค์การบริหารส่วนท้องถิ่นในการบริหารจัดการปัญหาการจัดการทรัพยากรน้ำ ข้อมูลภูมิอากาศระหว่างปี พ.ศ. 2513 ถึง พ.ศ. 2552 ได้ถูกนำมาศึกษาวิเคราะห์ ร่วมกับข้อมูลที่เกี่ยวข้องจากแบบสอบถาม การสัมภาษณ์ และการสนทนาหารือเชิงลึกกับผู้มีส่วนได้ส่วนเสียจำนวน 24 คน ใน 4 หมู่บ้านของเกาะช้าง ได้แก่ บ้านคลองนนทรี บ้านคลองพร้าว บ้านบางเบ้า และบ้านสลักเพชร

ผลการศึกษาพบว่า เกาะช้างมีฝนตกเพิ่มขึ้นซึ่งก่อให้เกิดน้ำปริมาณมากในช่วงฤดูฝน (พฤษภาคม - ตุลาคม) แต่ก็ยังมีการขาดแคลนน้ำโดยเฉพาะช่วงฤดูการท่องเที่ยว (พฤศจิกายน-กุมภาพันธ์) ทั้งนี้ เนื่องจากความไม่สอดคล้องกันของฤดูกาลท่องเที่ยวและฤดูฝน และยังพบว่าการเปลี่ยนแปลงรูปแบบฝนและอุณหภูมิได้ทำให้ปริมาณน้ำที่สามารถใช้ได้ลดลง นอกจากนี้ ยังพบว่าเกาะช้างไม่มีอ่างเก็บน้ำขนาดใหญ่ที่จะเก็บกักน้ำจากสายน้ำที่ชันและสั้นได้ การศึกษายังพบว่าองค์การบริหารส่วนท้องถิ่นขาดความสามารถในการบริหารจัดการทรัพยากรน้ำและการขาดแคลนน้ำซึ่งเป็นประเด็นสำคัญที่จะต้องให้ความสำคัญ ดังนั้น โมเดลเชิงแนวคิดในการเสริมสร้างสมรรถนะขององค์การบริหารส่วนท้องถิ่นจึงได้นำเสนอโดยพิจารณาจากนโยบายการเสริมสร้างสมรรถนะผ่านกระบวนการของการพัฒนาและให้ความรู้แก่ทรัพยากรมนุษย์ การประเมินความต้องการทางด้านเทคโนโลยี และระบบการบริหารจัดการน้ำ องค์การบริหารส่วนท้องถิ่นมีความจำเป็นที่จะต้องเพิ่มพูนความรู้และทักษะที่เกี่ยวข้องกับการเปลี่ยนแปลงสภาพภูมิอากาศและการปรับตัว การบริหารจัดการทรัพยากรน้ำและเทคโนโลยีที่เกี่ยวข้อง ที่มีความเชื่อมโยงกับเทคโนโลยีที่เหมาะสมเพื่อทำให้ระบบการบริหารจัดการน้ำ เป็นไปอย่างมีประสิทธิผล การเพิ่มพูนสมรรถนะขององค์การบริหารส่วนท้องถิ่นนั้นท้ายที่สุดแล้วจะส่งผลให้เกิดความยั่งยืนต่อการพัฒนาการท่องเที่ยวและต่อชุมชนบนเกาะช้าง ดังนั้น แผนดำเนินการเสริมสร้างขีดความสามารถขององค์การบริหารส่วนท้องถิ่นในการบริหารจัดการทรัพยากรน้ำทั้งในระยะสั้นและระยะยาวควรมีความสอดคล้องกัน ควรมีการศึกษาเพิ่มเติมการเสริมสร้างสมรรถนะของผู้มีส่วนได้ส่วนเสียอื่นๆ อาทิ ชุมชนท้องถิ่น นอกจากนี้โมเดลการเสริมสร้างสมรรถนะในการบริหารจัดการทรัพยากรน้ำขององค์การบริหารส่วนท้องถิ่นควรมีการศึกษาความเหมาะสมทางด้านเทคนิคต่อไป.

สาขาวิชา สิ่งแวดล้อม การพัฒนา และความยั่งยืน ลายมือชื่อนิสิต ....

ปีการศึกษา 2555 ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์หลัก ....

5187850020 : MAJOR ENVIRONMENT DEVELOPMENT AND SUSTAINABILITY
KEYWORDS : CAPACITY BUILDING MODEL/ LOCAL GOVERNMENTAL AGENCIES/ SUSTAINABLE TOURISM DEVELOPMENT/ ADAPTATION/ CLIMATE CHANGE

WANVICECHANEE TANOAMCHARD: CAPACITY BUILDING MODEL FOR LOCAL GOVERNMENTAL AGENCIES ON SUSTAINABLE TOURISM DEVELOPMENT ADAPTING TO CLIMATE CHANG. ADVISOR: SANGCHAN LIMJIRAKAN, D.Tech.Sc., 124 pp.

The lack of proper water resource management and water shortage likely caused by climate change would affect sustainable tourism development in Thailand. Local governmental agencies (LGAs) are the main body having directly role and responsibility to deal with such problem. Capacity building of the LGAs to handle water resource management and its shortage and its impacts would be beneficial not only to tourism but also to the community. The study on capacity building model for local governmental agencies on sustainable tourism development adapting to climate change was carried out at Koh Chang, Trat province, Thailand. The objectives of the study are to study the impacts of climate change on water resources affecting tourism businesses, to assess the capacity of the LGAs in addressing such the impacts, and to develop the conceptual model of capacity building for the LGAs in adapting to climate change impacts on water resources affecting sustainable tourism development on the island. Climate data between 1970 and 2009 were analyzed. Other relevant data were collected through questionnaire, interview and in-depth discussion with twenty four stakeholders in four villages of Koh Chang, namely Ban Klong Nonsri, Ban Klong Praw, Ban Bang Bao, and Ban Salak Petch.

The study results found that the island has significantly increased in rainfall producing large amounts of water during rainy season (May-October) but there still has water shortage particularly during the peak period of tourism (November-February). This problem is caused by the mismatch between the time period of tourism season and rainy season. It also found that changing in rainfall and temperature patterns reduced availability of water supply. Additionally, there is no a large reservoir to storage water from short and steep water tributaries. This study also found the incapability of the LGAs in managing water resources and its shortage that of the most concern. Therefore, the conceptual model of capacity building for the LGAs is proposed by taking initial consideration on capacity building policy through approaches of human resource development and education, technology need assessment, and water management system. The LGAs need to enhance their knowledge and skills on climate change adaptation and water resource management and relevant technology. The linkages of appropriate technologies for an effective water management system are also required. The enabling capacity of the LGAs would finally sustain the development of tourism and community on Koh Chang. Therefore, it would recommend that the LGAs' short term and long term implementing plans on capacity building on water resource management should be consistently developed. The capacity building of other stakeholders such as local community should be further studied. Furthermore, the model of capacity building of the LGAs' on proper water management needs to be further technical study.

Field of Study : Environment, Development and Sustainability Student's Signature ....

Academic Year: 2012 Advisor's Signature ....

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LIST OF ABBREVIATIONS

CC	Climate Change
CCAC	Climate Change Adaptive Capacity
CDD	Consecutive dry days
CWD	Consecutive wet days
DASTA	Designated Areas for Sustainable Tourism Administration
DHT	Department of Health of Thailand
DNP	Department of National Parks, Wildlife and Plant Conservation
DOLA	Department of Local Administration
DOPA	Department of Provincial Administration
DPT	Department of Public works and Town & Country Planning
EPA	United States Environmental Protection Agency
ESCAP	United Nations Economic and Social Commission of Asia and the Pacific
GTZ	German Technical Cooperation
HRD	Human Resource Development
ICC	International Chamber of Commerce
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
JICA	the Japan International Cooperation Agency
LGAs	Local Governmental Agencies
LAO	Local Administrative Organization
NESDB	National Economic and Social Development Board
PCD	Pollution Control Department of Thailand
PDC	Provincial Disaster Committee
PE	Polyethylene Pipe

SAO	Sub-district Administrative Organization
STD	Sustainable Tourism Development
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
WMO	World Meteorological Organization
WTO	World Tourism Organization

CHAPTER I

INTRODUCTION

1.1 Background and importance of the study

The adverse impacts caused by climate change have been an issue of interest to people around the world. The consequences of climate change have impacted on natural resources, environment, economic sectors, and livelihoods. For examples, the economics modeling carried recently out revealed that the impact of climate change in the Southeast Asia could be dramatically worse equivalent to 5.7% of GDP each year by 2100 (Asian Development Bank [ADB], 2009). Not only has climate change caused negative effects on a wide range of the country's natural resources that are significant to tourism, but also slows down country's competiveness and sustainability (United Nations World Tourism Organization [UNWTO], 2003). The attractiveness of a region for tourism activities depend strongly on the local weather and climate (Perch-Nielsen, 2009). Hence, changing in climate is likely to reduce growth of tourism sector. The impact of climate change makes tourism, which is particularly situated in the areas where constitute the major livelihood of local communities, now becoming unsustainable (UNWTO, 2003; Intergovernmental Panel on Climate Change [IPCC], 2007a). It is internationally recognized as mentioned in the Davos Declaration that tourism sector is at a greater risk from climate change that urgent actions are needed to cope with its adverse impacts (UNWTO, 2007).

In order to cope with this important issue, a number of countries have done many activities ranging from conducting research as well as launching and enforcing global and national policies, as, for example, mentioned in the Davos Declaration (UNWTO, 2007). At policy level, creating and transferring useful knowledge, technology, and financial have continuously been corroborated under international commitments (United Nations [UN], 2008). In addition, many countries especially developed countries have provided the tools responding and coping with climate change (UN, 2008). In spite of this effort, such tools need considering together with the ability of people to support the changes. It can be ascertained that capacity building could be attributed in several dimensions to promote the strengthening of sustainable tourism management and enhancing adaptation to climate change. Therefore, one of key aspects taking consideration on climate change impact on tourism is to build capacity of this sector to adapt to such impacts.

The government of Thailand has promoted various tourist destinations attracting tourists from all over the world. It has been well recognized that the tourism industry has become one of important service sectors of Thailand, generating significant income to the country. Over the past seven years (2004-2010), the number of tourists visiting Thailand has increased by 5.14 percent per year (Department of Touirsm, 2010). However, the country's tourism industry is likely to be negatively impacted by climate change, as the tourism destinations in Thailand especially the islands are highly exposed to climate-related hazards and sensitive to any changes in environment and natural resources.

Koh Chang is one of the most beautiful natural tourism destinations in the Gulf of Thailand. It is located in the eastern region of Thailand and has a total area of 650 square kilometers (Department of National Parks, Wildlife and Plant Conservation [DNP], 2004). In 2002, a number of related policies were set in place to promote Koh Chang Island to become one of the attractive tourist places in the eastern region of Thailand (National Economic and Social Development Board [NESDB], 2003). However, the island has a number of limitations to development, especially water resources and its supply. This is in spite of the fact that the island's tourism-economic growth is increasing rapidly and continuously (Department of Tourism, 2010).

In this regards, the capacity building to adapting and combating climate change is one of urgently needed agendas for local governmental agencies (LGAs) in order to secure economic and social well being on this island. Therefore, the studies on the impacts of climate change and capacity building of the LGAs were conducted to promote future sustainable tourism development on this island.

1.2 Objectives of the study

The objectives of this study are:

1.2.1 to study the impacts of climate change on water resources on Koh Chang,

1.2.2 to assess the local governmental agencies' capacities to adapt to climate change impacts on water resources and,

1.2.3 to develop the conceptual model of capacity building for the LGAs in adapting to climate change impacts on water resources affecting sustainable tourism development on the island.

1.3 Research questions

The study mainly addresses the following three research questions:

1.3.1 What are the possible impacts of climate change on water resources on Koh Chang?

1.3.2 How do the LGAs manage with such impacts?

1.3.3 How can the LGAs enhance their abilities to manage and adapt to such impacts that threaten the sustainable development of tourism on the island?

1.4 Scopes of the study

The scopes of this study are:

1.4.1 The study focuses on the impacts of climate change regarding to water shortage on tourism businesses, in 4 villages of 2 Subdistricts of Koh Chang.

1.4.2 The questionnaire, interview, and in-depth discussion were conducted to the respondents selected by the specific sampling method to whom having responsibility and role dealing with tourism development and working at the Subdistrict Administration Organization of Koh Chang Tai, the Subdistrict Municipality of Koh Chang, the district officers of Koh Chang, 4 village-heads, and representatives of tourism businesses.

1.4.3 Climate indicators such as temperature, rainfall, and humidity, including extreme events were statistically analyzed based on long-term, quality controlled daily records of the weather station near Koh Chang.

1.4.4 The collected secondary data were summarized and analyzed in complement with 1.4.3 to address any impacts of climate change on water resources.

1.4.5 The existing capacities of the LGAs were analyzed regarding to the factors affecting their adaptive capacity to climate change, followed by the framework of Yohe and Tol (2002).

1.4.6 The conceptual model was developed, focusing on capacity building policy of the LGAs adapting to climate change regarding water resources and affecting tourism businesses on Koh Chang.

1.5 Operational definitions

The study has operational definitions as follows:

1.5.1 Climate change referred to a significant statistically change in mean of climate or in its variability occurring for a widen period (IPCC, 2007a)

1.5.2 Adaptation referred to an adjustment in human systems in response to existing or expected climate change impacts, which harm or threaten beneficial opportunities of human living (IPCC, 2007b)

1.5.3 Capacity referred overall ability of people or organization to do their responsibilities by using their competencies and resources (Reis et al.,1998)

1.5.4 Capacity building referred to a conceptual approach to development government organizations to understand the obstacles hindering them from realizing their goals by enchaining their ability to achieve measurable and sustainable outcomes (United Nations Development Programme [UNDP], 1991)

1.5.5 Capacity building model for local governmental agencies adapting to climate change referred to a process to guide policy-making to strengthen the LGAs' abilities in adapting to climate change regarding water resource on Koh Chang.

1.5.6 Local governmental agencies (LGAs) referred to people working in the Subdistrict Administration Organization (SAO) of Koh Chang Tai and the Subdistrict Municipality of Koh Chang (Thai Ministry of Interior [MOI], n.d.), and having responsibilities and roles dealing with water shortage.

1.6 Expected outcomes

1.6.1 A better understanding of climate change impacts on water resources affecting tourism businesses

1.6.2 A conceptual model of the capacity building for the LGAs adapting to climate change regarding water resource affecting sustainable tourism development.

CHAPTER II

LITERATURE REVIEW

2.1 Framework of climate change: impacts, vulnerability, and adaptation

The 4th Assessment Report of the IPCC clearly shows that the major impacts of climate change are widespread (IPCC, 2007a). Climate change including global warming is ultimately caused by the effects of anthropogenic greenhouse gas. An increase in extreme events such as tropical cyclones, prolonged droughts, severe floods and heavy precipitation events is one of the most serious challenges to society in coping with the consequences of human-induced climate change (IPCC, 2007a). It is increasingly realized that alternations in their frequency and/or intensity can have profound impacts on both human society and natural environments (IPCC, 2007a).

The 4th Assessment Report of IPCC also makes clear that the impacts of climate change are now serious risks which lead to an obstacle to the accomplishment of the Millennium Development Goals, particularly poverty eradication (IPCC, 2007a). In the future, the projected warming trend will increase in range of 2-3°C by 2100. This change will sustainably affect on the environment, socio-economic, and related sectors, including human health, terrestrial ecosystem and biodiversity, coastal zone, water resources, agriculture, and food security.

With respect to the above mentioned, climate change caused by greenhouse gasses has increased global temperature. It produces change in precipitation, and other extreme weather events creating disasters that have an effect on biodiversity losses. The impacts of climate change also create vulnerability to the socio-economics of many regions discussed in more detail below.

2.1.1 Impacts and vulnerability

The impacts of climate change are associated and interlinked with "vulnerability". IPCC (2007) has defined vulnerability as a degree to which system cannot to cope with adverse impacts of climate change, including climate variability and extremes. The vulnerability can be a specific system to hazard (Brooks, 2003), and depends critically on contexts and factors (Brooks et al., 2004). Adger (2006) added that it is harmful exposure associating with environmental and social changes by less adaptive capacity. He further illustrated a general form of vulnerability that

$$\text{Vulnerability} = \frac{\text{Sensitivity to stress}}{\text{State relative to threshold x Probability of exposure to}}$$

In addition, Leary et al. (2008) remarked that vulnerability to climate change has three dimensions including (1) exposure, (2) sensitivity, and (3) adaptive capacity. They also pointed out that exposure is the frequency or intensity of climate events. While sensitivity is the degree that exposure to climate change affects a resource system. Furthermore, they noted that exposure and sensitivity determine environmental risk, and pointed out a relationship between adaptive capacity and vulnerability. Based on their conceptual framework, adaptive capacity is a system's ability to respond exposures and its effects in order to limit risk or give benefit. This point is supported by Smit and Wandel (2006), who reported that adaptation is considered as responses to risks related with the interaction between environmental hazards and human vulnerability.

It can be seen from the study of vulnerability by Kumpulainen (2006) that there has been a relationship among risk, hazard, and vulnerability. He defined the risk as the combination of potential hazard and vulnerability. In addition, he described that three dimensions of the vulnerability include (1) economic, (2) social, and (3) environment. The economic vulnerability concerns about risk of production, distribution and consumption. The social vulnerability emphasizes lacking capacity of people to cope with vulnerability in society. The environmental vulnerability is acknowledged as ecosystem vulnerability which is unable to recover from different hazards.

In Asia, there are evidences that the regions have faced with significant increases in the intensity and frequency of extreme weather events such as heat waves, tropical cyclones, prolonged dry spells, intense rainfall, and thunderstorms (United

Nations Framework Convention on Climate Change [UNFCCC], 2007a). The impacts of such changes caused vulnerabilities that affect human survival and well-being were documented by UNFCCC (2007a) as summarized in Table 2.1.

Table 2.1 Regional impacts and vulnerabilities to climate change in Asia.

Impacts	Vulnerabilities
Temperature has warming above the mean and fewer very cold days.	***Freshwater availability*** has decreased creating water stress in many regions. In addition, there also has increase in the number of severity of glacial melt related floods.
Precipitation has increased, but it has inversely decreased during the summer.	***Agriculture and food security*** have decreased. Furthermore, there has reduced in soil moisture and increased in evapotranspiration.
Extreme events including drought during the summer, El Niño events, extreme rainfall and winds associated with tropical cyclones have increased. In addition, the intense rainfall events cause landslides and severe floods also have increased. Furthermore, heat waves and hot spells in summer has been longer duration and more intense and frequent, particularly in East Asia.	***Health*** of people in the regions have been affected by heat stress and changing patterns in disease. ***Terrestrial ecosystems***, particularly many species has been affected by climate change causing extinction. In addition, there also has increased in frequency and extent of forest fires ***Coastal zones*** have been affected by sea level rise and increase in the intensity of tropical cyclones.

Source: UNFCCC (2007a).

Yusuf and Francisco (2009) found that the sub-national areas in Southeast Asia have been vulnerable to climate change impacts. It can be seen from the assessment of climate hazard, sensitivity maps, and adaptive capacity maps following the IPCC's framework that the increases in dominant hazards such as cyclones, droughts, floods, and sea level rise have created substantial impacts in the sub-national areas of Indonesia, Thailand, Vietnam, Lao PDR, Cambodia, Malaysia, and the Philippines.

2.1.2 Adaptation

According to the international efforts under the UNFCCC to cope with climate change impacts, the actions to mitigate and to adapt to climate change were emerged in 1992 (UN, 1992).

The meaning of adaptation to climate is an adjustment of human systems responding to existing or expected climatic impacts that threaten life (UN, 1992). Adaptation has ultimate goals to reduce impacts, to moderate potential damages and to take advantage of opportunities from climate change (Rosenzweig and Parry, 1994; Darwin and Tol, 2001). Adaptation is a concept which consists of initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change impact (IPCC, 2007b). It is considered as urgent, short-term actions for developing countries. It is indicated that many developing countries are more vulnerable to climate change (IPCC, 2007b). This is due to the fact that their socio-economic development and livelihoods are heavily dependence on climate-sensitive sectors, and they have generally low adaptive capacity.

In the past when such statement was remarked, UNFCCC stated that the policy makers such as governments in many countries should focus primarily on mitigation, meanwhile adaptation was a task for other stakeholders (UNFCCC, 2006). However, it is obvious that governments cannot pass adaptation wholly to social because there are needed both government and private sector to plan strategies and take actions for reactive and anticipatory adaptation together. In this regard, the UNFCCC has summarized the types of adaptation to climate change as shown in Table 2.2.

Table 2.2 Types of adaptation to climate change.

		Anticipatory	Reactive
Natural systems			• Longer or shorter growing seasons • Migration of wetlands • Changes in ecosystems
Human systems	Private	• Changing architecture of buildings • Buying hazard insurance • Devising new consumer products	• Moving home • Changing insurance premiums • Buying air conditioning systems
	Public	• Installing early warning systems • Establishing new building codes • Constructing dykes	• Offering compensation or subsidies • Enforcing building codes • Beach nourishment

Sorce: UNFCCC, 2006.

Simpson et al. (2008) stated that developing and implementing the process of climate change adaptation include seven steps that are 1) engaging the stakeholders, 2) defining the problem, 3) assessting of adaptive capacity, 4) identifying adaptation options, 5) evaluating adaptation options and choosing action course, 6) imlementing adaption, and 7) monitoring and evaluating adaptations.

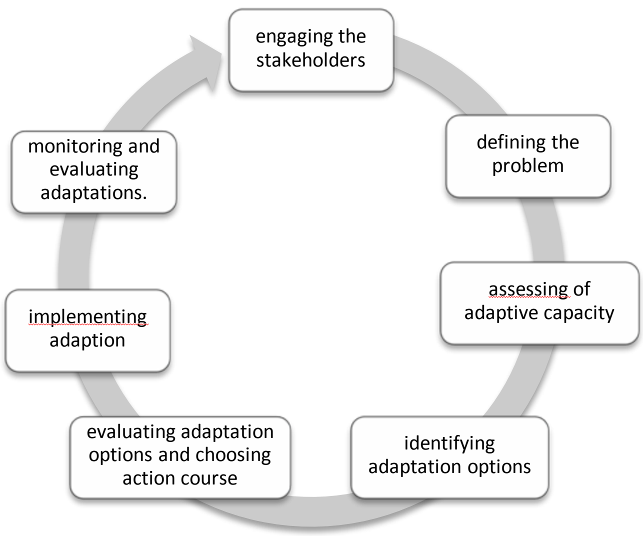

Figure 2.1 Sequence of steps in the process of adaptation.

Source: Simpson et al. (2008).

Figure 2.1 displays the sequence of steps in the process of adaptation. The first step is to invite stakeholders to take part in participation in order to promote better decision making. The next step is to understand the impact of climate change and risks. The third step is to assess adaptive capacity. However, in this step, adaptive capacity is viewed that it cannot be measured directly, but it may be defined toward eight determinants (Yohe and Tol, 2002). They include 1) available technological options, 2) resource, 3) the structure of critical institution and decision making authorites, 4) the invesment in human resource development, 5) the stock of social capital and the definition of property right, 6) the system accesses to risk, 7) information management to supply decision makers, and 8) the perceptions of risks and exposure. The fourth step is to identify adaptation options. It aims to list alternative technologies, management practices, or policies. The fifth step is to identify a list of potential adaptations options and determine criteria to evaluate them. The sixth and the last step are implementation and monitor adaptations, respectively. However, in the last step Simpson et al. (2008) stated that it required investment in human and financial resources to ensure the long term adaptation. Simpson et al. (2008) futher identified key areas needed to strengthen the adaptation for tourism in developing countries and small island developing states, through the process of data and policy requirement of climate change adaptation as shown in Figure 2.2.

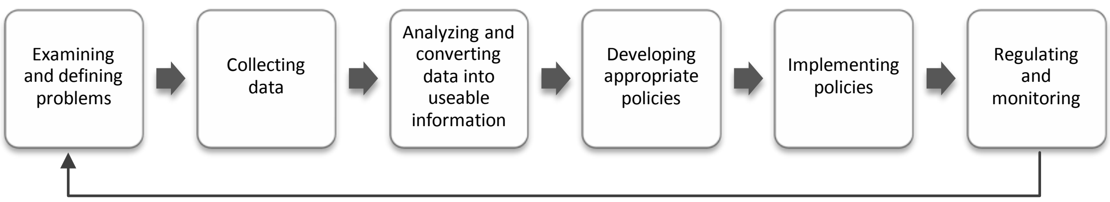

Figure 2.2 The climate change and tourism information and implementation: data and policy process requirements for developing countries and small island developing states.

Source: Simpson et al. (2008).

2.2 Climate change and its impacts in Thailand

Over the past five years or so, the evidence of climate change and its impacts at local scale in Thailand has been increasingly documented. Thailand's First Assessment Report on Climate Change released in 2011 and the observed trends in surface air temperatures and their extremes in Thailand by Limjirakan and Limsakul in 2012 are examples of such recent studies. The studies revealed that Thailand has experienced with temperatures and rainfall extreme events.

2.2.1 Changes in temperature and humidity

Based on daily data of air temperature recorded by the Thai Meteorological Department (TMD), Limjirakan and Limsakul (2012) analyzed trends in surface air temperatures and their extremes in Thailand between1970 and 2009. The results indicated that Thailand has experienced with significant increases in temperatures and associated extreme events have changed accordingly.

Trends in all temperatures (annual maximum, mean, minimum values) demonstrated a significant increasing, particularly during a dry season, comparing to a wet season (Table 2.3).

Table 2.3 Percentages of stations with statistically significant positive trends at the 5% level. The values in parentheses denote average trends (°C per 40 years). Rainy and dry seasons are defined by annual cycles of temperature and rainfall over Thailand.

Variables	Dry season (Nov-Apr)	Wet season (May-Oct)	Annual
Tmax	69.2 (1.02)	80.0 (0.90)	87.7 (0.96)
Tmean	83.1 (1.08)	70.8 (0.76)	84.6 (0.92)
Tmin	87.7 (1.38)	72.3 (0.72)	86.2 (1.04)

Source: Limjirakan and Limsakul, (2012).

On the basis of such results, trends of temperatures in each sub-region of Thailand has increased from 0.16 to 0.32 °C/decade, and the highest increases in the annual maximum and mean temperatures were in eastern region. In addition, the study also found that there have been increasing in the annual number of warm nights and days, the annual occurrence of warm spells, tropical night, summer days, and the highest and lowest minimum temperature (Limjirakan and Limsakul, 2011). These indicated that temperature extremes in Thailand have shifted towards warmer conditions.

Given the continued information of climate change, the report of Thailand's First Assessment on Climate Change (2011) by Working group I (Scientific Basis of Climate Change) presented that average annual of humidity in Thailand has increased significantly by 2.2 percent over the past forty-two years (1965-2006) with statistical significance at the 5% level by Kendall's test. The highest increase in humidity was observed in the eastern part of Thailand as well. This change is indeed consistent with the increase of temperature (Limsakul and Limjirakan, 2011).

2.2.2 Changes in rainfall and runoff

Based on the report of Climate Change of Thailand's First Assessment in 2011, Thailand has experienced a significant decrease in rainfall over past fifty-five years of 1995-2009 (-35.1 mm per 55 year; $p>0.05$). However, there were large interannual variations in rainfall amounts which are related to Asian monsoon and El Ñino Southern Oscillation (ENSO) (Limsakul and Limjirakan, 2011).

In the coastal zones of Thailand, trends of extreme rainfall events over the recent decades between 1965 and 2006 were examined by Limsakul et al. (2010). Analysis of a set core rainfall index including changes in intensity, frequency and duration of rainfall showed significant changes by increasing a wetter condition with increasing degree and frequency of more intense rainfall events. In addition, the changes were consistent with the intensified north-east winter monsoon. Their study also revealed that coastal areas of the country would be disproportion to increasing impacts of different extreme rainfall disasters such as increases in flash flood, coastal erosion, and sever water shortage. (Limsakul et al., 2010) In addition, climate change can affect the areas by altering rainfall and locally driven runoff or more notably, runoff from rivers can drain into the coastal zone resulting in water shortage (Bates et al., 2008).

Given the change in runoff, the report of Climate Change of Thailand's First Assessment in 2011 noted that there has a few both quantity and quality data of runoff in Thailand. Data of total annual runoff from twelve stations located in north, central, northeast, and eastern regions of Thailand were analyzed to explain change in runoff. The result shows that the total annual runoff in the Ping River Basin decreased during 1970 to 1993, but increased since 1993. While the total annual runoff in the Nan River Basin has increased since 1970. These changes caused more frequent floods in the Nan River Basin (Limsakul and Limjirakan, 2011).

In addition, the report discussed that trends in drought and flood in Thailand increased during 1989 and 2008, particularly, after the year 2000. People were affected by drought up to 2.5 times greater than those who were affected by flooding. The report also discussed that the tendency of the number of people affected by drought during the 1989 to 2008 increased more than the number of people affected by flood (Limsakul and Limjirakan, 2011).

2.3 Impacts of climate change on tourism sector and its vulnerability

Tourism is a major income of many countries. It depends strongly on the environment and natural resources. Changing in climate could directly affect on this sector by increasing their operation cost, decreasing a number of tourists, etc. The United Nations Conference on Environment and Development (UNCED, 1992) described that tourism in many countries is seen as the important sector that is vulnerable to climate change. Hence, the impacts of climate change on tourism reinforce national capacities to cope with it (UNDP, 2001).

In 2007, IPCC indicated that there is a need for societies and economic sectors such as tourism industry to adapt to climate change (IPCC, 2007b). In 2008, UNWTO stated that to reduce associated risks and take advantage of new opportunities in an economically, socially and environmentally sustainable manner, there are needed for all parties as well as tourism sector to take appropriate actions dealing with such impacts.

It is known that the impact of climate change has affected the tourism sector in many countries and it is one of the factors impeding development and sustainability. UNWTO (2003) remarked that tourism seems to experienced damage from most the effects of climate change, particularly beach erosion, sea levels rise, sea surges and storms, and reduce water supply. In addition, certain indirect impacts, such as losses in biodiversity, degradation of the aesthetics of landscapes, change in water availability and increasing natural hazards can become problems for tourism in the future (UNFCCC, 2007b). Major climate change impacts and implications for tourism are shown in Table 2.4.

Table 2.4 Major climate change impacts and implications for tourism sector.

Impact	Implications for tourism
Warmer temperatures	Altered seasonality, heat stress for tourists, cooling coasts, changes in plant-wildlife-insect populations and distribution, infectious disease ranges
Increasing frequency and intensity of extreme storms	Risk for tourism facilities, increased insurance coasts/ loss of insurability, business interruption coasts
Reduced rainfall and increased evaporation in some regions	Water shortages, competition over water between tourism and other sectors, desertification, increased wildfires threatening infrastructure and affecting demand
Increased frequency of heavy rainfall in some regions	Flooding damage to historic architectural and cultural assets, damage to tourism infrastructure, altered seasonality
Sea level rise	Coastal erosion, loss of beach area, higher costs to protect and maintain waterfronts
Sea surface temperatures rise	Increased coral bleaching and marine resource and aesthetics degradation in dive and snorkel destinations
Changes in terrestrial and marine biodiversity	Loss of natural attractions and species from destinations, higher risk of diseases in tropical-subtropical countries
More frequent and large forest fires	Loss of natural attractions; increase of flooding risk; damage to tourism infrastructure
Soil changes (e.g. moisture levels, erosion and acidity)	Loss of archaeological assets and other natural resources, with impacts on destinations

Source: UNWTO, 2008.

2.4 Impacts of climate change on water resources

Warming air temperature, increased evaporation, rising sea level, and changing in rainfall patterns are all related to water resources. Global data of temperature analyzed by the IPCC Working Group II in Climate change and water (2007) showed that the trend in global surface temperature from 1906 to 2005 increased by 0.74°C. In many regions, cold days and cold nights became less frequent, while hot days, hot nights and heat waves turned to occur more frequently over the past 50 years (Bates et al., 2008). This report indicated that precipitation generally increased over the twentieth century, but decreased in the past thirty to forty years. In addition, using multi climate models to project future change showed increases in global average precipitation and evaporation over the 21st century. The precipitation generally increases in the tropical areas. However, there is tendency for drought in these regions during summer. Significantly, this leads to problems when there are periods of intense and heavy rainfall making high runoff amounts and flooding. These increases are related with increased water vapor and are associated with warming temperature (Bates et al., 2008).

