CHAPTER 2

Literature review

2.1. The Karen

2.1.1 Origin and migration

The Karen are the largest hill tribe in Thailand (Department of Social Development and Welfare, 2002). The central Thais call them "Kariang" while the northern Thais refer to them as "Yang" (Perve, 2006). Historians believe the Karen originated in the land of "Thibi Kawbi" which some have thought that it may correspond to where now are Tibet and the Gobi desert 2000 years ago (Lewis and Lewis, 1984; Ratanakul and Buruspat, 1995). Owing to conflicts between the Karen and Chinese army, the Karen migrated southward to the Yangtze River basin in China and Salween River basin in Myanmar. From that time onward, the majority of the Karen resides in Myanmar and some of them have continually migrated to Thailand for many centuries (Buruspat, 1975; Fuangfoo, 2003). Hence, there were two major migrations of the Karen from Myanmar to Thailand in the 18th century and 19th century due to the Mon (an ethnic group in Myanmar) and Myanmese war and the colonization war between Myanmese and English, respectively. At present, the Karen establish mainly along the Thai-Myanmese border.

2.1.2 Subgroups

Karen in Thailand can be divided into 4 subgroups based on their languages and ways of life.

1) Sgaw Karen

   The Sgaw Karen refer to themselves as 'Pg'a Kanyaw Sg'aw', which means the Sgaw people (Lewis and Lewis, 1986). They are the largest Karen group in Thailand (Perve, 2006) with more than 200,000 Sgaw

Karens. They settle mainly in Mae Sot district in Tak, Mae Sariang district in Mae Hon Son, Mae Chem district in Chiang Mai, Kanchanaburi, Ratchburi province and along the Thai-Myanmese border.

2) Pwo Karen

Pwo Karen are the second largest Karen grouop which is more than 80,000 individuals in Thailand (Lewis and Lewis, 1986). They settle in Omkoi district in Chiang Mai, Li district in Lam Phung, Chiang Rai, Lam Phun, Mae Hong Son, Phrae, Tak, Kanchanaburi, Ratchburi, Prachuapkhirikhan and Uthaitani province.

3) Kayah or Bwe

The Kayah Karen are called "Yang Dang" by northern Thai people. Their population is approximately 2,000 Karens in Thailand which is found mainly in Huay Suea Tao, Huay Duea and Khun Huay Duea village, Mae Hong Son province (Suriya, 1988).

4) Taungthu or Pa-O

Myanmese and Tai Yai people called them "Taungthu", which means hill tribe people (Pojanart, 1983). Traditional costume for Taungthu women is black dress, they therefore known as "black Karen". The Taungthu in Thailand are sparse which population less than 1,000. They settle in Mae Hong Son province.

2.1.3 Languages

Karen spoken language belongs to the Tibeto-Karen language group of the Sino-Tibetan family. Linguists categorized Karen languages as in the below chart.

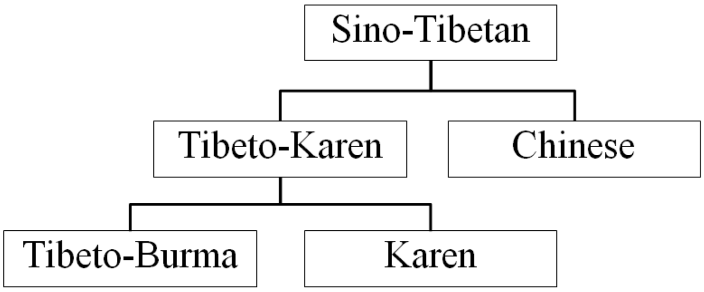

Figure 1 Sino-Tibetan language Family (Suriya et al., 1986)

Moreover, the Karen languages can be divided into four subgroups as in the below chart.

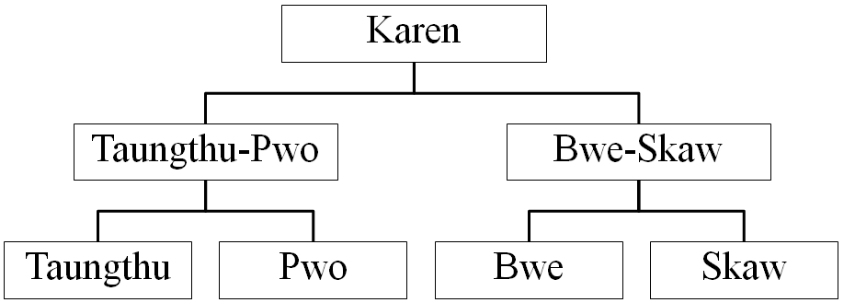

Figure 2 Group of Karen language (Pojanart, 1983)

2.1.4 Population

In present time, the Karen is the largest hill tribe in Thailand constituting 47.54% of the total hill tribe population corresponding to 437,171 Karens which are 221,380 men and 216,751 women (Department of Social Development and Welfare, 2002). They settle in 87,628 villages or 95,088 households in the provinces of Chiang Mai, Mae Hong Son, Tak, Chiang Rai, Lam Phung, Sukhothai, Lam Phun, Phrae, Kanchanaburi, Supanburi, Ratchburi, Prachuapkhirikhan, Uthaitani and Kamphaengphet particularly in Chiang Mai where the largest Karen population was found follow by Mae Hong Son and Tak province.

2.1.5 Traditional dress

The babyhood to marriage young girls wear a long white cotton dress (Figure 3), which may be decorated with pink or red stripes of varying width.

Married women wear a sarong made of two lengths of material sewn together and arranged to make a long skirt with a horizontal stripe in black, white or blue. They also wear a v-necked sleeveless blouse in black, green or dark blue color. Embroidered patterns or beads are used to decorate the tunics. Moreover, a cotton turban or a simple head-band may be worn on the head, though traditionally Karen women like to knot their long hair into a chignon on the crown of the head.

The men wear sleeveless, woven cotton shirts, with a deeper v-neck than the women’s blouses and decorated with red, white or yellow vertical stripes. They wear black or blue trousers, or sometimes a red or white sarong. Sometime the men cover their heads with a turban made from cotton or toweling.

