CHAPTER 5

Discussion

5.1 Medicinal plant used by the Karen and cultural important species

5.1.1 Medicinal plants used by the Karen people

A study of a total of 379 plant species belonging to 271 genera and 117 families revealed a large amount of traditional knowledge of medicinal plants that has been amassed by the Karen of Chiang Mai Province. Of 379 species, 311 species were wild species, whereas 68 species were cultivated in home-gardens or in fields. The highest numbers of medicinal plants were recorded in Mai Sa Wan (134 species) and the neighboring village of Huay Pu Ling (106 species), whereas Yang Tung Pong Village recorded the lowest number of traditional medicinal plants recorded (28 species). Moreover, the results showed that most Karen people in the study area acknowledged the use of medicinal plants for the treatment of common ailments, which are in accordance with the ethno-botanical study of the Karen people in the neighboring province of Mae Hong Son (Trisonthi and Trisonthi, 2009).

The most frequently reported use category was Digestive System Disorders (21%). These illnesses were the most important usage categories throughout many different countries and areas, such as in Ethiopia (Giday et al., 2009), Brazil (de Albuquerque et al., 2007), the Peruvian Andes (De-La-Cruz et al., 2007), Bolivia (Bourdy et al., 2000) and China (Zheng and Xing, 2009). As measured by the number of uses recorded, diarrhea was acknowledged as the highest digestive system disorder that was recorded (470 uses) (Table 11). This might reflect the fact that cases of diarrhea are quite prevalent in terms of morbidity among the Karen people. Most Karen villages are located in mountainous areas, which are geographically remote areas. Unsafe water supplies and inadequate levels of sanitation and hygiene may increase the transmission of diarrhea among the Karen people. However, the Karen also use medicinal plants to remedy other illnesses in the digestive system such as gastric ulcers, flatulence, carminative illnesses, constipation, geographic tongue, hemorrhoids and tooth decay.

Muscular pain was the most commonly treated ailment (653 uses) in most Karen villages. Being farmers, the Karen often suffer aches and pains in their skeletal muscles, especially in the back, legs and arms. Therefore, they commonly use medicinal plants to treat this condition and sometimes search for new medicinal plant species when the species that they typically used were difficult to find. Urethral stones were also an aliment, which had a high rate of occurrence (533 uses) among the Karen people. The causes of these illnesses were attributed to a lack of potable water and the inadequate consumption of oxalate-rich or high-protein foods (Urology Care Foundation, 2014). However, high uses of medicinal plant remedies were also recorded in the treatments of coughs (505 uses), fever (400 uses) and colds (341 uses).

5.1.2 Cultural important (CI) medicinal plant

The CI index is an efficient tool for highlighting those species of plants with a high-agreement for the survey culture and so to recognize the shared knowledge of the people of the respective culture (Tardío and Pardo-De-Santayana, 2008). In this study, most of the medicinal plants revealed different CI values among the different Karen villages. Many species have a high variation in CI values. This reflects the different importance of the medicinal plant species and the medicinal plant practices among the Karen villages.

The medicinal plants with high CI values for treating digestive system disorders were *Psidium guajava* (0.96), *Ensete glaucum* (0.81), *Cratoxylum formosum* subsp. *pruniflorum* (0.77), *Punica granatum* var. *granatum* (0.75) and *Ochna integerrima* (0.63) which were used to treat diarrhea; *Euphorbia heterophylla* (0.60), *Senna alata* (0.91), *Senna occidentalis* (0.73) and *Tamarindus indica* (0.52) which were used as laxatives; *Curcuma longa* (1.06), *Dillenia pentagyna* (0.59), *Euphorbia hirta* (0.86) and *Engelhardtia spicata* var. *colebrookeana* (0.76) which were used to treat gastric ulcers; *Zingiber montanum* (0.92), *Zingiber ottensii* (0.89) and *Alpinia galanga* (0.35), which were used in the treatment flatulence; *Clerodendrum serratum* (0.77), *Cassytha filiformis* (0.75), *Ochna integerrima* (0.64), *Flemingia macrophylla* (0.64), *Mussaenda sanderiana* (0.52) and *Croton kongensis* (0.52) which were used to treat jaundice; *Harrisonia perforata* (0.73) *Dischidia nummularia* (0.64) and *Dischidia imbricata* (0.25) which were used to treat toothaches; *Melastoma malabathricum* (0.34) and *Melastoma normale* (0.17) which were used in the treatment of mouth ulcers and geographic tongue.

