PRELIMINARY EVALUATING ENVIRONMENTAL HEALTH EFFECT OF CLIMATE CHANGE TOWARDS COMMUNITY ADAPTATION FRAMEWORK: A CASE STUDY OF MAHASARAKHAM PROVINCE, THAILAND

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Abstract

Thailand has already experienced on several impacts of global climate change which lead to various risks to Thailand's society and challenge the nation's development goals. This research investigated the climate change using the secondary data from the past 10 years in Maha Sarakham province. In terms of weather conditions, the significant climate change indicators including temperature, rainfall amount and seasons were examined to reveal the year-round temperature change of Maha Sarakham province. Comparing ten-year average temperatures from 2002 to 2012 with the ones from 2013, it was found that the highest temperature was 42 °C in both May 2003 and in April 2012. The lowest temperatures were 8.8 °C in January 2005 and 11 °C in December 2012. The reasons behind the natural disasters in the province were heavy rain which led to flooding many years ago, the lack of rain which resulted in draught, and alteration of seasons. In addition, the review of the results pointed out that the number of monthly rain days associated with the incidence rate of dengue fever and leptospirosis. The decrease of monthly rain days number during rainy season led to the higher temperature which enhanced dengue transmission, yet reduced Leptospira organism distribution in soil and water. The climate change adaptation framework in respect of community-based adaptation and vulnerability assessment is proposed. Towards the community adaptation to the infectious disease effects of climate change in Maha Sarakham province, the vulnerability assessment, especially in terms of socioeconomic condition and health risk knowledge, should be performed to complete the data base for the determinants of climate change adaptation. Then the data base can be used for designing the knowledge-based approaches and adaptation planning under climate change condition.

Keywords: climate change, environmental health, dengue fever, leptospirosis, adaptation, Thailand

INTRODUCTION

Climate change has significantly affected the world. Thailand will predictably be one of the most affected countries given its geography, economy and level of development (Mark, 2011). Thailand has already experienced on several impacts of global climate change which lead to various risk to Thailand's society and challenge the nation's development goals. In addition, the global climate change is linked to human health and influences the increase of the prevalence of non-communicable and infectious diseases. The climatic factors (e.g. air temperature, humidity, precipitation, extreme weather events etc.) can directly or indirectly affect the social and environmental determinants of health with the result of health vulnerability (Uzzoli, 2016). Appropriate climate and weather conditions are necessary for survival, reproduction, distribution and transmission of disease pathogens, vectors, and hosts. Therefore, changes in climate or weather conditions may impact infectious diseases through affecting the pathogens, vectors, hosts and their living environment (Epstein, 2001; World Health Organization, 2012; Baker-Austin et al., 2013; Vezzulli et al., 2016). The mitigation of climate change projects and its effects cannot be prevented completely. The Inter-governmental Panel on Climate Change (IPCC) scientists suggested that a combination of the strategy for reducing GHGs emissions and the adaptation to the impacts of climate change. The adverse effects of climate change can reduce by adaptation, which will work best if it is integrated into policies dealing with current climate related risks to ongoing sustainable development (Netherlands Red Cross, 2003; Ford and Pearce, 2010; Mortimore, 2010; Pearce et al., 2011; Lesnikowski et al., 2016). However, most countries have well established public policies to promote human health, still many have not yet prepared to cope with the range of problems regarding the consequences of climate change (Ulisses et al., 2015).

Maha Sarakham province is one of the provinces in the northeastern region of Thailand and lies on a plain of undulating and rolling areas with the altitude of 130-230 meters above sea level without mountains (Ongkosit, 2013). Some parts of it are placed on the Chi River Plain, which is one of the best rice-growing areas in Thailand (Maha SaraKham Provincial office, 2017). Unfortunately, there are many areas repeatedly flooded almost every year. During the monsoon season, flooding is one of the frequent natural disasters experienced by people on the plains of the Chi Watershed in Maha Sarakham and other provinces along the Chi River. In 2011, the Department of Disaster Prevention and Mitigation of Maha Sarakham reported that more than 60% of Maha Sarakham's total population were impacted as 6,860 houses and 99,356 acres of agricultural land were submerged (Ongkosit, 2013). Nevertheless, flooding is not the only problem since the province also suffers drought in the dry season every year (Ongkosit, 2013). The Ministry of Natural Resources and Environment (2012) had presented the flood and drought risk areas in Maha Sarakham province; however, there are limited reports on the impact of climate change in general and its impact to human health in Maha Sarakham province. Moreover, there is not a health promotion plan or policy concerning climate change effect in area approach. Therefore, this research aims to investigate the change of weather in the over past years to study how the changes of major climate variables affected environmental and health through reviewing the past years' climate data and examine the correlation of climate data and infection cases reported in Maha Sarakham province in order to identify possible adaptation guideline to improve current and future management of the burden of infectious diseases attributed by climate change, with a focus on area base approach. Furthermore, this review sheds light for future studies to respond, adapt, and prepare for the impacts of climate changes to health.