Figure 3 Karen traditional costumes. Left white dress girls are single Karen women, middle black blouse women are married Karen, right is Karen man.

2.1.6 Societies

Karen society is matriarchal. The Karen are monogamous, and the family e.g. a married couple and their children, constitutes the social and economic base of the tribe. So each family or household contains only one or two generations, in contrast with most of the other hill tribes, where there will be three or four generations in one house (Perve, 2006).

In each village, there is a priest (the *Sapwa hi akhu* in the Karen language) who inherited the priesthood from generation to generation in family lineage. He is responsible for maintaining harmony between the world of the living and the world of the spirits, who are largely appeased by offering which have to be made in accordance with precise rituals. The village's leaders include the shaman who is knowledgeable in spirit ritual, the medicine man that is knowledgeable in herbal medicine, the priest and the village headman who is elected by the villagers as a response to the modern time government.

2.1.7 Religious beliefs

Most Karens are animists and believe in the existence of a Lord of the Earth and Water who is the master of virtually all natural phenomena. However, in the 20th century many Karen were converted to Christianity by Western missionaries. Others, particularly those living in lowland areas of Thailand have converted to Buddhism (Lewis and Lewis, 1986).

Animist Karen believe that the world is inhabited by many different kinds of spirits, including lineage or ancestral spirits, and spirits of places and objects. They conduct routine ceremonies to appease these spirits. Moreover, they make special sacrifices to a specific spirit if diagnosis determines that spirit has caused an illness. Moreover, Karen believe in ancestral spirit. Each family has ancestral spirit which ensures the protection of all the members. It is honored once a year at a ceremony officiated over by the oldest woman in the community. All the members of the community have to attend this ritual, dressed in Karen costume, and to divide up and eat the pigs and chicken which are sacrificed (Perve, 2006).

However, there are many taboos, the violation of which can cause illness or misfortune, for example the taboo on marriage between certain classes of close relative.

2.1.8 Village, houses and ways of life

Karen villages are usually made up of about twenty houses (Lewis and Lewis, 1986). The villages are normally sited at lower altitudes than those of other hill tribes. Many of them are in valleys or on low hills not above 500 meters high. However, the Karen move less frequently, and this allows the inhabitants to undertake longer-term farming projects.

Figure 4 Karen village on mountain.

Karen houses are usually built on stilts (Perve, 2006). The walls are made from bamboo, split in half, and the roofs are covered with thatched reeds or large leaves (Figure 5). The height of the posts used for the stilts varies from 2 to 3 meters. The house has a large veranda running around it, which is partially roofed over and used for cooking and weaving, and a single large room, at the center of which is the hearth. In the evening, the family sleeps on mats on the floor. A screen is put up to give some privacy to adolescent girls.

Figure 5 Karen house

Karen households traditionally depend on rice, grown on swiddens or irrigated paddies, as the staple subsistence crop. Swiddening has traditionally been practiced on a rotation system, cultivating for one year and fallowing for about five to nine years. Recent population increase, government restrictions on use of highland areas and reforestation projects have increased the pressure on land, and fallow times have been reduced to as short as three to five years. They also grow vegetables and many kinds of fruit plants. Animal husbandry is variously practiced and includes the raising of chickens, pigs and cows. Their income is obtained from gathering and selling forest product, being labor in Hmong and or northern Thai fields or selling livestock and orchard products (Hayami, 1993), and their economic status is poor.

2.2 The studies of medicinal plants used by Karen people

Studies of plant utilization have been going on for at least a century. However, studying how people of a particular culture or region make of use of indigenous plants is called ethnobotany (Veilleux and King, 2010). Ethnobotanical studies have become increasingly valuable in the development of health care and conservation programs in different parts of the world (Balick, 1996). Particularly, medicinal plants used by ethnic groups are widely studied.

Additionally, there are several recorded of medicinal plants used by the Karen mainly in Thailand. For example, Trisonthi and Trisonthi (2009) reported the study of traditional plants used by the Karen in Khun Yuam district in Mae Hong Son province. Eighty-five medicinal plants were found and organized into use categories. There are some interesting medicinal plants in this study such as medicinal plants for tonic are *Miliusa thorelii* Finet& Gagnep., *Polygala chinensis* L. and *Bauhinia nervosa* Bak. Moreover, *Phyllanthus emblica* L. is the interesting plant which used for relieving cough. *Picrasma javanica* Blume and *Acorus calamus* L. are used for relieving fever. *Mahonia siamensis* Takeda is used for antidiarrhea. *Sambucus javanica* Reinw. is used for bone fracture. *Caesalpinia sappan* L. is used for antianemic. *Zingiber ottensii* Vale is used for postpartum and *Thunbergia coccinea* Wall. is used for detoxification.