Regarding above discussion, water resources as runoff and river discharge are associated with temperature, evaporation and rainfall. However, it can be associated with the effect from human interventions such as a reservoir construction. Changes in climate can further affect groundwater flows as it is an important part of the hydrological cycle. There is evidence that groundwater levels have been decreasing over the last few decades due to imbalance in recharge process by climate variability and surpassing pumping (Bates et al., 2008).

In Thailand, changing rainfall is the most significant factor influencing water resources. Thailand's First Assessment Report on Climate Change 2011 described by the Working Group II indicated that changing rainfall in the main river basins in the north, northeast, and central regions of Thailand in the medium period (30-50 years) would increase and decrease the amount of water in the river basins by no more than 10 percent per year. However, rises in temperature will lead to increased evaporation and result in reduced runoff. The report also specifed that in the long period (50-100 years), water in most river basins of the country would increase greater than evapotranspiration, resulting in the long-term increasing trend of runoff.

Given trends of changing in rianfall in Thailand, the report further explained that the country's small-mediun size river basins, particularly located in the coast such as the eastern coast are at risk of water shortage, especially during the dry season. Moreover, decreasing in rainfall, increasing in temperature, and rasing in sea level will reduce both the quantity and quality of surface water and groundwater (Thailand Research Fund [TRF], 2011).

2.5 Water-related adaptation to climate change

The challenges of reducing impacts on water resources caused by climate change are overriding issues that have been especially concerned. In 2011, The United States Environmental Protection Agency (EPA) described that the impacts of climate change on water resources would depend on trends in both climatic and non-climatic factors. Hence, evaluating climate change impacts is needed because water availability, quality and quantity are fluctuated by temperature, rainfall and climate-related factors.

Climate change impacts on water resources affect sustainable development and put it at risk. Bates et al. (2008) noted that sustainable water resource management is needed to be achieved to reduce negative impacts on water resources. On the other hand, the interpretation of water resource management varies considerably. It can be generally included the concept of maintaining and enhancing the environment, and mainly the water environment, with regards to water users. In addition, water resource management is considered to be relevant to the policy and governance. Some adaptation options involving both supply and demand sides are designed to ensure water supply as shown in Table 2.5.

Table 2.5 Supply side and demand side adaptation options for water shortage.

Supply side	Demand side
Prospecting and extraction of groundwater	Improvement of water use efficiency by recycling water
Increasing storage capacity by building reservoirs and dams	Reduction in water demand for irrigation by changing the cropping calendar, crop mix, irrigation method, and area planted
Desalination of sea water	Promotion of local practices for sustainable water use
Expansion of rain water storage	Expended use of water markets to reallocate water to highly valued uses
Water transfer	Expanded use of economic incentives to encourage water conservation

Source: Bates et al., 2008.

Given other alternatives for water-related adaptation, UNFCCC (2006) provided examples of the technological options as regards to water concern. Some options are listed with boosting supplies, for example, building more reservoirs or harvesting rainwater for agricultural use. Some are engaged to reduce demand by cutting leakage from pipes or changing from flush toilets to dry forms of sanitation. These options can also be classified as hard technological options involving new constructions or different types of equipment and soft technological options concerning with changing consumption behavior.

Table 2.6 Examples of adaptation technological options for water-related adaptation.

Use category		Supply side	Demand side
Municipal or domestic		• Increase reservoir capacity • Desalinate • Make inter-basin transfers	• Use "grey" water • Reduce leakage • Use non-water-based sanitation • Enforce water standards
Industrial cooling		• Use lower-grade water	• Increase efficiency and recycling
Hydropower		• Increase reservoir capacity	• Increase turbine efficiency
Navigation		• Build weir and locks	• Alter ship size and frequency of sailings
Pollution control		• Enhance treatment works • Reuse and reclaim materials	• Reduce effluent volumes • Promote alternatives to chemicals
Flood management		• Build reservoirs and levees • Protect and restore wetlands	• Improve flood warning • Curb floodplain development
Agriculture	Rain-fed	• Improve soil conservation	• Use drought-tolerant crops
	Irrigated	• Change tilling practices • Harvest rainwater	• Increase irrigation efficiency • Change irrigation water pricing

Source: UNFCCC, 2006.

Another emerging challenges of the technology for water-related to climate change adaptation are suggested by Ministry of Nature Protection of the Republic of Armenia and UNDP (2003). These technological options include increasing the volume of accumulation of river flows by construction of new water reservoirs; diverting part of the flows from water abundant basins to those with water shortage; using of non-traditional methods for replenishing water resources such as artificial rainfall; reconstructing irrigation systems for reducing water losses and applying modern water saving irrigation technologies such as sprinkler and drip irrigation; balancing the use of artesian and ground waters for drinking and irrigation; saving and rational use of waters in all sectors of economy by using semi-closed cycle and closed-cycle system of water supply; improving the monitoring of water resources; and developing national program for use of water resources taking into account the future needs of economy and possible changes in the climate.

As mentioned above, water-related to climate change adaptation technology can be grouped into two categories including water provision methods and water conveyance systems (Roark et al., 1998). Water provision methods comprise of spring, dug well, drilled well, dam and catchment, while water conveyance methods consist of gravity fed pipeline, hand pump, diesel engine, solar pump, and windmill. Details of some accepted methods have been described by Roark, et al. (1998) and can be summarized as follows.

1) *A spring development* is capturing an underground water flows in a protective structure as it comes out at the surface. This process involves the construction of a cutoff wall to channel the flow into a collection gallery and then allowing the water to flow into a pipe. Water may be stored at the spring. However, if the geography is supporting, water may be piped lengthy distances by gravity. However, spring method may not be available in some location, and opportunities for spring capping are further limited to few regions where flow of the spring cannot be increased.

2) *Dug well* is usually modern method by hand dig. It can be depth up to 30 meters, or deeper wells exist. The average depth is about 12 meters. Dug wells

usually go through only about one meter into the dry season water table. In addition, it depends on seasonal variation and droughts. However, this method is created to utilize water from groundwater sources; therefore, it may cause water penetration in the areas near the sea. Stefano (2004) specified that groundwater over utilization happens when the volume of utilization of groundwater exceeds the average annual replenishment of the groundwater body. Consequently, there is a decrease in the groundwater table. In other words it is important to have a greater balance between usage and the water levels created by reduced rainfall. Moreover, over-exploitation in coastal areas alters the equilibrium of the interface between freshwater and sea water in the groundwater body, which activates saline water intrusion.

3) *Dam* is a technology which is constructed to effectively hold water in large quantities. However, the site must be assessed individually with appropriate location, size, and material of building. Buildings of dam and reservoir or water transfer system are considered as options for complementary water sources to satisfy the vast demand on water. However, reservoir and dam have negative effects on environment and community. Moreover, it causes uncertainties in planning because the amount of surface water that is influenced by rainfall fluctuated from year to year, particularly from small watersheds. A recent study of the World Resources Institute (WRI) (2004) emphasizes that dams can make the dynamics of watersheds in terms of water flow systems and transportation of sediments. This leads to changes in the chemical and physical characteristics of rivers that harmfully influence fish species (WRI, 2004).

4) *Catchment* is similar to dams since both of them rely on annual surface runoff to stock up water supplies. Catchment, however, applies water-resistant surface to channel water into a storage container. A large catchment usually relies on runoff from a rock outcrop which is collected in an underground concrete. A small side of the catchment approach relies on runoff from roofs to store water in tanks.

5) *Gravity Fed Pipeline* is normally applied to bring water from storage tanks or spring gallery boxes at higher distance from the grounds to points of suitable access. If distances from the ground are large as in the case of springs located in hills then pipelines can be many kilometers. The laying of pipeline is labor intensive method

involving community participation. Long pipelines and large storage tanks require professional expertise in the design. However, opportunities for complete gravity fed systems are few and limited to mountainous areas.

Given other technological options to increase supply of water, the areas close to the sea like the islands and beaches in some countries have more options to use technology to make salt water into fresh water. A new Yale University study revealed that, in the situation of world's population increase, seawater desalination should take part in a significant role in helping struggle fresh water shortage when conservation, resue and other methods have been inapplicable and far from sustainable (Muzzin, 2011). A recent study of Desalination Technology in 2011 disclosed that several large scale seawater desalination plants have been built in water-stresses countries to increase available water resources; further, it expects to increase in the near future. However, the study also indicated that although major advancements in desalination technologies, but seawater desalination still consumed more energy compared to conventional technologies for treatment of fresh water. There are also potential environmental impacts of large-scale seawater desalination plants. Therefore, this technology is considered as limitation for increasing water supply in many countries (Elimelech and Phillip, 2011).

The relevance of technology and the capacity was identified by the International Chamber of Commerce (ICC) in 2008. They suggested that technology requirements and capabilities will be different in the situations of adaptation and mitigation to climate change. They specified that the successful deployment of technologies depends on the strengthening of different factors, including enabling framework conditions, local circumstances and the commitment of local business communities and public authorities, technology option, infrastructure, and capacity building appraisal.

Linking between technology and capacity building has been mentioned by ICC that technologies are not sufficient to address climate change, human and physical resources must be available to utilize the technology. To advance capacity building, ICC recommended governments should: (1) unleash technology innovation and nature knowledge-based development, (2) create incentive for technologies and business process that meet the climate change challenge, (3) enhance communications infrastructure and tools to facilitate access to and transfer of information, (4) foster knowledge to industry and professional associations to support the private sector in developing tools to address climate change, (5) build scientific, technological, and management capacities in developing countries to enable people, governments, and enterprises to assess the challenges posed by climate change and to start effective actions, and (6) make sure that effectively trained human resource is available to work technologies acquired (ICC, 2008).

2.6 Capacity building

In 1991, UNDP and the International Institute for Hydraulic and Environmental Engineering defined capacity building as

> *"the creation of an enabling environment with appropriate policy and legal frameworks, institutional development, including community participation (of women in particular), human resources development and strengthening of managerial systems*, adding that, *UNDP recognizes that capacity building is a long-term, continuing process, in which all stakeholders participate (ministries, local authorities, non-governmental organizations and water user groups, professional associations, academics and others."*

In addition, UNDP identified that capacity building is *"a long-term continuous process which should be phased to accommodate requirements of national government. Each individual phase should have clearly defined and measurable targets"* (UNDP, 1991, p. 31). Besides, they stated that capacity building should be aimed at three levels as follows

"(1) Sectoral level: provision of an enabling environment for effective sector and sub-sector management; (2) Institutional level: development of planning and management processes so that the collective skills of the staff can be effectively used in the achievement of the institution's objective;(3) Individual level: comprehensive human resources development strategies programmes to enhance skill of individuals in accordance with institutional needs."

Capacity building has, therefore, become a central concept since the UNCED in 1992. A primary goal of capacity building is to increase the ability of people to assess and address the critical questions related to policy choices and processes of implementation among development alternatives, based on an understanding of environment potentials and limits and consideration of needs perceived by the people of the country concerned.

According to Agenda 21, developing abilities of people must be focused as a key path to enhance the policy implementation and to achieve sustainable development of each country. To achieve environmental and economic needs, the Agenda 21 encourages countries to identify priorities and determine the meaning of capacity building for national plans or the implementation of national policies.

Based on the need of sustainable development in Agenda 21, skills, knowledge, and technical know-how at the individual and institutional levels are required to establish strategic planning and priorities on environment and development of countries (UN, 1997a).

Consistent with a meaning of capacity building, James (1998) debated that capacity building means maintaining the integrity of the environmental circumstances which are held by the ability of communities and institutions. While Reis et al. (1998) viewed that capacity is associated with the skills, knowledge and attitudes of personnel necessary to perform their tasks. Sobeck and Agius (2007) elaborated this point stating that capacity building is a process or activity to raise the ability of individuals, strengthen performance, in protecting environment, in order to achievable objectives and policy implementation intended. Furthermore, Stephen and Triaganon (2009) described in the International Union for Conservation of Nature (IUCN) capacity strengthening program that capacity is the overall ability of the individual or group to carry out their responsibilities. It depends not only on the capabilities of the people, but also on the overall size of the task, the resources and the framework.

From this view point, it has been recognized that the capacity involved capabilities which are the knowledge, skills and attitudes of the individuals, and competence to undertake the responsibilities taking into consideration the resources and the framework.

It has been recognized that capacity building is multi-dimension. An example of building capacity project could also be seen in 2004 when Laos PDR developed their project on capacity building for environmental and social mitigation of the Nam Theun 2 hydropower. They divided the capacity into the institutional level, the organizational level, and the individual level (Ministry of Industry and Handicrafts of Laos [MIH], 2004). The three levels of capacity were also highlighted in the guidelines of capacity building in the regions by German Society for Technical Cooperation (GTZ) about the Support for Decentralization Measures (Rohdewohld and Poppe, 2005).

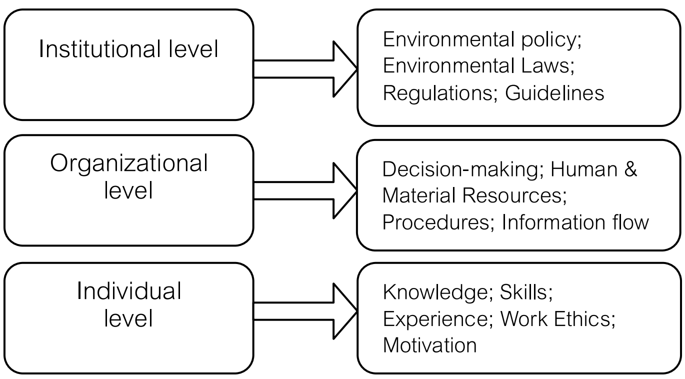

Figure 2.3 The multi-dimension of capacity building of Laos PDR Projects.

Source: Ministry of Industry and Handicrafts, Laos PDR (MIH), 2004.

Regarding the capacity building reviewed, it was found that the capacity could be categorized into 9 types including 1) knowledge, 2) skill, 3) understanding, 4) experience, 5) awareness, 6) attitudes/motivation, 7) work ethics, 8) resources, 9) technology.

Further project on capacity building of Laos PDR in 2004 also defined the capacities of environmental and social mitigation for governmental hydropower project. Motivation, experience, knowledge, skills, and work ethics were significantly included as key capacities. In 1998, Reis et al. carried out studies on building human capacity on coastal and ocean management implementing the Train-Sea-Coast program in Brazil. The study concluded that the capacities such as attitude, knowledge, and skill are needed for the program. Interestingly, some of these capacities both found in Laos PDR's project and Reis's study were similar to the IUCN's project on a capacity needs assessment in 2009 (Setphen and Triagana, 2009). Within this ambitious project, considerable attention is being paid to strengthening capacity to enhanced skill, understanding, attitude, managing resources and technology to their stakeholders. Capacities' components mentioned can be therefore summarized into 9 key issues comprising knowledge, skill, understanding, experience, awareness, attitudes/ motivation, work ethics, resources, and technology.

Table 2.7 Comparable capacities assessment on capacity building among different projects.

Projects of capacity building / Capacities	A capacity needs assessment process of IUCN in 2009	Capacity building for environmental and social mitigation for NT2 and other hydropower projects in Lao PDR in 2004	Building human capacity on coastal and ocean management: implementing the Train-Sea-Coast Progamme in Brazil in 1998
Awareness	Yes	-	-
Attitudes/Motivation	Yes	Yes	Yes
Experience	-	Yes	-
Knowledge	-	Yes	Yes
Resources	Yes	-	-
Skills	Yes	Yes	Yes
Technology	Yes	-	-
Understanding	Yes	-	-
Work Ethics	-	Yes	-

Source: Setphen and Triagana, 2009; MIH, 2004; Reis, et al.,1998.

In 1996, the government of Thailand developed the Regional Urban Development Program under technical and financial assistances from the UNDP. The project aimed at the set of strategies and policies helping urban centers to strengthening their capacity at the local level. It found that the implementation among agencies should consider improving conditions of capacity at the local level (Tai, 2000). In 2002, a joint research project on capacity building of Thailand was studied by the Japan International Cooperation (JICA) and the Department of Local Administration (DOLA), Ministry of Interior. This project promoted social and economic development of the country and intended to improve the quality of life of people so that the capacity of the local institutions could be built by their own administrative. The projects highlighted the importance of building capacity for local governments and agencies to support the needs of the country (JICA and DOLA, 2002).

Honadle and Howitt (1986) proposed a specific framework and structure for local organization addressing problems occurring and stating certain accountabilities to conduct capacity building at the local level. Generally, local governments frequently managed capacity building depending on their size. Size is rarely defined rigorously, though population is an important aspect, if it is small and suitable to develop. In addition, an advantage of smaller size makes for accurate and efficient study and development. A small size of local government constitutes a threshold of capacity. It can be concluded that a framework of capacity of local government consists of the ability to predict change, build informal policies, develop programs, manage resources, evaluate current activities to guide future actions, mitigate the risks, and provide incentives for all stakeholders.

In 2006, Australian Government developed a stage approach to assess, plan and monitor capacity building for implementing in their organization. It was a systematic approach to assess the capacity of individuals and groups by indentifying needs, developing strategies in order to build capacity and assess the results. In the implementing the staged capacity building model, they suggested 7 steps including (1) preparation and planning, (2) agree definitions of capacity building stages, (3) identify and document functions of the work group, (4) assess current stage of capacity for each function, (5) set target levels of capacity, (6) identifying strategies to build capacity, and (7) reviewing capacity building progress and redeveloping the plan.

2.6.1 Capacity building in the context of climate change

Capacity building in the context of climate change was defined by the United Nations (UN) in 2008. Overall 15 priority areas of needs identified in the capacity-building framework comprising:

- capacity building activities in support of institutional capacity building,
- enhancement and creation of an enabling environment,
- national communities,
- national climate change programs,
- greenhouse gas inventories,
- vulnerability and adaptation assessment,
- implementation of adaptation measures,
- assessment for implementation of mitigation options,
- research and systematic observation,
- development and transfer of technology,
- improved decision making,
- the clean development mechanism,
- needs arising out of the implementation of the climate change convention,
- capacity building through education and training and public awareness, and
- information and networking.

Examples of such capacity building activities noted by the UN (2008) include:

- establishing national coordinating bodies in some countries to enable action plans of relevant national,
- developing legislation on climate change,
- contributing national communications with some countries to enhancing capacity building at the technical, legal, and institutional levels,
- taking mechanisms for preparing greenhouse gas (GHG) inventories and strengthen the technical capacity of inventory experts,
- developing action plans for vulnerability assessment and adaptation measure and including training programs for experts and local communities,
- launching mitigation action plans with focusing on promoting renewable and raising energy efficiency,
- creating activities in the area of research and systematic observation to strengthen research capabilities and development of early warning system,
- replacing obsolete technologies,
- increasing knowledge and awareness if climate change among policymakers involved in the implementation of sustainable development programs in order to enable them to take informed decisions,
- taking legislative of the CDM at the national level,
- introducing education, training and raising awareness, and educational programs on climate change and environment issues within targeted community groups in order to increase awareness and possible response to climate change impacts.

2.7 Sustainable tourism development

As promoting tourism industry has become a source of society incomes in many countries. Such countries have attracted tourists by promoting the ideas of sustainability. The debate of sustainable tourism development was first considered in 1998.The United Nations General Assembly issued the five-year implementation of Agenda 21 (UN, 1997b). The sustainable tourism development concept was set by the UNWTO as the guideline which is appropriable to all tourism destinations. The concept of sustainable tourism development promotes a balance among the environmental, economic, and soico-cultural aspects of sustainability in the long term. It means to maintain the high level of tourists and raise their responsiveness to resources that have been involved in leisure, and encourages their compliance to the idea of sustainable development (UNWTO, 2004).

The United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) (1999) stated that achieving long term sustainability, tourism policy and the efforts of national tourism organizations should be considered under the relevant factors related to sustainable tourism development, such as human resource development, the economic impact, environmental management, and cooperation at the regional or sub regional level. Connell, et al. (2008) emphasized this claiming that it should be more focused on the integration of the principles of sustainability and practicality within policy planning.

In order to comprehend the sustainable tourism concept, the indicators measuring the sustainability of tourism has developed and studied. In 2001, Miller has sought to determine expert opinion on the indicators of sustainable tourism. In his study, he focused on the role of the consumer and the industry in promoting sustainable tourism development. He found that indentifying sustainable indicators of tourism development may vary from location to location. The results of experts surveyed in this study have shown considerable disagreement over “sustainability” and unlimited border of the concept, exist. Namely, it is necessary to capture what is specific to individual locations and what is also common to tourism in general. On the other hand, any indicators that would be used should be important for the community and could measure the sustainability of tourism when it is affected by negative events.

However, there was an attempt to develop the indicators as a result of 2006 when Choi and Sirakaya making the checklist indicators of sustainability for managing tourism in community as shown in Table 2.8. These indicators were expected to help local communities examine the current condition of their resources, but were not used to measure developing impact or progress of process. The authors concluded that these proposals would be effective only for the planning or policy level.

Table 2.8 Checklist indicators of sustainability for managing community tourism.

Area	Indicators
Human resource	Resident advisory, Tourism authority or planner in the community, Permanent staffs in information or visitor centre
Policy and regulations	Development control policy, Legal related compliance regulations, Air and water pollution and waste management and policy, Land zoning policy, Visitor safety, security, and health policy, Formal control required over development of sites and use densities, Local purchasing policy, Mandated use of environmental impact assessment, Local/regional/national protected area classification
Area	Indicators
Funding	Local reinvestment fund, Local credit to local entrepreneurship, Cultural and natural site maintenance fund
Planning and education	Visitor safety, security, and health policy related funding, Existence of an adequate fee structure, Tourism development master plan, Existence of sustainable tourism development plan, Tourism as one of major components in a community planning process, Continuous monitoring programs delivered, Performance-based incentive programs, Training programs for local stakeholder groups, Use of new and/or low-impact technologies, Code of ethics at all level of governments

Source: Choi and Sirakaya, 2006.

2.7.1 Sustainable tourism development in the context of climate change

According to Davos Declaration in 2007, tourism sector is seen as a vital component of the global economy contributing to the Millennium Development Goals. The conference agreed that tourism sector is now highly sensitive to climate change impacts and global warming. Hence, the policies and tools to respond to this challenges impact are an urgent requirement towards sustaining the tourism sector. Regarding the policies, required actions are mitigating GHG emission, especially from transportation and accommodation activities, adapting to changing in climate conditions, applying existing and new technology to improve energy efficiency, and securing financial resources to assist poor countries (UNWTO, 2007).

To achieve a sustainable tourism, the impacts of climate change on water resources must be considered. It could be seen that an aspect of the development of sustainable tourism is associated with water resources that have been negatively affected by climate change. In 2003, UNWTO remarked that the wider areas of the sustainable tourism were concerned not only to energy efficiency bust also water and its consumptions. They further identified that tourists' water consumption was extremely in excess of local residents. This caused water stress in regions that have experienced with climate change and water shortages. Given the impact of climate change on water resources, water consumption in tourism sector can be reduced if tourism, government, and individual tourists take appropriate actions and use efficiency tools such as installing water saving devices, reusing water, setting policies and plans that respects climate change and environmental concerns (Stefano, 2004).

To cope with adverse impacts of climate change and reduce as fundamental aspects of sustainable development in the tourism sector, German Technical Cooperation (GTZ) by Lengefeld (2010) discussed in the report of Coping with climate change in the Pacific Island Region that the process of tourism component should be focused on three key areas to introduce climate change adaptation. The first key area is to address climate change for existing and new major tourism sites, surrounding communities and areas under its influence. The second key area is to develop and implement climate change adaptation approach for community based tourism. The third key area is to integrate climate change considerations in strategies and plans for national tourism development, based on leraning lessons from climate change approaches.

2.8 Role of local government engaging in climate change adaptation and implementation

There have been some links between climate change and the ability of local governments needed to achieve adaptation. Honadle and Howitt (1986) proposed a specific framework and structures of local organizations addressing problems occurring and stating certain accountabilities to conduct capacity building at the local level. Generally, local governments are frequently managing capacity building according to their size. Size is rarely defined rigorously, though those with a smaller population are more suitable to develop. In addition, an advantage of smaller size makes for more accurate and efficient study and development. A small size of local government constitutes a threshold of capacity. It can be concluded that a framework of the capacity of local government consists of, the ability to predict change, build informal policies, develop programs, manage resources, evaluate current activities to guide future actions, mitigate the risks, and provide incentives for all stakeholders (Honadle and Howitt, 1986).

In Thailand, the rural local self-governing body known as the Subdistrict Administrative Organization (SAO) made clear that the local government and their ability to manage resources are closely related to strengthening sustainable tourism development in their communities, consequently their priority for adaptation is to enhance understanding of them, as well as developing the capacity to adapt to climate change influencing the development of sustainable tourism. Building the capacity of local governments to adapt to climate change is essential to be implemented in tourism areas.

The SAOs have authorized to develop their community economically, socially, and culturally (Article 66). In this regard, the SAO's law has stipulated the following functions and responsibility of the SAO in Article 67 as follows (Department of Provincial Administration [DOPA], 2009a):

(1) To build and maintain parks, public building and supply water to the community adequately;

(2) to provide and clean waterway, public streets or sidewalks and other public areas including removal of solid waste and garbage;

(3) to preserve and maintain natural resources and environment;

(4) to prevent and protect disease;

(5) to provide fire extinguishers;

(6) to provide education and training for people;

(7) to promote public occupations;

(8) to promote development of women, children, youth, elderly, and disabled;

(9) to maintain local arts, local tradition, local knowledge, and local culture; and others.

In addition, the SAOs may opt to perform the following functions as of Article 68 including (1) provision of water for consumption and farming; (2) provision and maintenance of electricity or other methods of lighting; (3) provision and maintenance of drainage systems; (4) provision and maintenance of community halls, sport centers, recreation places, and public parks; (5) provision and promotion of famer groups and co-operative activities; (6) promotion of household industry; (7) maintenance and promotion of people's livelihood; (8) maintenance of public properties; (9) seeking benefits from the SAOs' properties; (10) provision of market places, boat landing and wharfs; (11) commercial affairs; (12) tourism; and (13) town planning (DOPA, 2009a).

Apart from the above-mentioned functions, the abilities' local governmental agencies to manage resources are closely related to strengthen sustainable tourism development in their communities. Consequently, enhancing the abilities of them to adapt to climate change impacts toward sustaining tourism is necessary to be implemented.

2.9 Capacity building model on climate change adaptation

Capacity building model on climate change adaptation currently has no direct related research on process of preparation and its implementation. However, under the initial concept of capacity building defined by UNDP in 1991, capacity building focused on creation of an enabling environment. The key elements to enabling capacity building include appropriate policy, legal frameworks, institutional development, community participation, human resource development, and strengthening of managerial system which can be shown in Figure 2.4.

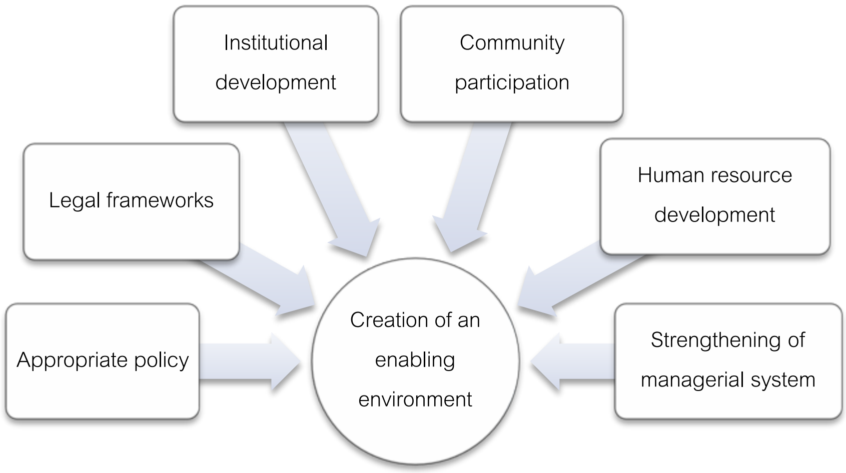

Figure 2.4 The key elements to enabling capacity building (modified from UNDP, 1991).

The initial key elements of capacity building of UNDP could be further added and detailed in the Table 2.9.

Table 2.9 Elemental of capacity building adapting to climate change

The key elements to enabling capacity building (UNDP, 1991)	Capacity building activities to climate change adaptation (UNFCCC, 2009)
Appropriate policy	- Action plans for vulnerability assessment and adaptation measure, and training program for experts and local communities should be developed - Mitigation action plans have been launched by focusing on promoting renewable and raising energy efficiency
Legal frameworks	- Develop or upgrade legislations on climate change issues
Institutional development	- National coordination bodies and entities have been established in some countries to enable action plans of relevant nations
Community participation	- Involving all levels of community in the education, training and raising awareness programs on environmental issues and climate change as well as exchanging and disseminating information on climate change issues with them
Human resource development	- Increasing knowledge and awareness of climate change among policymakers involved in the implementation of sustainable development
Strengthening of managerial system	- Creation of institutions to record information on climate change - Replacing obsolete technologies

Source: UNDP, 1991 and UNFCCC, 2009.

CHAPTER III

RESEARCH METHODOLOGY

3.1 Research framework

This research aims at studying the impact of climate change on water resources on Koh Chang, and assessing the LGAs' capacities to adapt to such impacts, as well as developing a conceptual model of capacity building for the LGAs for adapting to the climate change impacts on water resources affecting sustainable tourism development on the island.

Procedures for conducting the study relied primarily on Creswell's (2007) approach. It begins with determined boundaries of the study including studying factors affecting the shortage of water on Koh Chang based on supply and demand sides.

On the supply side, factors that are significant to water availability on the island included 1) climate change, 2) the island's geographical characteristics, and 3) capability of the LGAs on water management. Climate change, particularly changes in rainfall and temperature were studied towards 26 climate indicators developed by the World Meteorological Organization (WMO). These indicators were analyzed using statistical techniques. While the geographical characteristics that influence the ability to supply water such as water tributaries of the island were studied through multiple sources such as documents, interviews, and direct observations. While the capacity of the LGAs on water management regarding climate change was assessed through five main categories of adaptation to climate change derived from Yohe and Tol (2002).

On the demand side, water demands of the main two water user groups including tourism businesses and local people would be studied. This also included an interview to explore a possible conflict of water use between the two groups resulting from over water demand.

Concerning the above mentioned factors, water supply and demand data were compiled and compared to the corresponding period of the rainfall season and tourism season. Regarding the situation of water shortages that would make unsustainable tourism and problem to the communities, the study therefore focused on strengthening the capacity of the LGAs to manage such issues. A key issue of capacity building of the LGAs was analyzed by modifying concepts of capacity building adapting to climate change developed by UNDP (1991) and UNFCCC (2009) through describing the case. In the final interpretive phase, the study proposed a conceptual model of capacity building for the LGAs for adapting to climate change impacts on water resources affecting sustainable tourism on the island. A conceptual study framework presents in Figure 3.1.