METERIALS AND METHODS

Study area

Maha Sarakham is one of the provinces in the northeast part of Thailand as shown in Fig.1, with an area of 2,043.112 square miles, bounded by Khon Kaen and Kalasin provinces to the north, Surin and Buriram provinces to the south, Kalasin and Roi Et provinces to the east, and Khon Kaen and Buriram provinces to the west. The province is mostly a plain covered with rice fields, only in the north and east are small hills. The major surface water resource in Maha Sarakham is the 765 kilometers long Chi river. Maha Sarakham's climate is classified as tropical. The rainy season is from May to October, and the dry season is from November to April. Maha Sarakham was chosen as the main research site because it has the large partly urbanized areas flooded repeatedly between 2000 to 2002 and there are the periodic flooding and drought area. (Kangrang et al., 2011). From 2005 to 2011, the water level of Chi River had increased and caused flooding in Kosum Phisai district in 2010 (Hydrology Irrigation Center for Upper Northeastern Region (Khon Kaen, Thailand), 2011). Therefore, it is the significant area to investigate the climate change phenomena and its effects on public health implication for the adaption to the climate change.

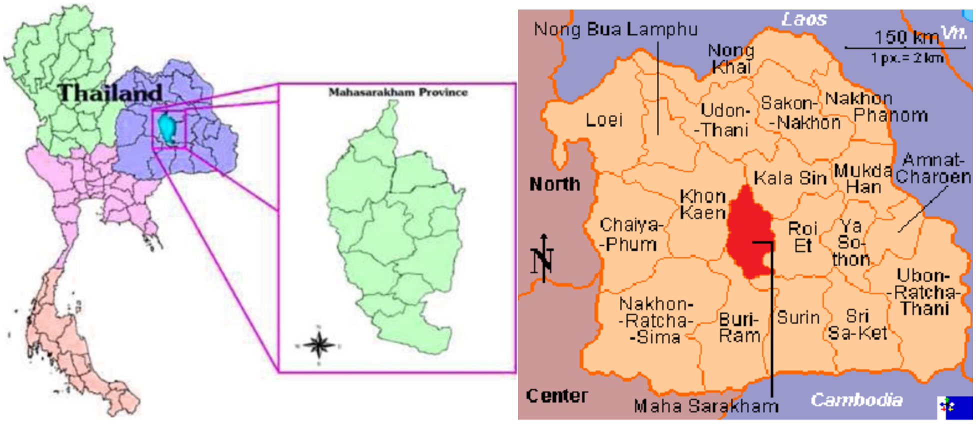


Figure 1. Location of Maha Sarakham province, Thailand (Kangrang et al., 2011)

Data Collection and analysis

Methodically, the framework of the hypothesized relationships between climate change or weather data, consequences of climate change and health impact, which proposed by WHO (Fig.2), was considered and reviewed (Morin et al., 2013). For secondary data collection, the long-term changes of the temperature and precipitation (rainfall) during the year 2002 to 2013 from The Thai Meteorological Department were obtained. In terms of the consequences of climate change, the data of floods and droughts from Disaster Mitigation Centre, Department of Disaster Prevention and Mitigation was collected. Then, the incidences of water-related vector-borne diseases, dengue fever and leptospirosis between 2002 to 2013 were collected from Maha Sarakham Provincial Public Health Office. The secondary climate data included monthly mean values of the maximum and minimum temperatures (in degrees Celsius), monthly precipitation (rainfall) amounts (in millimeters) and monthly numbers of rain days. The reason for using monthly parameters was that the incidences were too low at the weekly or daily scale. The average weather data from year 2002 to 2012 was selected to compare with the data of year 2013 to reveal the changes of climate. Data analysis was conducted for each independent variable, and cross-correlations were used to compute a series of correlations between the weather variables and the incidences of dengue fever and leptospirosis. (Hu et al., 2007, Hii et al., 2009, Honda, 2007). Lastly, the recommendations were provided for future research or community work to enhance performance leading to the adaptation for consequences of climate change in Maha Sarakham province.