Furthermore, there are some Karen traditional medicinal plants records in Chiang Mai province. Surveys such as that conducted by Winijchaiyanan (1995) have shown that the Karen in five villages in Chiang Mai province (Ban Mae Lord Tai, Ban Pha Taek, Ban Mae Hae Nua, Ban Huey Tong, and Ban Thung Luan) use 158 plant species for medical proposes. Most medicinal plants are utilized for simple illness. It has also been reported that there are differences between the use patterns and plant species for curing various illnesses. Some interesting medicinal plants used by the Karen including medicinal plants for tonic are *Asparagus filicinus* Buch.-Ham., *Betula alnoides* Buch.-Ham., *Elephantopus scaber* Linn., and *Hiptage bengalensis* Kurz. Other used species include *Careya sphaeriea* Roxb. (for burn injury), *Vernonia volkameriaefolia* Wall. Ex DC. (for jaundice), *Zizyphus cambodiana* Pierre (for kidney stone), *Hedychium flavum* Roxb., *Ochna integerrima* Merr. and *Plumbago indica* Linn. (for women recovering after labor). Furthermore, the study of medicinal plants at Ban Angka Noi, and Ban Mae Klangluang, Chomthong District, Chiang Mai province were reported 30 medicinal plant species used by the Karen. They are classified into 28 genera 26 plant families. Most of them are utilized for tonic and curing wound. The interesting medicinal plants are *Asparagus filicinus* Buch.-Ham. (for tonic), *Costus speciosus* Smith (for eye tonic), *Xantolis cambodiana* (Pierre) Baehni (for galactogoque), *Gnetum montanum* Markgraf (for cough and sore throat), *Melastoma* *malabathricum* L. (for mouth ulcer), *Schima wallichii* Korth. (for cold) and *Scoparia duclis* L. (for wound) (Puling, 2001). Besides, Pongamornkul (2003) investigated the traditional uses of plants by Karen in Chiang Dao District, Chiang Mai province. He reported 52 plants species were utilized as medicinal plants. The interesting medicinal plant is *Miliusa velutina* (Dunal) Hook.f. & Thomson which (for muscular pain and dental disorders), *Phlogacanthus curviflorus* Nees (for dysuria), *Cassia tora* L. (for headache), *Anogeissus acuminata* (Roxb.ex DC.) Guill&Perr (for diarrhea), *Terminalia chebula* Retz. (for cough), *Croton roxburghii* N.P.Balakr (for postpartum recovery), *Scoparia dulcis* L. (for kidney stone) and *Harrisonia perforate* (Blanco) Merr. (for toothache). Besides, Sukkho (2008) reported the study of medicinal plants used by Karen people in Mae Chaem district, Chiang Mai province. There are 183 medicinal plant species belong to 71 families and 141 genera were either found in forest or were cultivated in home garden and agricultural fields. The important medicinal plant used by Karen people are *Acorus calamus* L. (used to decrease fever), *Senna alata* (L.) Roxb. (for skin disease), *Archidendron clypearia* (Jack) I.C.Nielsen (for sore eye), *Zingiber ottensii* Valeton (for carminative), *Caesalpinia sappan* L. (for menstrual disorders and maternity problem), *Sambucus javanica* Reinw. ex Blume (for bone fracture), *Paris polyphylla* Sm. (for wounds), *Embelia sessiliflora* Kurz (for killing intestinal worms), *Aporosa villosa* (Wall. ex Lindl.) Baill. (for detoxification), *Plumbago indica* L. and *Plumbago zeylanica* L. (for backache, painful joints), *Punica granatum* L. var. *granatum* (for diarrhea), *Ricinus communis* L. (for menstrual disorders and dizzy), *Curcuma longa* L. (for gastric problem), *Inula cappa* (Ham.) DC. (for maternity problem). Moreover, Kamwong (2009) reported that there are 206 medicinal plants species used by the Karen at Ban Mai Sawan and Ban Huay Pu Ling, Ban Luang sub-district, ChomThong District, Chiang Mai province. The interesting medicinal plants are *Ochna integerrima* Merr. and *Celastrus paniculata* Willd. (for jaundice), *Betula alnoides* Buch.-Ham., *Hiptage benghalensis* (L.) and *Elephantopus scaber* L. Kurz (for tonic), *Equisetum debile* Roxb. ex Vaucher (for urethral stones), *Phlogacanthus curviflorus* Nees (for amenorrhea), *Ensete glaucum* (Roxb.) Cheesman (for beriberi), and *Duabanga grandiflora* (Roxb. ex DC.) Walp. (for diabetes).

2.3 Chiang Mai Province

Chiang Mai province is located in northern Thailand (18° 48′ 0″ N, 98° 58′ 48" E) at 310 meters above sea level (Asavachaichan, 2010). The width from the east to the west is about 138 kilometers and the length from the north to the south is about 320 kilometers. Surrounded by high mountain ranges, it covers an area of 20,107 km². The majority of Chiang Mai (70%) is cover with forest. Farmland or croplands and others cover 13% and 17% of the total area, respectively (Department of provincial administration, 2010). The major types of forests in Chiang Mai are mixed deciduous forest, tropical ever green forest and dry dipterocarp forest. Several national parks are also located in the province (Table 1, Figure 6). Chiang Mai, therefore, is an area with high natural resources and biodiversity of Thailand.

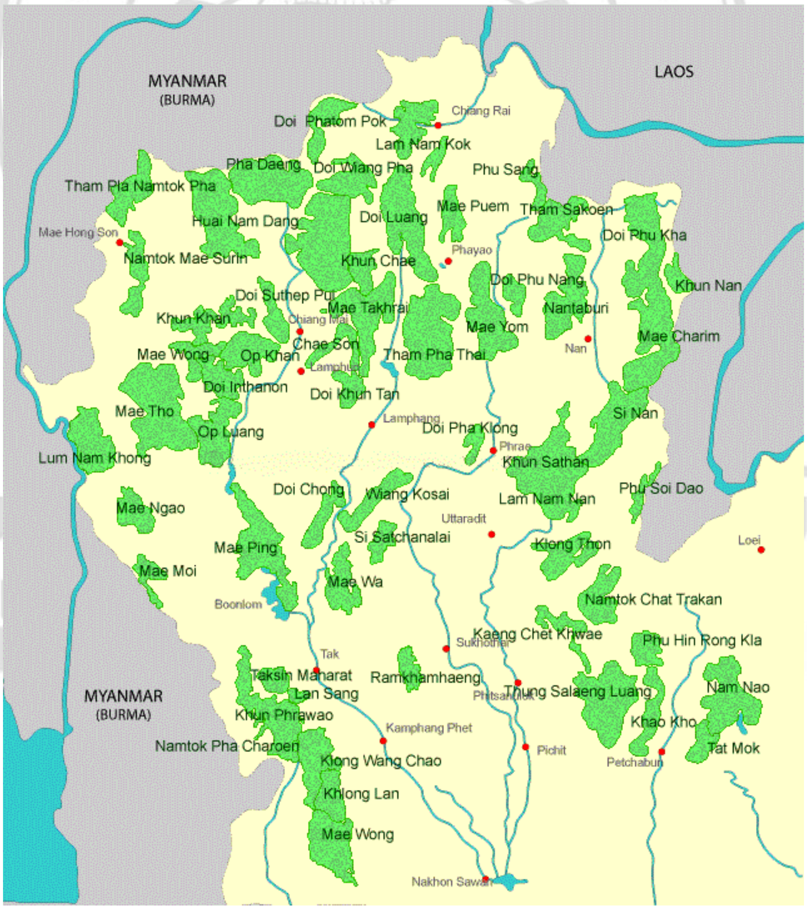

Figure 6 Nation parks in northern Thailand (Maps-Thailand, 2014)

