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The vulnerability of water resources management as a result of climate change in Chiang Rai province

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Abstract

This article provides an overview of a study undertaken in Bandu, Chiang Rai into potential climate change effects and the involvement of the community in water resource management to demonstrate the vulnerability of the area to cope with climate change related events such as flooding, etc. The Providing Regional Climates for Impacts Studies (PRECIS) model based on Scenario B2 was used to predict likely weather patterns and events. This modeling showed that for the period 2014 to 2023, there will be a tendency for average annual rainfall to increase by up to 86% over that shown in the historical records for the previous thirty years. Coupled with the increase in rainfall will be a rise in average maximum and minimum temperatures of 1 to 4 degrees centigrade. These increases in temperature and rainfall will impact on the water infrastructure's ability to cope with the demands. In this study, the researchers administered a survey questionnaire to the local villagers in the Bandu Municipal District, Chiang Rai. Analysis of the survey data reveals that the local people feel aware of the changes that are occurring in their communities but feel that they have no opportunity to participate in the planning and development of the water infrastructure. Consequently, this is likely to result in an increase into the severity of future disasters such as flooding. In response to this increase in severity, the communities will need to make preparations to respond to such events. This includes adapting their lifestyles to enable them to live with future changes.

Keywords: *climate change, flooding, rainfall, water resource management, vulnerability, Chiang Rai*

1. Introduction

Scientific evidence suggests that the climate has changed dramatically due to global warming. The Earth's atmosphere acts like a greenhouse that allows the heat from the sun to penetrate to the planet's surface but does not allow it to escape (Sukwan, 2008). The climate has changed due to both natural and human causes and is having an impact on the natural environment. The trend for climate change indicates that during the in season intervals both the maximum and minimum temperatures as well as the seasonal rainfalls will increase; but on the contrary during the offseason all these three parameters will decrease (Sributta & Saenjan, 2002).

Climate change has already resulted in increasing of severity and frequency of natural disasters such as floods, storms and droughts that affect the health and wellbeing of people as well as the ecological systems (Pleerux, 2013). Similar results have been documented about natural disasters in Bangladesh (Ali et al., 2015). According to these studies, people need to be prepared to face uncertain water and food supplies while experiencing an increase in natural disasters. Furthermore, the change in the climate is likely to cause the disappearance of local herbs that are commonly used in people's diets (Tangjitman, Wongsawad, & Trisonthi, 2015).

The climate change model developed by the Meteorological office of the United Kingdom is highly beneficial as it enables future climate predictions to be made (Chinvano, Laung-Aram, & Thanakitmetavut, 2009). It has been used to study the effects of global warming and climate change in the basin of the Chi and Mun rivers in the Northeast of Thailand. In this region, using the Providing Regional Climates for Impacts Studies (PRECIS) mathematical model, it was found that climate change would have a significant effect on plant growth (Palakit, Duangsathaporn, Siripatanadilok, & Lumyai, 2015). It is also found that the average temperature is likely to rise and the annual rainfall will increase. It is important that farmers understand the changing rainfall patterns for the dry and wet spells as well as the El Nino and La Nina phenomenon plus the normal rain events in order to know how best to manage the available water resources (Yuttaphan, Chuenchooklin, & Baimoung, 2015). More intense rain events will result in an increased risk of flooding if preventative measure are not prepared.

Srivichai has brought the Geographical Information System (GIS) in to the management, rehabilitation and preparations for future disasters by developing a map to the areas of areas at risk (Srivichai, 2013). This can then be used to develop guidelines for the mitigation and or the prevention of disasters in the future. The severity of disasters is due to many factors, vulnerabilities and incidents. If these factors are reduced, the intensity of the disasters can also be reduced, as shown in Figure 1.