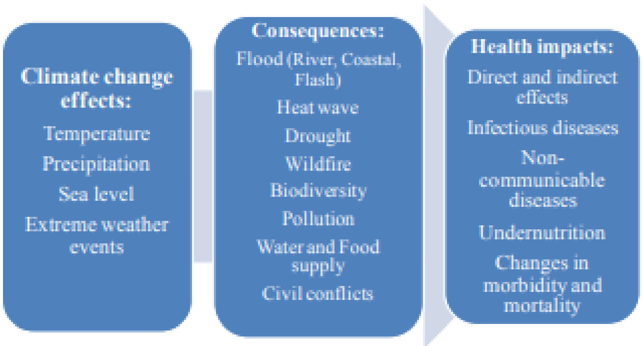


Figure 2. Potential impacts of global climate change on human health (Uzzoli, 2016)

RESULTS

Climate data

In terms of weather conditions, the significant climate change indicators including temperature, rainfall amount, humidity, and seasons were examined to disclose the temperature changes in Maha Sarakham province over the past years. Comparing ten-year average temperatures from 2002 to 2012 with the ones from 2013, it was found that the highest temperature was 42 °C in both May 2003 and in April 2012. The lowest temperatures were 8.8 °C in January 2005 and 11 °C in December 2012. Fig. 3 shows the average, highest, and lowest temperatures during the year 2002 to 2012 in comparison to 2013. The average temperature of 2013 was 27.5 °C which rose for 0.73% from the last ten years; in addition, the average monthly temperatures also shows the similar trend.

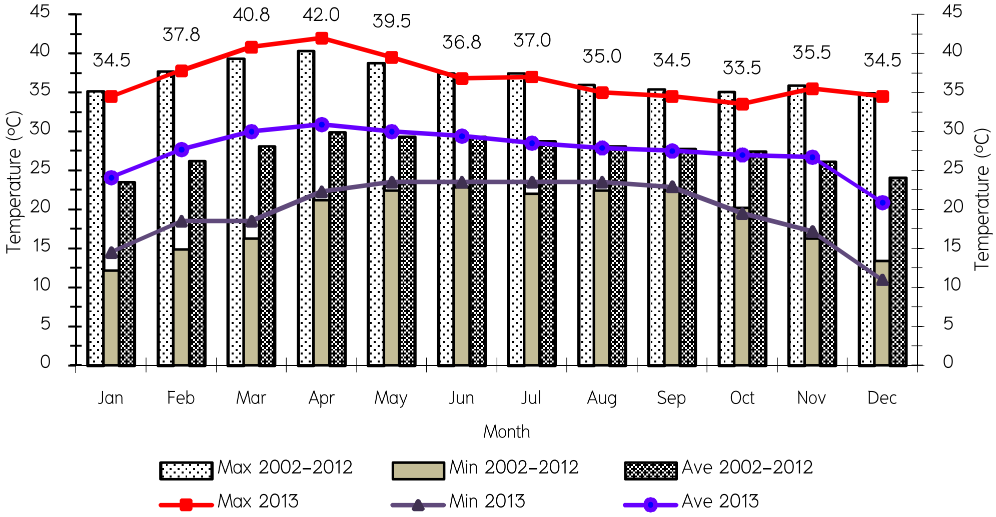


Figure 3. The comparison of average temperatures between 2002–2012 and 2013

The rainfall amounts from 2002 to 2012 were between 0.7–440 ml. The heaviest rainy period took place in September 2007 with 440 ml. of rainfall amount. In 2013, the highest rainfall amount was 330.5 ml. in September. The highest number of rain days was 27 days in September 2011, whereas in 2013, the highest number of rain days was 17 days. When the mean values of rainfalls amount and numbers of rain days from 2002–2012 were compared to the 2013's, it pointed to the decline of rainfall amount and rain days in most months as seen in Fig. 4 and 5.