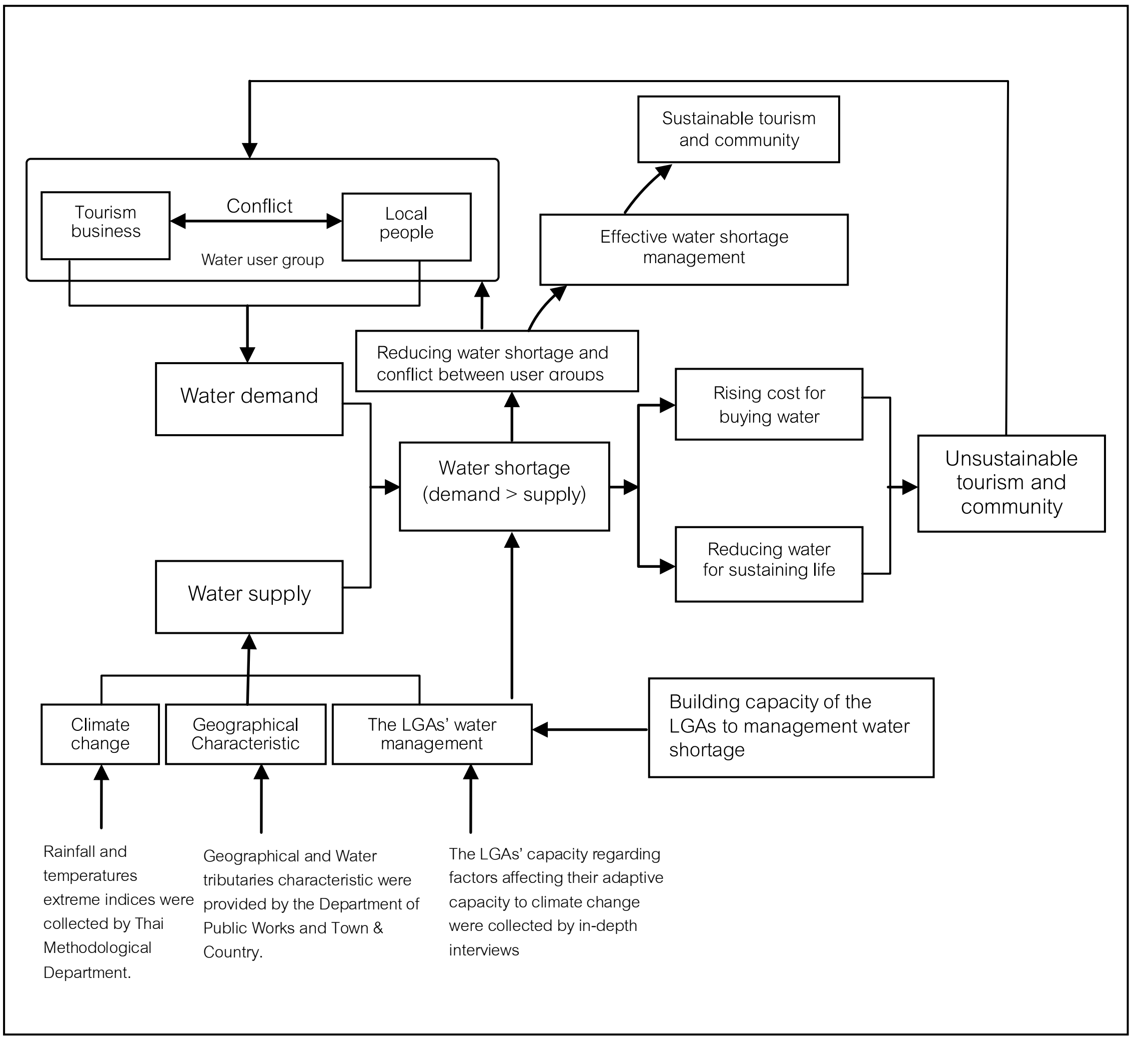

Figure 3.1 The conceptual framework of the study.

3.2 The study areas

The study areas composed of 4 villages within 2 Subdistricts of Koh Chang namely Ban Klong Nonsri and Ban Klong Praw located on Koh Chang Subdistrict, while Ban Bang Bao and Ban Salak Petch located on Koh Chang Tai Subdistrict (Figure 3.2). These villages were selected based on locations, tourism activities, topography, and administration as shown in Table 3.1

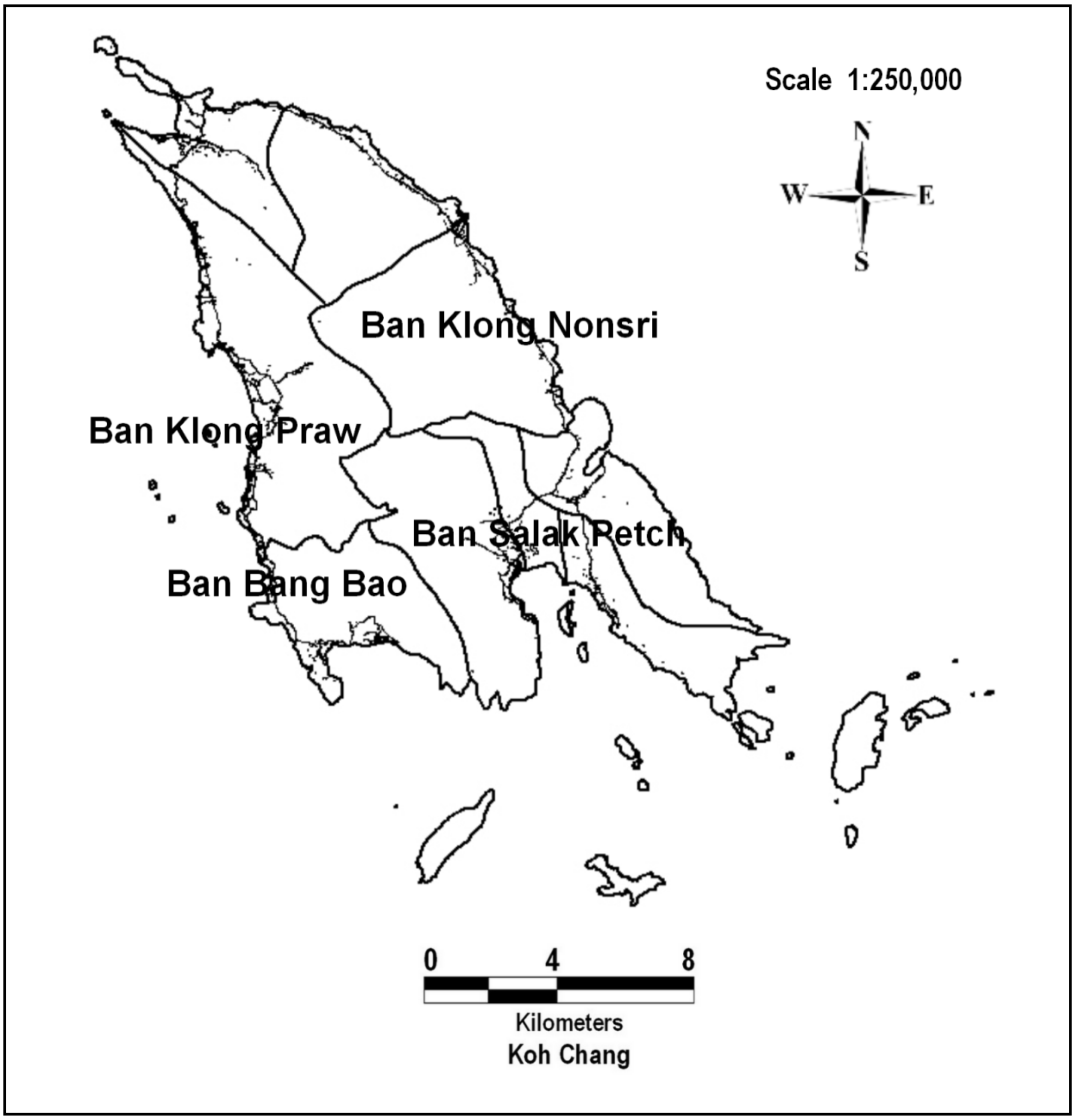

Figure 3.2 The study area (4 villages of Koh Chang District).

Source: Trat Office of Public Works and Town & Country Planning, 2009.

Table 3.1 The criteria used in selecting the appropriate study areas.

Characteristics of the areas	Ban Klong- Nonsri	Ban Klong- Praw	Ban Bang- Bao	Ban- Salak Petch
Location	In the middle of the east coast of the island	In the west coast of north of the island	In the south of west side of the island	In the southern end of the island
Tourism activities	Garden fruit trips, small-size resorts, shrine worship.	Entertainment centre, large size hotels and resorts, , restaurants	Fishing village, home-stay, restaurant , snorkeling	Mangrove field trip Small size resort, home-stay, restaurant, snorkeling
The topography	Plateau and mountain, no sand beach,	Upland areas, White sand beach,	Bay, beach, marshland	Mountain, bay, mangrove
The administrative organization	Subdistrict Municipality of Koh Chang	Subdistrict Municipality of Koh Chang	Subdistrict Administration Organization of Koh Chang Tai	Subdistrict Administration Organization of Koh Chang Tai

Source: Department of National Parks, Wildlife and Plant Conservation (DNP), 2004.

3.3 Respondents

Respondents of this study were selected by the specific sampling method (Creswell, 2007) to whom having responsibilities or roles dealing with tourism development and working at the Subdistrict Municipality of Koh Chang, the Subdistrict Administration Organization of Koh Chang Tai (SAO of Koh Chang Tai), the district officers of Koh Chang, 4 village-heads, and representatives of tourism businesses.

The study selected 24 respondents to represent local governmental agencies' capacities to adapt to climate change that would affect on water resource on the island. Those respondents included the chief executives and members of two local organizations (Subdistrict Administration Organization of Koh Chang Tai, and Subdistrict Municipality of Koh Chang), the district officers of Koh Chang, village leaders from four selected villages (Ban Klong Nonsri, Ban Klong Praw, Ban Bang Bao, and Ban Salakpetch), as well as representatives of tourism businesses. The numbers of the respondents by categories are shown in Table 3.2.

Table 3.2 Respondents by category.

Category of respondents	Numbers of respondents
- Chief Executive of SAO of Koh Chang Tai	1
- Members of SAO of Koh Chang Tai	3
- Mayor and Deputy Mayer of Subdistrict Municipality of Koh Chang	2
- Members of Subdistrict Municipality of Koh Chang	5
- Chief District Officer of Koh Chang	1
- Assistant District Chief Officer of Koh Chang	2
- Village leaders	6
- Representatives of tourism businesses	4
Total	24

3.4 Data collection

Data collection techniques employed in this study included desk study, interviews, and direct observations in order to study impact of climate change on water resource and to assess capacity of the LGAs in dealing with such issue. The techniques were designed as details shown in Table 3.3.

Table 3.3 Summaries data collection techniques used in the study.

Data collection techniques	Types of collected data	Sources of data
1. Desk study	- ***Daily record of climate*** includes maximum, mean and minimum temperatures, rainfall and relative humidity.	- The quality controlled data sets (Limjirakan et al., 2010) from the Thai Meteorological Department. (2006).
	- ***Water resources*** include supply and demand.	- Estimated water demand based on the number of tourists and local people [Department of tourism, 2010 and the Department of Provincial Administration (DOPA), 2009(b)]. - Water supply from rainfall data from the Thai Meteorological Department, (Limjirakan et al., 2010) and runoff data from the Department of Groundwater Resource (2010).
	- ***Geographical characteristic*** of the study areas.	- Geographical characteristic of the island, and water tributaries (Department of Public Works and Town & Country, 2009).
2. In-depth interviews	- ***Impacts of climate change** on water resources* affecting tourism sector - ***The capacity of the LGAs*** in dealing with the impacts of climate change on water resources.	- Interviewed 24 respondents on factors affecting their adaptive capacity to climate change, and the framework of Yohe and Tol (2002).
3. Direct observations	- ***Physical existing problems*** in the study areas such as damaging of weirs after consecutive heavy rainfall.	- Direct observed in 4 villages selected.

3.4.1 Desk study

Various sources of information and data were collected and reviewed to understand the changes in climate impacts, water demand and supply, and existing capacity of the LGAs.

Daily records of climate data between 1970 and 2009 which include maximum, mean and minimum temperatures, rainfall and relative humidity at the Klong Yai Station were obtained from Limjirakan et al. (2010). These controlled quality data sets were originally obtained from the Thai Meteorological Department. The location of the Klong Yai Station is shown in Figure 3.3. A multi-stage suite of objective quality and homogeneity checks were employed to address the quality of data in addition to a visual examination of any obvious outliers and discontinuities (Limjirakan et al., 2010). The most accepted objective approaches were tests of spatial and temporal outliers, data missing interpolation and homogeneity checks (Wijngaard et al., 2003; Feng et al., 2004; Auer et al., 2005; Wang et al., 2007). Whereas, data homogeneity was assessed using an R-based program, namely RHtest, developed at the Climate Research Branch of Meteorological Service of Canada (Wang et al., 2007). This program is capable to identify multiple step changes based on a two-phase regression model with a linear trend for the entire base series (Wang, 2003).

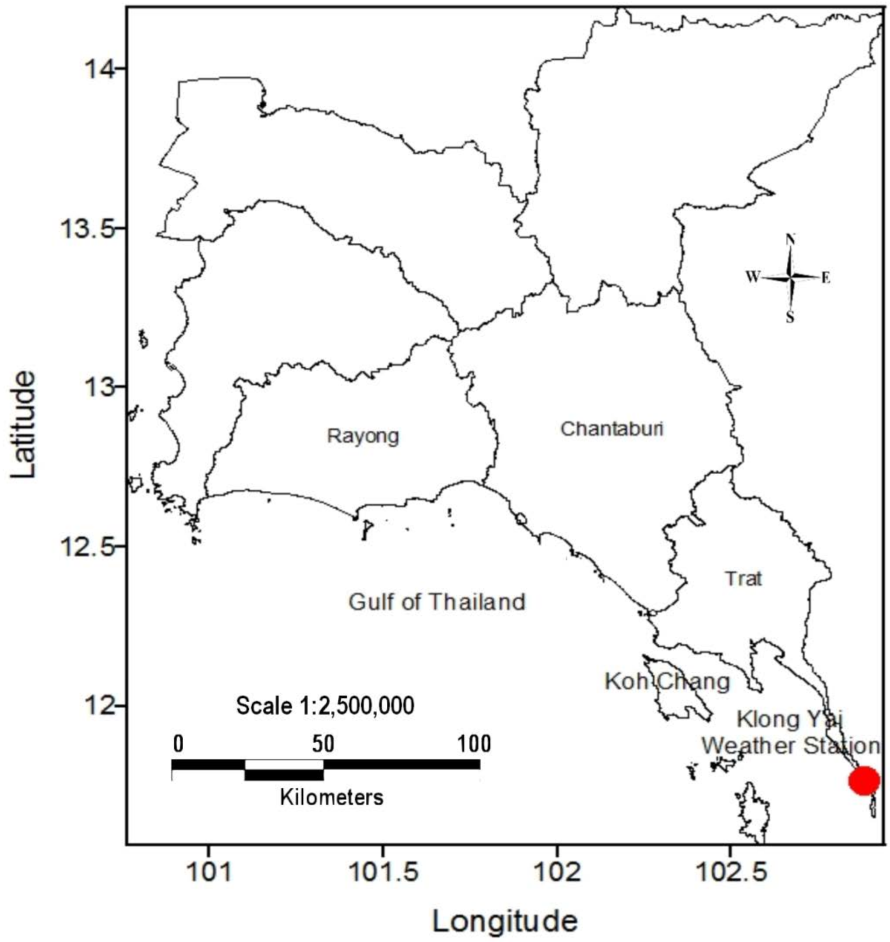

Figure 3.3 The location of the Klong Yai Weather Station.

The water demands were estimated based on the number of tourists and local people collected by the Department of tourism and the Department of Provincial Administration (DOPA) (2010), respectively. Due to water resources of the island normally come from natural source, this makes a difficulty to estimate size and carrying capacity of the study areas such canals, creeks, and waterfalls. In addition, the island has no any reservoir. Regarding this limitation, the amount of water on the island could be estimated by means of rainfall and runoff during the wet and dry seasons.

In addition, the data of geographical characteristic and water tributaries of the island were further obtained from the Department of Public Works and Town & Country (2009).

3.4.2 In-depth interviews

A tool used for In-depth interviews was an interview guide (Appendix A). A series of dialogues were held with the respondents on Koh Chang Subdistrict and Koh Chang Tai Subdistrict by conducting discussion on the capacity of the LGAs to manage and reduce impacts of climate change on water resources, and possible actions to be taken regarding five main categories derived from Yohe and Tol (2002) including;

(1) the range of available technological options for adaptation;
(2) the available resources and distribution across the communities;
(3) the structure of critical institutions and the criteria for decision making;
(4) the stock of human capital; and
(5) the system access to risk-spreading processes.

Twenty-four respondents include LGAs, district officers, village leaders, and representatives of tourism business in the study area were in-depth interviewed during February to May 2010 on the issues of climate change, water shortage (water resource) and its effects on tourism development and their accomplishment. These respondents were selected based on their qualifications mentioned in section 3.3.

Through in-depth interview, twenty-four respondents were also discussed on the LGAs' capacity toward the ability to manage water shortage affected by climate change, and also the future actions or plans to be taken regarding five main categories (Yohe and Tol, 2002).

3.4.3 *Direct observations*

To identify the physical existing problems in the study areas and to obtain adequate information, direct observations were conducted during the interviews at Ban Klong Nonsri, Ban Klong Praw, Ban Bang Bao, and Ban Salak Petch. The field survey were chosen based on the qualifications mentioned in section 3.2.

3.5 Data analysis

3.5.1 Climate indicators

To analyze climate extreme events, the study selected 14 indicators for temperature and 12 indicators for rainfall. These selected indicators were recommended by the World Meteorological Organization–Commission for Climatology (WMO-CCI)/World Climate Research Programme (WCRP)/Climate Variability and Predictability (CLIVAR) project's Expert Team on Climate Change Detection, Monitoring and Indices (ETCCDMI) (Peterson, 2005). The climate indicators were chosen primarily for assessment of many aspects of a changing climate, which include changes in intensity, frequency and duration of precipitation events (Zhang et al., 2005; Alexander et al., 2006; Klein Tank et al., 2006). They represent events that occur several times per year, giving them more robust statistical properties than measures of extremes which are far enough into the tails of the distribution so as not to be observed during some years. The extreme indices of rainfall and temperatures can be divided into 5 different categories which are described in Table 3.4.

Table 3.4 The extreme indices groups of rainfall and temperatures.

Indices groups	Temperature extreme indices	Rainfall extreme indices
1) percentile-based indices	TN10p, TN90p, TX10p, and TX90p	R95p, and R99p
2) absolute indices	-	RX1day, and RX5day
3) threshold indices	-	R10,R20, and R50
4) duration indices	CSDI, and WSDI	CDD, and CWD
5) other indices	TXX, TXN, TNX, TNN, DTR, Tmin, Tmean, and Tmax	SDII, PRCPTOT, and T12

Table 3.5 presented the extreme indices groups of rainfall and temperatures which are 1) percentile-based indices (R95p, R99p,TN10p, TN90p, TX10p, and TX90p), 2) absolute indices (RX1day, and RX5day , 3) threshold indices (R10,R20, and R50), 4) duration indices (CDD,CWD, CSDI, and WSDI) and 5) other indices (SDII, PRCPTOT, T12, TXX, TXN, TNX, TNN, DTR, Tmin, Tmean, and Tmax). RClimDex, an R-base software package developed at the Climate Research Branch of Meteorological Service of Canada on behalf of ETCCDMI was used to calculate these indicators. The complete lists of the 26 indicators are shown in Table 3.5 and Table 3.6.

Table 3.5 List of 14 indices of temperature.

ID	Indicator name	Definitions	UNITS
Tmin	Annual mean of minimum temperature	Annual average of monthly minimum temperature	°C
Tmean	Annual mean of mean temperature	Annual average of monthly mean temperature	°C
Tmax	Annual mean of maximum temperature	Annual average of monthly maximum temperature	°C
TXX	Max Tmax	Monthly maximum value of daily maximum temperature (TX)	°C
TNX	Max Tmin	Monthly maximum value of daily minimum temperature (TN)	°C
TXN	Min Tmax	Monthly minimum value of daily maximum temperature	°C
TNN	Min Tmin	Monthly minimum value of daily minimum temperature	°C
TN10p	Cool nights	Percentage of days when TN < 10th percentile	Day
TX10p	Cool days	Percentage of days when TX < 10th percentile	Day
TN90p	Warm nights	Percentage of days when TN > 90th percentile	Day
TX90p	Warm days	Percentage of days when TX > 90th percentile	Day
WSDI	Warm spell duration indicator	Annual count of days with at least 6 consecutive days when TX > 90th percentile	Day
CSDI	Cold spell duration indicator	Annual count of days with at least 6 consecutive days whenTX < 10th percentile	Day
DTR	Diurnal temperature range	Monthly mean difference between TX and TN	°C

Table 3.6 List of 12 indices of rainfall.

ID	Indicator name	Definitions	UNITS
RX1day	Max 1-day rainfall amount	Monthly maximum 1 day rainfall amount	mm
RX5day	Max 5-day rainfall amount	Monthly maximum consecutive 5-day rainfall amount	mm
SDII	Simple daily intensity index	Annual total rainfall divided by the number of wet days (defined as PRCP≥1.0mm) in the year	mm/day
R10	Number of heavy rainfall days	Annual count of days when PRCP≥ 10mm	Day
R20	Number of very heavy rainfall days	Annual count of days when PRCP≥ 20mm	Day
R50	Number of days above 50 mm	Annual count of days when PRCP≥50 mm, 50 is a user defined threshold	Day
CDD	Consecutive dry days	Maximum number of consecutive days with RR < 1mm	Day
CWD	Consecutive wet days	Maximum number of consecutive days with RR ≥ 1mm	Day
R95p	Very wet days	Annual total PRCP when RR > 95th percentile	mm
R99p	Extremely wet days	Annual total PRCP when RR > 99th percentile	mm
PRCPTOT	Annual total wet-days rainfall	Annual total PRCP in wet days (RR≥1mm)	mm
T12	Number of the wet days	Annual number of the wet days when rainfall≥1 mm	Day

3.5.2 Trends analysis

Trends of climate indicators were analyzed by statistical techniques. Linear trends of temperature and rainfall indices series were calculated using a non-parametric Kendall’s tau based slope estimator (Sen, 1968; Aguila et al., 2005; Zhang et al., 2005), to account for time series autocorrelation. This method is resistant to the effect of outliers in the series. It has been widely used to compute trends in hydro-meteorological series (e.g. Wang and Swail, 2001; Zhang et al., 2000; Alexander et al., 2006). The significance of the trends was determined using Kendall’s test, since this approach does not assume an underlying probability distribution of the data series resulting robust significant trends (Limjirakan et al.,2010). A trend is considered to be statistically significant if it is significant at the 5% level.

3.5.3 The capacity of the LGAs

The existing capacity of the LGAs in dealing with impacts of climate change on water resources was assessed through five main categories of adaptation to climate change derived from Yohe and Tol (2002) as mentioned in sections 3.4.2

3.6 The process to develop a capacity building model

The process of developing the conceptual model of capacity building for the LGAs was applied from designing and method of case study written by Yin (1994) comprising 1) outlining a case conclusion, 2) modifying theories and concepts, 3) developing policy implication, and 4) drawing a model

In the first stage of developing the model, the impacts of climate change on water resources would be analyzed in accordance with the implementation of the LGAs regarding five main categories of adaptation to climate change adopt by Yohe and Tol (2002). Then, theories and concepts of capacity building and climate change adaptation would be modified to develop possible aspects of policies in capacity building of the LGAs. Regarding the key elements to enabling capacity building of UNDP (1991) and the capacity building activities to climate change adaptation of UNFCCC (2009), the policies on capacity building should involve strengthening the capacity of people to apply appropriate technological options for climate change adaptation and to manage an effective adaptation system. Indeed, possible aspects of the policies in capacity building would be implemented towards people, technology, and management. In the final step of developing the model, relevant variables that will enable the capacity of the LGA's would be drawn to guide policy to respond appropriately. The process of developing the conceptual model of capacity building for the LGAs is shown in Figure 3.4.

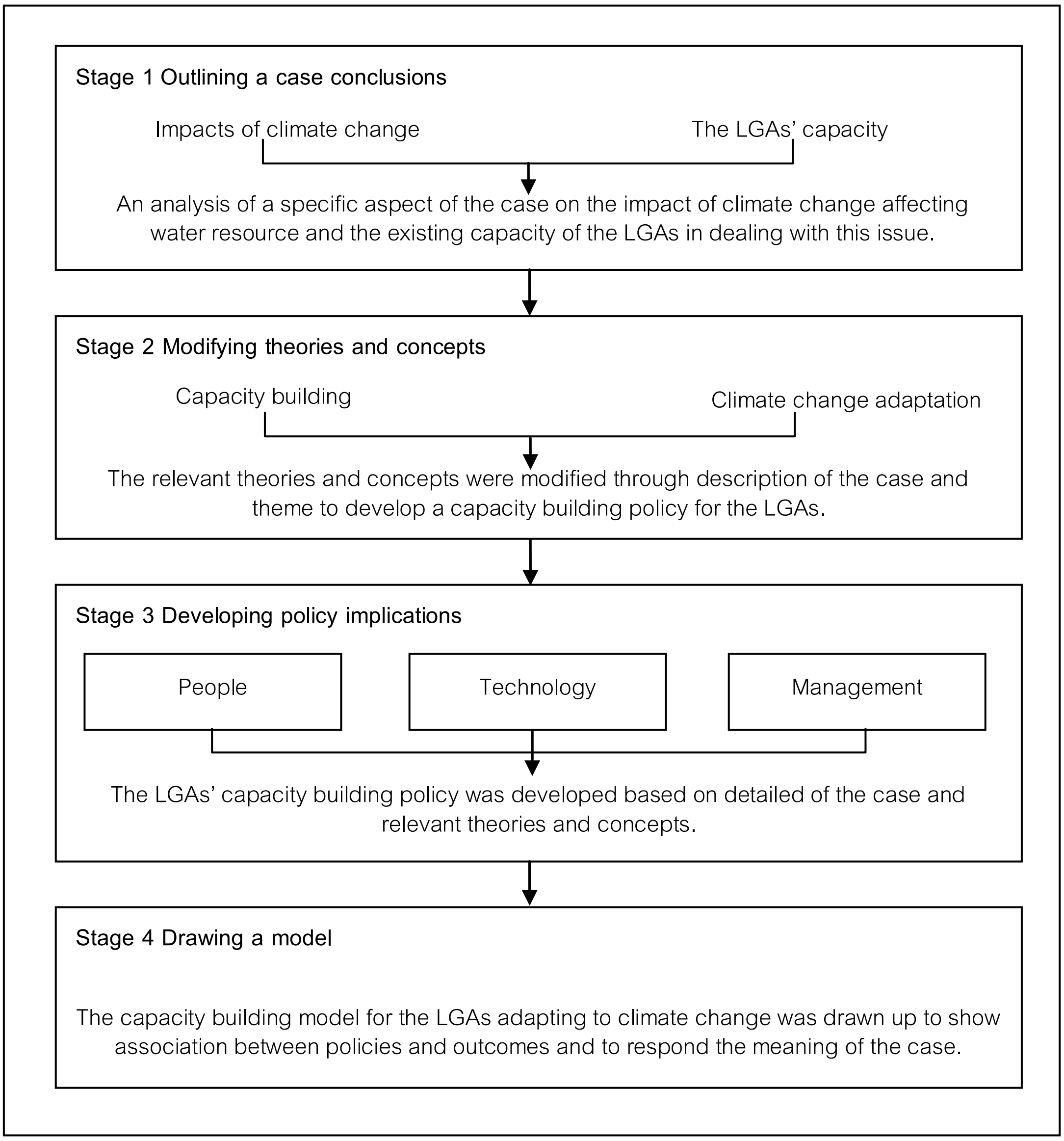

Figure 3.4 The process of developing a capacity building model.

CHAPTER IV

RESULTS AND DISCUSSIONS

4.1 Koh Chang and its climate

Koh Chang is located in Trat Province, the eastern region of Thailand, with a total area of 650 square kilometers. Most of the middle land area are covered by mountains of the height varies between 100 and more than 700 meters above mean sea level (Figure 4.1). The highest peak is Khao Yai on Koh Chang Tai Subdistrict with its height 743 meters. The areas with a slope more than 100 meters are more than 70% of the total area, while the plain areas with a slope lower than 100 meters are less than 30% of the total area, respectively. The geological structure of Koh Chang is igneous rocks in Tertiary period, sedimentary and metamorphic rocks. While the Subdistrict Municipality of Koh Chang has high mountains continuously laid into two lines. One lies from the north to the east with the highest peak at Kao Chom Prasat Nueng (661 meters). Another lies from the north to the west of Khao Chom Prasat Song (626 meters). Those two mountain lines cause the small coastal plain in ravine and Klong Son Bay. The west and east coast of Koh Chang are jagged shore. The west coast has beautiful beaches while most of east coast areas are rocky beaches. The famous beaches in the west coast are Sai Khao Beach (or White Sand Beach), Klong Praw Beach, and Kai Bae Beach. The southern area of Koh Chang is in the boundary of Koh Chang Tai Subdistrict comprising several bays of high cliffs that are continuously set along the seashore. The most famous bays in this area are Bang Bao Bay, Salak Petch Bay, and Salak Kok Bay. Such areas consist of mangrove forests and local fishermen villages (Department of National Parks, Wildlife and Plant Conservation [DNP], 2004).

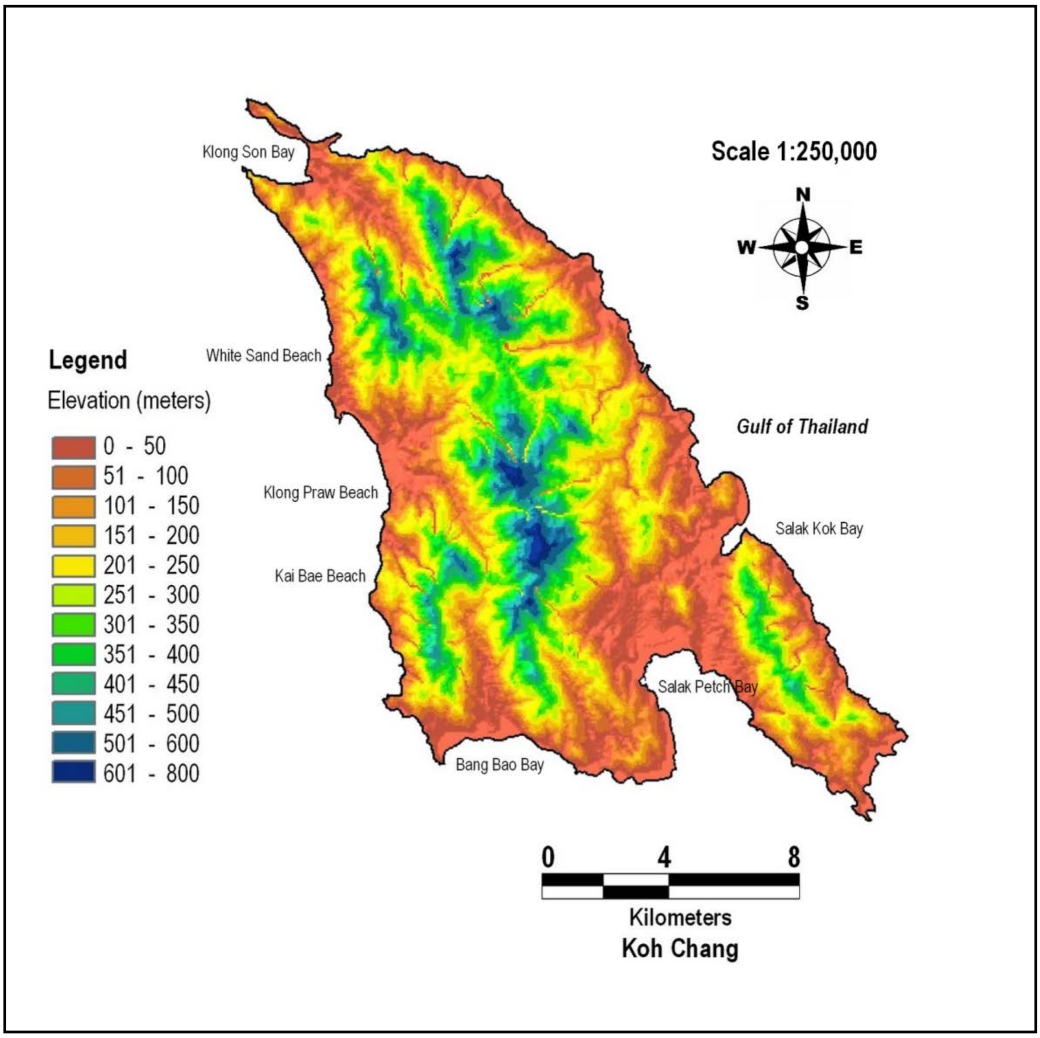

Figure 4.1 Topographical map of Koh Chang

Source: Trat Office of Public Works and Town & Country Planning, 2009

Koh Chang lies in the tropical area which is dominantly influenced by the southwest and northeast monsoons, leading to two contrasting seasons, which are the wet and dry seasons. The wet season often starts from mid-May to mid-October as a result of influence of the southwest monsoon causing a lot of rain (Figure 4.2). During this period, maximum, mean, and minimum temperatures are in range of 30.4-32.4°C, 27.1-28.4°C, and 23.3-24.5°C, respectively (Figure 4.3) with the relative humidity being between 82.89% and 84.41% (Figure 4.4). For the dry season, it can be divided into two periods of the summer and winter. The summer often starts from mid-February to mid-May. During this period, the weather is generally dry and warm with average mean temperature between 22.6 and 33.0°C (Figure 4.3). While the relative humidity (77.03 - 82.89%) is lower than that during the wet season (Figure 4.4). From mid-October to mid-February, the island has under influence of the northeast monsoon associated with the intensification of Siberian High (Wongsaming and Exell, 2011; Sooktawee et al., 2012). The weather during this period is cold, dry air and has generally lower mean temperature ranging from 21.4 to 31.9 °C (Figure 4.3) with comparable level of relative humidity (68.77 - 84.41%) (Figure 4.4).