Table 1 List of national park in Chiang Mai province

Name	Area (km^2)
Sri Lanna	1,406
Huay Nam Dung	1,252
Pha Daeng	1,155
Mae Ping	1,003
Op Lunang	553
Doi Pha Hom Pok	524
Doi Inthanon	482
Doi Suthep-Pui	261
Khun Khan	208
Mae Wang	120

Chiang Mai province is the second largest in Thailand and the city of Chiang Mai is the second biggest city in country. The province includes 25 districts, 204 sub-districts, and 2,066 villages. The districts in Chiang Mai province are Mueang Chiang Mai, Chom Thong, Mae Chaem, Chiang Dao, Doi Saket, Mae Taeng, Mae Rim, Samoeng, Fang, Mae Ai, Hot, Phrao, San Pa Thong, San Kamphange, San Sai, Hang Dong, Doi Tao, Omkoi, Saraphi, Wiang Haeng, Chai Prakan, Mae Wang, Mae On, Doi Lo, and Kallayaniwattana (Asavachaichan, 2010).

Chiang Mai province contains the highest population of hill tribe population in Thailand. The largest hill tribe is the Karen with a population of 138,447 out of a total ethnic groups population of 322,709 in Chiang Mai province. The Karen reside in 670 villages, 56 sub-districts, and 18 districts in Chiang Mai province. The districts where the Karen live are occupied by Karen are Chom Thong, Mae Chaem, Chiang Dao, Doi Saket, Mae Taeng, Mae Rim, Sa Moeng, Fang, Mae Ai, Hot, Phrao, Doi Tao, Omkoi, Wiang Haeng, Chai Prakan, Mae Wang, Mae On, Doi Lo, and Galyani Vadhana (Department of Social Development and Welfare, 2002).

2.4 Climate change

Currently, climate change has a profound effect for many organisms throughout the world. It results from increase in anthropogenic green house gases (GHG) emission into the atmosphere which is corresponding to CO_2 which produced from using of fossil fuel, biomass burning and deforestation, CH_4 (methane) produced from livestock, wet rice paddy field, different fermentation processes or (agriculture) energy and waste, N_2O (nitrous oxide) produced due to human activities in agriculture (use of ammonia based fertilizer) and combustion of hydrocarbon fuel and F-gases (includes hydroflurocarbon, sulpherhexafluoride, perfluorocarbon, etc.) produced from industrial activities, use of old air conditioners and refrigerators (Ravindranath and Sukumar, 1998; IPCC, 2007). Moreover, it has been reported that the total anthropogenic GHG emissions have continued to increase over 1970 to 2010 (IPCC, 2014). Annual GHG emissions grew on average by 1.0 gigatonne carbon dioxide equivalence ($GtCO_2eq$) (2.2%) per year from 2000 to 2010 compared to 0.4 $GtCO_2eq$ (1.3%) per year from 1970 to 2000 (Figure 7). Beside, total anthropogenic GHG emissions reached 49 $GtCO_2eq$/yr in 2010. Of the 49 $GtCO_2eq$ emissions in 2010, 25% of GHG emissions were released in the energy supply sector, 24% in agriculture, forestry and other land use (AFOLU), 21 % in industry, 14% in transport and 6.4 % in buildings (Figure 8).

To mitigate this problem, there are cooperation between scientists and World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP) to establish The Intergovernmental Panel of Climate Change (IPCC). Its main focus is to provide the world with a clear scientific view on the current state of climate change and its potential environmental and socio-economic consequences (IPCC, 2010). The IPCC (2013) reported that the globally averaged combined land and ocean surface temperature data as calculated by a linear trend, show a warming of 0.85 (0.65 to 1.06) °C, over the period 1880 to 2012 (Figure 9 and 10). The rate of warming over the last half of that period was almost double that for the period as a whole. Moreover climate model projections summarized in the latest IPCC report indicate that the global surface temperature will probably rise a further 1.0-7.8 °C during the 21st century (IPCC, 2014).

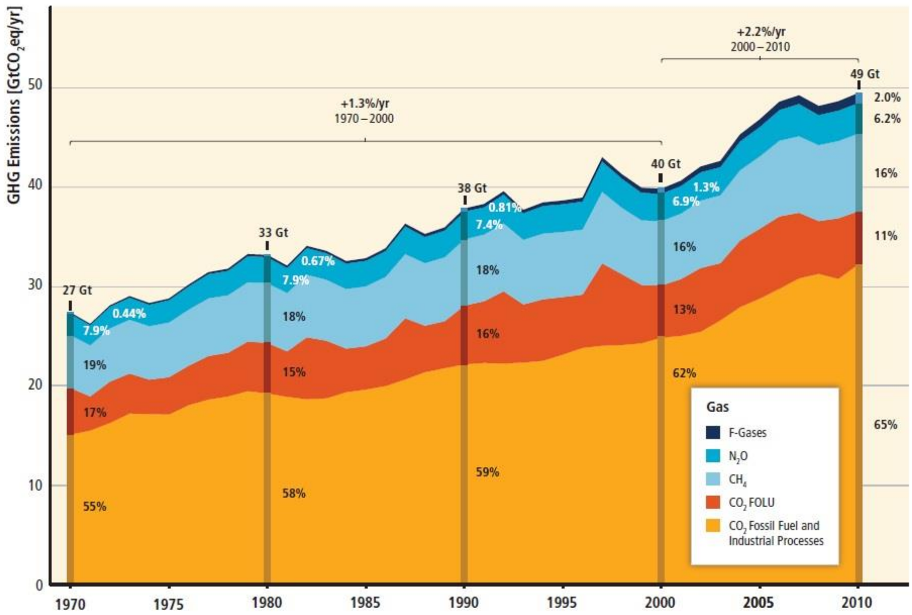

Figure 7 Total annual anthropogenic GHG emissions by groups of gases 1970-2010: CO_2 from fossil fuel combustions and industrial processes; CO_2 from forestry and other land use (FOLU); methane (CH_4); nitrous oxide (N_2O); fluorinate gases (F-gases) (IPCC, 2014).