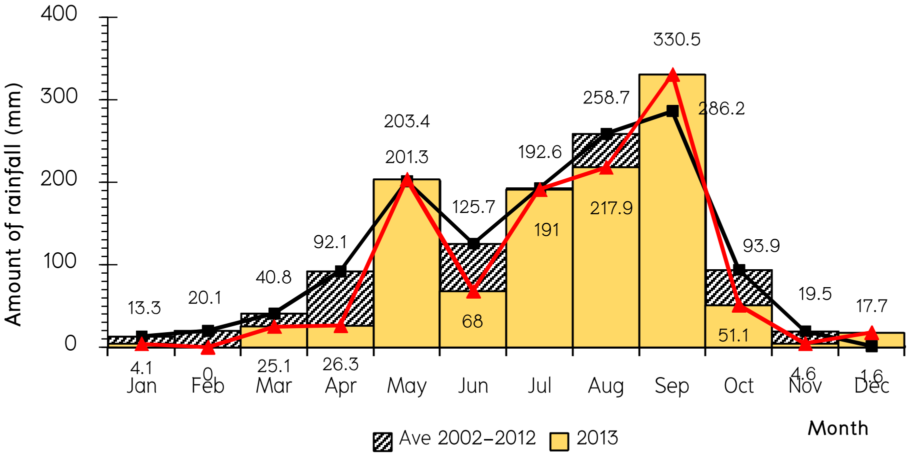


Figure 4. The comparison of average rainfall amounts between 2002–2012 and 2013

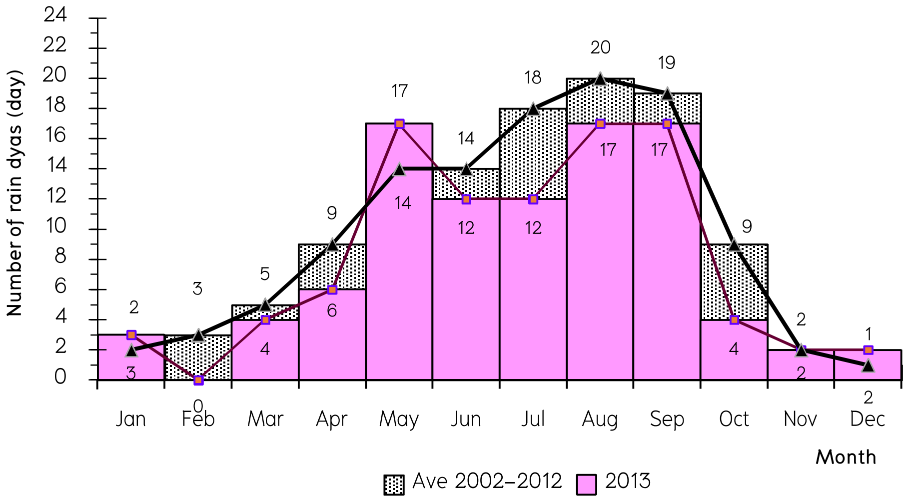


Figure 5. The comparison of average rain days numbers between 2002-2012 and 2013.

The effect of climate change

The drought risk will be explained as stated in the Ministry of Natural Resources and Environment (2012), the obtained records of drought areas between 2004-2008 from Disaster Mitigation Centre, Department of Disaster Prevention and Mitigation, and the annual reports from all the districts in the province. The drought risk is divided into 4 levels including high risk area, moderate risk area, low risk area, and unaffected area. Fig. 6 shows the evaluation of drought risk area for each sub-district in Maha Sarakham. It can be concluded that among all the 132 sub-districts in the province, 104 sub-districts are categorised as high-risk area, 7 sub-districts as moderate risk area, 9 sub-districts as low risk area, and 12 sub-districts as unaffected area. It means that the province faces with a considerate lack of water. Regarding the flooding in Maha Sarakham where most areas are rice fields, the areas next to the main distributaries in the province such as Chi river, Lam Sieow Yai, Lam Sieow Noi, and Law Tao are affected by drainage floods in the rice fields almost every year, namely, Mueung district, Kantharawichai district, and Kosum Phisai district. The cause was the continuous heavy rain which resulted in the high water level of Chi river during September to November in 2010-2011. Fig.7 reveals the flood risk map for Maha Sarakham.

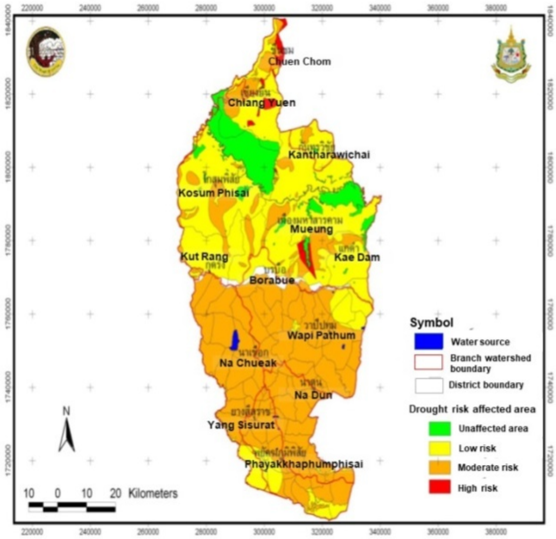


Figure 6. Drought risk map for Maha Sarakham province (The Ministry of Natural Resources and Environment, 2012)