During 1970-2009, Koh Chang has annual rainfall amounts of, on average, 4,798 mm. Most of the annual rainfall amounts (89.1%) occur during May to October, and the rainfall peak takes place in August which an amount of about 1,026 mm. whereas rainfall amount during November-February is lower than 100 mm. (Table 4.1).

Table 4.1 Long term means of annual rainfall amounts averaged during 1970-2009 at the Klong Yai Weather Station.

Month	Average annual rainfall (mm)
Jan	38.69
Feb	83.11
Mar	118.58
Apr	179.30
May	408.98
Jun	862.14
Jul	942.69
Aug	1,026.18
Sep	682.37
Oct	352.87
Nov	78.93
Dec	23.77
Total	4,797.61
Rainy season (May - October)	4,275.23
Dry season (November - April)	522.38

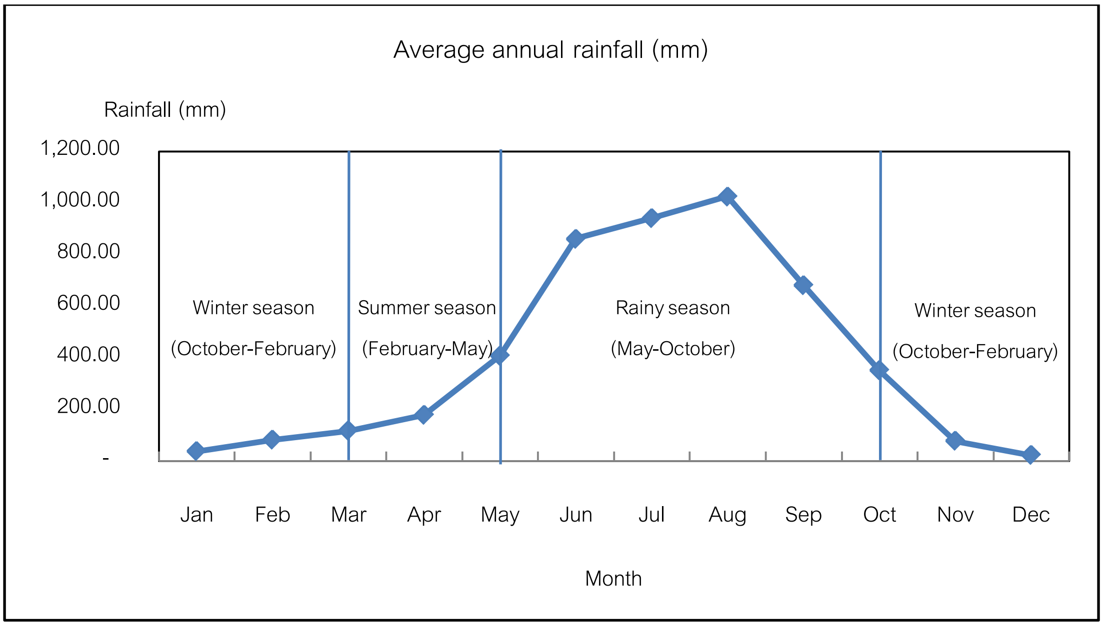

Figure 4.2 Average annual rainfall (mm) during 1970-2009 at the Klong Yai Weather Station.

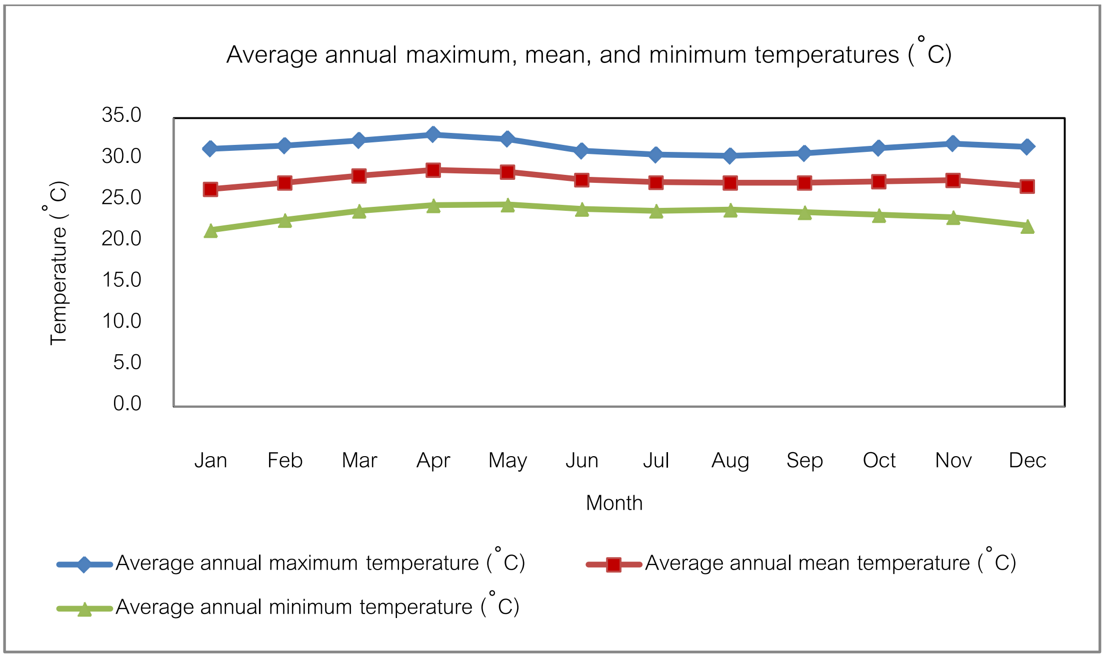

Figure 4.3 Average annual maximum, mean, and minimum temperatures (°C) during 1970-2009 at the Klong Yai Weather Station.

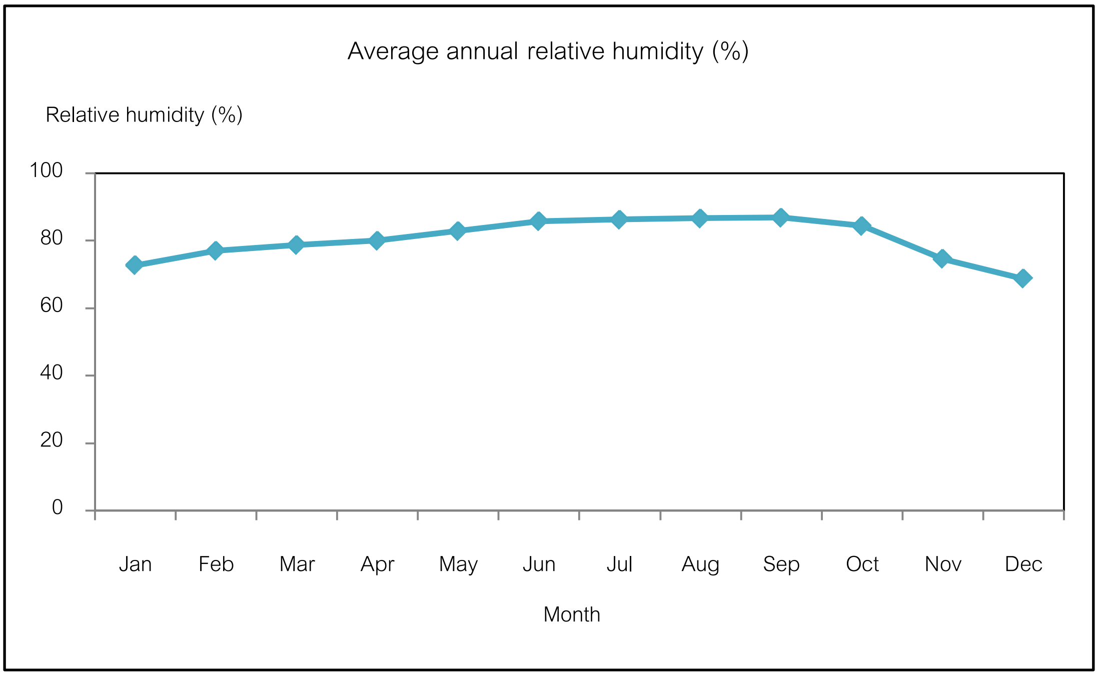

Figure 4.4 Average annual relative humidity (%) during 1970-2009 at the Klong Yai Weather Station.

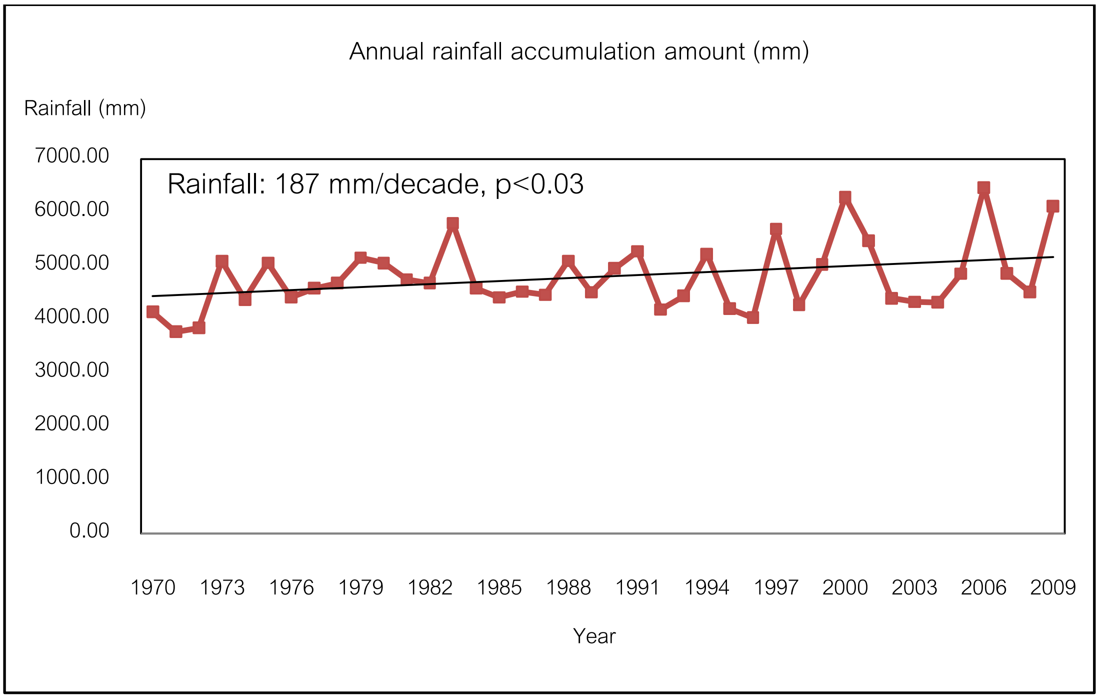

Figure 4.5 Trend of annual rainfall accumulation amount during 1970 - 2009 at the Klong Yai Weather Station.

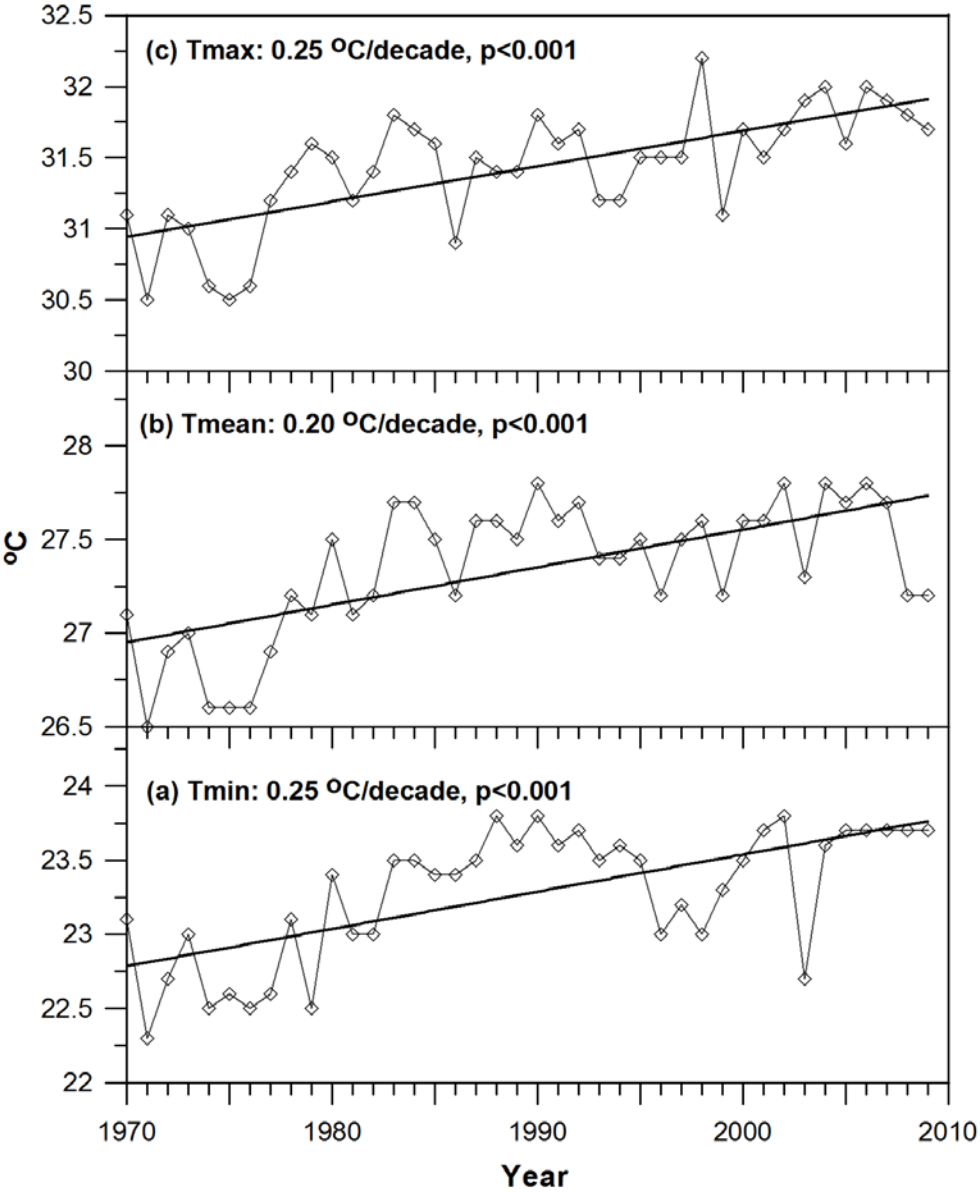

Figure 4.6 Trend of average annual maximum, mean, minimum temperatures during 1970- 2009 at the Klong Yai Weather Station.

On the basis of the results of climate data analysis, there has been evidence of significant changes in rainfall and temperature indices in the recent decades (1970-2009). A trend of average annual rainfall showed an increasing in amount of rainfall over past four decade (Figure 4.5). It also has increased in the intensity of rainfall during wet period (Figure 4.2). This change is also consistent with the observed changed in rainfall along Thailand's coastal zones by Limsakul et al. (2010).

In accordance with the observed trends in temperature in Thailand by Limjirakan and Limsakul (2012), the study revealed that Koh Chang has indeed experienced significant warming over the last four decades (Figure 4.6). Changes in these extreme weather events were further discussed in section 4.7.1.

4.2 Local governmental agencies on Koh Chang

4.2.1 Organizational structure

Koh Chang District was a small district separated from Laem Ngop District, Trat province in 1994 and became a district on September 8, 2007 (DOPA, 2009a). Currently, the district consists of two Subdistricts namely Koh Chang and Koh Chang Tai.

The districts used to manage by two local governmental organizations namely Subdistrict Administrative Organization of Koh Chang (SAO Koh Chang) and Subdistrict Administration Organization of Koh Chang Tai (SAO Koh Chang Tai). In 2008, Koh Chang Subdistrict was enhanced to be a Subdistrict Municipality.

Koh Chang Subdistrict is located on the north of the island. There have a lot of high mountains locating from east to west. There are four villages in the eastern and the western coasts, namely Ban Klong Nonsri, Ban Dan Mai, Ban Klong Son, and Ban Klong Praw, respectively.

Koh Chang Tai Subdistrict locates in the south of the island and consists of five villages, namely Ban Bang Bao, Ban Jek Bae, Ban Salak Petch, Ban Salak Petch Nuea, and Ban Salak Kok.

4.2.2 Responsibilities, roles, and management regime

The Subdistrict Municipality of Koh Chang and the Subdistrict Administration Organization of Koh Chang Tai are typical types of Thailand's local administration. Their responsibilities and authorities are under the Municipality Act, and

Tambol Council-Tambol Administrative Act. Although the municipality and the Subdistrict are under a different Act, however, responsibilities among them can be summarized as stated in Tambol Council and Tambol Administration Organization Act., 2003 including;

(1) to build and maintain parks, public building and supply water to the community adequately;
(2) to provide and clean waterway, public streets or sidewalks and other public areas including removal of solid waste and garbage;
(3) to preserve and maintain natural resources and environment;
(4) to prevent and protect disease;
(5) to provide fire extinguishers;
(6) to provide education and training for people;
(7) to promote public occupations;
(8) to promote development of women, children, youth, elderly, and disabled;
(9) to maintain local arts, local tradition, local knowledge, and local culture; and others.

4.3 Population structure

4.3.1 Demography

In 2009, the numbers of populations on the island were 7,033 with households of 4,304. There were 3,625 of males and 3,408 of females as shown in Table 4.2 (Department of Provincial Administration [DOPA], 2009b). Regarding these data, the study found that the number of population increased 52.9% between the year 2000 and 2009 at an average 4.7% per year, excluding a number of migrated workers of about 11,000 (Koh Chang District Office, 2009).

Table 4.2 A number of population on Koh Chang district during 2000-2009.

Year	Male (persons)	Female (persons)	Total (persons)	Household (units)
2000	2,333	2,268	4,601	1,484
2001	2,361	2,268	4,629	1,626
2002	2,438	2,351	4,838	1,895
2003	2,538	2,432	4,970	2,177
2004	2,752	2,604	5,356	2,547
2005	3,067	2,848	5,915	3,036
2006	3,276	3,032	6,308	3,504
2007	3,399	3,169	6,568	3,717
2008	3,529	3,325	6,854	3,940
2009	3,625	3,408	7,033	4,304

Source: Department of Provincial Administration (DOPA), 2009(b).

4.3.2 Occupation

According to data from Agricultural Office of Koh Chang District (2007), the main occupations on the island are fishery and agriculture. Fishery is a small-scale. The study found that local people usually used small fishing gears for fishery (e.g. shrimp gill net, fish gill net, and surrounding net). While agriculture area is about 11,932 rai of 1,477 famers' households. The main agricultural products generating income to the local people were durian, rambutan, mangosteen, pomelo, coconut, and rubber as shown in Table 4.3.

Table 4.3 Major agricutural production on Koh Chang district.

Number	Crops	Areas (rai)	Households (units)
1	Rubber tree	6,067	280
2	Coconut	2,453	241
3	Pomelo	1,442	153
4	Durian (Chanee)	930	180
5	Wollongong	394	394
6	Durian (Monthong)	200	94
7	Mangosteen	196	81
8	Eaglewood	115	21
9	Pineapple	85	3
10	Durian (Kadum)	50	30

Source: Koh Chang District, 2007.

The respondents noted that the career of local people has changed at present. Since tourism on Koh Chang has been developed, many local people then changed their previous occupations to tourism services particularly during an off season of agricultural product.

4.4 Water resources

Most of water on Koh Chang comes from rainfall as natural resources of waterfalls and canals that is not enough using throughout the year. Another main water source comes from groundwater and shallow wells. The island has a catchment area of 3,050 rai (Trat Office of Public Works and Town & Country Planning, 2009).

Koh Chang has an average runoff from main seven canals of 110,000,000 cubic metres (Department of Groundwater Resource [DGR], 2010). The main canals of the west of the island are Klong Praw and Klong Phu. The main canal in the north is Klong Son and in the south is Klong Salak Petch, while the main canals of the east of the island are Klong Had Sai Dang, Klong Ma Yom, and Klong Dan Mai, respectively (DGR, 2010) (Figure 4.7).

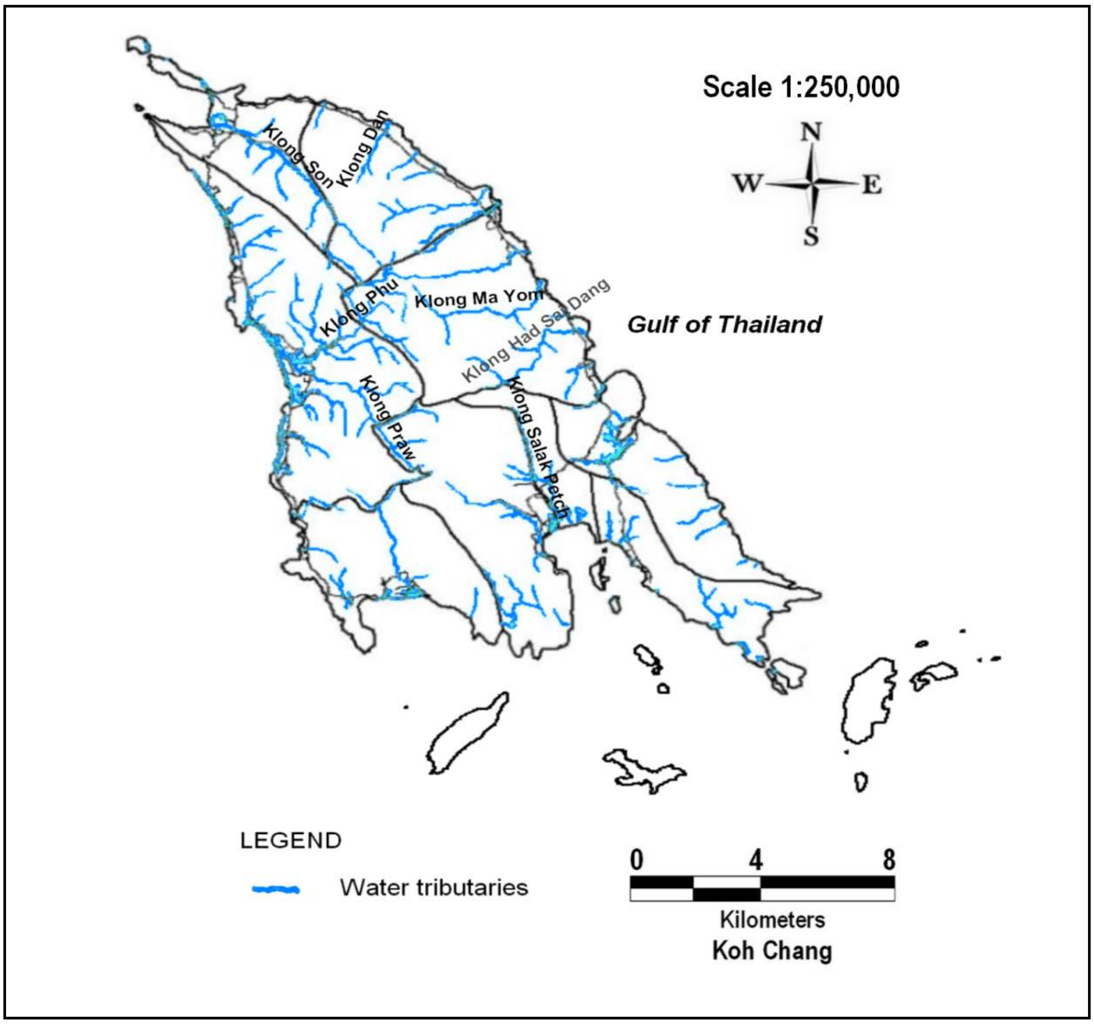

Figure 4.7 Main water tributaries of Koh Chang.

Source: Trat Office of Public Works and Town & Country Planning, 2009.

4.4.1 Water resources on Koh Chang Subdistrict

Koh Chang Subdistrict has four main waterfalls namely Klong Phu Waterfall, Klong Nonsri Waterfall, Than Ma Yom Waterfall, and Klong Dan Waterfall. Such waterfalls are abundant during May to October, but always dry during March to April. These waterfalls can serve as water resources for the agricultural land areas of about 770 rai (Pollution Control Department [PCD], 2005). Klong Phu Waterfall is in Klong Praw Village. It is a headwater of Klong Phu Canal and Klong Praw Canal. While Klong Nonsri Waterfall and Than Ma Yom Waterfall are in Klong Nonsri Village. These headwaters flow to Had Sai Dang Canal and Ma Yom Canal. Another waterfall namely Klong Dan Waterfall is a main water resource of Dan Mai Village which has three canals namely

Klong Nonsri, Klong Dan Mai, and Klong Dan Kao. While Klong Son Village has canals namely Klong Son and Klong Ka Leng which can serve as main water resources for the agricultural land areas of about 285 rai. In addition, Koh Chang Subdistrict has other water sources which have been used for multipurpose such as artesian wells, public well, and private wells (Trat Office of Public Works and Town & Country Planning, 2009).

4.4.2 Water resources on Koh Chang Tai Subdistrict

Koh Chang Tai Subdistrict has five main waterfalls namely Bang Bao Waterfall, Klong Jak Waterfall, Klong Nueng Waterfall, Kiri Petch Waterfall, and Jak Bae Waterfall which can serve as water resources for the agricultural land areas of about 320 rai. These waterfalls are abundant during May to October, but always dry during March to April. Bang Bao Waterfall and Klong Jak Waterfall are in Bang Bao Village which also has three canals namely Klong Bang Bao, Klong Kloi, and Klong Hin. While Klong Nueng Waterfall and Kiri Petch Waterfall are in Salak Petch Village, the village also has Klong Salak Petch which connects to the sea. Another waterfall namely Jak Bae Waterfall is in Jak Bae Village making a canal namely Klong Tean. In Salak Kok Village, there has two canals namely Klong Ra Kam and Klong Kao Noi. In addition, Koh Chang Tai Subdistrict also has other water sources which have been used for multipurpose such as artesian wells, public well, and private wells (Trat Office of Public Works and Town & Country Planning, 2009)

4.5 Water demand

Based on the number of local people and tourists during a last decade (2000-2009) provided by DOPA (2009b) and Department of tourism (2010), water demand on Koh Chang is estimated about 1,030,075 cubic metres per year. However, such the demand is expected to increase because the increasing of local people and tourists by 4.7% and 1.40%, respectively.

It could be recognized that the demand for water on the island would depend on tourism and its season. Normally, the demand for water is high during the dry period (November-February), but is lower during the rainy period (May-October) as clearly seen in Figure 4.9. Although Koh Chang has an average runoff up to 110,000,000 cubic metres/year, the island still has water shortage particularly during the peak period of tourism. This is due to there has no a large reservoir to reserve water from short and steep tributaries. Additionally, the lack of capacity of the LGAs in water management also makes the worse situation that need to be considered and further discussed in section 4.8.

4.5.1 Water demand for tourism

Water demand for tourism on the island can be calculated from the statistical data of the number of tourists collected by the Department of tourism during the year 2003-2010 (Table 4.4). Number of tourists to Koh Chang increased over the years 2003 to 2007 and declined since 2008 (Figure 4.8). This would be a political situation.

Table 4.4 Number of tourist in Koh Chang during 2003-2010.

Year	Thai tourist (persons)	Foreign tourist (persons)	Total (persons)
2003	210,669	35,989	246,658
2004	243,855	38,054	281,909
2005	314,669	149,108	463,777
2006	441,485	198,450	639,935
2007	431,407	249,344	680,751
2008	398,607	190,522	589,129
2009	224,897	71,347	296,244
2010	149,838	122,225	272,062

Source: Department of tourism, 2010.

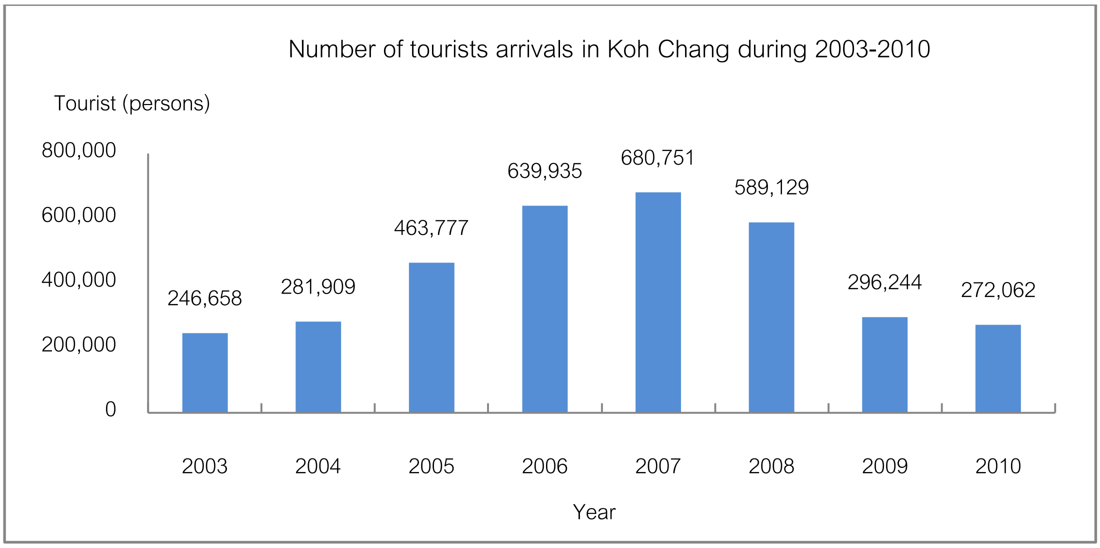

Figure 4.8 Number of tourists in Koh Chang during 2003-2010.

Source: Department of tourism, 2010.

However, the tourism on Koh Chang tends to increase as the expansion of economic and political stability forecasted by the Tourism Authority of Thailand in 2012. The report of the Tourism Authority of Thailand (TAT) mentions that the overall increasing of travelers visiting Thailand has greater potential growth. During the first six months of 2012 (between January and June), the country has a number of tourist arrivals of 9.68 million, which accounting increase of 28.13 percent from 2011. Estimated number of foreign tourists traveling to Thailand for the year 2012 is 18.39 million with the growth rate increase of about 15.4 percent.

Tourism's water demand can be estimated from average number of tourists between 2007 and 2010 (Table 4.5) and the period of staying. Data from interviews of twenty-two home-stays and resorts on Koh Chang revealed that average amount of water use was about 300 liters/person/day. Whilst average days of staying were 2.9 days for Thai tourist and 7.8 days for foreign tourist (Department of tourism, 2010). This reflected that average water demand for tourism, between 2007 and 2010, was about 613,449 cubic metres per year (Table 4.6).

Table 4.5 Average number of tourists in Koh Chang during 2007-2010.

Year	Number of tourists (2007-2010) (persons)				
	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Total
2007	179,870	180,855	119,279	150,510	630,514
2008	165,625	148,528	93,923	164,037	572,113
2009	78,329	107,602	58,692	51,622	296,245
2010	87,168	53,820	40,552	90,522	272,062
Average	127,748	122,701	78,112	114,173	442,734

Source: Department of tourism, 2010.

Table 4.6 Water demand for tourists in Koh Chang during 2007-2010.

	Water demand (cubic metres)				
Year	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Total
2007	254,661	228,695	174,450	225,588	883,394
2008	261,898	198,055	137,248	194,220	791,421
2009	86,467	118,355	80,805	76,988	362,615
2010	172,996	61,591	52,679	129,099	416,365
Average	194,006	151,674	111,296	156,474	613,449

Source: Department of tourism, 2010.

4.5.2 Water demand for local people

Water demand for local people in Koh Chang can be calculated from the statistical data of population in Koh Chang collected by DOPA (2009(b)). Number of population increased over ten years (2000-2009) with a demand of water about 200 liter/person/day (DPT, 2006). This leads to an average annual water demand of about 416,626 cubic metres/year (Table 4.7).

Table 4.7 Annual demand for water on Koh Chang (cubic metres).