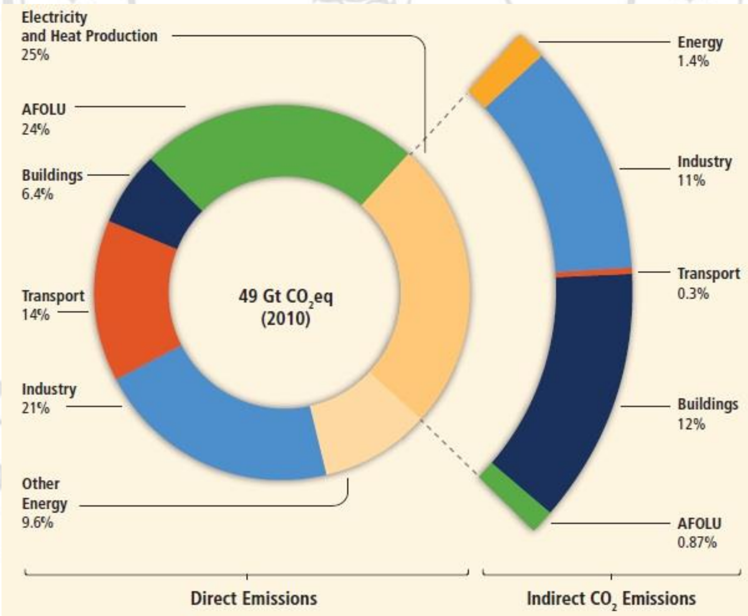

Figure 8 Total anthropogenic GHG emissions by economic sectors. Inner circle shows direct GHG emission shares (in % of total anthropogenic GHG emissions) of five economic sectors in 2010. Pull-out shows how indirect CO2 emission shares (in % of total anthropogenic GHG emissions) from electricity and heat production. AFOLU = agriculture, forestry and other land use (IPCC, 2014).

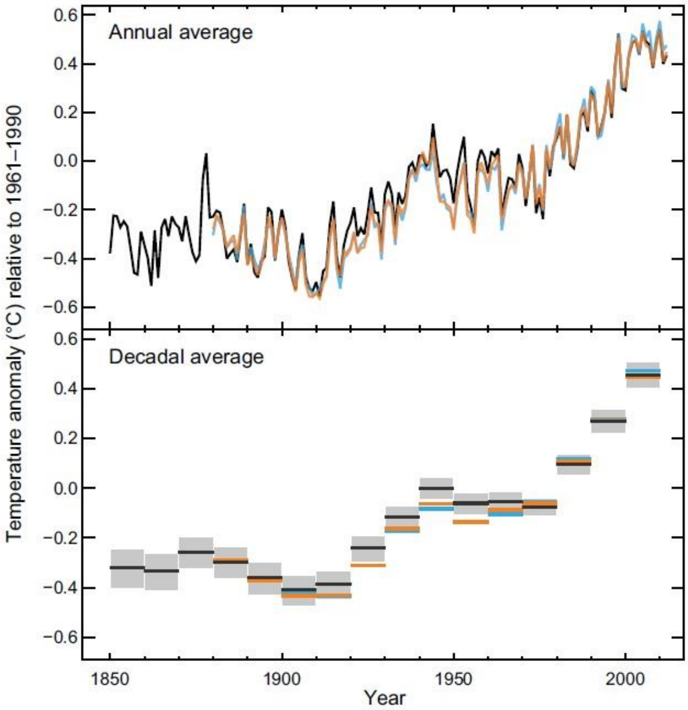

Figure 9 Observed global mean combined land and ocean surface temperature anomalies, from 1850 to 2012. Top panel: annual mean values. Bottom panel: decadal mean values (IPCC, 2013)

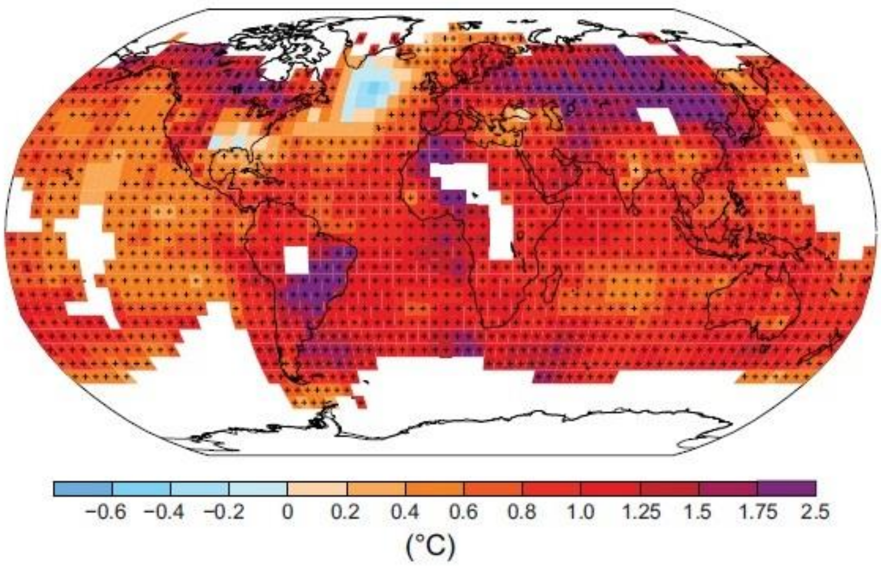

Figure 10 Map of the observed surface temperature change from 1901 to 2012. Solid colors are significant trend while white are insufficient data. Grid boxes where the trend is significant at the 10% level are indicated by a + sign (IPCC, 2013).