Moreover, the medicinal plants, which revealed high CI values in the treatment of muscular pain, were *Miliusa velutina* (1.00), *Heteropanax fragrans* (0.87), *Paris polyphylla* (0.87), *Terminalia chebula* (0.82), *Flacourtia jangomas* (0.81), *Miliusa thorelii* (0.74), *Centella asiatica* (0.73), *Elephantopus scaber* (0.69), *Asparagus filicinus* (0.64), *Betula alnoides* (0.65) and *Pothos scandens* (0.63).

The medicinal plants which revealed high CI values in the treatment of urethral stones were *Coix lacryma-jobi* (0.81), *Verbena officinalis* (0.77), *Mimosa pudica* (0.91), *Averrhoa carambola* (0.82), *Imperata cylindric* (0.52), *Equisetum debile* (0.86) and *Orthosiphon grandiflorus* (0.56). The Karen people prefer to mix these plants during process of preparation. However, single plants might be used in the event they could not find the supplemental plants.

Colds and fever are also prevalent illnesses among the Karen people, especially children. The medicinal plants with high CI values for the treatment of colds and fever were *Acorus calamus* (1.00), *Picrasma javanica* (0.96), *Alstonia scholaris* (0.81), *Flacourtia indica* (0.82), *Cassytha filiformis* (0.75), *Tinospora crispa* (0.71), *Scoparia dulcis* (0.71), *Elephantopus scaber* (0.69), *Schima wallichii* (0.68) and *Andrographis paniculata* (0.52).

The medicinal plants with high CI values for the treatment of coughs were *Phyllanthus emblica* (1.24), *Zingiber officinale* (0.93), *Terminalia chebula* (0.82), *Flacourtia indica* (0.82), *Alpinia malaccensis* (0.71), *Melicope pteleifolia* (0.66), *Polygonum paleaceum* (0.61), *Cyclea barbata* (0.57) and *Terminalia bellirica* (0.55).

Injuries are also considered common illnesses among the Karen people. These types of illnesses were found to frequently occur while people were doing field-work or were gathering forest products. The medicinal plants with high CI values in the treatment of injuries, particularly in the treatment of wounds and cuts, were *Chromolaena odorata* (1.15), *Eleutherine americana* (0.77), *Lygodium flexuosum* (0.77), *Ageratum conyzoides* (0.75), *Scoparia dulcis* (0.71), *Curcuma aeruginosa* (0.71), *Ageratina adenophora* (0.70), *Nicotiana tabacum* (0.52) and *Paris polyphylla* (0.50).

Medicinal plants that were considered relevant for women's healthcare were also found to be important for the livelihood of the Karen people. Most of the Karen people prefer to use medicinal plants in the treatment of amenorrhea and postpartum recovery. The medicinal plants with high CI values in the treatment of these illnesses were *Blumea balsamifera* (1.19), *Croton roxburghii* (1.09), *Inula cappa* (1.00), *Cleidion javanicum* (0.78), *Schefflera leucantha* (0.70), *Caesalpinia sappan* (0.61) and *Mussaenda sanderiana* (0.52). Another prevalent medicinal plant was *Xantolis cambodiana* (0.71), which the Karen people used as a lactation stimulant.

However, some medicinal plants, which had high CI values in the treatment of other illnesses, were *Sambucus simpsonii* (1.00) and *Sambucus javanica* (0.89), which were used to treat sprains; *Artemisia* sp. (0.90), *Ricinus communis* 0.82), *Usnea siamensis* (0.59) and *Inula cappa* (0.57), which were used to treat dizziness; *Thunbergia laurifolia* (0.96), which was used to treat intoxication; *Embelia sessiliflora* (0.75), which was used for anthelmintic illness; *Costus speciosus* (0.67), which was used to treat otorrhea; *Gmelina arborea* (0.63), which was used in the treatment of athlete's foot; *Plantago major* (0.81), which was used to treat joint pain; and *Cissus bicolor* (0.57), which was used in the treatment of allergically contacted dermatitis.