Year	Population (persons)	Annual demand for water (cubic metres/ year)
2000	4,601	335,873
2001	4,629	337,917
2002	4,838	353,174
2003	4,970	362,810
2004	5,356	390,988
2005	5,915	431,795
2006	6,308	460,484
2007	6,568	479,464
2008	6,854	500,342
2009	7,033	513,409
Average	5,707	416,626

Source: DOPA, 2009(b).

As mentioned in section 4.5, water demand of Koh Chang water demand was about 1,030,075 cubic meters/year. This included water demand for tourists of about 613,449 cubic metres/year and water demand for local people of about 416,626 cubic metres/ year. Actually, an annual runoff of Koh Chang is about 110,000,000 cubic metres/ year (DGR, 2010). This number reflects to the lack of appropriate water management, as well as, currently the island has no a large reservoir to reserve water from short tributaries. This leads to a shortage of water in a few months in the island.

In addition, a water shortage in certain months of the year is caused by the time period of tourism season that always peaks during the dry season between November and February. The mismatch between water demand for tourism and rainfall period are shown in Figure 4.9 and Figure 4.10.

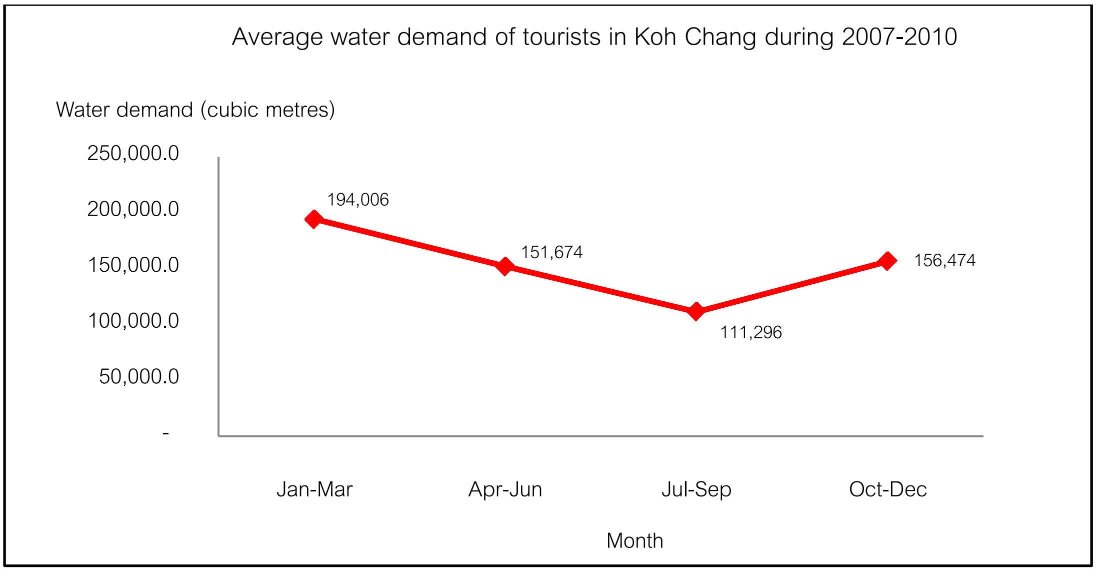

Figure 4.9 Average water demand for tourists in Koh Chang during 2007-2010 (cubic metres).

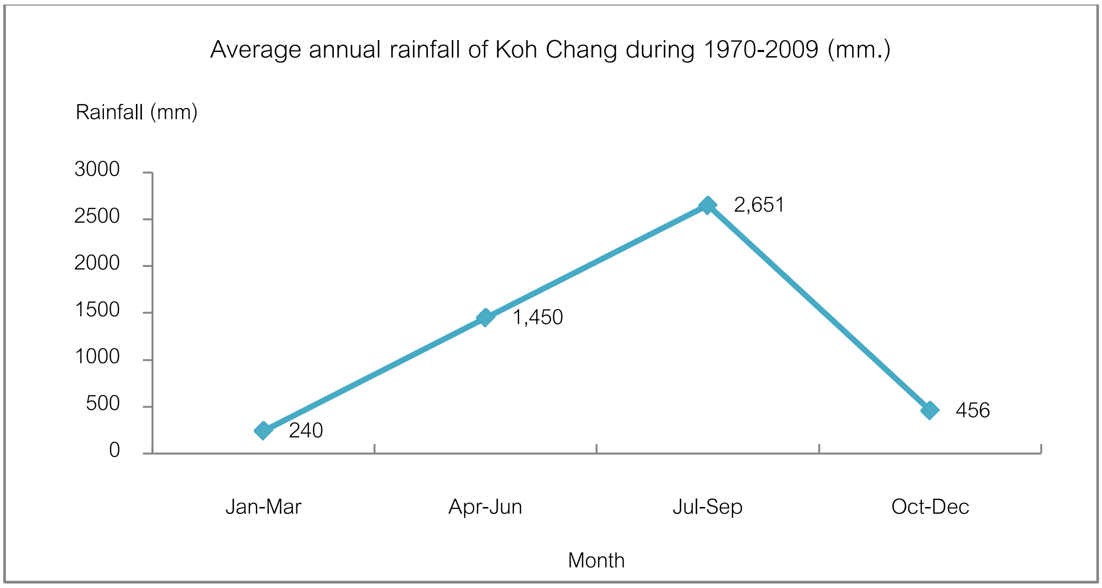

Figure 4.10 Average annual rainfall of Koh Chang during 1970-2009 (mm.).

4.6 Tourism development on Koh Chang

The information obtained from the District Officer of Koh Chang found that the entire island has been reserved as the fourth Thailand Marine National Park by the Department of Forestry since 1982. Due to the richness of natural resources both inland and sea, Koh Chang has been dubbed as the Eastern Andaman and has been promoted as the most beautiful beach in the Gulf of Thailand. There have many natural attractive tourist destinations where tourist can enjoy their vacation not only on the island such as beach, mangrove forest, waterfall, and fishing communities, but also gain experience the beauty of under sea water by diving to see corals reef, and marine fish. In addition, the national tourism policies and plans have promoted Koh Chang as one of the most tourist destination of the world.

The development projects on Koh Chang was set up into three phases. During the first phase, Koh Chang was only a port where local people called Than Mayom, visitors were allowed to set up and stay overnight in their tents within the certain areas provided. The construction of local road between the north coast and the south east coast areas was made. As a result, tourism development projects on Koh Chang was spreaded out to the east coast of the island. The second phase of tourism development project was made during 1986-1997, when more piers and roads were built into the west coast especially in White Sand Beach area, Klong Praw Beach area, and Kai Bae Beach area.

Despite a number of development projects, it found that Koh Chang was not ready to welcome tourists during the rainy season due to the carrying capacity of ships and narrow roads along the cliff between the north coast and the west coast. The development of basic infrastructure took place since Koh Chang became a district in 1994. This made access roads to natural tourism destinations on Koh Chang including Klong Phu Waterfall, Klong Nonsri Waterfall, Kiri Phet Waterfall, as well as several beaches along the East coast. The current phase of tourism development project has started since 1997 with an increasing number of the ferry terminals.

In 2003, the Thai government highlighted the importance of sustainable development on Koh Chang and established the public organization namely the Designated Areas for Sustainable Tourism Administration (DASTA) to set policies and development plans for sustainable tourism development on the island (NESDB, 2003).

Afterwards, the increasing of development projects in the area has continuously grown. More building and infrastructures have been put in many places. This makes Koh Chang become more recognizing to foreign visitors as the most beautiful island in the Eastern part of Thailand.

4.7 Impacts of climate change on the tourism sector

As discussed in the survey methodology (Chapter 3), respondents were interviewed and discussed on problems caused by climate change regarding water shortage affecting tourism businesses, and the capacity of local governmental agencies to manage with such problems as well as their possible actions to be taken.

Regarding questionnaire # 2.1 related to types of water resources available in the communities and impact of climate change on those water resources. Respondents indicated that the tourism businesses were faced with climate change impacts as follows:

- Changes in rainfall and temperature pattern that reduces availability of water supply
- Intrusion of salt water affecting ground water quality
- The impact of extreme weather events on water storage

The findings were analyzed and discussed in the following section.

4.7.1 Changes in rainfall and temperature patterns reduce availability of water supply

Two main water resources used on Koh Chang come from surface water and ground water. All respondents indicated that the most important source of water was surface water that came from rainfall which used to be prevalent throughout the year. However, it seems to be that rainfall has significantly changed in the study area. Based on the discussions provided by respondents, 62.5% of them revealed that rainfall patterns of Koh Chang have changed, particular in 2006-2008 that was a small rain during the rainy season and became more rain in December 2009 and January 2010. Respondents (54.2%) indicated that the dry season was prolonged.

To understand climate situation on Koh Chang, rainfall and temperatures data obtained from Limjirakan et al. (2010), which had originally been collected at the Klong Yai Weather Station by Thai Meteorological Department were analyzed. These data revealed that over the last four decades (1970-2009), Koh Chang has experienced changing in climate particularly rainfall and temperature (Table 4.8).

Table 4.8 The Klong Yai extreme indices during 1970-2009.

Indices groups	Temperature extreme indices	Slope	p-value	Rainfall extreme indices	Slope	p-value
1) Percentile-based indices	TN10p (day/decade)	***-2.78***	***<0.01***	R95p (mm/decade)	***148.90***	***<0.03***
	TN90p (day/decade)	***3.12***	***<0.00***	R99p (mm/decade)	94.80	<0.06
	TX10p (day/decade)	***-2.43***	***<0.00***			
	TX90p (day/decade)	***4.29***	***<0.00***			
2) Absolute indices	-	-	-	RX1day (mm/decade)	***27.52***	***<0.02***
				RX5day (mm/decade)	***75.41***	***<0.01***
3) Threshold indices	-	-	-	R10 (day/decade)	1.38	<0.32
				R20 (day/decade)	1.34	<0.21
				R50 (day/decade)	1.42	<0.08
4) Duration indices	CSDI (day/decade)	0.08	<0.97	CDD (day/decade)	0.68	<0.76
	WSDI (day/decade)	***3.95***	***<0.01***	CWD (day/decade)	***-2.78***	***<0.01***
5) Other indices	Tmin (°C/decade)	***0.37***	***<0.00***	SDII (mm/day/decade)	0.78	<0.14
	Tmean (°C/decade)	***0.35***	***<0.00***	PRCPTOT(mm/decade)	***185.7***	***<0.03***
	Tmax (°C/decade)	***0.41***	***<0.00***	T12 (day/decade)	1.24	<0.45
	TXX (°C/decade)	0.18	<0.09			
	TNX (°C/decade)	***0.22***	***<0.01***			
	TXN (°C/decade)	***0.13***	***<0.02***			
	TNN (°C/decade)	***0.54***	***<0.00***			
	DTR (°C/decade)	0.00	<1.00			

Table 4.8 showed the extreme climate indices at the Klong Yai Weather Station located near Koh Chang between 1970 and 2009. The extreme indices can be divided into five different categories as mentioned in section 3.5.1 and described as follows:

1) Percentile based indices including the annual number of warm nights and days (TN90p and TX90p) have significantly increased by 3.12 days/decade and

4.29 days/decade, respectively (Figure 4.11 and 4.12). Conversely, two trends of indices including the annual number of cool night and days (TN10p and TX10p) have considerable decreased by -2.78 days/decade and -2.43 days/decade, correspondingly (Figure 4.13 and 4.14). These results revealed significant decreases in the annual number of cool days and nights, but increases in the annual number of warm days and nights. Given the continued change in rainfall, two indices such as the annual total rainfall above 95th percentile (R95p) and 99th percentile (R99p) presented the larger amounts in wet climate on the island. Both indices indicated significant increasing by 148.90 mm/decade and 94.8 mm/decade (Figure 4.15 and 4.16).

2) Absolute indices including the monthly maximum 1-day (RX1day) and consecutive five-day rainfall amount (RX5day) can be found in both significantly increased by 27.52 mm/decade and 75.41 mm/decade, correspondingly (Figure 4.17 and 4.18).

3) Threshold indices such as the number of heavy rainfall days above 10 mm (R10), 20 mm (R20), and 50 mm (R50) showed the observed increasing in days in threshold amount rainfall. R10, R20, and R50 have increased by 1.38 days/decade, 1.34 days/decade, and 1.42 days/decade, but there have low significant with p-value >0.05 (Figure 4.19, 4.20, and 4.21).

4) Duration indices such as the number of days in warm spells which is defined as at least 6 days in row of temperature exceeding 90th percentile (WSDI) has significantly increased by 3.95 days/ decade (Figure 4.22). While the number of days in cold spells at least same duration days at 10th percentile (CSDI) has weaker change and less significantly increased by 0.08 day/decade (Figure 4.23). It is reasonable to mention that Koh Chang has increased in the number of warm spells duration. This also associated with warming temperature as previously presented in percentile based temperature indices. In addition, Koh Chang has experienced changing in rainfall patterns. While consecutive wet days (CWD) has significantly decreased by -2.78 days/ decade (Figure 4.24). But, there has no significant increased in a trend in consecutive dry day (CDD) by 0.68 days/decades (p-value>0.05) (Figure 4.25).

5) Other extreme climate indices such as TXN, TNX, and TNN showed some significant increases in temperature by 0.13 °C/ decade, 0.22 °C/ decade, and 0.54 °C/ decade, respectively (Figure 4.26, 4.27, and 4.28). These indices indicated an increasing in monthly minimum and maximum temperature on Koh Chang. While, average annual maximum, mean, and minimum temperatures have significantly increased by 0.41, 0.35, and 0.37 °C/decade, respectively (Figure 4.34, 4.35, and 4.36). In addition, some indices such as TXX is discernible increased, but low significant by 0.18°C/ decade (p-value>0.05), while, DTR, which has no linear trend change, showed no difference between monthly maximum value of daily maximum (TX) and minimum (TN) temperature that caused by coordinate increasing in temperature level (Figure 4.29 and 4.30). Given more clearly changes of climate change on Koh Chang, two trends of rainfall indices such as annual total rainfall above 1 mm (PRCPTOT) and number of wet days (T12) presented significantly increased by 185.7 mm/decade and 1.24 day/decade, respectively (Figure 4.31 and 4.33), while, annual total rainfall divided by the number of wet days defined when rainfall above 1 mm in the year (SDII) has also increased (Figure 4.32).

With respect to above discussion, it could be concluded that Koh Chang has experienced with significant increases in amount annual rainfall (R95p and PRCPTOT) which was mostly in the wet period particularly during May to October, equivalent to 89.1% of the total rainfall for year (Table 4.1). The high intense presented through RX1day and RX5day could be demonstrated risk of flash flood as a result of consecutive heavy rains that may destroy and reduce ability of water storages on the island. In addition, such rainfall was normally distributed relatively low and less than 100 mm. in the dry period especially during November to February. Accordingly, warming temperature (TNX, TXN, TNN, Tmax, Tmean, and Tmin) refer to changes in hydrological system which could affect to water resources on the island by increasing in evapotranspiration that create longer and more severe droughts during the dry period as specified by IPCC (1998).

To understand the situation of water and its vulnerability on Koh Chang, the next section provided in-depth discussion on unconformity of water demand which was influenced by tourism seasons and water supply which was mainly depended on rainfall.

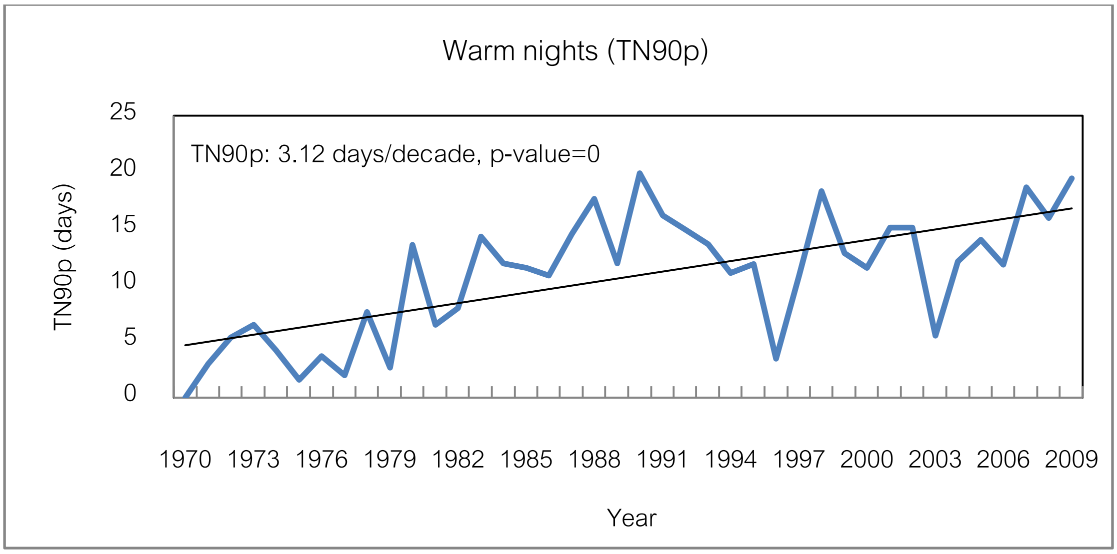

Figure 4.11 Trend of warm nights (TN90p) during 1970-2009 at the Klong Yai Weather Station.

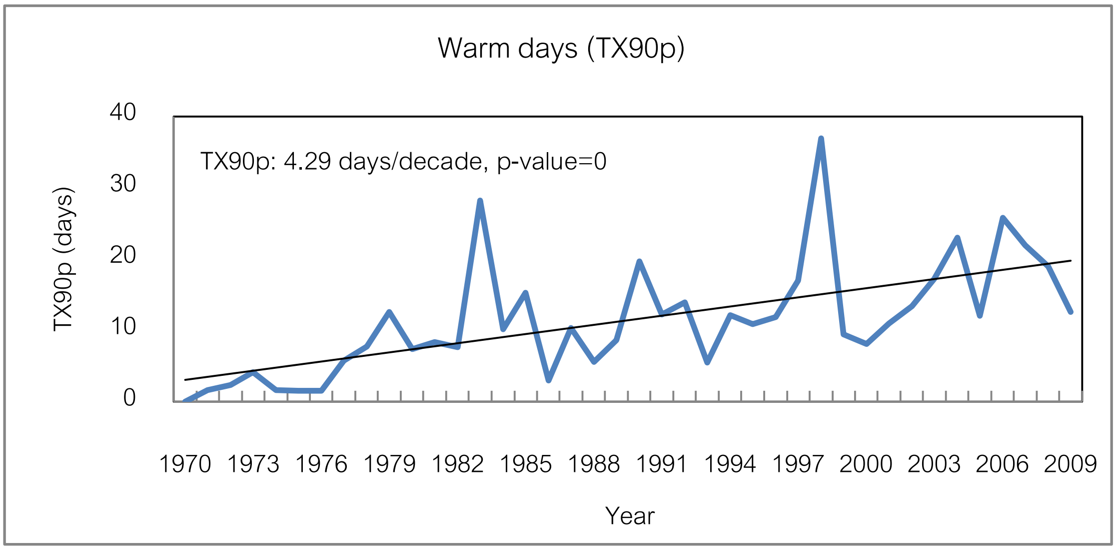

Figure 4.12 Trend of warm days (TX90p) during 1970-2009 at the Klong Yai Weather Station.

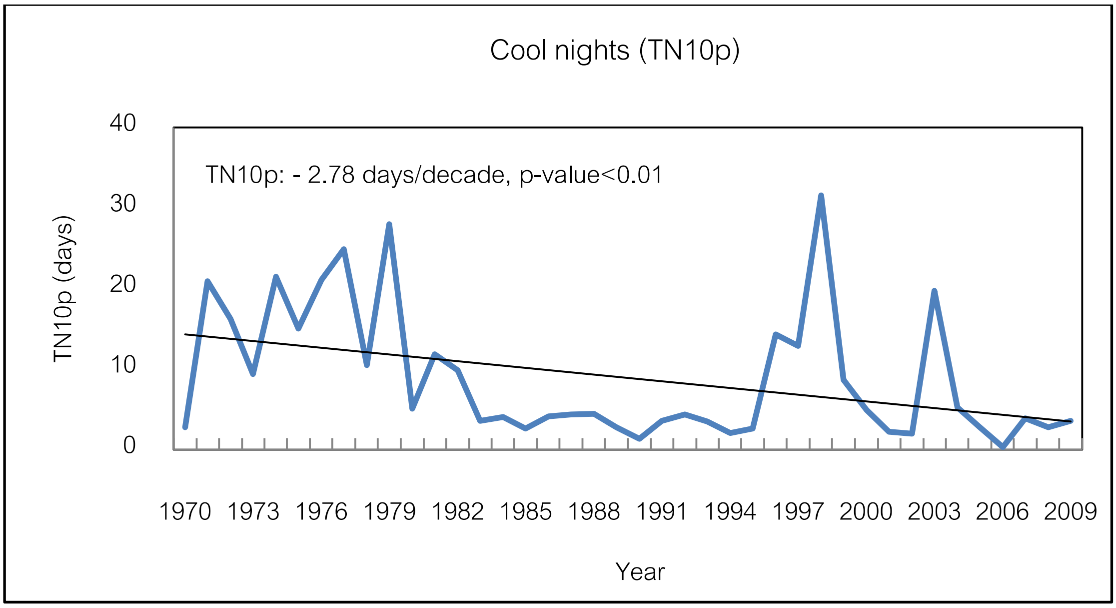

Figure 4.13 Trend of cool nights (TN10p) during 1970-2009 at the Klong Yai Weather Station.

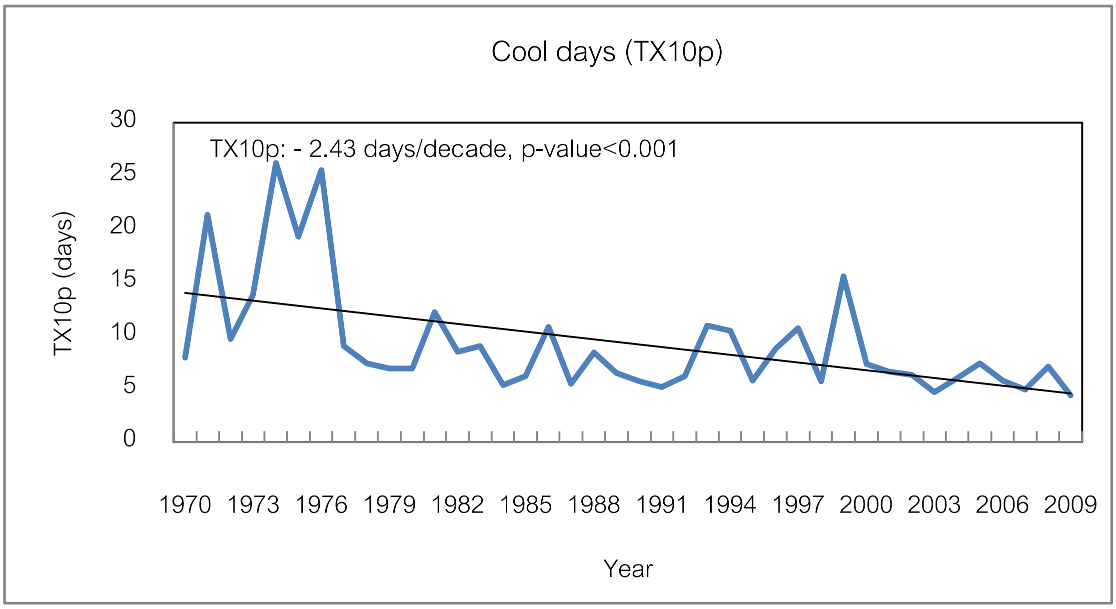

Figure 4.14 Trend of cool days (TX10p) during 1970-2009 at the Klong Yai Weather Station.

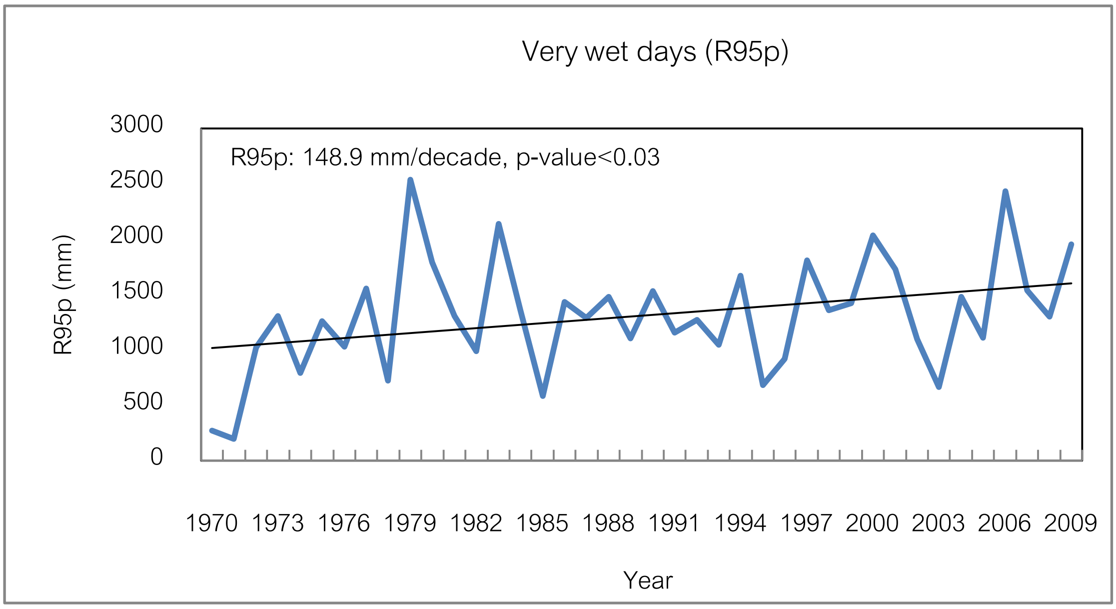

Figure 4.15 Trend of very wet days (R95p) during 1970-2009 at the Klong Yai Weather Station.

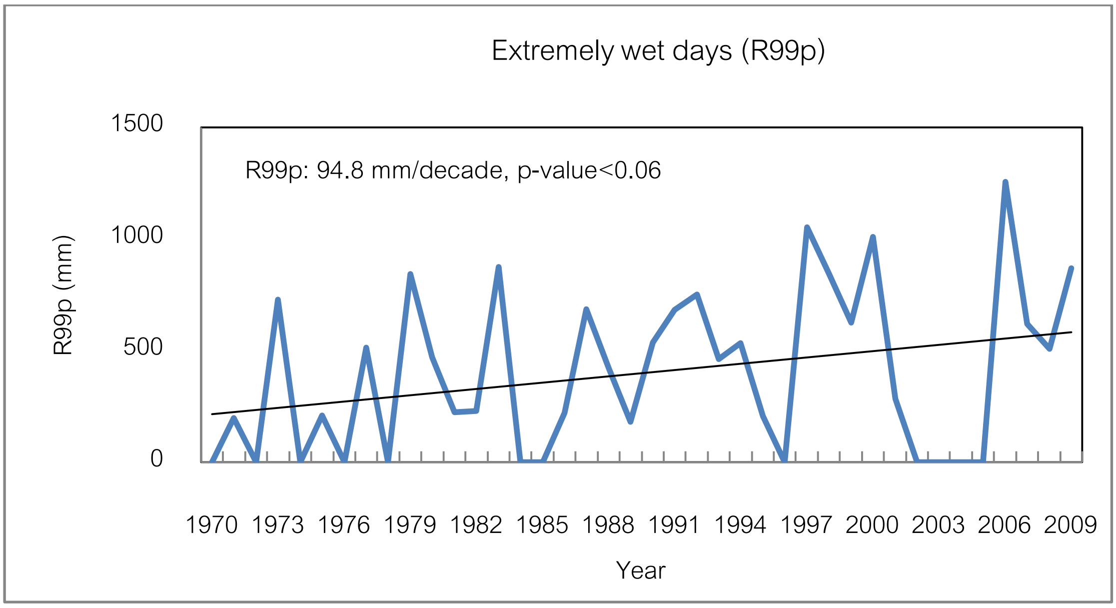

Figure 4.16 Trend of extremely wet days (R99p) during 1970-2009 at the Klong Yai Weather Station.

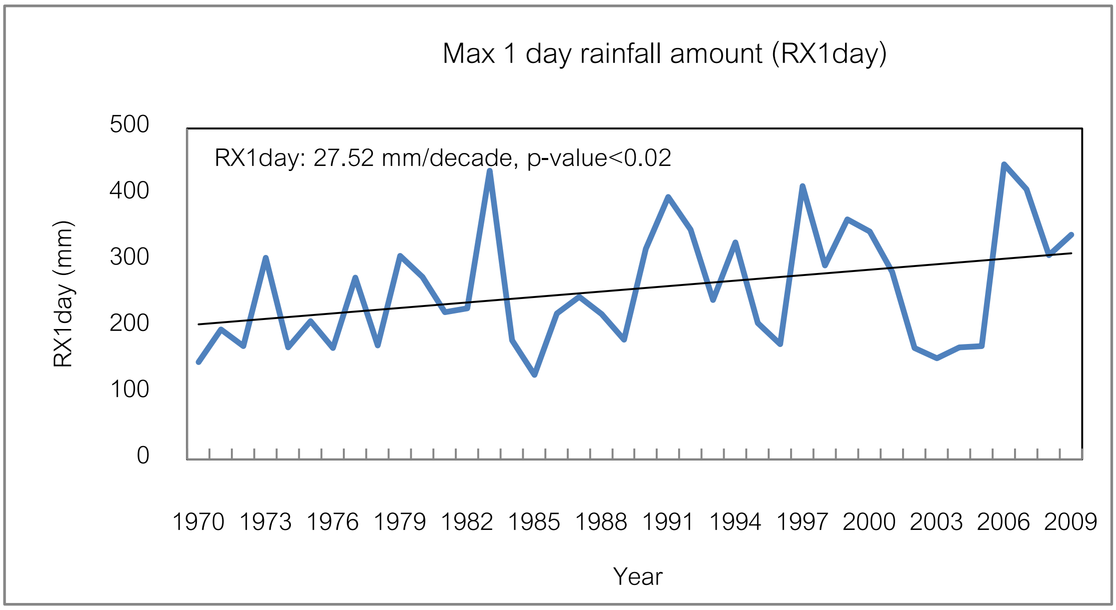

Figure 4.17 Trend of max-1 day rainfall amount (RX1day) during 1970-2009 at the Klong Yai Weather Station.

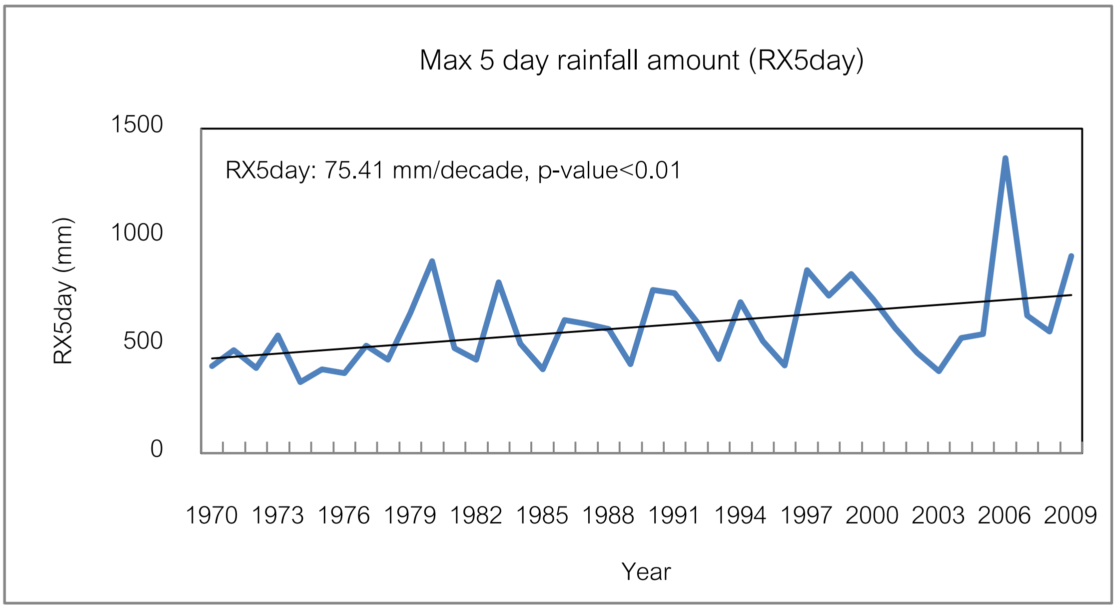

Figure 4.18 Trend of max-5 day rainfall amount (RX5day) during 1970-2009 at the Klong Yai Weather Station.