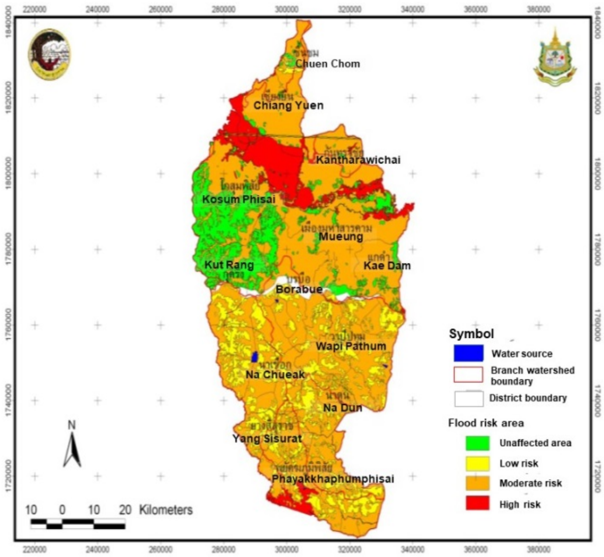
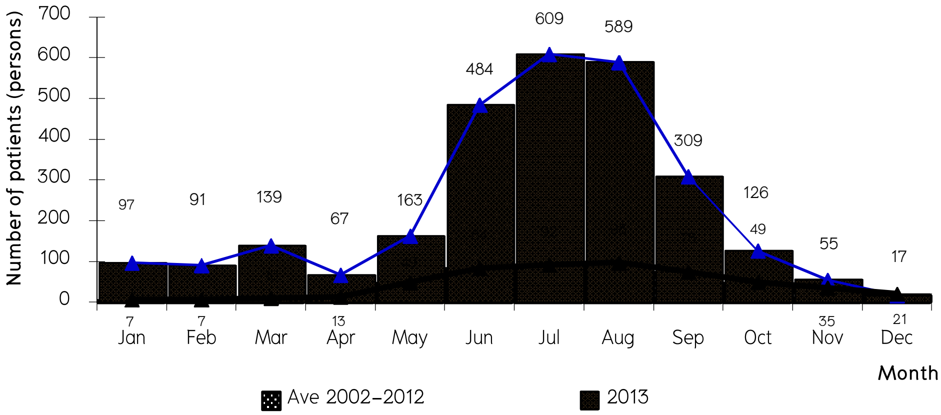


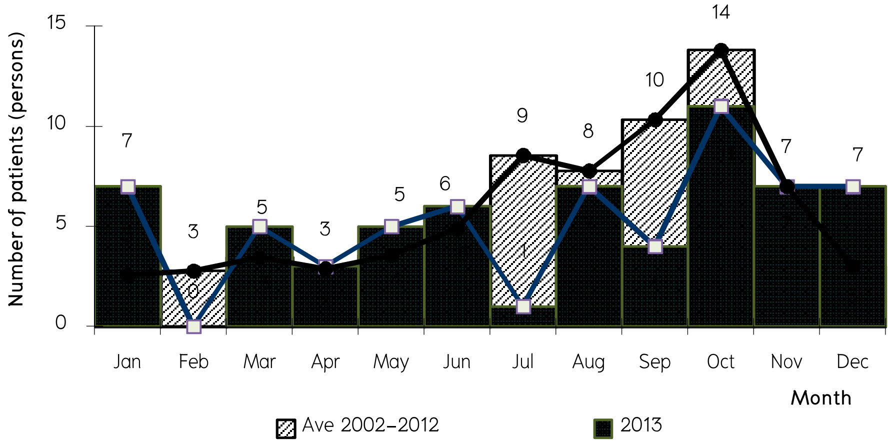
Figure 7. Flood risk map for Maha Sarakham province (The Ministry of Natural Resources and Environment, 2012)

Climate change and water-related vector-borne diseases

The data of water-related vector-borne diseases, dengue fever and leptospirosis during the year of 2002–2013 were collected from Maha Sarakham Provincial Public Health Office. The numbers of the dengue fever and leptospirosis patients per months were plotted then shown in Fig.8 (a) and (b), respectively. Considering the change in one-year period, the raising trend of dengue fever was found when comparing the average numbers of patients between 2002-2012 and 2013, while the numbers of leptospirosis patients was in vicinity. Furthermore, it was clear that the numbers of the cases for both diseases increased during rainy season (Middle of May – Middle of October). The maximum number of patients with Dengue fever, which was 609, was found in July before it dramatically decreased by the early of winter. Meanwhile, the maximum number of leptospirosis patients was found in October.



(a)



(b)

Figure 8. The numbers of (a) dengue Fever (b) leptospirosis patients during 2002-2013 in Maha Sarakham province.