Moreover, this result also showed that some medicinal plant species had few use recorded and low CI values. This can be implied that some medicinal plant knowledge were maintained and used by few or a specific group of Karen people. However, Tardío and Pardo-De-Santayana (2008) stated that a plant with a low CI value could be a very important plant for few people. Likewise, in north America, it was shown that some meaningful medicinal plants used by few cultures of native Americans have lower cultural consensus because they have narrow distributions and might not be generally available elsewhere (Moerman, 2007).

5.2 Species distribution modeling (SDM)

In this study, Maxent models showed the average high level of predictive power when compared to random prediction (where the AUC would be 0.5) in both the training and testing data (Appendix B). This result indicated that the Maxent model is and suitable for evaluating the potential distribution of these medicinal plant species.

The Jack-knife evaluation results indicated contributions of climatic and non-climatic factors which varied from species to species (Appendix B). The distribution of the medicinal plants were largely affected by soil type, which was the most important contributor for 65 species (Figure 22), followed by temperature diurnal range (bio2) (54 species), temperature seasonality (bio4) (27 species), slope (24 species), precipitation of the hottest quarter (bio18) (20 species), precipitation of the driest period (bio14) (17 species), annual precipitation (bio12) (12 species), isothermality (bio3) (8 species), mean minimum temperature of the coldest period (bio6) (7 species), the human influence index (HII) (5 species), precipitation of the driest quarter (bio17) (3 species), and mean maximum temperature of the hottest period (bio5) (1 species). Tuomisto et al. (1995) stated that the spatial distributions of many tropical plant species show strong associations with the edaphic conditions. Soil properties are likely to influence nutrient uptake and the life functions of tropical trees (ter Steege et al., 2006). They may be important factors for shaping the species boundaries or in addressing species absence (Thuiller, 2013). Moreover, certain evidence has revealed that soil type was an important factor that affected plant species distribution in tropical forests on landscape scales (10^3-10^5 km^2) (e.g. Eiserhardt et al., 2011, Tuornisto et al., 2002).

Temperature diurnal range (bio2) was also considered an important contributor in this study. It is the mean of difference between the monthly maximum and minimum temperatures (maximum temperature - minimum temperature) (Worldclim, 2014). IPCC (2013) reported that the minimum daily temperatures have increased faster than the maximum daily temperatures since 1950. Therefore, the differences between the maximum and minimum temperatures have narrowed down by an average of -0.04 °C per decade from 1950 to 2011. Moreover, the temperature diurnal range was also a major contributing factor of several modeling investigations on plant species (Holcombe et al., 2010; Yu et al., 2013). However, this finding also showed that the distribution of most plant species was controlled mainly by a combination of climatic and non-climatic predictors. Some studies have shown that at continental scale (>10^5 km^2) and climatic variables are strong environmental controlling factors of plant distribution (Trivedi et al., 2008, Willis and Whittaker, 2002), whereas the combination of climatic and non-climatic factors showed strong responses in plant distribution on a regional scale (Blach-Overgaard et al., 2010). Similarly, in a species distribution study in the forests in northern Thailand, non-climatic factors (slope, elevation and longitude) appeared to be the main factors influencing the distribution of most plant species, whereas the climatic variables (bio6, bio14 and bio19) were shown to have moderate effects (Trisurat et al., 2009).

The human influence index revealed that humans had a relatively low impact compared with other predictor variables in this study. Sandel and Svenning (2013) stated that human impacts are strongest on flat terrain, whereas topographic slope areas experience low levels of human stress influences. Owing to the fact that flat areas benefit more from human activities, forests, however, are easily threatened from deforestation, grazing, clearing for agricultural uses and other human influences. On the other hand, sloped terrain is more difficult to clear by humans. Consequently, steep mountains experience low levels of human influence and this factor may serve as a redeeming quality for forests.