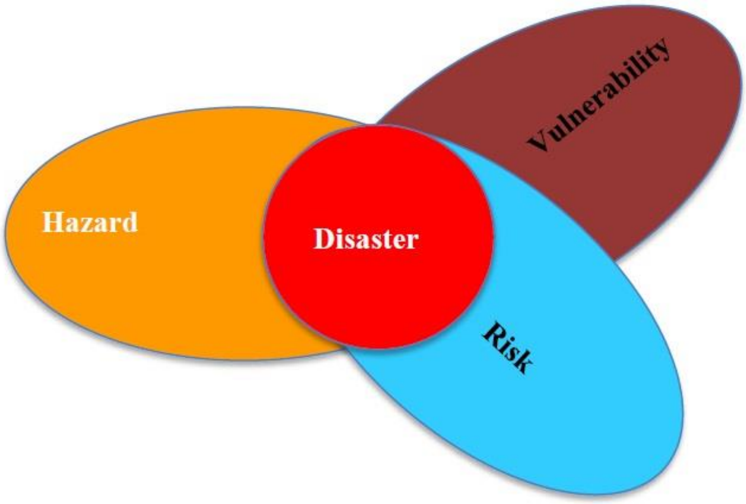

Figure 1 Severity factors of a disaster

Water is essential to life, for consumption, everyday household use, as well as industrial and agricultural activities. As the human population grows, there will be a greater demand for water. However, the available water resources will not be sufficient to meet this growing demand. A study by Prakongsri (2012) indicates that factors that increase water consumption include increasing population and the way people earn their livelihoods in communities. With the expansion of communities, existing diminishing in natural resources can cause a loss in the natural balance (Noommeesri, 2012). Water quality in various water resources has been reduced by human activity. It is necessary to improve the water quality to ensure it is safe for consumption.

Communities must be responsible for resource management (Pikul & Puchthonglang, 2013). A precise plan to manage resources efficiently, helps develop the communities and is beneficial to sustainable living (Tepsongkroh, et al., 2013). This research project aims to study the impact of climate change and the communities' participation in resource management, in order to reduce their vulnerability to the changing climate in the future.

2. Trends in climate change

Chiang Rai is located in the northern most part of Thailand, 416 meters above sea level, consists of 18 districts, and covers an area of approximately 11,680 square kilometres. The physical characteristic of Chiang Rai is an intermontane plateau with 30% of plain for cultivation, and 66% of forest. The climate is divided into three seasons: summer with a highest maximum temperature of 38.8 °C, from mid-February to mid-May; the rainy season with average rainfalls of 1287 mm, from mid-May to mid-October; and winter and from mid-October to mid-February with the minimum temperatures as low as 8 °C.

The study of climate change in this study starts from comparing data obtaining from the theory of climate models with the data of the Department of Meteorology by using the statistical correlation of data sets (R^2), which are collected by the Centre of Excellence for Climate Change (CCKM), Chulalongkorn University. Data from the two models, B2-PRECIS and A2 PRECIS are used to compare with data collected by the Meteorological Station of Chiang Rai. The information consists of the average monthly rainfall, the average maximum and minimum temperatures, and the average temperature. The readjustment for error in the model was done, by using the equation (1) – (2) to rectify the error of rainfall and the equation (3) – (4) to rectify the error of temperature. This information is used to analyze the trend of climate change and the results are shown in Table 1.

$$ki = \frac{Psimulated}{Pobserved} \quad (1)$$

$$P'i = \frac{Pi}{ki} \quad (2)$$

where

$P'i$ is the daily rainfall after the error was readjusted

Pi is the daily rainfall before the error was readjusted

ki is the Coefficient of the error readjustment

$$gi = Txsimulated - Txobserved \quad (3)$$

$$Tx'i = ki + Txi \quad (4)$$

where

T is the temperature in every decade

$Tx'i$ is the temperature after the error was readjusted

Txi is the temperature before the error was readjusted

gi is the adjustment of the error coefficient

Table 1 Data from the analysis of the relationship based on static equation

	R^2 1984-2012			
	Rainfall	The lowest temperature	maximum temperature	the average temperature
All year	B2-PRECIS=0.533	B2-PRECIS=0.677	B2-PRECIS=0.615	B2-PRECIS=0.581
	A2-PRECIS=0.510		A2-PRECIS=0.599	A2-PRECIS=0.581
Wet Season	A2-PRECIS=0.164	B2-PRECIS=0.607	A2-PRECIS=0.217	B2-PRECIS=0.450
	B2-PRECIS=0.158		B2-PRECIS=0.192	A2-PRECIS=0.434
Dry season	B2-PRECIS=0.410	B2-PRECIS=0.736	B2-PRECIS=0.709	B2-PRECIS=0.808
	A2-PRECIS=0.304		A2-PRECIS=0.692	A2-PRECIS=0.796