Moreover, there has also been precipitation changes, and precipitation is likely to increase at high latitudes, but decrease at tropical latitudes (Figure 11) (IPCC, 2013). Changes in many extreme weather and climate events have also been observed since about 1950. It was reported that the number of cold days and nights has decreased and the number of warm days and nights has increased on the global scale. The frequency of heat waves has increased in large parts of Europe, Asia and Australia. The frequency or intensity of heavy precipitation events, tropical cyclone intensity and frequent droughts has increased (IPCC 2013).

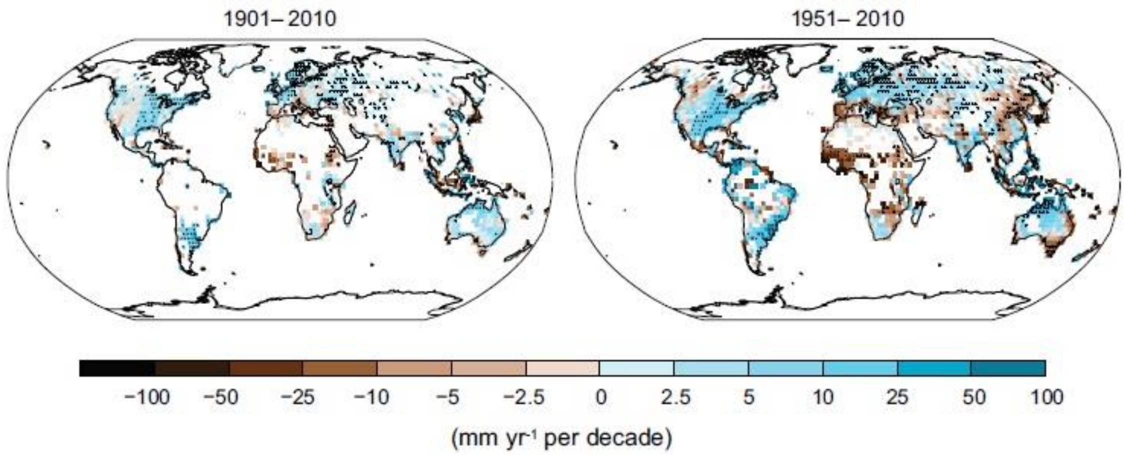

Figure 11 Map of observed precipitation change from 1901 to 2010 and from 1951 to 2010 (IPCC, 2013).

Global climate change affected plants both directly and indirectly (Barbosa et al., 2012). Many studies particularly on agricultural crops and forest showed that the enhanced atmospheric CO_2 directly increase productivity, because higher ambient CO_2 concentration stimulates net photosynthetic activity (IPCC, 2013). Moreover, increasing in temperature raises the rate of many physiological processes such as photosynthesis in plants, to an upper limit. Nutrient up take by tree is an active process supported by enzyme activity, and is highly dependent on temperature (Lahti et al., 2005). Bassirirad (2000) claim that nutrient uptake increases with rising temperature, but similar to enzymatic processes, the rate of uptake increases only until a threshold temperature reached. Therefore, extreme temperatures can be harmful when beyond the physiological limits of a plant. Moreover, the timing of plant reproductive events such as flowering is often related to climatic factor. Rising temperature is therefore expected to lead to changes in life cycle events, and these have been recorded for many species of plants (Parmesan and Yohe, 2003). If climatic factors such as temperature and precipitation change in a region beyond the tolerance of a species, then distribution changes of the species may be inevitable. There is already evidence that plant species are shifting their ranges in altitude and latitude as a response to changing regional climates (Bertrand et al., 2011). Chen et al. (2011) revealed that the distributions of many terrestrial organisms are currently shifting in latitude or elevation in response to changing climate. Moreover they found that distributions of species have recently shifted to higher elevations at a median rate of 11.0 meters per decade, and to higher latitudes at a median rate of 16.9 kilometers per decade. These rates are approximately two and three times faster than previously reported. However, many plants have limited dispersal (Svenning and Skov, 2004). Many of them, particular tree species have delayed response due to their long life span, and are not able to rapidly colonize at newly suitable climatic areas (Lenoir and Svenning, 2013). Therefore, climate change is likely to increase plant mortality and extinction risk in many areas (IPCC, 2013).

2.5 Emission Scenarios

The Special Report on Emission Scenarios (SRES) is a report by IPCC (IPCC, 2000). The greenhouse gas emissions scenarios described in the report have been used to make projection of possible future climate change. Scenario families contain individual scenarios with common themes. The families of scenarios discussed in the IPCC Fourth Assessment Report (AR4) (IPCC, 2007) (Figure 11) were predicted in different possible future climate change (Table 2, Figure 12 and Figure 13) and are including:

A1: globalization, emphasis on human wealth globalized

The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil-intensive (A1FI), non-fossil energy sources (A1T) or a balance across all sources (A1B) (where balanced is defined as not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end use technologies).

A2: regionalization, emphasis on human wealth regional

The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population. Economic development is primarily regionally oriented and per capita economic growth and technological change more fragmented and slower than other storylines.

B1: globalization, emphasis on sustainability and equity globalized

The B1 storyline and scenario family describes a convergent world with the same global population, that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability, including improved equity, but without additional climate initiatives.

B2: regionalization, emphasis on sustainability and equity regional

The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social and environmental sustainability. It is a world with continuously increasing global population, at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented towards environmental protection and social equity, it focuses on local and regional levels.

The predicted possible future temperature changes in each SRES scenarios were shown in Table 1, Figure 12, Figure 13 and Figure 14.