5.3 Potential impact of climate change on medicinal plants

Model predictions using Maxent showed variables in the projection of species' range occupations, with some species having projected to gain or have no change and most species having projected to lose their suitable habitats, depending on the scenario (Figure 24, Appendix C). However, there were no significant differences found between the changes in the suitable range under A1B and A2 scenarios by year 2050 (*t*-test: p = 0.963) and 2080 (*t*-test: p = 0.378) in this study. According to the IPCC Special Report on Emission Scenarios (SERS), the A2 scenario is expected to be warmer than the A1B scenario (Table 1). However, Chula Unisearch and Southeast Asia START Regional Center (2012) revealed that the mean temperatures during the next 60 years were predicted to be higher than the present at the same rate (>2 °C) under A1B and A2 scenarios throughout Chiang Mai Province and northern Thailand. Therefore, this might be a cause of no significant in prediction results under A1B and A2 scenario in this study.

Averages of 21% and 19% of the total medicinal plants were predicted to benefit by gaining suitable ranges by 2050 and 2080, respectively (Figure 23). *Garcinia xanthochymus* is a plant species, which is predicted to gain the highest suitable range of more than 240% in Chiang Mai Province followed by *Breynia vitis-idaea* at 116% (Appendix C). Regarding the recorded occurrences of the plant species, *Garcinia xanthochymus* and *Breynia vitis-idaea* were found mainly in southern of Thailand, Indonesia and the Philippines. Due to global warming, plant species were predicted to shift their distribution pole-ward to find suitable climate conditions (Feeley et al., 2013; Skov and Svenning, 2004). Therefore, these two species were predicted to shift northward and this could result in northern Thailand seeing higher numbers of these species.

More than 60% of the plants were predicted to experience an increase in the loss of their suitable ranges by 2050 and 2080, respectively (Figure 23). Moreover, increased turnover rates of plant species were also indicated. This could potentially result in species extinction and a decline in biodiversity. The highest turnover rates were found in *Lilium primulinum*, *Lycopodium cernuum* and *Vitex trifolia*, which would likely suffer a 100% loss and no gain in areas of their suitable ranges in Chaing Mai Province by 2080.

Overall, it was shown that climate change is predicted to accelerate over the current and coming centuries (Feeley, et al., 2013). Most medicinal plant species were predicted to face a critical situation through the reduction in their suitable growing areas. Moreover, Feeley et al. (2013) revealed that tropical plants are expected to be more sensitive to climate change than those of other eco-regions due to their narrow climatic tolerance. The study on climate change effects on plants species in tropical regions stated that tropical plants will not be able to continue to keep pace with future climate change trends and, thus, their persistence in the face of climate change will depend on their successful migration to more suitable areas (Feeley et al., 2013). However, many plants have limited dispersal range (Svenning and Skov, 2004). Many of them, particularly tree species, have shown delayed responses due to their long life span, and are not able to rapidly colonize at newly suitable climatic areas (Lenoir and Svenning, 2013). Under warming climates, plant species will move upward to retain their thermal niche (Feeley et al., 2013). As mountains usually have conical shapes, plants, which are not able to shift their growing territories upward, might experience a loss in range and may even suffer incidences of mountain-top extinction (Dullinger et al., 2012). Therefore, tropical mountain plants, which have a low tolerance to climate change and a slow migration rate, may be at a relatively high risk of extinction from future climate change trends (Feeley et al., 2013).

However, it should be noted that this SDM study has some limitations as following:

1) Area of study site

This SDM study was investigated on a local scale in Chiang Mai Province. However, the results showed that the potential distribution of most medicinal plants was not only found to be limited to Chiang Mai Province, but were also found throughout northern Thailand (Appendix C). Therefore, an incorporation of the changes in spatial patterns in Chiang Mai Province and northern Thailand is suggested in future studies in order to fully investigate the potential distribution of medicinal plants in the future.

2) Quality and quantity of occurrence data

The small number of available occurrences data is the most important problem for modelers particular in tropical regions (Cayuela et al., 2009). Drake et al. (2006) studied how model performance depends on the sample size of the training dataset, and concluded that at least 40 observations were necessary to obtain consistent models. However, average occurrences data in this study were 20 records per plant species. However, Pearson et al. (2007) argued that the SDM study by using Maxent could evaluate a good predictive power with few occurrence records as 5. Additionally, lack of data quality can result from sampling bias. It can come in many different forms, though bias owing to accessibility and a focus on priority areas. Moreover, sampling bias has been observed along rivers, roadside and near cities. These could be a problem to SDM study. Therefore, the ongoing initiatives to improve data quality and quantity should be supported in order to predict more accuracy of models.