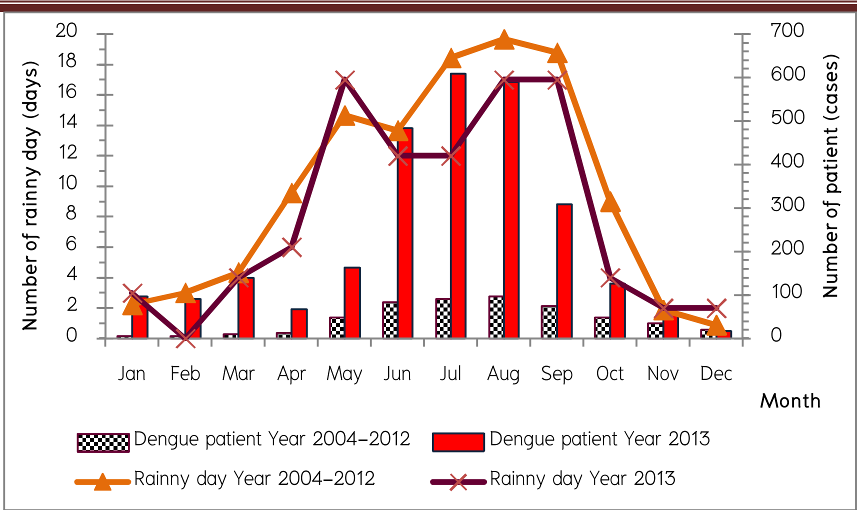


Figure 9. Plotting of numbers of dengue fever patients and monthly numbers of rain days in 2004-2013.

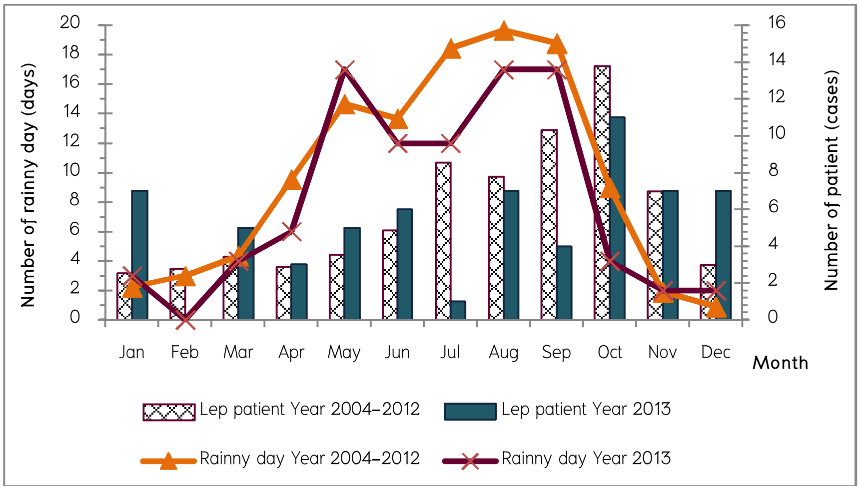


Figure 10. Plotting of numbers of leptospirosis patients and monthly numbers of rain days in year 2004-2013.

In order to study the effect of climate change to incidence rate of water-related vector-borne diseases, namely dengue fever and leptospirosis, respectively in Maha Sarakham province, the climate data which are the average maximum temperature (°C), amounts of rainfall (mm) and rain days versus the patient numbers of the diseases were plotted, and then the consistent correlation of the monthly number of rain days and the increase of incidence rate of the dengue fever and leptospirosis was indicated as shown in Fig.9 and 10, respectively. Fig.9 exhibits the rise of incidence rate in dengue fever once the rain season started and declined in winter. Furthermore, the incidence rate in year 2013 was much higher than the rate of the previous 9 years since the average monthly rain days number in 2013 decreased from the average number in 2004-2012. Unlike the incidence rate of leptospirosis, the decrease of the monthly number of rain days in year 2013 resulted in the lower incidence rate found.

DISCUSSION

This study aims to study the effect of climate change in terms of environmental health towards climate change adaptation framework in area – based approach. Changes in temperature and rainfall result in changes in soil moisture, increase of sea level and more extreme weather events such as floods and droughts which are among the most known impacts of global climate change (IPCC, 2001; WHO, 2009). According to the climate records including temperature, rainfall amounts, and numbers of rain days mentioned above, the fluctuation of rainfall that happened naturally may lead to short of water, drought, and flood in Maha Sarakham province. Drought could occur during the lack of rain during rainy season, especially in the area far from a water resource or even in the area next to a distributary. If the lack of rain continues for a long time, it could result in water scarcity. It can be seen from the ten-year and 2013 records that the average amount of rainfall and rain days tended to drop while the temperature increased, and the level of runoff also reduced (data not shown). For these reasons, it can be expected of future drought impacts caused by severe droughts due to climate change (Nam et al., 2015). These changes had an impact on drought and water scarcity in some areas of Maha Sarakham province. Regarding the flooding in Maha Sarakham, the cause was the continuous heavy rain which resulted in the high water level of Chi river during September to November in 2010-2011. Consequently, water from Chi River flooded into the agricultural areas as the dam in the river could not release the water quickly enough. This can be explained that the climate change leads to changes in global hydrological systems, resulting in changes in rainfall intensity and distribution, the consequent regional heavy rainfall results in river flow changes, which will probably exacerbate flooding and flood-prone urban area (Chiang, 2018). The modeling at the global scale suggests a warmer climate carries a greater risk of flooding (Hirabayashi, 2013) and it is noted that increase of intensity of rainfall under climate change is of significant societal concern regarding derived flood frequency correlated to rainfall (Hallegatte, 2013; Westra, 2014).