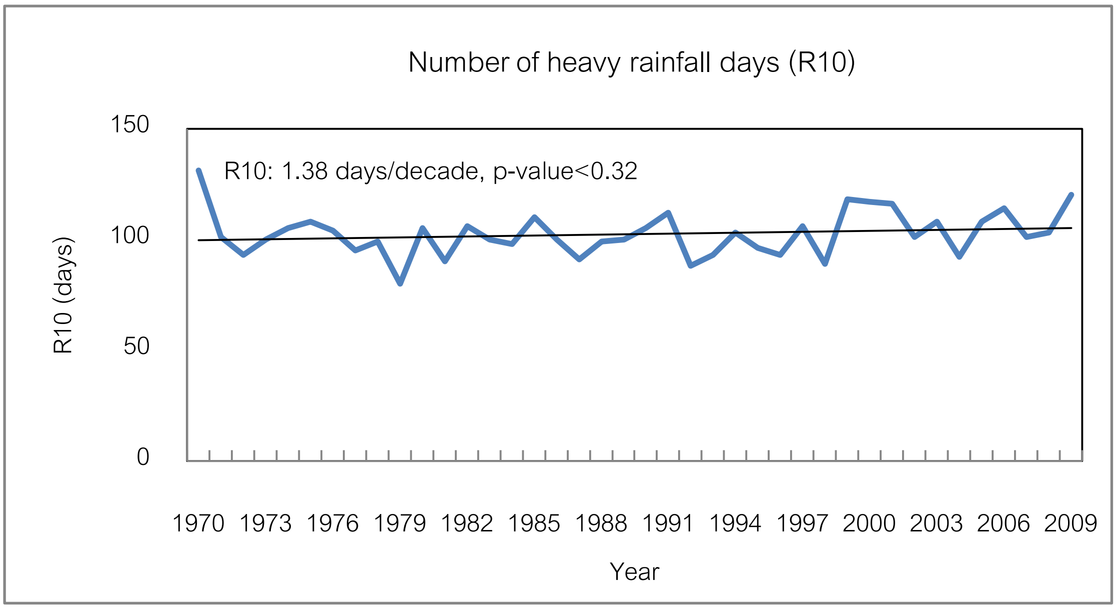

Figure 4.19 Trend of number of heavy rainfall days (R10) during 1970-2009 at the Klong Yai Weather Station.

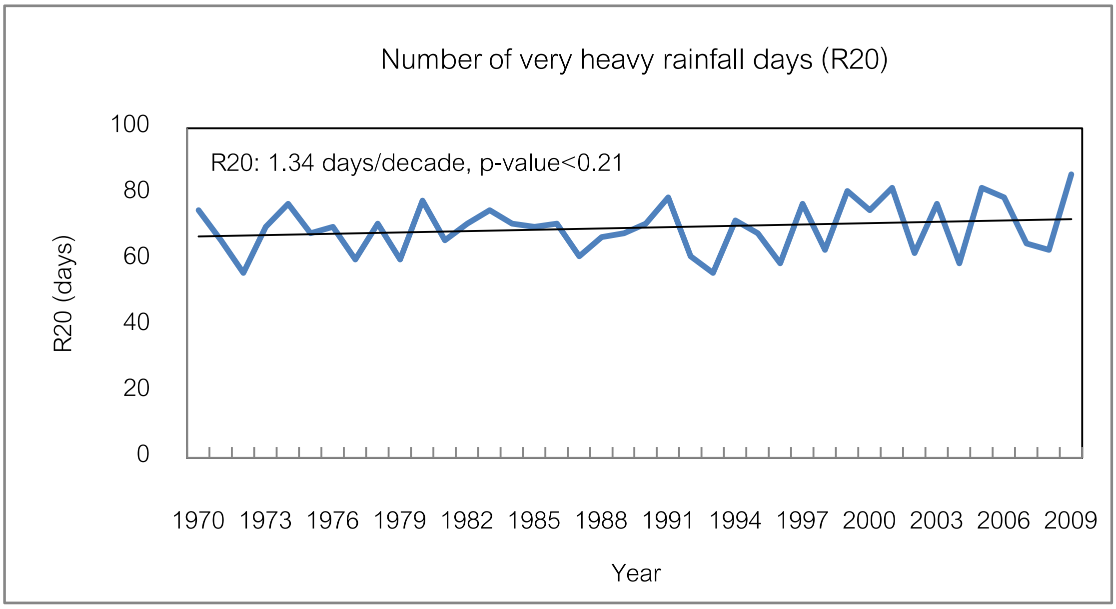

Figure 4.20 Trend of number of very heavy rainfall days (R20) during 1970-2009 at the Klong Yai Weather Station.

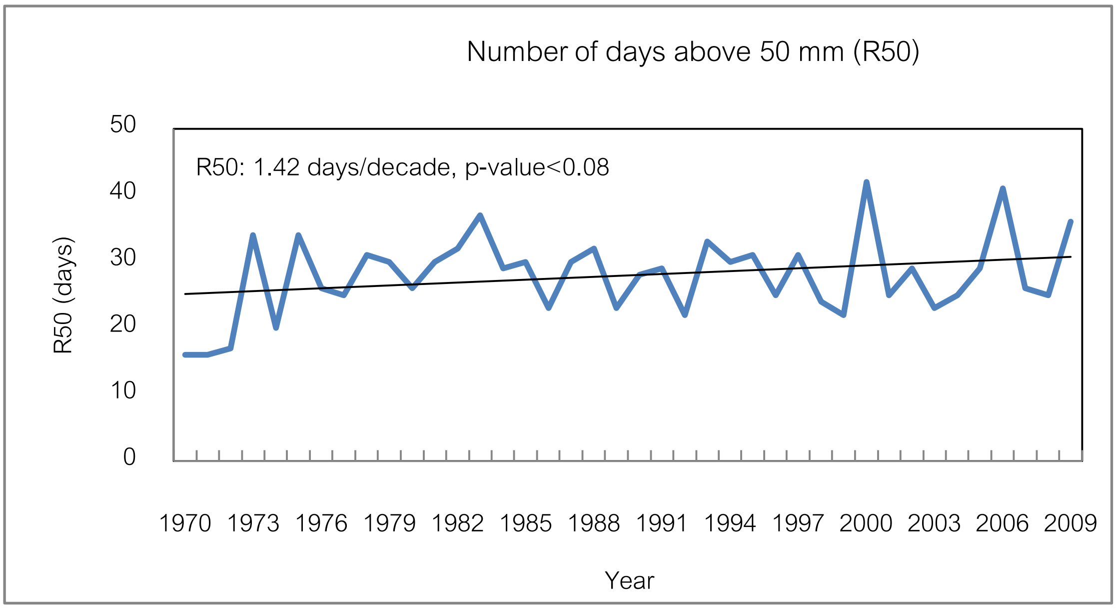

Figure 4.21 Trend of number of days above 50 mm (R50) during 1970-2009 at the Klong Yai Weather Station.

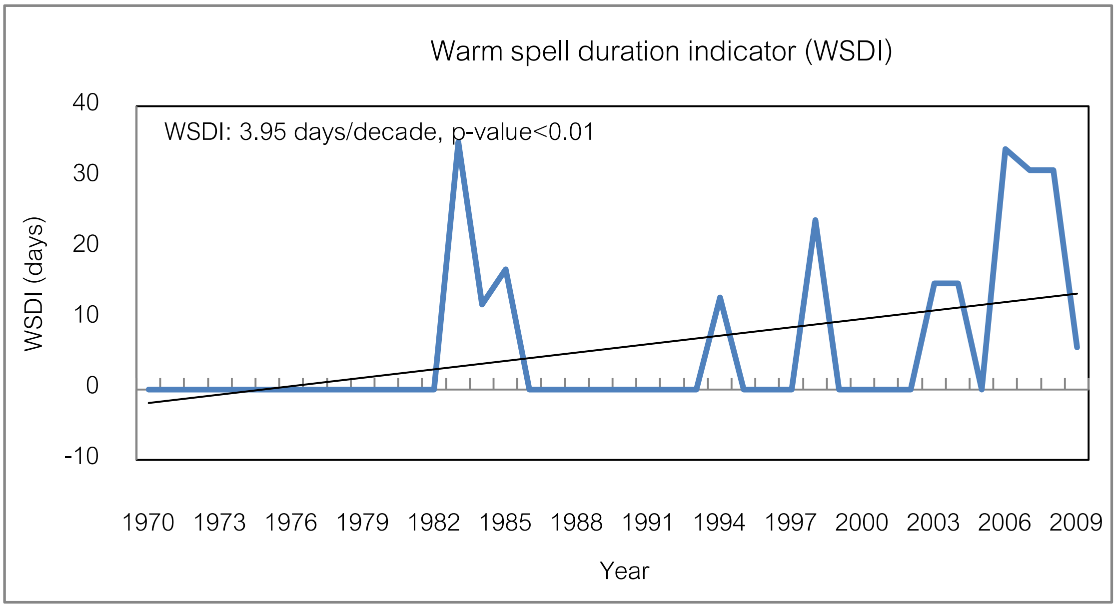

Figure 4.22 Trend of warm spell duration indicator (WSDI) during 1970-2009 at the Klong Yai Weather Station.

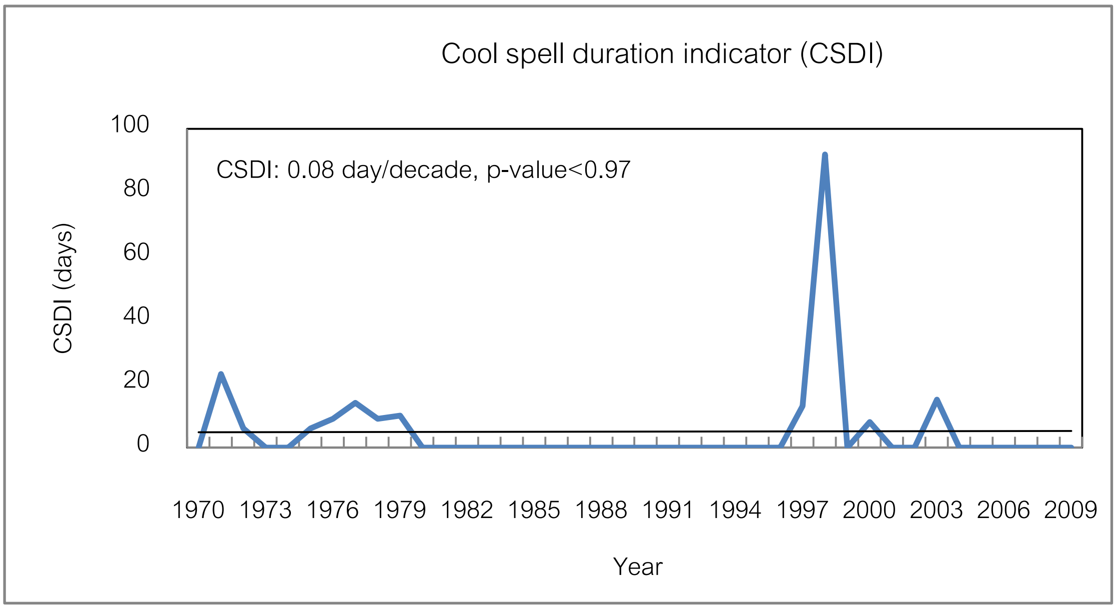

Figure 4.23 Trend of cool spell duration indicator (CSDI) during 1970-2009 at the Klong Yai Weather Station.

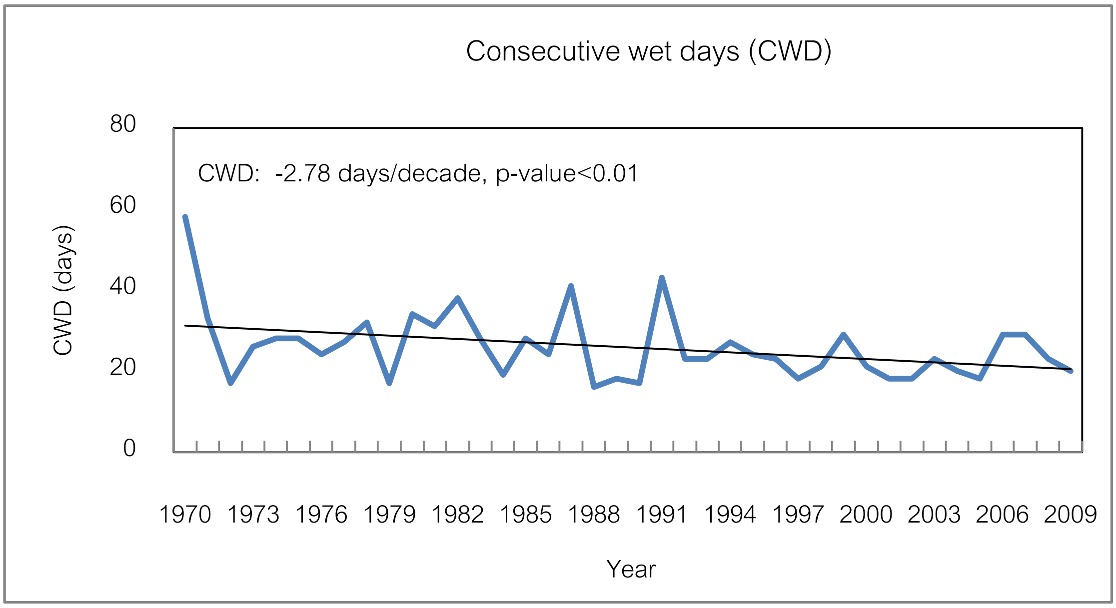

Figure 4.24 Trend of consecutive wet days (CWD) during 1970-2009 at the Klong Yai Weather Station.

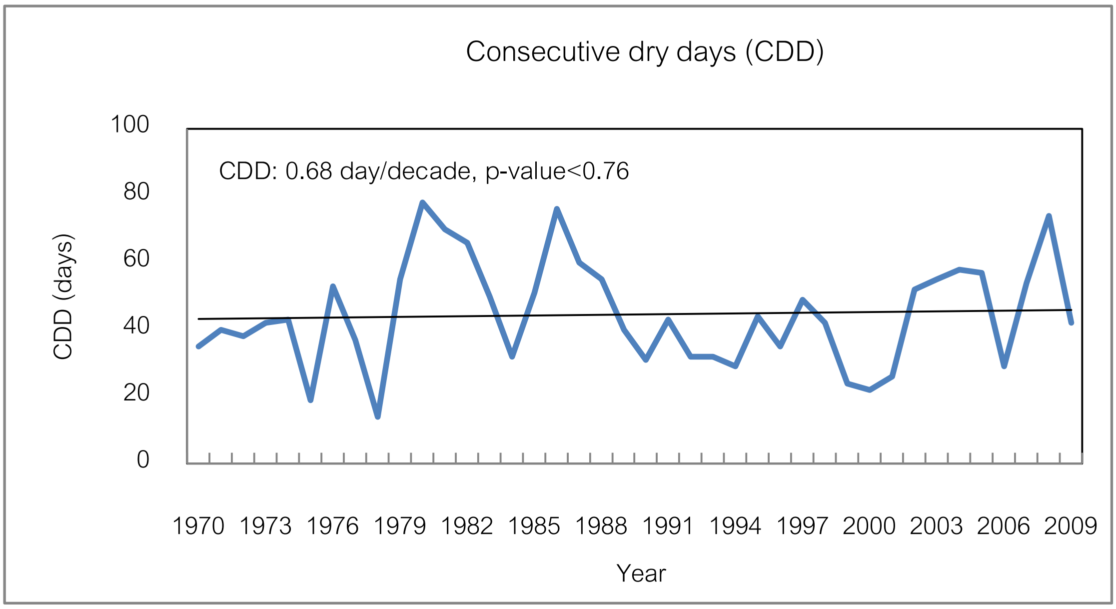

Figure 4.25 Trend of consecutive dry days (CDD) during 1970-2009 at the Klong Yai Weather Station.

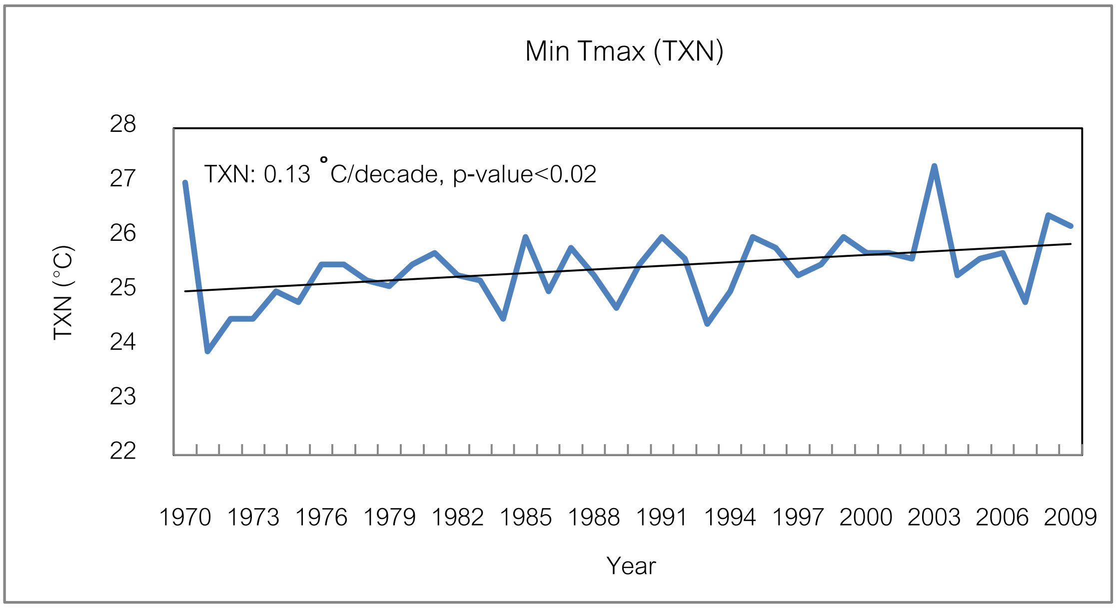

Figure 4.26 Trend of min Tmax (TXN) during 1970-2009 at the Klong Yai Weather Station.

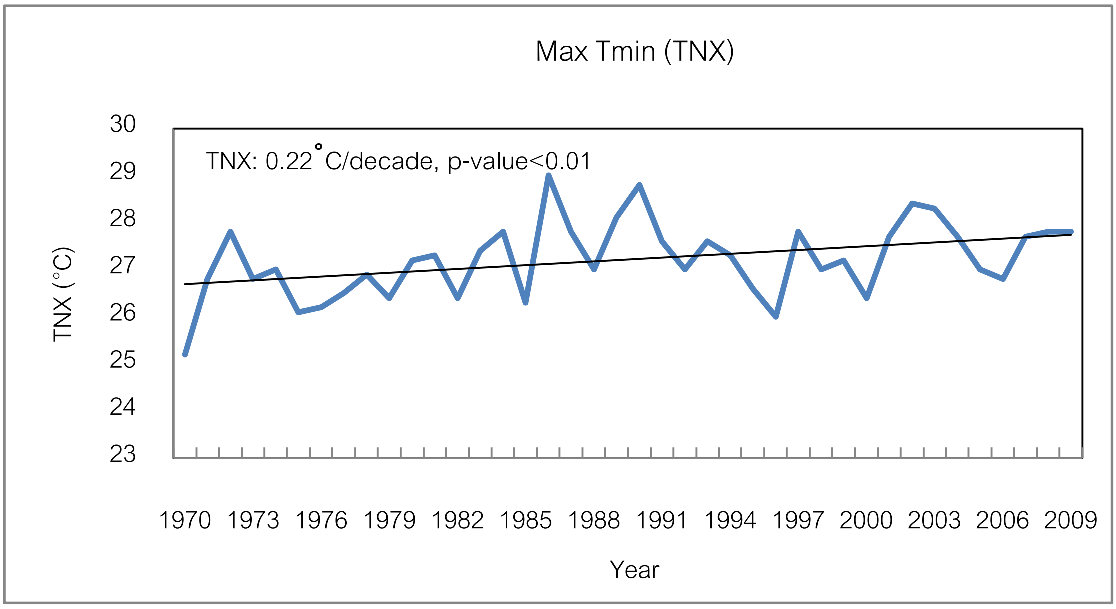

Figure 4.27 Trend of max Tmin (TNX) during 1970-2009 at the Klong Yai Weather Station.

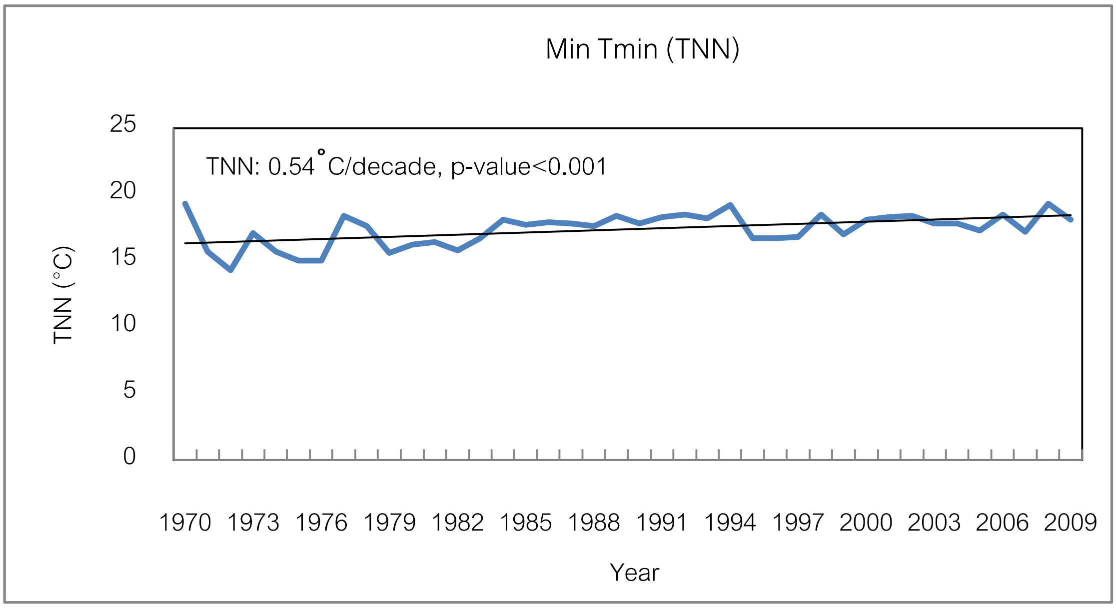

Figure 4.28 Trend of min Tmin (TNN) during 1970-2009 at the Klong Yai Weather Station.

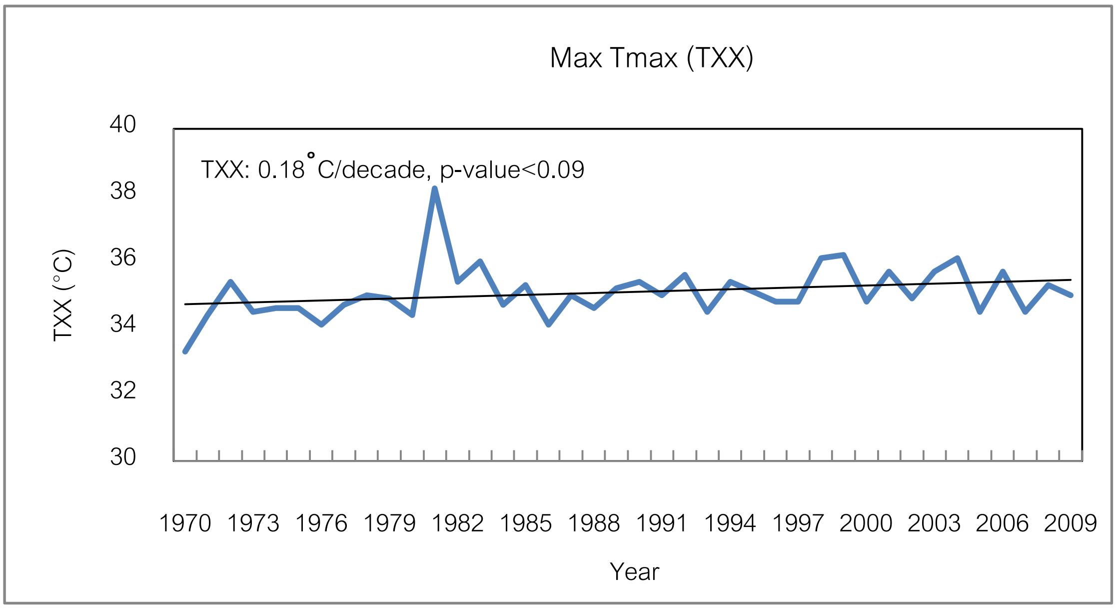

Figure 4.29 Trend of max Tmax (TXX) during 1970-2009 at the Klong Yai Weather Station.

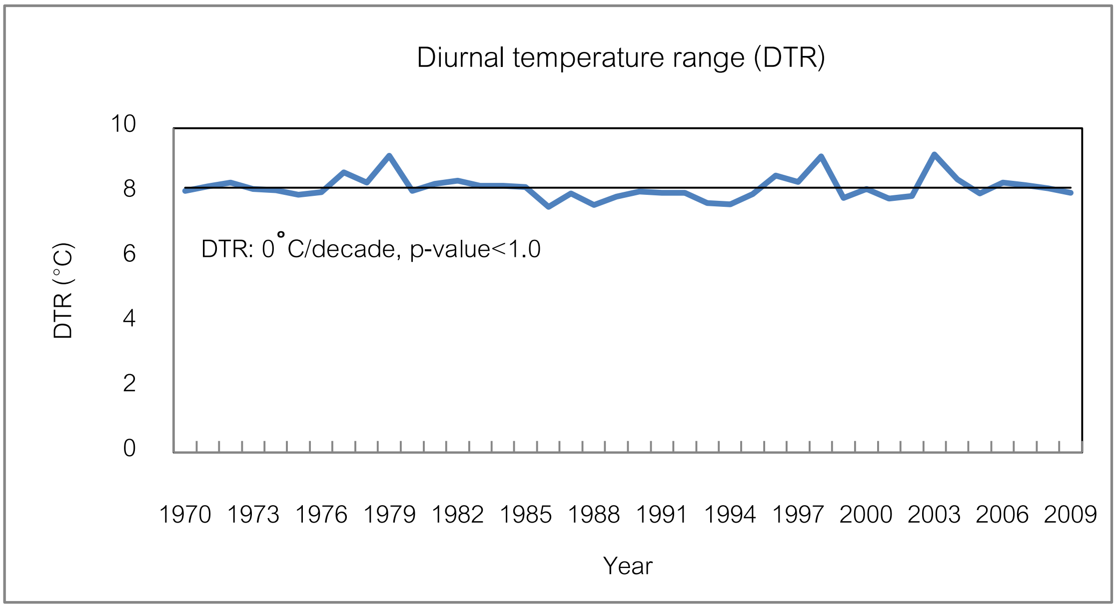

Figure 4.30 Trend of diurnal temperature range (DTR) during 1970-2009 at the Klong Yai Weather Station.

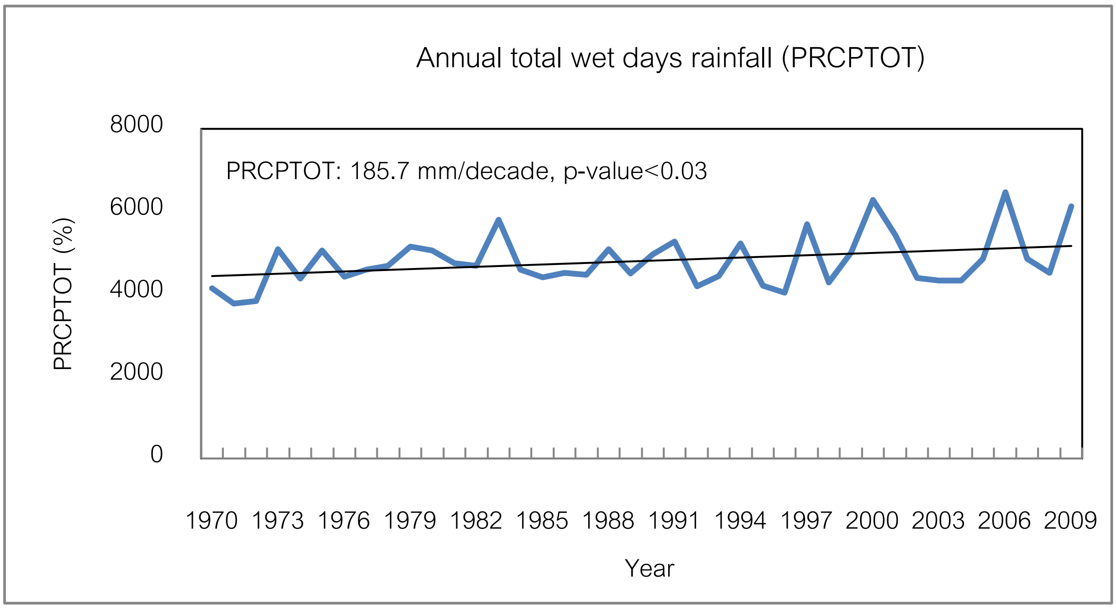

Figure 4.31 Trend of annual total wet days rainfall (PRCPTOT) during 1970-2009 at the Klong Yai Weather Station.

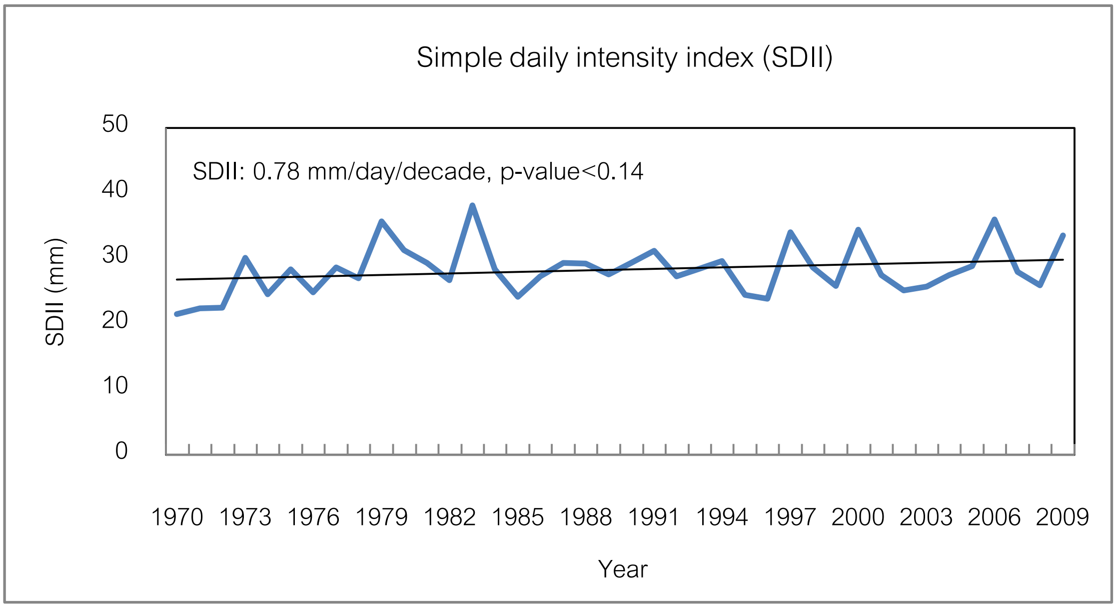

Figure 4.32 Trend of simple daily intensity index (SDII) during 1970-2009 at the Klong Yai Weather Station.