3) Predictor variables

SDM investigations in this study emphasized the consequences of future climate change on plant distributions; therefore, other variables, such as biotic interactions (competitors, predators or parasites), geographical barriers, current land use changes and fragmentation infrastructure development were treated as stable. However, climate change is only one of the many stressors of biodiversity, and climate change has a much lower impact compared to the other driving stressors (Trisurat et al., 2011). However it will become a more important driver in the 21st century

(Leadley et al., 2010). Therefore, researchers in the future should elaborate on the interactions between climate change, biotic interactions and current land use practices.

5.4 Vulnerability of medicinal plants

Based on the IUCN Red List assessment rang-loss criterion (IUCN, 2004), the prediction of the species vulnerability of the medicinal plant species varies with the emission scenario (Appendix C). In pessimistic situations, one (*Lycopodium cernuum*) and four (*Lilium primulinum*, *Lycopodium cernuum*, *Schima wallichii* and *Vitex trifolia*) species were predicted to become extinct through the influences of climate change in Chiang Mai in 2050 and 2080, respectively. Moreover, a total 171 plant species were predicted to lose their suitable ranges and were categorized as critically endangered (51 species), endangered (44 species), vulnerable (25 species) and near threatened (51 species), respectively, whereas 73 species were predicted to gain more ranges or have no change of their areas and were categorized as being of least concern under A1B or A2 scenarios by 2080.

However, it should be noted that the predicted extinction species in this study were determined as locally extinction or extirpation owing to some species (*Lilium primulinum*, *Schima wallichii* and *Vitex trifolia*) which were categorized as extinction in Chiang Mai province could be found in other areas in northern Thailand.

Regarding the cultural importance (CI) index, it was used to identify the highest priority medicinal plants for conservation in this study, especially those that make a direct contribution to the Karen livelihood and healthcare system. Moreover, species, which had high CI values, were used extensively and recognized as important medicinal plants within the Karen culture. However, the predicted IUCN status of the high CI value (>0.50) medicinal plants is shown in Table 13. In 2080, plants tended to have more severe IUCN status due to a greater reduction of suitable growing areas than 2050. Interestingly, most high CI value medicinal plants were classified as being critically endangered (24 species), followed by near threatened (18 species), least concerned (12 species), vulnerable (5 species) and extinct (1 species) (Table 13). This situation might strongly affect the livelihood of the Karen people, particularly with regard to the traditional remedies of their common health problems by reducing the suitable ranges and availability of these important medicinal plants.

Another factor that may accelerate plant extinction risk is overexploitation. High CI value medicinal plants, which were important for the herbal practices of the Karen people, tended to be overexploited. Ullah and Rashid (2014) stated that overexploitation was the most important contributor (77.55%) threatening medicinal plant numbers following by habitat loss (35.55%), over grazing (28.88%) and deforestation (15.55%), respectively. Besides, Rai et al. (2000) also revealed the severe reduction of natural populations of some high therapeutic value medicinal plants in the Sikkim Himalayas due to overexploitation by intense commercialization, over-harvesting and the collecting methods of untrained and unskilled individuals.

However, there were 135 plant species, which were not evaluated in the SDM. Sixty-eight species were cultivated species, which were grown in home-gardens or fields of the Karen people. Nabout et al. (2012) stated that cultivated species are strongly influenced by several factors usually not included as model predictors, such as biotechnical resources, irrigation, soil types and fertilization, as well as other local factors. Moreover, cultivated species tend to have the lowest extinction risk due to the special care given by humans during cultivation (IUCN, 2004).

Sixty-four plant species, which could be not identified to the species rank, were excluded from the SDM study due to their limited availability and the ambiguity of the recorded occurrences. However, the quantitative ethno-botanical study of these plants found that some of them had high CI values (>0.50) and were still important in the Karen healthcare system (Table 14). Therefore, further investigations of these plants are needed in order to identify their significance.