The climatic factors such as air temperature, humidity, rainfall, can directly or indirectly affect the environmental determinants of health (Uzzoli, 2016). Climate-related disturbances in ecological systems can indirectly impact the incidence rate of infectious diseases including vector-borne, water-borne (related), air-borne and food-borne diseases (IPCC, 2007; Wu et al., 2016). Three components are needed for the epidemiology of infectious diseases namely an agent (or pathogen), a host (or vector) and transmission environment (Epstein, 2001). Climate change may impact the survival, reproduction, or distribution of disease pathogens and hosts, as well as the availability and means of their transmission environment (Wu et al., 2016).

The cases of dengue fever and leptospirosis were reported in Mahasarakham during 2004-2013. From the attempt to find the climatic factor relating to the disease incidences, it was found that the monthly number of rain days affected the variation of the both disease incidences. The shorter period of rainfall in a month would probably result in the warmer temperature and extend the hot environment in rainy season. Previous work indicated that dengue epidemics have been associated with temperature and rainfall (Niash et al., 2014) especially, warming temperatures are related with the spread of the main dengue vectors such as Aedesaegypti and Aedesalbopictus (Murray et al., 2013) and the increase of dengue outbreaks (Niash et al., 2014). Temperature is important to the mosquito's life cycle and behavior, and its feeding behavior is also more frequent at the higher temperature leaning to the higher transmission risk (Ebi and Nealon, 2016). Similarly, in Thailand and Korea, the higher temperature significantly enhances dengue incidence rate of multiple blood feeding (Morin et al., 2013; Lee et al., 2018). As for leptospirosis, the decrease of monthly rain days resulted in reducing the leptospirosis case in Maha Sarakham province. During the rainy season, the soil accumulates moisture, creating small or large water pools which Leptospira organisms grow in the water-soaked soil (Chadsuthi et al., 2102). There is possibility that decline of monthly rain days can cause the hotter weather with the higher daily soil evaporation rate; therefore, the small or large water pools should be decreased. Moreover, the higher leptospirosis incidence rate was found after a long or heavy rainfall, which supported the previous studies that concluded that the high-intensity of rainfall and flooding associated with the reports of leptospirosis (Pappachan et al., 2004; Slack et al., 2006; Gubler et al., 2001; Brockmann et al., 2010, Chadsuthi et al., 2102). Additionally, the Incidence and Incidence rate (per 100,000 population) of dengue fever and leptospirosis in Maha Sarakham province were compared with Thailand's rate during 2007-2012 as shown in Fig.11. It clearly shows the increasing trend of incidence rate of both diseases and higher than the country's rate. This can be noted that climate change plays a crucial role in elevating the transmission of the diseases as discussed above.

Regarding the framework for community-based adaptation, the results of this study showed that flooding and drought in Maha Sarakham province were in accordance with climate change during 2004-2013. In terms of environmental health, the infectious diseases such as dengue fever and leptospirosis were reported to be epidemiological diseases in the same year duration. Towards the community adaptation to the infectious disease effects of climate change in Maha Sarakham province, the determinants of climate change adaptation (Fig.12) were considered. It has been shown that behavioral adaptations and changes in public health preparedness can reduce the incidence (Honda, 2007). Due to the limited amount of reports and lack of the literacy related to vulnerability and adaptation to climate change in Maha Sarakham province, the vulnerability assessment, especially in socioeconomic condition and health risk knowledge, is suggested to conduct for the framework of the future research and/or community work/literature work on adaptation to the infectious disease effects of climate change in this area.

Understanding the environmental drivers of leptospirosis infection is useful to effectively promote community awareness and hazard reduction and to build local capacity to prepare for the increasing risk of leptospirosis because of climate change (Lau et al.,2010). Similarly, socioeconomic and demographic factors relating to dengue transmission are social and demographic changes, economic status, human behavior and education (Naish et al., 2014). Health impact assessments are based on burden of diseases integrating socioeconomic factors to analyze health effects of climate change providing the comparable information in different geographic regions (Uzzoli, 2016) which useful to recognize that social and economic factors play a significant role in predicting the changing risk of infectious diseases caused by climate change because population and regions are more vulnerable to the elevated risks due to their lack of the ability to effectively respond to the stresses and challenges imposed by climate change (Wu et al., 2016). Hence, Knowledge-based approaches can increase awareness of hygiene and health and how to protect oneself as it pertains to epidemic control under climate change condition (Chen et al., 2012).