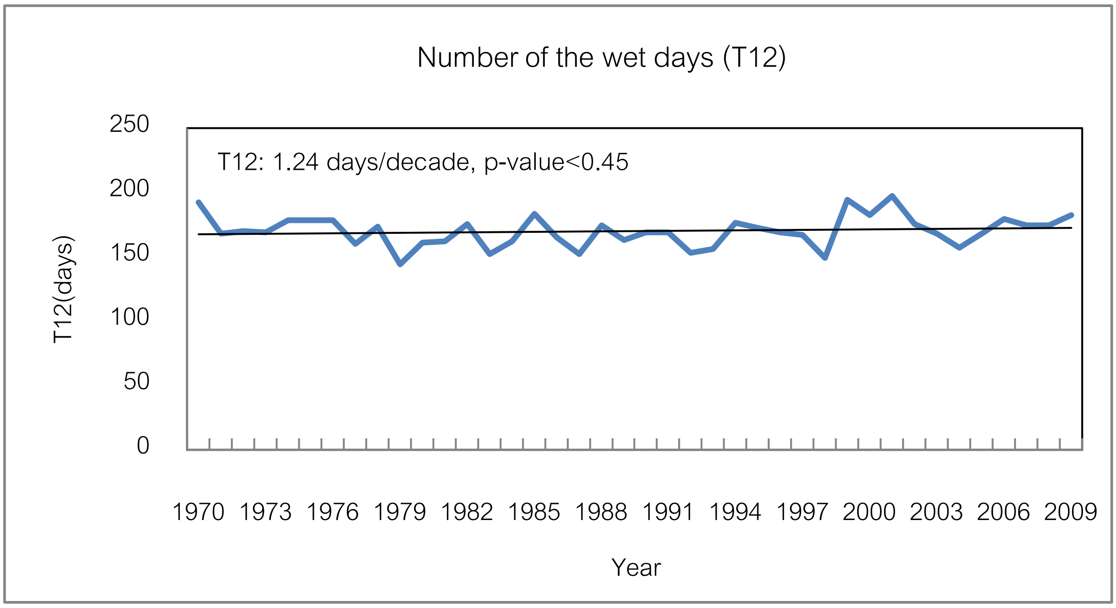

Figure 4.33 Trend of annual number of wet day (T12) during 1970-2009 at the Klong Yai Weather Station.

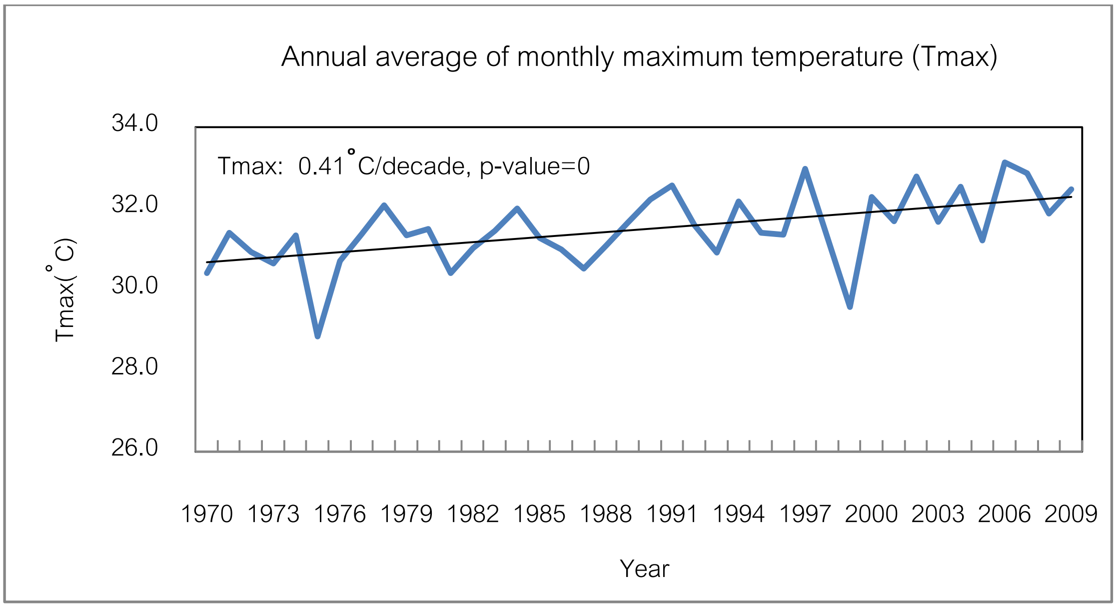

Figure 4.34 Trend of annual average of monthly maximum temperature (Tmax) during 1970-2009 at the Klong Yai Weather Station.

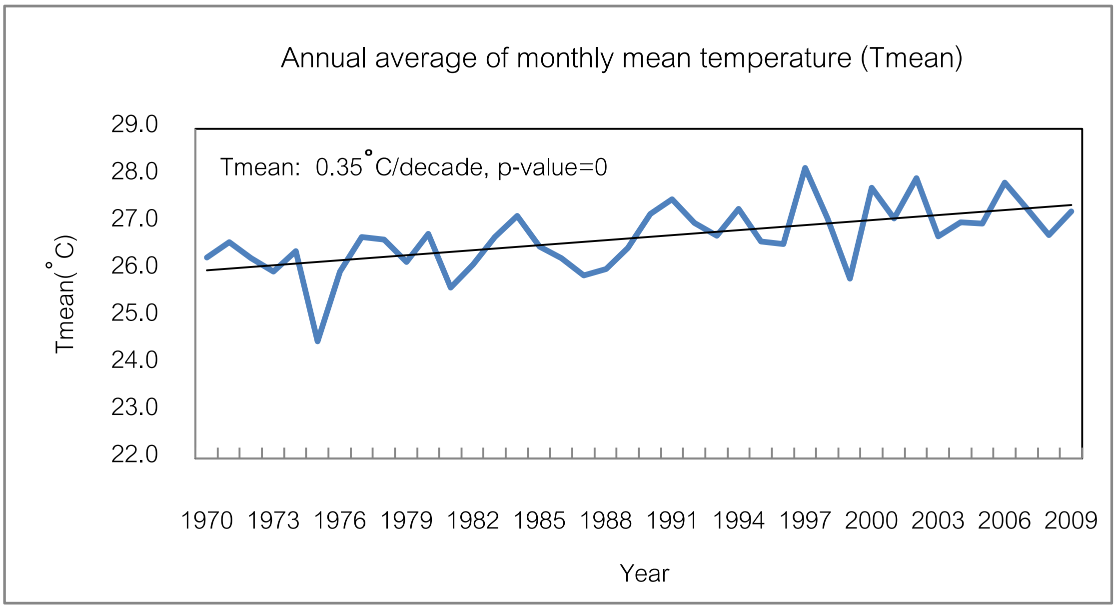

Figure 4.35 Trend of annual average of monthly mean temperature (Tmean) during 1970-2009 at the Klong Yai Weather Station.

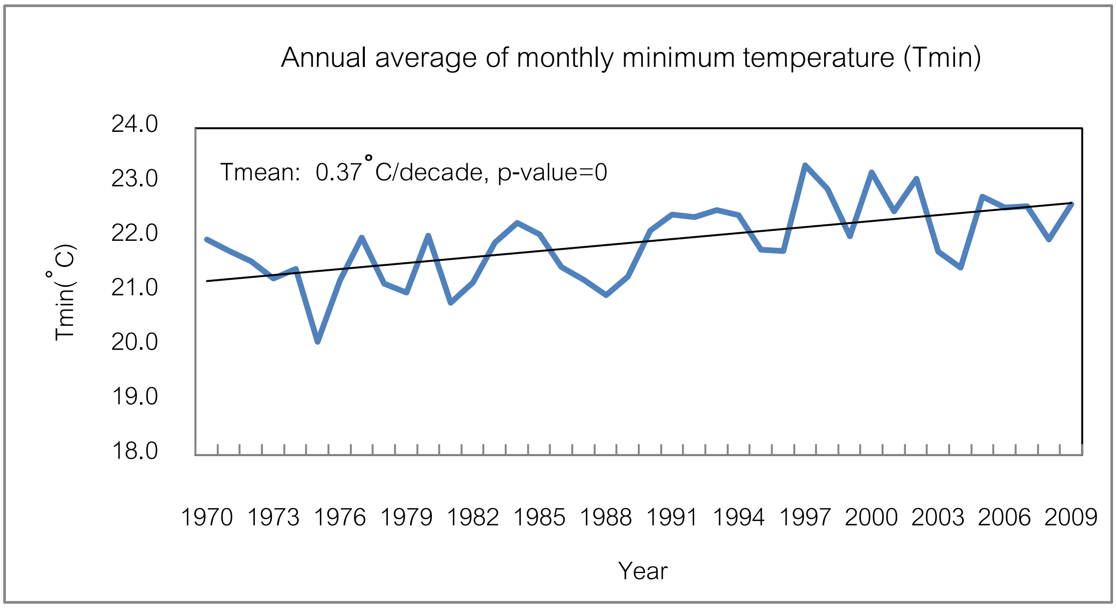

Figure 4.36 Trend of annual average of monthly minimum temperature (Tmin) during 1970-2009 at the Klong Yai Weather Station.

Regarding above discussion, it could be understood that the change in rainfall and temperature patterns would be an influence of climate change affecting consequently on water resources on Koh Chang. This would induce less water on the island and affect on tourism activity during the peak period especially in November to February.

The study also found that when the demand of water for tourism businesses has increased, the purchasing of water has become necessary. The severe shortage of water has become the biggest problem on Koh Chang and made the strong impact on tourism business.

In this regard, it could be concluded that the crisis of water shortage occurred on Koh Chang due to the rainfall pattern changing that would unavoidable impact to livelihood of people and tourism business when the amount of water in the rainy season was not enough for the use of water by tourists coming in high-season (November-February).

4.7.2 Intrusion of salt water affecting ground water quality

Water using in households on Koh Chang generally comes from waterfall, ground water, artesian and shallow wells, pond and purchasing. The study found that another concern of people in this area is an intrusion of salt water to artesian and shallow wells that can affect water quality.

Figure 4.37 shows the distribution of the settlement of the community and tourism businesses in Klong Praw Village which has the greatest tourism development on the island. In this area, many businesses and households are located quite near the coast at the distance of about 100-800 meters. Observed evidence indicates that they have been affected by the intrusion of sea water that reduces the ground water's quality even though further distance from the coast.

Respondents (54.2%) disclosed that water from wells is obtained by drilling at 30-40 meters deep from the ground. In addition, water quality has decreased during the past 5-10 years. A rusty smell occurred in artesian wells that cannot be used for consumption. This water quality problem significantly affects not only to the tourism industry but also to the community at large.

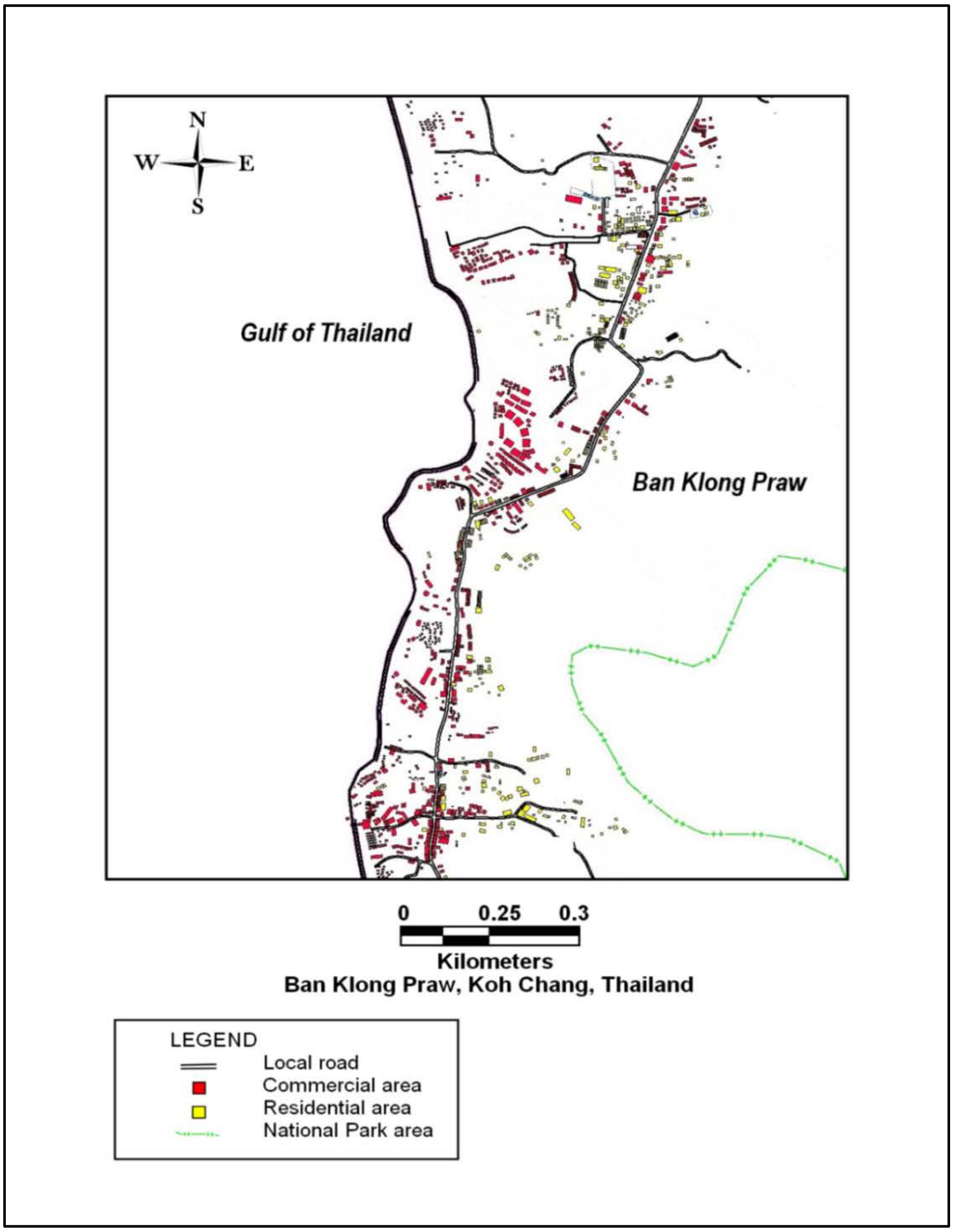

Figure 4.37 The distribution of settlement and tourism business along the coast of Klong Praw Village.

Source: Trat Office of Public Works and Town & Country Planning, 2009.

Another area which has been severely affected by the intrusion of salt water is Bang Bao Village that houses were built into the sea as seen in Figure 4.38. This makes an advantage to the local people to operate home-stay business. Water used in this village is groundwater from the artesian well, which is already brackish.

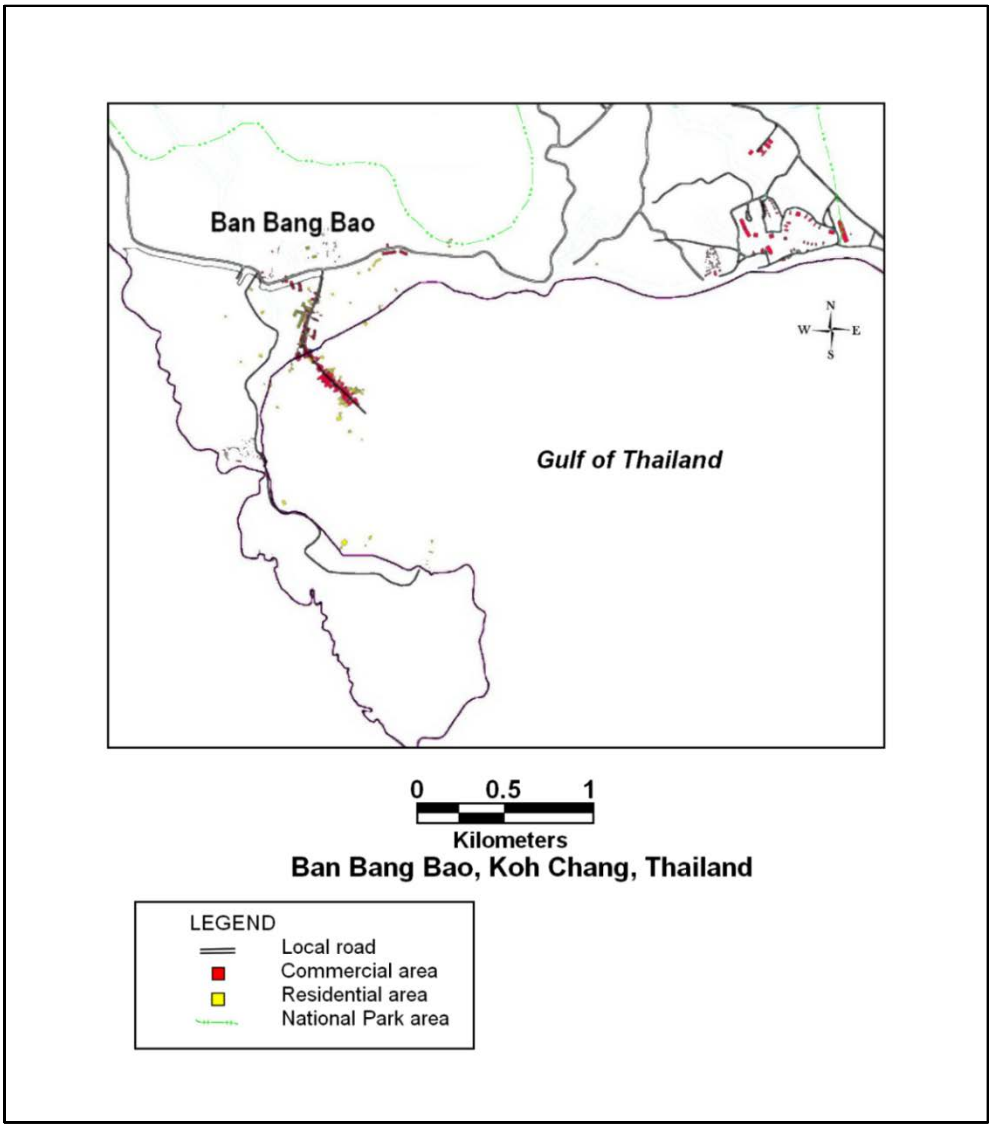

Figure 4.38 The distribution of home-stay businesses in Bang Bao Village.

Source: Trat Office of Public Works and Town & Country Planning, 2009.

Based on a relevant study of groundwater depletion, a shorter duration but extreme intense of rainfall events making exceptionally high runoff and less infiltration as well as increased evaporation due to higher temperature in combined with an increase in exploitation, lead to groundwater depletion (Konikow and Kendy, 2005).

Consistently, over-exploitation of ground water in coastal area alters the equilibrium of the interface between freshwater and sea water which causes saline water intrusion (Stefano, 2004).

It is reasonable to say that salt water intrusion reducing water quality on Koh Chang would affect water consumptions of local communities and tourism businesses.

4.7.3 The impact of extreme weather events on water resources

The impact of climate change on water resources has been aggravated due to the physical limitations of the island. This is due to the fact that most of the water tributaries were short and on steep slope. When it rains, water is rapidly drained into the sea (Figure 4.39).

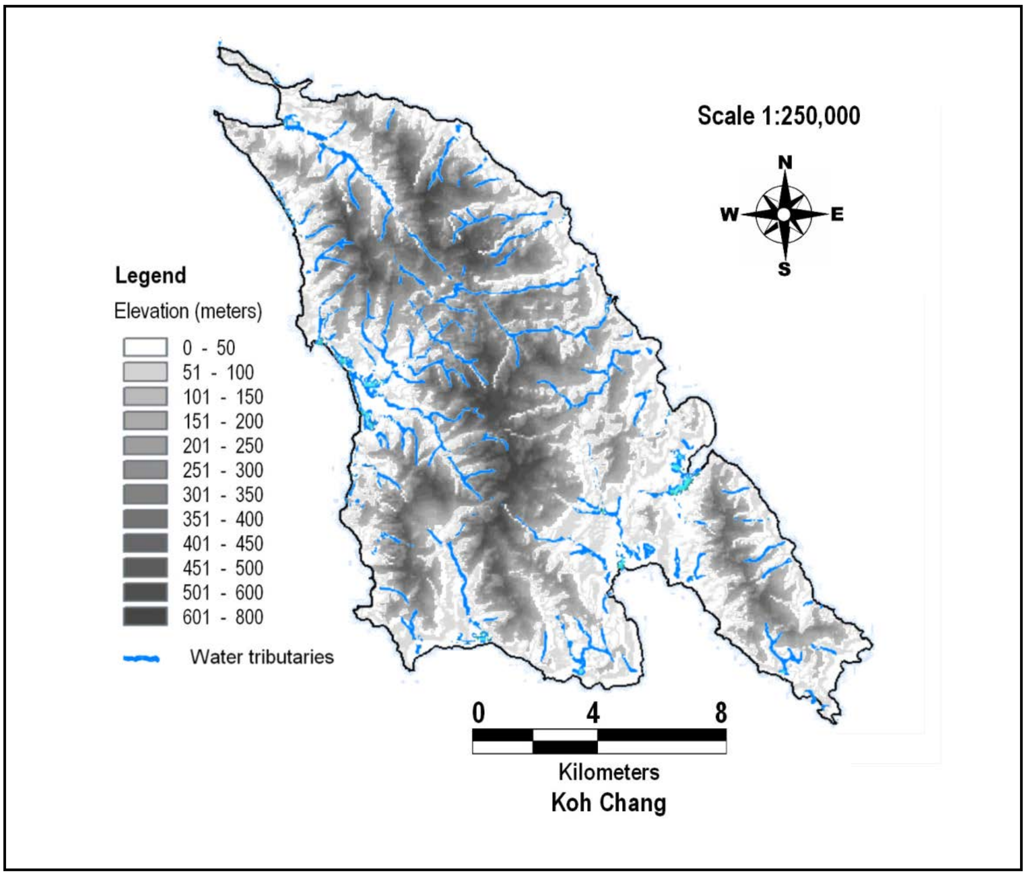

Figure 4.39 Water tributaries on Koh Chang.

Source: Trat Office of Public Works and Town & Country Planning, 2009.

Moreover, observed evidence shows that extreme rainfall events affected water storages of Koh Chang such as village weirs using to slow down water flows during the rainy season and to reserve water in the storages for multipurpose uses. This physical damage as observed in the study area is consistent with the results of extreme weather events indicating a significant increase in intense and heavy rainfall events during 1970-2009.

The extreme indices of rainfall and temperature described in section 4.7.1 showed remarkable changes under warmer condition towards increased severity and frequency in the last few decades on Koh Chang. This is consistent with the results based on questionnaires and in-depth interviews, revealing similar the impact of climate change on water resources on Koh Chang. Respondents (79.2%) revealed that the extreme rainfall destroyed water storage construction such as weir that, in turn, affects the amount of water storage on the island. While the geography of the island consists of steep slopes, man-made weirs were damaged and could not resisted to consecutive heavy rainfall and its rapidly flow from the mountains (Figure 4.40).

Figure 4.40 The damage of weir after consecutive heavy rainfall.

It would be concluded that water shortages, despite observed increased rainfall and its extremes, occurred on Koh Chang due to inability of water storage during extreme heavy rainfall and the physical limitation of the island. The impact on local people and tourism businesses especially when there is more water demand is expected to be unavoidable consequences of these problems.

4.8 Local governmental agencies and their existing adaptive capacity

Regarding research findings in previous sections, it seems to be that climate change in the form of extreme event of rainfall has already taken place and have consequently impacted on flood and water shortage to all stakeholders, particularly tourism business on Koh Chang. Hence, the challenges of reducing vulnerability on water resources caused by climate change are issues that have to be paid attention.

The following section provides an overview of the existing adaptive capacity of local governmental agencies to combat climate change. Information relevant was collected by in-depth interviewing and surveying in the study areas using a set of questionnaires and discussion (Appendix A). The findings are discussed under the important themes as follows:

- A range of available technological options for adaptation
- An available resources and their distribution across the communities
- A structure of critical institutions and the criteria for decision making
- A stock of human capital
- A system access to risk-spreading processes.

4.8.1 The range of available technological options for adaptation

Questionnaire # 1 was designed to understand a capacity of the LGAs on the range of available technological options for adaptation. The results of interview found that the LGAs were use technology and local knowledge to manage water use as follows:

(a) Technology to explore and drill ground water

(b) Village weirs to slow down water flowed during the rainy season and store water for consumptions, irrigations, and tourism. One example of village weirs is shown in Figure 4.41.

(c) Village water supplies

(d) Polyethylene water pipelines to transport water from waterfalls and canals to communities (Figure 4.42).

Given the emerging technologies, the LGAs are mainly concerned on the intrusion of salty water, properly technology for sustained weirs, sanitary water supply and sustainable maintenance. However, respondents (81.8%) eventually felt that polyethylene water pipelines was quite useful to directly access water from the waterfalls and canal, and then distribute to the communities.

While technology (b), (c), and (d) can be used effectively only the rainy season when having plenty of water, the study also found that most respondents (90.9%) did seem to be able to access to general technological options used, but they may not recognize which technology is the most appropriate for relevant climate infrastructure impacts. They also had little available expertise on this issue.

Figure 4.41 The Salak Petch village weir.

Figure 4.42 The polyethylene water pipelines.

4.8.2 The available resources and their distribution across the communities

The understanding of the LGAs on impact of climate change on water resources in the communities and their actions or conflict over water using between tourism and other sectors were discussed in questionnaire #2.

All respondents included eleven LGAs, three district officers, and four representatives of tourism businesses were asked to identify types of water available on the island. 83.3% of respondents agreed that water not only came from canal and waterfall but also derived from man-made wells and ponds were not adequate for using throughout the year. Thoroughly, respondents were also asked to express their opinions on a main cause of water shortages on the island. 58.3% of them noted that the villagers never faced with water shortage until the tourism was developed on this island. 95.8% of respondents clearly highlighted their opinions that even though there have been various sources of water available on this island, but these are not enough for the rapid growth of tourism.

While respondents (23 of 24, or 95.8%) who understood that water shortage has caused from tourism expansion had further discussion on conflict between tourism businesses and villagers. Respondents (14 of 23, or 60.9%) indicated that there was conflict between tourism businesses and villagers on the island, while 6 of 23 or 26.1% of them mentioned that there was only negative attitude between tourism businesses and villagers and the problem could be occurred only in dry season when demand of water was high.

However, respondents further mentioned on other cross-cutting issues related. Respondents (91.6%) mentioned that the shortage of water because of no a large reservoir on the island. Only 12.5% of respondents understood that changing in rainfall patterns was another cause of water shortage and water storage limited in the rainy season.

This could be concluded that respondents did seem to be familiar with water shortage. They seem to be less recognized that this was a result of climate change. Most of them understood that water shortage was because of increasing of tourist and the growth of tourism business. This leaded to conflict between tourism businesses and villagers.

4.8.3 The structure of critical institutions and the criteria for decision making

Questionnaire # 3 addressed the structure of critical institutions and the criteria for decision making. Respondents were asked to explain the process of water shortage relief, the structure of critical institution involved, and the criteria for their decision making to assist water users. The discussion on the controlling or regulations to manage water supply during dry season was also introduced. The collaboration among local governmental organizations to alleviate the water shortages on this island, the water shortage relief process, and its relevant working by various organizations can be summarized and shown in Figure 4.43.

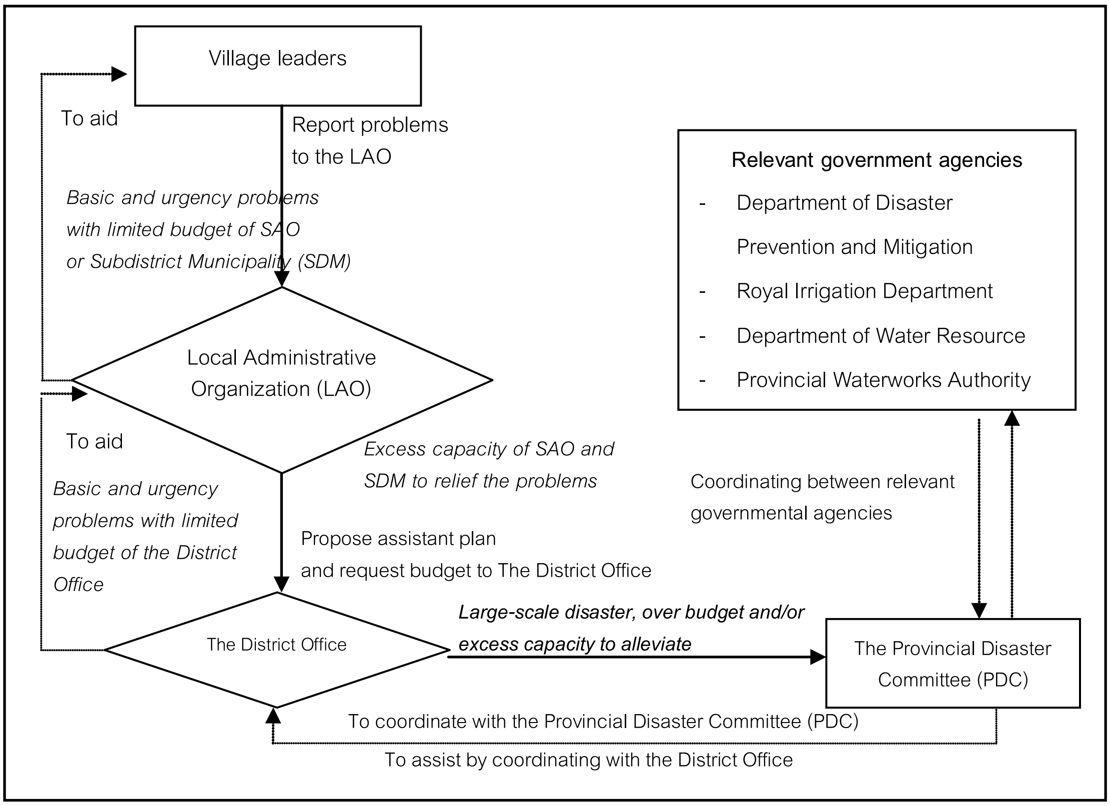

Figure 4.43 Flow chart of the water shortage relief process on Koh Chang.

Figure 4.43 describes the process of water shortage relief by local governmental agencies on Koh Chang. Whilst water shortage taken place in the villages, the village leaders would report and have a meeting with the LGAs. The LGAs would provide assistance to reduce the problems through their own capacities (e.g. tools, technologies, people, and budgets). If the problem was unable to manage and beyond the capacity of the LGAs, they would take action by proposing plans to the District Office. Thereafter, the District Office would consider that problem to assist under the government criteria whether their capacity can be handled. If yes, they would provide help to the LGAs. If not, they would ask for more supporting from other government authorities concerned, e.g. the Provincial Disaster Committee of Trat.

To comprehend the criteria of decision making of the LGAs, eleven respondents of the LGAs were questioned on issue related. The results of the interview and discussion are prioritized as a criterion to be assisted as follows:

- <u>Criteria 1</u>: Types of water users, which can be grouped into villagers and tourism businesses
- <u>Criteria 2</u>: The purpose of the water use, which is divided into consumption, irrigation, and tourism.
- <u>Criteria 3</u>: The availability of water resource.

All respondents of the LGAs noted that the type of water users (criteria 1) was the most influence on the decision. They stated that the villagers who were faced with water shortage would be assisted before the tourism businesses because the villagers did not make the problem of water shortage. They viewed that tourism businesses had ability to buy water.

According to this first criteria of the decision, water would be provided and distributed using the LGAs' water trucks and water tanks.

Base on the second criteria, all respondents from the LGAs stated that the purpose of water using was necessary to consider together with the first criteria. They noted that they were willing to provide first assistance to the villagers' water consumption. They viewed that tourism businesses are able to solve problem.

However, an issue of equity was raised during the interview. This decision making would affect tourism businesses on the island, especially small businesses such as home-stays, and small resorts. Respondent (8.3%) who were running their home-stay business at Ban Bang Bao disclosed that they increased a room rate, but still cheaper than larger hotels and the LGAs did not prevent them to use water from waterfalls and canals.

For the availability of water resources, all respondents of the LGAs recognized this criteria for water resource management in their community. Respondents (27.3%) noted that they have a water resource management system in their community calling open-closed sharing water system operated and used by Ban Bang Bao and Ban Salak Petch. This makes no conflict of water use in these villages.

The system currently is managed by the sub-committee of such two villages and operated during the dry season only.

Regarding the above discussion, it could be concluded that the LGAs have potential to alleviate water shortage for local people, except for the tourism business because decision-making were designed as such criteria mentioned above. This leads to affect several tourism businesses especially home-stay and small resorts by increasing operation costs.

4.8.4 The stock of human capital

Questionnaire # 4 addressed the ability to manage human resource in the LGAs organization. Respondents were discussed on the LGAs' capacity toward the ability to manage and develop their human resources.