Table 13 List of medicinal plants which had high CI values (>0.50) and their predicted IUCN status

IUCN status	2050	2080
EX	-	*Schima wallichii*
CR	-	*Blumea balsamifera, Caesalpinia sappen, Cassytha filiformis, Chromolaena odorata, Cissus bicolor, Clerodendrum serratum, Costus speciosus, Equisetum debile, Euphorbia heterophylla, Euphorbia hirta, Gmelina arborea, Inula cappa, Lygodium flexuosum, Mussaenda sanderiana, Phyllodium pulchellum, Paris polyphylla, Polygonum paleaceum, Pothos scandens, Rauvolfia verticillata, Sambucus javanica, Senna alata, Thunbergia laurifolia, Verbena officinalis, Viburnum sambucinum*
EN	*Cissus bicolor, Heteropanax fragrans, Melicope pteleifolia, Paris polyphylla, Polygonum paleaceum, Pothos scandens, Rauvolfia verticillata, Sambucus javanica, Senna alata, Viburnum sambucinum*	*Acorus calamus, Ageratum conyzoides, Baliospermum calycinum, Coix lacryma-jobi, Croton roxburghii, Elephantopus scaber, Eleutherine americana, Ficus auriculata, Flacourtia jangomas, Heteropanax fragrans, Melicope pteleifolia, Mimosa pudica, Phlogacanthus curviflorus, Plantago major, Schefflera leucantha, Senna occidentalis, Tinospora crispa, Xantolis cambodiana*

Table 13 (continued)

IUCN status	2050	2080
VN	*Ageratum conyzoides, Baliospermum calycinum, Caesalpinia sappen, Cassytha filiformis, Chromolaena odorata, Costus speciosus, Eleutherine americana, Equisetum debile, Euphorbia heterophylla, Euphorbia hirta, Ficus auriculata, Flacourtia jangomas, Gmelina arborea, Inula cappa, Miliusa velutina, Mussaenda sanderiana, Phlogacanthus curviflorus, Phyllanthus emblica, Plantago major, Schefflera leucantha*	*Betula alnoides, Flemingia macrophylla, Miliusa velutina, Phyllanthus emblica, Tithonia diversifolia*
NE	*Acorus calamus, Alpinia malaccensis, Asparagus filicinus, Betula alnoides, Blumea balsamifera, Clerodendrum serratum, Coix lacryma-jobi, Croton roxburghii, Curcuma aeruginosa, Dillenia pentagyna, Dischidia nummularia, Elephantopus scaber, Embelia sessiliflora, Engelhardtia spicata, Flacourtia indica, Flemingia macrophylla, Harrisonia perforata, Helicia nilagirica, Imperata cylindrica, Lygodium flexuosum, Miliusa thorelii, Mimosa pudica, Ochna integerrima, Phyllodium pulchellum, Polygala crotalarioides, Thunbergia laurifolia, Tinospora crispa, Tithonia diversifolia, Usnea siamensis, Verbena officinalis, Xantolis cambodiana*	*Alpinia malaccensis, Asparagus filicinus, Cleidion javanicum, Curcuma aeruginosa, Dillenia pentagyna, Dischidia nummularia, Embelia sessiliflora, Engelhardtia spicata, Flacourtia indica, Harrisonia perforata, Helicia nilagirica, Imperata cylindrica, Miliusa thorelii, Ochna integerrima, Phyllanthus amarus, Picrasma javanica, Polygala crotalarioides, Usnea siamensis,*

Table 13 (continued)

IUCN status	2050	2080
LC	*Andrographis paniculata, Biophytum umbraculum, Cleidion javanicum, Crinum asiaticum, Croton kongensis, Cyclea barbata, Cymbidium bicolor, Dendrocalamus strictus, Hiptage benghalensis, Orthosiphon grandiflorus, Phyllanthus amarus, Picrasma javanica, Sambucus simpsonii, Senna occidentalis, Terminalia bellirica, Terminalia chebula*	*Andrographis paniculata, Biophytum umbraculum, Crinum asiaticum, Croton kongensis, Cyclea barbata, Cymbidium bicolor, Dendrocalamus strictus, Hiptage benghalensis, Orthosiphon grandiflorus, Sambucus simpsonii, Terminalia bellirica, Terminalia chebula,*

Table 14 List of medicinal plant which had high CI values (>0.50) and were classified as cultivated species and not indentified to species rank