The analysis of the data as shown in Table 1, using static equation to find the relationship (R^2), B2-PRECIS shows the value of R^2 is the most reliable. Moreover, according to the mathematics principles of Chinvano et al. (2009), the future data sets of B2-PRECIS are arranged into a monthly form, divided into three decades of YR2014-2023, YR2024-2033, and YR2034-2043. This study also compares data and models collected by the Meteorological Station of Chiang Rai and makes some adjustments to the value of deviation for the accuracy of the data, as shown in Figure 2.

As illustrated in Figure 2, during the 30year base period the average annual rainfall is about 1695 mm/year. From the prediction of the model, in the decade of 2014-2023, the average annual rainfall is predicted to be about 3167 mm./year, with a trend increase of 86% over the 30 year base period. During June in this decade, the model predicts 1300 mm, the highest monthly rainfall. Moreover, in the decade of 2034-2043, the rainfall is predicted to drop back to 1745 mm/year, with an increasing trend of 3% over the 30year base period.

The lowest minimum average temperature during the 30year base period is 13°C for the months of December to February. During the decade of 2024-2033, the average minimum temperature is predicted to rise to 15°C, an increase from the 30year base period of about 1-2°C. Additionally, during the 30year base period, the average maximum temperature is about 35°C. In the future, from 2014 to 2023, 2024-2033, and 2034-2043, the average maximum temperature is predicted to be 42°C, 43°C and 43°C respectively, with an increase over the 30year base period of between 5-8°C. The overall average temperature for the 30year base period is about 25°C, while predicted to increase by 1-4°C, over the base period.