The results of this study revealed that human resource development in the two LGAs' organizations did not much provide. According to the SAO Koh Chang Tai development plans, only 5.14% of the total fiscal budget in 2011 was set to enhance their human resources competencies. Thoroughly, all respondents of the LGAs felt that they have spent more budgets on waste management caused by tourism activities. While, respondents (63.6%) viewed that capacity building of the LGAs was ineffective due to lacking of sense of belonging, high turnover rate, no continuity in their works, and conflicts within the organization.

When respondents were asked to discuss on the obstacles faced in their organizations, 72.7% of them stated that the problem of lacking manpower was the most critical weakness in both the LGAs organizations. Indeed, the SAO of Koh Chang Tai and the Subdistrict Municipality of Koh Chang were not enough staff, particular in Division of Public Work that lack of civil technicians to conduct their work related and their existing capability are also limited.

Furthermore, it could be concluded the capacity development of human resources in both the LGAs on Koh Chang has less taken into account. Most of the fiscal budget was not used to enhance their human resources' competencies. The problem of manpower in terms of specific knowledge, skill, and ability required, has, thus, become an obstacle impeding staff to perform their effective function and work.

4.8.5 The system access to risk-spreading processes

The final question of the questionnaire looked at the ability to deal with water shortage by concerning on the system access to risk processes.

Respondents were asked about barriers and challenges dealing with water shortage, plans or preparation dealing with water shortage problems, types of strategies used, and communities involved to the problems solving process.

In addition, to understand the risks of tourism from climate change by focusing on the impact of water shortage, all respondents also were questioned on barriers and challenges on such issue. The perspectives of various respondents are summarized as follows:

1) The availability of water and its shortage are critical issues that need a strong action to solve the problem for sustainable tourism of Koh Chang.
2) A usable groundwater is quite limited due to the low quantity and quality for consumption.
3) Waterfalls and natural canals are important sources on the island for consumption, irrigation, and tourism purposes.
4) Many water weirs built are out of order because of inappropriate construction, and regardless geography.
5) No large water reservoir to storage water during the rainy season and use during dry season.
6) Local people have realized that polyethylene water pipelines make directly water access from waterfalls and canals.

During the in depth-interview, all respondents were also asked to described plans or preparation of the LGAs in dealing with water shortage problems and types of strategies they used. Respondents (83.33%) indicated that due to lack of proper planning, various stakeholders were face with water shortage. When the LGAs were asked to discuss on this issue, all of them agreed that they did not have any plans for an effective water management system which is one of fundamental infrastructures to support people and tourists. Presently, around 200 hotels have been affected by water shortages, and costly purchased water for their business. However, respondents (81.8%) proposed to build village weirs. They would like to have a plan of weirs projects to get financial support from the government, whilst 27.3% of them only mentioned the increasing of ponds and artesian wells.

There have been several attempts to find the way dealing with water shortage on Koh Chang, respondents (18.2%) viewed that saving water program is possible to take action at all levels and all sectors. While 81.8% of them believed that there was very difficult to motivate people to save water, whether from the small home stays to the large hotel. Obviously, most respondents (90.9%) strongly supported the plan of building a large water reservoir at Klong Praw Village. They believed that the reservoir will be a majority potential source of water storage on this island and can provide sufficient water, especially for tourism businesses throughout all seasons. The findings are not surprising, when 91.7% of respondents expected that a large reservoir would be a long-term solution for water shortage and the replacement of groundwater use on Koh Chang.

Based on the discussion from the results, it could be concluded that both the LGAs have some weaknesses to deal with water shortage on the island. Their weaknesses were the lack of expertise in water management and technology use. Moreover, they lacked of investment in human resource development and inappropriate decisions-making on water management.

To enhance the LGAs' capacity to manage such problem, the capacity building model should be developed based on information and results obtained.

4.9 The capacity building model for the LGAs adapting to climate change

Regarding the results of the study, one problem related to the issue of climate change is water shortage taken place on Koh Chang. This came from the changing of rainfall pattern, as well as the lack of knowledge and capacity of the LGAs to handle this issue. This circumstance would leaded to vulnerable and unsustainable tourism of Koh Chang consequently.

Causes of water shortage and its effects can be shown in Figure 4.44. It could be indentified that water shortage on Koh Chang is caused by its geographical characteristic, changing in rainfall pattern and temperatures, and incapable management of the LGAs. Lacking of capabilities to manage water shortage would lead not only to unsustainable tourism but also to unsustainable community. Thus, the conflict between tourism business and local people would occur.

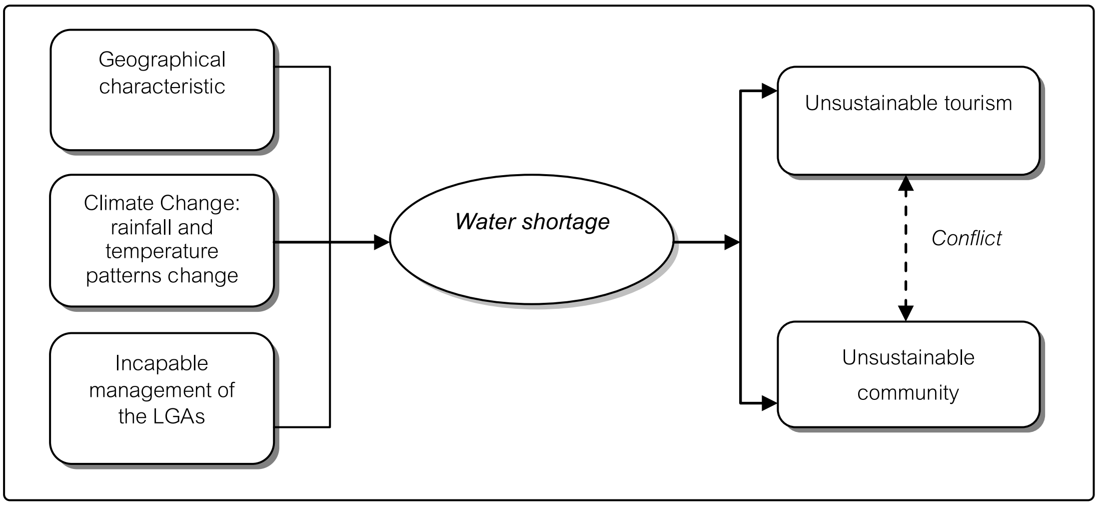

Figure 4.44 Causes of water shortage and its effect on Koh Chang.

To resolve the mentioned problem, the possible approach would be the capacity enhancement of the LGAs to have knowledgeable understanding to manage and adapt to the changing of climate.

Regarding a conceptual capacity building model adapting to climate change mentioned in section 2.9, a capacity building model may include strengthening the ability of people to apply appropriate technological options for climate change adaption and to manage an effective adaptation system. Therefore, such a concept of capacity building model in the study could be an integration of the group of key elements to enabling capacity building and the activities to climate change adaptation which is shown in Figure 4.45.

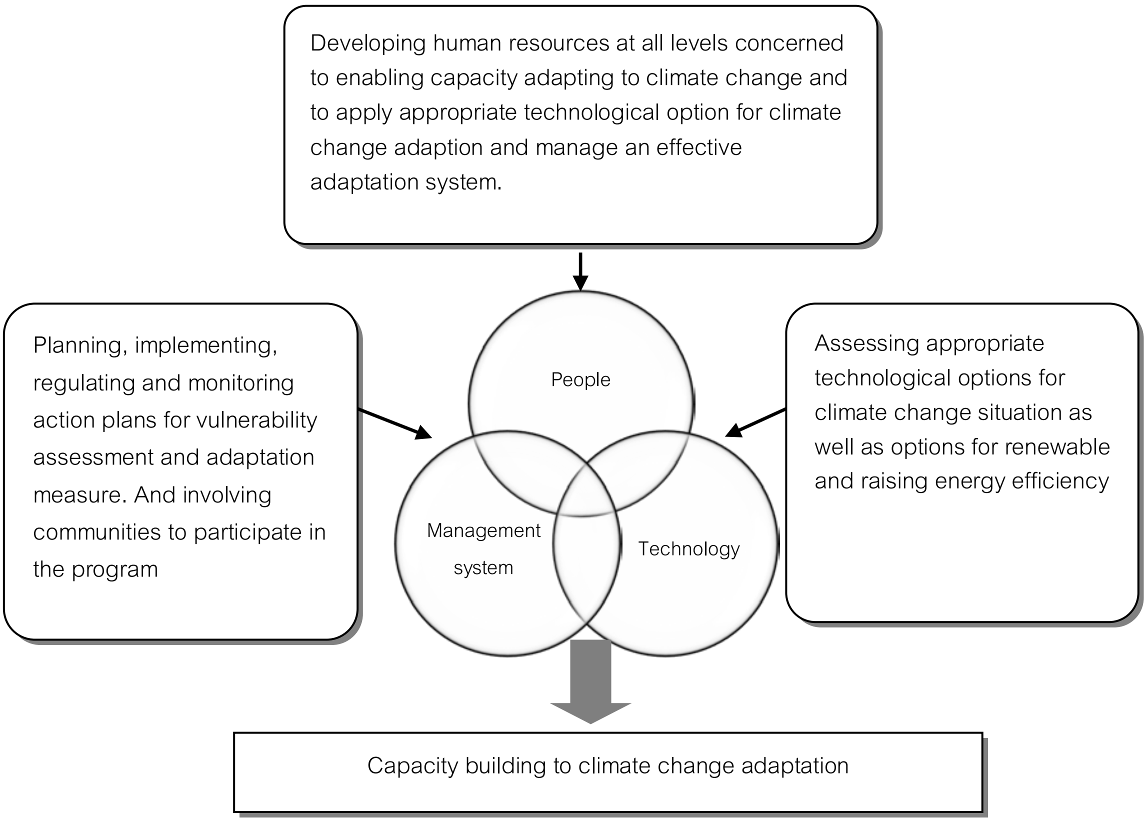

Figure 4.45 A draft of conceptual model in capacity building adapting to climate change (modified from UNDP, 1991 and UNFCCC, 2009).

A proposed conceptual model of capacity building of the LGAs in adapting to climate change is shown in Figure 4.46. The model aims to enabling capacity building of the LGAs to manage water shortage leading to sustainable tourism and community.

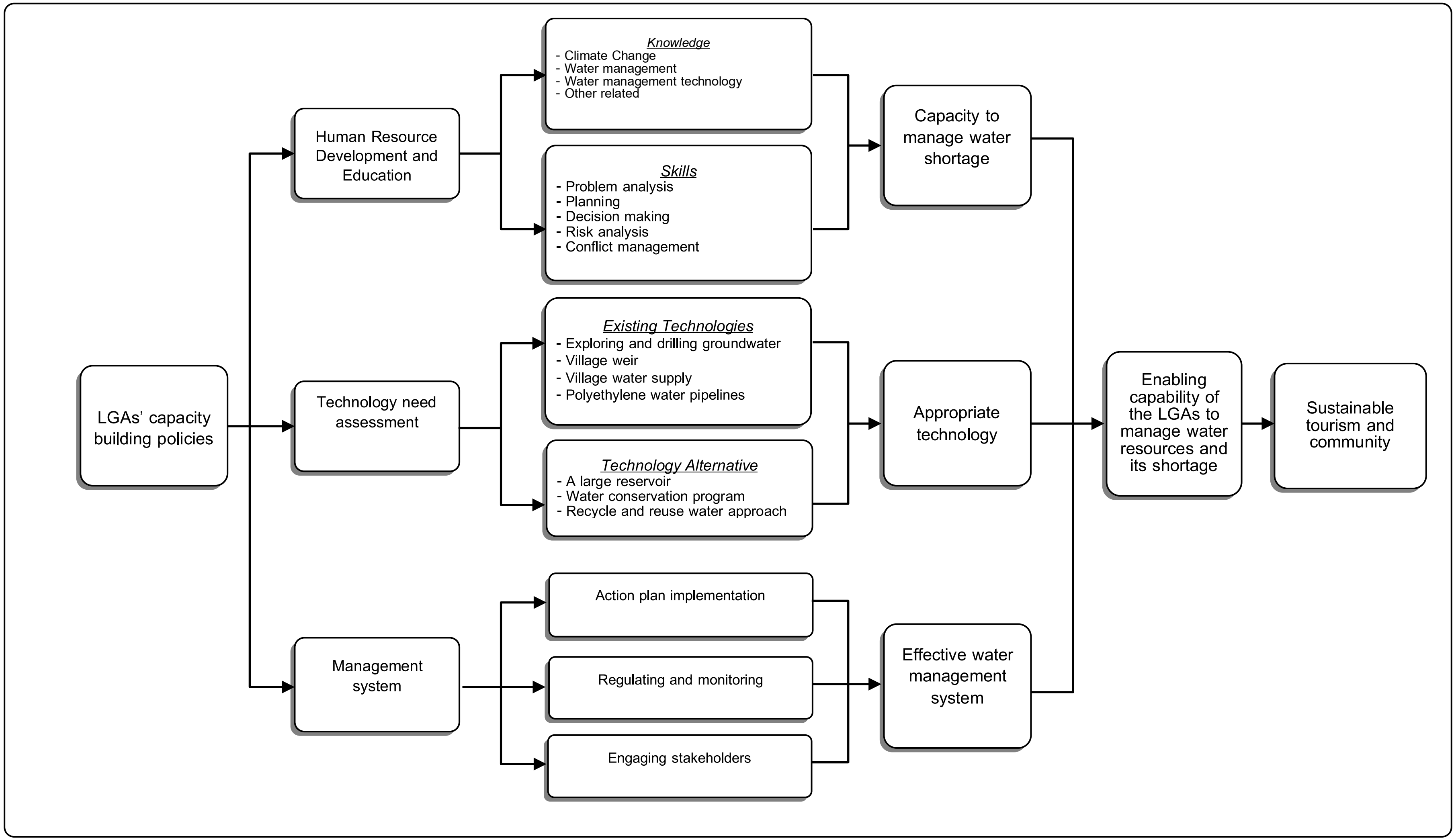

Figure 4.46 The capacity building model for the LGAs adapting to climate change.

From the proposed model, the policy should be set up to build a capacity of the LGAs. Through means of human resource development and education, technology needs assessment, and water management system.

4.9.1 Human resource development and education

Human resource development and education is one of the key elements to enhance capacity of the LGAs to manage water shortage.

The LGAs should be educated on issues of climate change, water management, and water management technology. Additionally, they need to have skills to introduce such knowledge to analyze problem, planning and decision making process, risk analysis, and conflict management.

4.9.2 Technology need assessment

The LGAs should have ability to assess what appropriate technology could be applied to resolve the problem. The existing technologies used, e.g. exploring and drilling ground water, polyethylene water pipeline, etc. should be taken into account. Other alternative such as a large reservoir or water conservation program would be conducted in an integrated manner.

4.9.3 Water management system

The LGAs also need a capacity to manage an effective management system to deal with not only water shortage but also other environmental issues. A water management system has to be implemented under the action plans and regulation/ monitor processes. The LGAs should capable to work out with all stakeholders to participate in management process/system. This would lead to the effective water management system afterwards.

Regarding the above approaches, the LGAs are enabling their capacity to handle the problem of water shortage which is toward to not only a sustainable tourism, but also a sustainable community as well.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

This research was carried out to study the impacts of climate change on water resources affecting tourism businesses on Koh Chang, to assess the local governmental agencies' capacity to address the impacts, and to develop a conceptual model of capacity building for the LGAs to adapt to climate change regarding water shortage. The study can be concluded and recommended as follows.

5.1 The impacts of climate change on water resources on Koh Chang

The impacts of climate change on Koh Chang came from the changing in rainfall patterns and the extreme weather events that caused water shortage. While the changes in rainfall patterns reduced availability of water supply, the study also found that the extreme weather events destroyed village weirs that built to storage water use on the island.

The study also found that the other factors affected on water shortage are the limitation of the geographical characteristic of the island, the mismatch between water supply and demand, and incapable management of the LGAs to handle such problems. Eventually, these have particularly affected not only tourism business but also community in the study area.

5.2 Water supply and water demand in Koh Chang

Although Koh Chang has significantly increased in rainfall that produces a lot of runoff up to 110,000,000 cubic metres/ year, while the island's water demand was about 1,030,075 cubic metres/year, there still has water shortage during the peak period of tourism. This problem is caused by the mismatch between the time period of tourism season and rainy season. Actually, tourism in this island always peaks during the dry season between November and February and lowers during the rainy season between May and October. Additionally, the island also has less ability to storage water because there has no a large reservoir to reserve water from short and steep tributaries. These could reflect a lack of ability to manage water resources and its shortage of the LGAs that needed to enhance their capacity appropriately.

5.3 The capacity of the LGAs to manage water shortage

The capacity of the LGAs to handle water shortage is considered to be low. The LGAs had less investment in human resource development and did not know how to apply appropriated technology. They had a few resource persons working on this issue. Generally, they focused mostly on a short-term implementation on increasing water supply but no water conservation and management plans. Furthermore, their decisions and actions on water management would affect on tourism business and the communities.

5.4 The capacity building model for the LGAs adapting to climate change

To enhance capacity of the LGAs, the capacity building model is proposed through the policy towards human resource development and education, technology need assessment, and water management system. Knowledge and skills on climate change and water management and its technology are an obligation to build capacity of the LGAs. The appropriate technology assessments as well as effective water management system also need conducting to support the enabling capability of the LGAs to manage water shortage and adapt to climate change. This would ensure the sustainable development of tourism and community of Koh Chang.

5.5 Recommendations

Regarding the proposed model, it is further recommended that:

(1) A short term implementation plan on the LGAs' capacity building on water management should be consistently developed to a long term implementation plan for sustainable community and tourism,

(2) The capacity building to adapt to climate change of other group of stakeholders such as the local people should be further studied to enhance their roles and abilities in the potential water management system,

(3) The model of capacity building of the LGAs needs to be further technical study on proper water management.

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APPENDICES

APPENDIX A
KEY INFORMATION QUESTIONNAIRE

Examining the Local Governmental Agencies to adapt with water shortage affecting tourism development on Koh Chang

Key Information Interview

Date: ___________________________

Interviewer: _____________________

Interviewee Code: ______________

Dear Respondents,

My name is Miss Wanvicechanee Tanoamchard, a Ph.D Candidate in Environment Development and Sustainability Program of Chulalongkorn University and I am now conducting the study entitled “Capacity Building Model for Local Governmental Agencies on Sustainable Tourism Development Adapting to Climate Change”. My key informants are people taking part in coping and managing with the problems of water shortage on Koh Chang.

The objectives of this interview are to gather information about the current problems of climate change (mainly focused on water shortage) in your communities and to study the way you deal with these problems.

Thank you very much for sharing your meaningful experience with me

KEY INFORMATION QUESTIONNAIRE

This is an in-depth interview guide having the main topics as the following questions:

Part 1: The range of available technological options for adaptation

1.1 What are the critical impacts of climate change affecting water shortage on Koh Chang?

1.2 What are technologies that you used to cope with water shortage in your communities? (e.g. reserving water, preventing water evaporation, recycling water, desalination)

1.3 How are these technologies chosen?

1.4 How does the community benefit from using these technologies?

1.5 How can these technology help to alleviate the problems in the community?

1.6 Do you need any other supporting technology (technology transferring) from the government?

<u>Part 2</u> **The available resources and distribution across the communities**

2.1 What are the main causes of water shortages on the island?

2.2 What are the types of water resources available in the communities? How much it can provide water to people?

2.3 How are available water resources distributed to the communities?

2.4 Who are water users? And how do they utilize the water?

2.5 Are there any conflict regarding water distribution? If so, what are they? And how are the conflict showed?

2.6 Is there enough water for all users?

<u>Part 3</u> **The structure of critical institutions and the criteria for decision making.**

3.1 What are the processes of the water shortage relief in your communities? And what are the structures of those critical institutions involved?

3.2 What are the criteria for making decisions to assist all groups of water users?

3.3 How do you manage water supply during dry season? Do you have any controlling, system, or regulations?

Part 4 The stock of human capital

4.1 How many staff have you got in your organization?

4.2 Do you have any problems about manpower planning?

4.3 What are the organization's competencies expected by all members in your organization?

4.4 Have you invested in developing human resources (e.g. developing their skills, knowledge)?

Part 5 The system to access risk-spreading processes

5.1 What are barriers and challenges in managing water shortage in the island?

5.2 How does your organization cope with those problems? And what kind of strategies you are use?

5.3 How do the communities involve to solve the problem of water shortage?

5.4 What advice may you give to such these problems?

Part 6 Conclusions

6.1 Is there anything else you would like to add that you felt was not covered in this interview?

6.2 Could you please suggest the next person whom I should interview regarding the issue of water shortage in the island?

6.3 Please give me their contact details such as e-mail or telephone.

APPENDIX B

RAINFALL AND TEMPERATURE DATA

Part 1 The rainfall extreme indices

Year	RX1day	Rx5-day	R95p	R99p	R10	R20	R50	CWS	CDD	PRCPTOT	SDII	T12
1970	146.4	402.0	271.5	-	131.0	75.0	16.0	58.0	35.0	4136.4	21.5	192
1971	196.5	476.0	196.5	196.5	101.0	66.0	16.0	33.0	40.0	3763.9	22.4	168
1972	171.1	392.5	1024.6	-	93.0	56.0	17.0	17.0	38.0	3830.0	22.5	170
1973	304.5	542.5	1306.6	727.7	100.0	70.0	34.0	26.0	42.0	5078.5	30.1	169
1974	169.4	326.8	793.4	-	105.0	77.0	20.0	28.0	43.0	4365.9	24.5	178
1975	208.4	384.6	1262.7	208.4	108.0	68.0	34.0	28.0	19.0	5044.3	28.3	178
1976	168.1	367.0	1028.1	-	104.0	70.0	26.0	24.0	53.0	4408.3	24.8	178
1977	274.1	496.3	1553.2	513.2	95.0	60.0	25.0	27.0	37.0	4575.2	28.6	160
1978	172.2	430.7	725.3	-	99.0	71.0	31.0	32.0	14.0	4671.9	27.0	173
1979	306.9	646.2	2539.1	842.1	80.0	60.0	30.0	17.0	55.0	5142.9	35.7	144
1980	275.2	886.2	1790.3	470.0	105.0	78.0	26.0	34.0	78.0	5046.4	31.3	161
1981	222.6	482.4	1307.5	222.6	90.0	66.0	30.0	31.0	70.0	4740.2	29.3	162
1982	228.0	429.2	988.2	228.0	106.0	71.0	32.0	38.0	66.0	4674.9	26.7	175
1983	435.6	789.4	2140.2	874.7	100.0	75.0	37.0	28.0	50.0	5791.4	38.1	152
1984	179.9	503.6	1356.6	-	98.0	71.0	29.0	19.0	32.0	4577.2	28.3	162
1985	127.5	387.4	586.7	-	110.0	70.0	30.0	28.0	51.0	4404.6	24.1	183
1986	220.5	614.5	1432.9	220.5	100.0	71.0	23.0	24.0	76.0	4511.6	27.3	165
1987	245.8	596.7	1289.2	683.9	91.0	61.0	30.0	41.0	60.0	4451.8	29.3	152
1988	219.6	570.8	1482.7	420.5	99.0	67.0	32.0	16.0	55.0	5082.6	29.2	174
1989	180.9	410.6	1103.2	180.9	100.0	68.0	23.0	18.0	40.0	4497.3	27.6	163
1990	317.7	752.2	1534.2	535.6	105.0	71.0	28.0	17.0	31.0	4949.0	29.3	169
1991	395.7	738.1	1158.7	681.6	112.0	79.0	29.0	43.0	43.0	5265.0	31.2	169
1992	347.2	603.7	1271.2	751.3	88.0	61.0	22.0	23.0	32.0	4176.5	27.3	153
1993	240.9	434.3	1049.5	461.1	93.0	56.0	33.0	23.0	32.0	4430.2	28.4	156
1994	327.8	695.3	1670.6	533.5	103.0	72.0	30.0	27.0	29.0	5208.8	29.6	176
1995	205.9	515.2	681.6	205.9	96.0	68.0	31.0	24.0	44.0	4198.1	24.4	172
1996	173.7	402.5	917.7	-	93.0	59.0	25.0	23.0	35.0	4024.3	23.8	169
1997	412.4	843.9	1813.1	1051.1	106.0	77.0	31.0	18.0	49.0	5680.3	34.0	167
1998	292.6	724.6	1361.8	846.2	89.0	63.0	24.0	21.0	42.0	4266.0	28.6	149
1999	362.7	825.3	1422.4	624.7	118.0	81.0	22.0	29.0	24.0	5006.0	25.8	194
2000	343.8	710.4	2035.0	1009.6	117.0	75.0	42.0	21.0	22.0	6266.8	34.4	182
2001	282.6	576.6	1728.3	282.6	116.0	82.0	25.0	18.0	26.0	5421.0	27.5	197
2002	168.3	464.2	1098.2	-	101.0	62.0	29.0	18.0	52.0	4383.8	25.1	175
2003	152.2	376.3	662.6	-	108.0	77.0	23.0	23.0	55.0	4322.5	25.7	168
2004	169.0	530.6	1479.7	-	92.0	59.0	25.0	20.0	58.0	4320.3	27.5	157
2005	170.7	548.2	1112.3	-	108.0	82.0	29.0	18.0	57.0	4842.6	28.8	168
2006	445.3	1361.6	2437.1	1254.6	114.0	79.0	41.0	29.0	29.0	6451.5	36.0	179
2007	408.0	634.0	1539.7	618.2	101.0	65.0	26.0	29.0	54.0	4850.1	27.9	174
2008	308.4	561.7	1302.4	507.3	103.0	63.0	25.0	23.0	74.0	4501.3	25.9	174
2009	338.9	910.0	1953.9	868.6	120.0	86.0	36.0	20.0	42.0	6105.0	33.5	182

Part 2 The temperature extreme indices

Year	TN90p	TX90p	TN10p	TX10p	WSDI	CSDI	TXN	TNX	TNN	TXX	DTR	Tmax	Tmean	Tmin
1970	0.0	0.0	2.7	8.0	0.0	0.0	27.0	25.2	19.3	33.3	8.1	31.1	27.1	23.1
1971	3.0	1.6	20.9	21.3	0.0	23.0	23.9	26.8	15.7	34.4	8.2	30.5	26.5	22.3
1972	5.3	2.3	16.2	9.7	0.0	6.0	24.5	27.8	14.3	35.4	8.3	31.1	26.9	22.7
1973	6.5	4.1	9.4	13.8	0.0	0.0	24.5	26.8	17.1	34.5	8.1	31	27	23
1974	4.2	1.6	21.4	26.2	0.0	0.0	25.0	27.0	15.7	34.6	8.1	30.6	26.6	22.5
1975	1.6	1.5	15.0	19.3	0.0	6.0	24.8	26.1	15.0	34.6	7.9	30.5	26.6	22.6
1976	3.7	1.6	21.0	25.6	0.0	9.0	25.5	26.2	15.0	34.1	8.0	30.6	26.6	22.5
1977	2.0	5.8	24.9	9.0	0.0	14.0	25.5	26.5	18.4	34.7	8.6	31.2	26.9	22.6
1978	7.6	7.7	10.5	7.4	0.0	9.0	25.2	26.9	17.6	35.0	8.3	31.4	27.2	23.1
1979	2.7	12.6	28.0	6.9	0.0	10.0	25.1	26.4	15.6	34.9	9.2	31.6	27.1	22.5
1980	13.6	7.4	5.1	6.9	0.0	0.0	25.5	27.2	16.2	34.4	8.1	31.5	27.5	23.4
1981	6.5	8.3	11.9	12.2	0.0	0.0	25.7	27.3	16.4	38.2	8.3	31.2	27.1	23
1982	7.9	7.6	9.9	8.5	0.0	0.0	25.3	26.4	15.8	35.4	8.4	31.4	27.2	23
1983	14.3	28.2	3.5	9.0	35.0	0.0	25.2	27.4	16.7	36.0	8.2	31.8	27.7	23.5
1984	11.9	10.2	4.0	5.4	12.0	0.0	24.5	27.8	18.1	34.7	8.2	31.7	27.7	23.5
1985	11.5	15.3	2.6	6.2	17.0	0.0	26.0	26.3	17.7	35.3	8.2	31.6	27.5	23.4
1986	10.8	3.0	4.1	10.8	0.0	0.0	25.0	29.0	17.9	34.1	7.6	30.9	27.2	23.4
1987	14.5	10.3	4.3	5.5	0.0	0.0	25.8	27.8	17.8	35.0	8.0	31.5	27.6	23.5
1988	17.6	5.6	4.4	8.4	0.0	0.0	25.3	27.0	17.6	34.6	7.6	31.4	27.6	23.8
1989	11.9	8.6	2.7	6.5	0.0	0.0	24.7	28.1	18.4	35.2	7.9	31.4	27.5	23.6
1990	19.9	19.6	1.3	5.7	0.0	0.0	25.5	28.8	17.8	35.4	8.0	31.8	27.8	23.8
1991	16.2	12.2	3.5	5.2	0.0	0.0	26.0	27.6	18.3	35.0	8.0	31.6	27.6	23.6
1992	14.9	13.9	4.4	6.2	0.0	0.0	25.6	27.0	18.5	35.6	8.0	31.7	27.7	23.7
1993	13.6	5.4	3.5	11.0	0.0	0.0	24.4	27.6	18.2	34.5	7.7	31.2	27.4	23.5
1994	11.1	12.2	2.1	10.5	13.0	0.0	25.0	27.3	19.2	35.4	7.6	31.2	27.4	23.6
1995	11.8	10.9	2.6	5.8	0.0	0.0	26.0	26.6	16.7	35.1	8.0	31.5	27.5	23.5
1996	3.5	11.9	14.3	8.8	0.0	0.0	25.8	26.0	16.7	34.8	8.5	31.5	27.2	23
1997	10.8	17.0	12.8	10.7	0.0	13.0	25.3	27.8	16.8	34.8	8.3	31.5	27.5	23.2
1998	18.3	36.9	31.6	5.7	24.0	92.0	25.5	27.0	18.5	36.1	9.1	32.2	27.6	23
1999	12.8	9.4	8.6	15.6	0.0	0.0	26.0	27.2	17.0	36.2	7.8	31.1	27.2	23.3
2000	11.5	8.1	4.9	7.4	0.0	8.0	25.7	26.4	18.1	34.8	8.1	31.7	27.6	23.5
2001	15.1	11.0	2.2	6.6	0.0	0.0	25.7	27.7	18.3	35.7	7.8	31.5	27.6	23.7
2002	15.1	13.4	1.9	6.3	0.0	0.0	25.6	28.4	18.4	34.9	7.9	31.7	27.8	23.8
2003	5.5	17.3	19.7	4.7	15.0	15.0	27.3	28.3	17.8	35.7	9.2	31.9	27.3	22.7
2004	12.1	23.0	5.2	6.0	15.0	0.0	25.3	27.7	17.8	36.1	8.4	32	27.8	23.6
2005	14.0	12.1	2.7	7.4	0.0	0.0	25.6	27.0	17.3	34.5	8.0	31.6	27.7	23.7
2006	11.8	25.8	0.3	5.8	34.0	0.0	25.7	26.8	18.5	35.7	8.3	32	27.8	23.7
2007	18.6	21.9	3.8	4.9	31.0	0.0	24.8	27.7	17.2	34.5	8.3	31.9	27.7	23.7
2008	15.9	18.9	2.7	7.1	31.0	0.0	26.4	27.8	19.3	35.3	8.2	31.8	27.2	23.7
2009	19.5	12.6	3.6	4.4	6.0	0.0	26.2	27.8	18.1	35.0	8.0	31.7	27.2	23.7

BIOGRAPHY

Miss Wanvicechanee Tanoamchard was born in Chonburi on 16 October 1978. In 2000, she obtained her Bachelor's Degree in Business Administration (BBA) with First class honors from Kasetsart University. During studying, she received four years scholarship for the outstanding academic results. In 2005, she earned Master's Degree in Business Administration with concentration on Human Resource and Organization Management (MBA-HRM) at Thammasat University. Since then, she has been working as a lecturer in Human Resource Management Program at Faculty of Management and Tourism, Burapha University.

Currently, she has been studying PhD in Environment, Development and Sustainability (EDS) Program at Chulalongkorn University. Her main research interest includes building capacity of human resources and climate change adaptation. During the study, she received research fellowships from the Graduate School, Chulalongkorn University and tuition scholarships from the Environment, Development and Sustainability (EDS) Program.

In the last year of her studying, she received fund from the Graduate School of Chulalongkorn University and the EDS program to present her research results at the 2nd International Conferences on Human and Social Sciences in Albania.