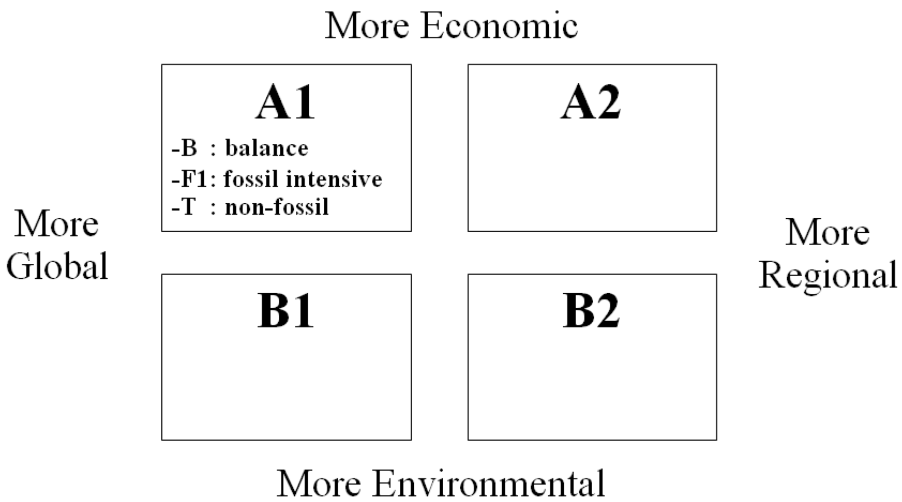

Figure 12 Four families of emission scenarios in IPCC Fourth Assessment Report (AR4) (IPCC, 2007)

Table 2 Projected global average surface warming at the end of the 21st century (IPCC, 2007)

Scenario	Temperature change (˚C)	
	Best estimate	Likely range
B1	1.8	1.1-2.9
A1T	2.4	1.4-3.8
B2	2.4	1.4-3.8
A1B	2.8	1.7-4.4
A2	3.4	2.0-5.4
A1F1	4.0	2.4-6.4

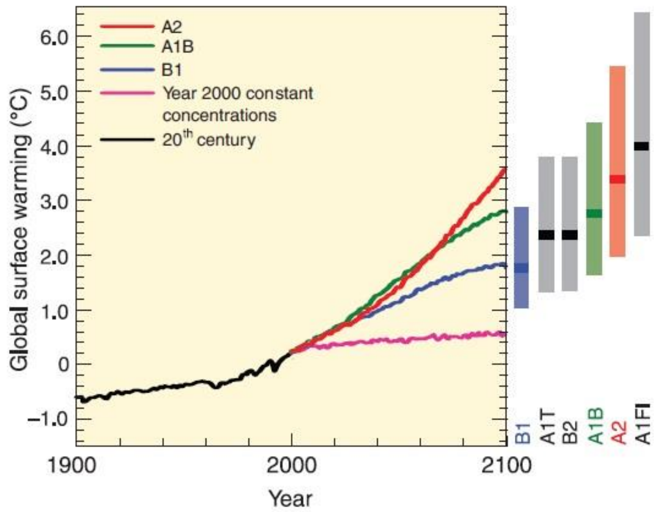

Figure 13 Projection of surface warming at 21st century. Solid lines are multi-model global averages of surface warming for the SRES scenarios A2, A1B and B1, shown as continuations of the 20th century simulations. The bars indicate the best estimate (solid line within each bar) and the likely range assessed for the six SRES marker scenarios at 2090-2099 relative to 1980-1999 (IPCC, 2007).

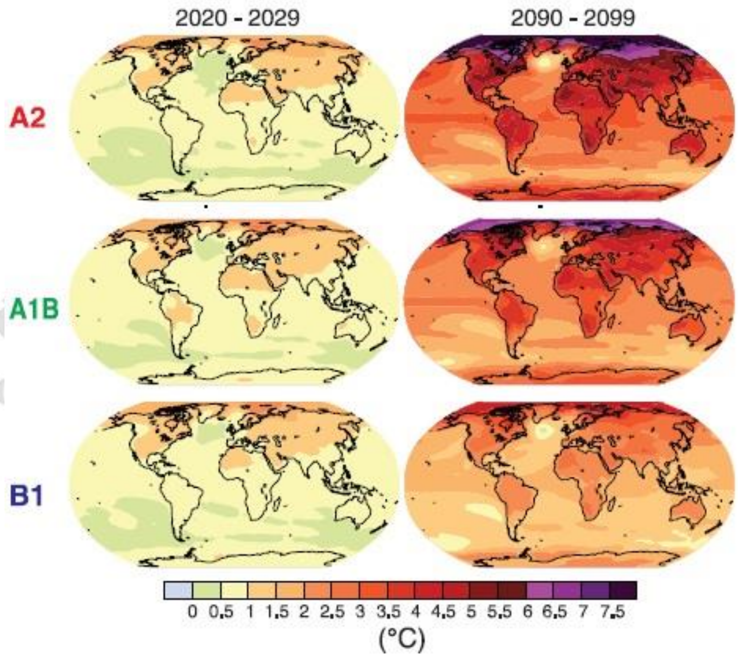

Figure 14 Projected surface temperature changes for the early and late 21st century. The panels show the projections for the A2 (top), A1B (middle) and B1 (bottom) SRES scenarios averaged over decades 2020-2029 (left) and 2090-2099 (right) (IPCC, 2007).

2.6 Species distribution model

Species distribution models (SDM) have become increasingly popular in recent years among researchers. They can be applied in many ways including predicting a species' potential distribution (Skov and Svenning, 2004), guiding search for unrecorded populations or rare species (Powell et al., 2005), predicting potential spread of diseases (Mayer et al., 2008), forecasting the spatial spread of invasive species to new geographical area (Dullinger, 2009), evaluating in terms of ecological theory used (Austin, 2007), assessing extinction-risk of endangered species (Benito et al., 2009) and supporting conservation planning (Rodríguez et al., 2007).

As all modeling techniques, SDM are based on certain assumptions and theory (Guisan and Thiller, 2005). The major development and subsequent applications of SDM is supported by niche theory, which describes the climatic niche as a functional or conceptual space defined on multiple axes of climatic variables (Rose and Burton, 2009). The climatic niche is one aspect of an organism's or ecosystem's realized niche, excluding several admittedly important environmental constraints based on soils, topography, biotic interactions (such as competition or predation), etc. Furthermore, the climatic niche is assumed to remain static and does not take dispersal ability or evolutionary adaptation into consideration when extrapolating from current distributions to future potential distributions (Pearson and Dawson, 2003; McKenney et al., 2007).