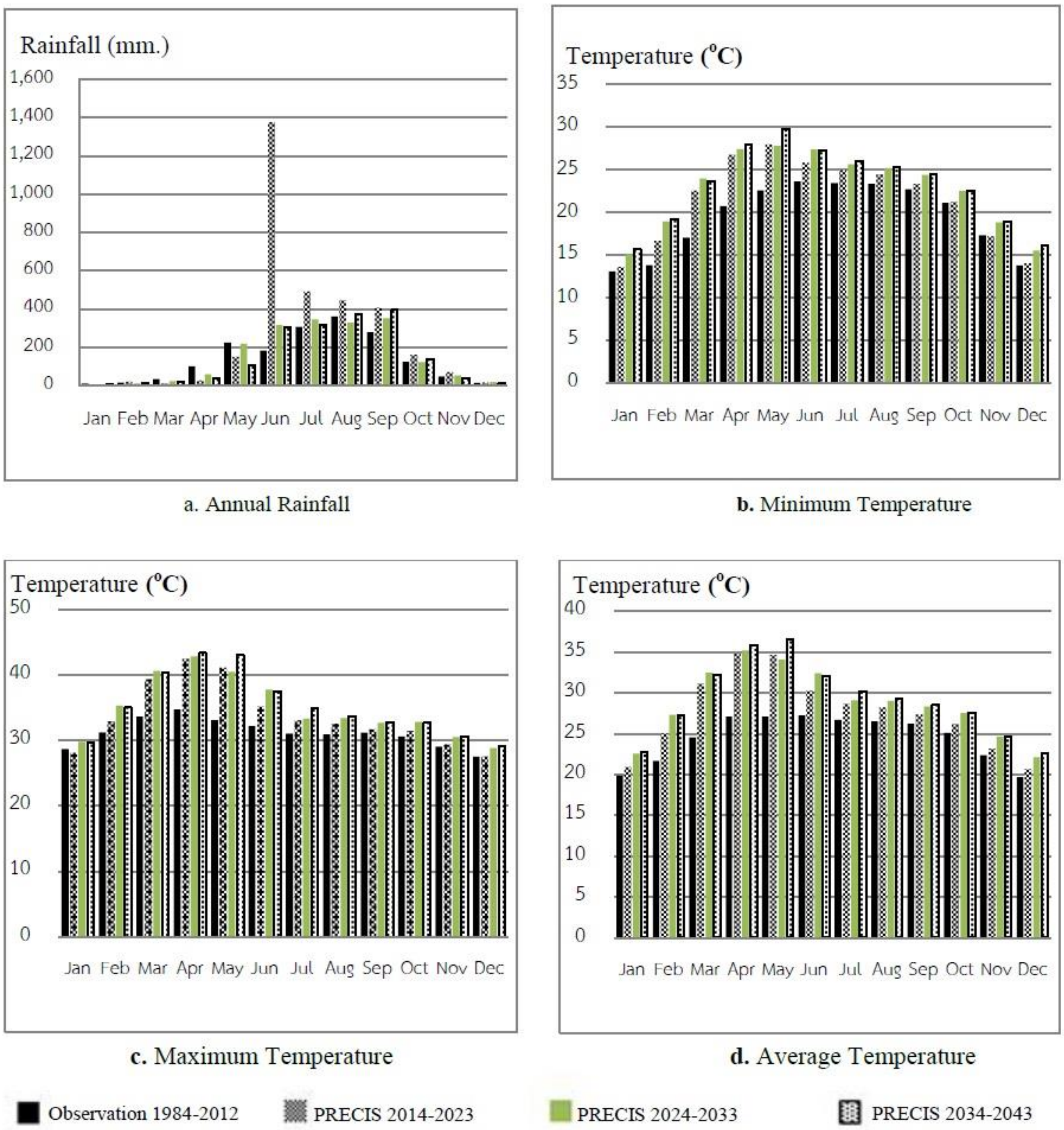

Figure 2 Graph from the comparison between data collected by the Meteorological Station of Chiang Rai and the model of B2-PRECIS

3. The vulnerability of water resources management

Bandu Municipal District, Chiang Rai, has 19 villages with a total of 14.79 km^2 of agricultural area, 4.23 km^2 of plantation area, and approximately 3.41 km^2 of farmland, an area for commerce, living spaces, and dormitories. These places have varying habits of using their water resources. Chiang Rai Rajabhat University is also located in this area. As a result, the area has been expanded progressively. The population has grown quickly and the changing lifestyle of the people from an agricultural to urban environment is increasing. The study was done by interviewing the local community leaders and sample groups of people in the area, (one person per household was selected, in a total of 400 households). Data was collected by interviews and questionnaires and statistically analyzed as shown in Table 2.

Table 2 Level of participation in water resources management

	ITEM	Mean	Standard Deviation	Results
1.	Water resource development activities	2.03	1.27	medium
2.	Planning water resources management	1.93	1.11	medium
3.	Satisfaction with the use of water resources	2.64	0.99	high
4.	Jealousy on water resources	2.92	0.90	high

Table 2 shows the participation of people in Bandu Municipal District in water resource management. With regards to the physical participation, the result is moderate with an average total of 2.03. Nonetheless, people tend to participate less in the planning of water resources management, with an average of 1.93. This is a result of a shift from agricultural communities where people participate in local meetings run by the village leader to urban communities where people are too busy to attend meetings. Even though the result is considered moderate, it implies that people are moving towards urban lifestyles rather than to traditional ones. Moreover, satisfaction levels with regards to drainage infrastructure and preservation are still high. As a result, it is necessary for local authorities to implement plans and/or policies to make people understand the importance of drainage infrastructure and that they have to help preserve them for such benefit of their communities.