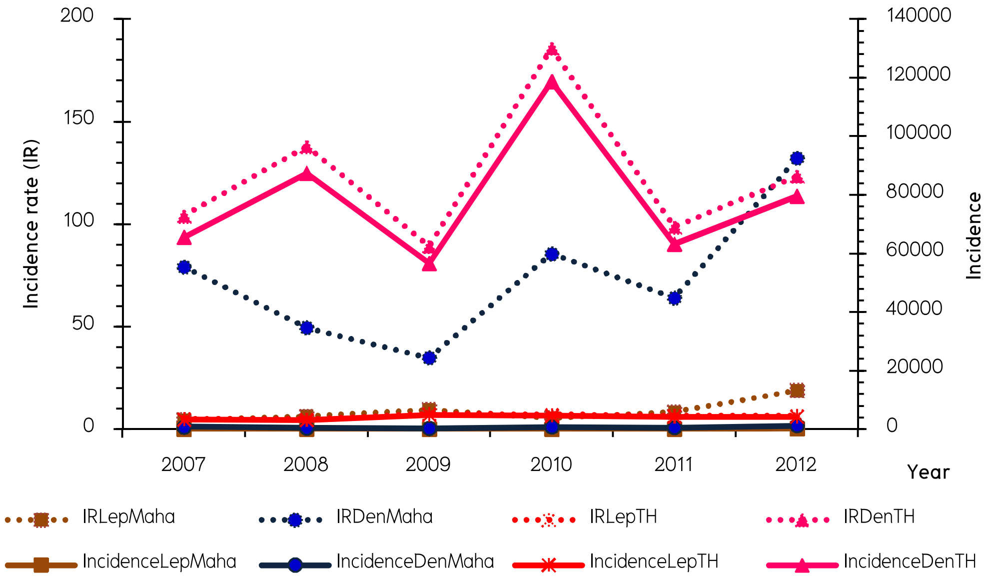


Figure 11. Comparison of Incidence and Incidence rate (IR) of dengue fever (Den) and Leptospirosis (Lep) in Maha Sarakham (Maha) province and Thailand (TH) (MOPH, 2007-2012).

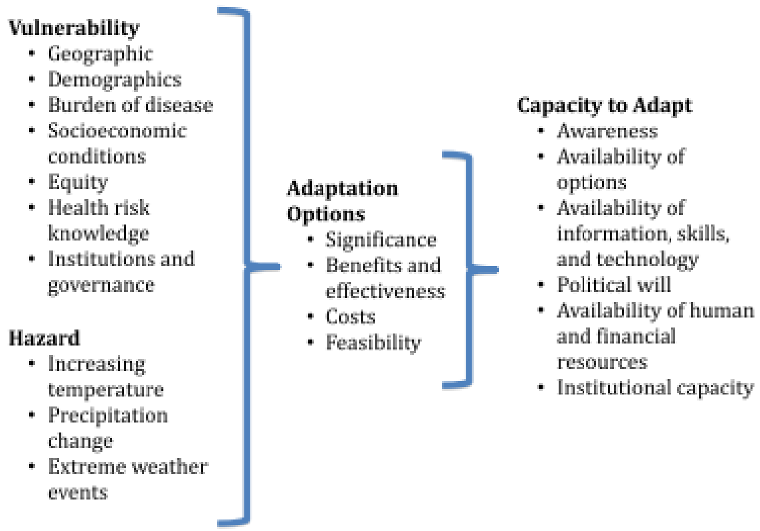


Figure 12. Determinants of climate change adaptation (Ebi et al, 2013)

CONCLUSIONS

This study aims to investigate the long–term climate change affecting environmental and health in Maha Sarakham province, Thailand. The climate data from 2002–2013; temperature and rainfall, flood and drought risks, and infection rates of dengue fever and leptospirosis were collected and reviewed. The review of results revealed the trend that temperature increased while rainfall decreased. In Maha Sarakham, its residents had been facing with natural disasters, mainly floods and drought due to climate change. The results indicated the connection between the monthly number of rain days and the incidence rate of dengue fever and leptospirosis since the shorter rain days bring about the warmer weather leading to more frequent feeding behavior of mosquitoes which causes the higher dengue transmission risk. On the other hand, the warmer weather resulted in reducing the leptospirosis cases due to the hotter environment does not support the water–soaked soils which is the habitat where Leptospira organisms grow. For a success of the community adaptation to the infectious disease effects of climate change in Maha Sarakham province, vulnerability assessment, particularly in socioeconomic condition and health risk literacy, are suggested to be conducted and collected in the data base to complete the determinants of climate change adaptation. Furthermore, the data base can be used to design the knowledge–based approaches and adaptation planning under climate change condition.

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