The study of SDM to predict potential plants distribution under future climate change has been carried out throughout the world. For example, Skov and Svenning (2004) have evaluated the possible consequences of climate change on 26 forest herbs that were selected to represent a wide spectrum of range size and range locations in Europe. They used a fuzzy climatic envelope which is a modified version of the standard rectilinear climatic envelope to predict the location of suitable climatic conditions under two climate change scenarios; A2 and B1. The results have shown that the total suitable area will on average move strongly northwards and moderately eastwards under the relatively mild B1 scenario and more strongly so under the A2 scenario. Moreover, the required average minimum migration rate per year to track the potential range shift is 2.1 km under the B1 scenario and 3.9 km under the A2 scenario. They have argued that an analysis of potential migration routes shows the importance of maintaining and, if possible, improving the network of forest throughout Europe to make migration possible. Miles et al. (2004), have predicted the potential distribution of 69 Angiosperm species in Amazonia from 1990-2095 by combining a suitability index and general linear model based on bioclimatic variables. They selected arbitrary Amazonia plant species to model long-term trends in plant species distributions in response to global climate change. To achieve this, they generated challenging procedures consisting of i) Family selection, ii) species selection by spatial and data availability, iii) species selection by climate occupancy, and iv) species selection by plant functional types. As a result, final sample of 69 plant species were selected to SDM. Then, the population density of 69 plant species in each stage of their life-cycle (survival, growth, and reproduction) was determined for the response of each species under future climate change. Not only simulating in potential distribution but they also considered realized distributions by using spatial limitation and contiguous with the species record. In the resulting simulations, 43% of all species became non-viable by 2095 because their potential distributions had changed drastically, but there was little change in the realized distributions of most species, owing to delays in population responses. Another example was investigated by Garcia et al. (2013). They predicted potential distribution of 14 threatened forest tree species in the Philippines. Maxent algorithm was used to predict future distribution. The result showed that Maxent did an excellent job in characterizing the distribution of all tree species under present climate. Seven species (*Afzelia rhomboidea*; *Koordersiodendron pinnatum*; *Mangifera altissima*; *Shorea contorta*; *Shorea palosapis*; *Shorea polysperma*; *Vitex parviflora*) were found to likely benefit from future climate due to the potential increase in their suitable habitat while the other seven species (*Agathis philippinensis*; *Celtis luzonica*; *Dipterocarpus grandiflorus*; *Shorea guiso*; *Shorea negrosensis*; *Toona calantas*; *Vatica mangachapoi*) will likely experience decline in their suitable habitat.

In Thailand, the study of SDM on plant species hasn't been carried out so far. However, there were some studies of evaluating model to predict forest distribution in Thailand. Tovaranonte et al. (2013) studied distribution and diversity of palms in Thailand by using SDM. They used different combinations of climatic, non-climatic environmental and spatial predictor for predicting palm distribution. The four strongest single predictors of palm species distributions were 1) latitude, 2) precipitation of driest quarter, 3) annual precipitation, and 4) minimum temperature of the coldest month, suggesting rainfall patterns and latitudinal spatial constraints as the main range determinants. Moreover, they found that potential palm hotspots are situated in the provinces of Satun and Yala in southern Thailand where vast areas remain relatively open to the discovery of new palm records and perhaps even new species.

Boonpragob and Santisirisomboon (1996) studied the possible impact of changing climate on potential forest distribution in Thailand. General circulation models (GCMs) and the Holdridge Life Zone Classification systems are used to evaluate shifts in the boundaries of major forest types under doubling CO_2 scenarios. The results of this investigation show the preliminary forest types described by Holdridge life zone are subtropical dry forest, subtropical moist forest, subtropical wet forest, tropical dry forest, tropical moist forest and tropical wet forest. The predictions of forests covers based on changing climate simulated by the three GCMs, consistently suggest that global change will potentially lead to the replacement of the subtropical life zone with the tropical life zone. These results indicate that Thai forests response to global climate change by shifting their boundaries into a higher temperature zone in a northward where the annual temperature is lower. Another study on SDM in Thailand was carried out by Trisurat et al. (2009). They investigated the consequence of climate change in distribution of forest tree species in northern Thailand for the year 2050. The Maxent program was employed to generate ecological niche models of 6 evergreen species and 16 deciduous species. The results shown that 10 plant species will loss their ecological niches (suitable locations) ranging from 2 - 13%, while the remaining 12 species will gain substantial suitable habitats. The assemblages of evergreen species or species richness are likely to shift toward the north where low temperature is anticipated for year 2050. In contrast, the deciduous species will expand their distribution ranges. Moreover, based on the *International Union for Conservation of Nature (*IUCN) Red List criteria, 10 plant species will be categorized as near threatened and 12 species will be listed as concerned status.

Moreover, there are some studies the response of medicinal plants used by indigenous people to climate change. Grabherr (2009) has been carried out the study in the Central Alps areas where traditional healers use 268 medicinal plant species of which 158 can be considered native to that area. Moreover, medicinal plant species were estimated the elevation niche for exploring how they might be threatened by warming. The GLORIA (Global Observation Research Initiative in Alpine Environments) was used to estimate niche breath, the presence or absence of a medicinal plant species. The results have shown that 25 predominantly Alpine species tree are restricted to the highest Alps where warming might lead to their extinction; they are *Achillea erba-rotta* subsp. *moschata*, *Primula glutinosa* and *Artemisia genipi*. Another investigation was reported by Kanum et al. (2013). They predicted impacts of climate change on three medicinally important Asclepiad species: *Pentatropis spiralis*, *Tylophora hirsuta*, and *Vincetoxicum arnottianum* of Pakistan using Maxent modeling. The results showed that under the future climate change scenario, *Vincetoxicum arnotianum* showed the most variation responses, as it would lose habitats in its current range but gain habitat in higher altitudes. Plant from moderate altitude and climate (*Tylophora hirsuta*) will suffer more habitat loss from climate change compared to others. Therefore, they suggested that the conservation action is immediately needed for *Tylophora hirsuta*. Multiple strategies could be used to preserve the medicinal Asclepiads and maintain not only the pharmaceutical and income resources of local people in Pakistan, but also the ecosystems.