4. The impact and how to cope with consequences

Catastrophic events that have occurred recently are in part due to the rise in global temperatures. These temperature rises affect the tropical climate areas with higher temperatures and humidity. Heavy rains in several areas of Chiang Rai have caused localized disasters; and the weather will become worsen in the future. From the climate model, it can be seen that preparing for changing weather circumstances is necessary. Both public sectors and local people need to adapt their life styles to prepare for these changes.

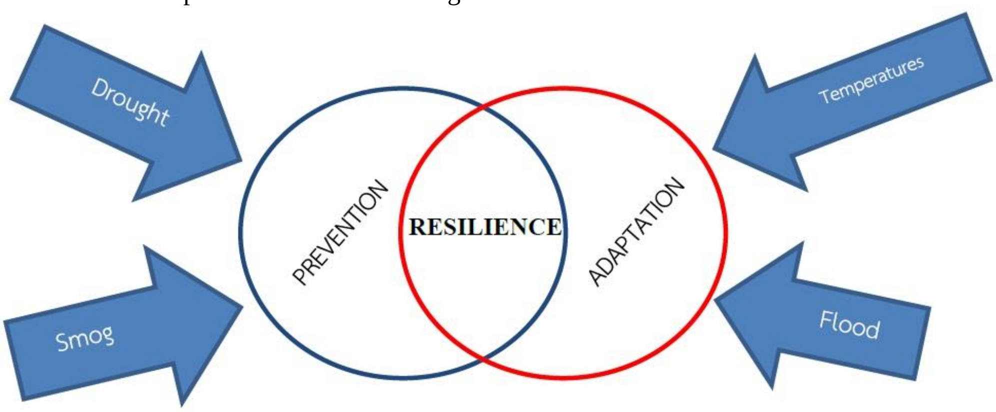

Figure 3 Resilience

The climate model also indicates less rainfall during the dry season which will increase drought periods, reduce surface water and groundwater that supplies wells resulting in a lack of water for domestic and agricultural uses. Low levels of humidity in the air and low soil moisture content caused by the dry weather heighten the risk of creating fires in forest and increasing smoke haze. The overall temperature will also increase by 1-4ºC, resulting in health problems, since food will rot more readily and could cause food poisoning, diarrhoea, increasing the spread of harmful bacteria and lower agricultural production with unsatisfactory quality. Moreover, increased rainfall during the rainy season will cause more frequent and more severe floods which will affect agricultural production and living areas while spreading disease and causing landslides.

In order to deal with this changing weather, it is necessary to have both hard and soft preventions for people to adapt their life styles and for local authorities to implement plans and managerial system to improve the quality of life. Examples are as below:

1. Practice new agricultural theory by dividing the and into 4 sections: 30% of water resources, 30% of paddy plantation, 30% of crops plantation, and 10% of living area. This new theory recommends a reservoir during the rainy season to save water for agriculture purposes throughout the year.
2. Build small dams in the forest areas to save water in the rainy season to retain moisture and maintain abundance of the forest during dry season. Moreover, trenches and canals should be cleaned to ensure drainage infrastructure works effectively for the communities.
3. Prepare an evacuation plan if disaster occurs, including contingencies to deal with the situation both during a disaster and afterwards.
4. Develop a healthcare system to manage and prevent expansion of diseases during disaster periods.

5. Summary of the study

The study aims to find the vulnerabilities within the water resource management in Bandu Municipal District, Chiang Rai. This area was chosen due to the changing demographics of the people and their life styles from agricultural to urbanised. According to the climate model PRECIS, in which all data was collected by the Center of Excellence for Climate Change (CCKM), the weather patterns are changing. The total rainfall is likely to increase during rainy season. This also causes the area to be vulnerable to flooding. Moreover, from the people's viewpoints about water resources management, it is important to help preserve water resources but they are unable to participate in the planning and development of the resources. This suggests deficiencies in the available human resources in relation to their water resources. Changing weather and geography might cause more severe disasters in the future; therefore, preparations are necessary for both the public sector and local people to help plan and develop their communities in order to live with these changes.

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