Category	Species
Cultivated species	*Acmella oleracea*, *Averrhoa carambola*, *Centella asiatica*, *Curcuma longa*, *Curcuma* sp.2, *Cymbidium* sp., *Cymbopogon citratus*, *Jatropha curcas*, *Jatropha podagrica*, *Kalanchoe pinnata*, *Luffa* sp., *Nicotiana tabacum*, *Psidium guajava*, *Punica granatum* var. *granatum*, *Radermachera ignea*, *Solanum lasiocarpum* var. *domesticum*, *Tamarindus indica*, *Zingiber montanum*, *Zingbiger officinale*, *Zingiber ottensii*
Not indentified to species rank	*Actinodaphne* sp., *Artemisia* sp.,*Cinnamomum* sp., *Curcuma* sp.2, *Cymbidium* sp., *Luffa* sp., *Maclura* sp., *Paederia* sp., *Schefflera* sp.

5.5 Implications for conservation

The conservation of threatened medicinal plants at higher altitudes is important because people living in isolated areas are far removed from urban centers and are completely dependent on plants and plant products for their livelihood and for the curing of different ailments (Ullah and Rashid, 2014). Therefore, it is necessary to carry out concrete steps for the conservation of medicinal plants that are used by the Karen people in order to ensure their availability for future Karen generations in the face of a changing climate.

Firstly, raising awareness of climate change to the Karen people is crucial in order to engage their attention and inspire individual and community action. In this step, it is suggested that scientists and local environmental authorities educate the Karen people on the current situation of climate change and its future impact on the environment and the livelihood of the Karen people. Moreover, an awareness of the vulnerabilities of the traditional medicinal plants used by the Karen people with regard to future climatic changes needs to be shown to the Karen people in order to inform them of the extinction risk that exists and to raise awareness of the importance of the conservation of these medicinal plants. Furthermore, an education in the sustainable use of these medicinal plants also needs to be promoted to the Karen people. Several medicinal plants have been assessed as being vulnerable due to over harvesting or unskillful harvesting practices in the wild. The use of certain plant parts like roots, bark, wood, stems, as well as the entire plant, is needed in the event of an acceleration of the loss of the availability these plants, as well as an increased risk of extinction of these medicinal plants. Therefore, the harvesting methods need to be done according to appropriate amounts and the gathering of the plant organs, such as the leaves, branches, fruits or other non-subsistence parts of the plants that do not affect the plant’s life function, need to be promoted as a more sustainable practice. Additionally, promoting medicinal plants, which have been traditionally used in treating specific illnesses, particularly plants which have high CI values, is also an important strategy which could reduce the intensive uses of many of these medicinal plants. Regarding the highly important cultural species of plants, they have been used prevalently within the Karen culture and may serve as an indication of their effectiveness as natural medicines with a high healing potential. Therefore, if one of the medicinal plant species declines in numbers or became less available within its natural habitat, some other high CI value plants, which have the potential to be used as a remedy for the same illness, could be used in its place.

It is also crucial that Thai government authorities, such as the Ministry of Natural Resources and Environment, the National Parks Wildlife and Plant Conservation Department, the Royal Forest Department, the Royal Project Foundation, the Highland Agricutural Extension Center and the University, help to conserve medicinal plants that have been traditionally used by the Karen people. It is recommended that the government establish natural protected areas with proper management and control plans in order establish *in situ* strategies for the conservation of medicinal plants and to ensure that as many wild medicinal species as possible can continue to survive in their natural habitats. Moreover, they should then create new protected areas and extend existing ones to ensure that all medicinal plants are conserved. Furthermore, species that have been heavily depleted by over-collection should be re-introduced into areas where they once grew wild. Another potential *in situ* conservation strategy involves introducing a forestry law that prohibits the collection of threatened medicinal plants from the wild, except for the purposes of propagation. Moreover, the government should control the trade in medicinal plants and their products in order to reduce the overexploitation of all medicinal plants.

Ideally, all medicinal plant species should be conserved as evolving populations in nature. However, these species should also be conserved *ex situ*, as well. The primary purpose of this would be to create a type of an insurance policy. However, it also has the advantage that it is usually easier to supply plant materials for the purposes of propagation, for re-introduction purposes, for agronomic improvement, and for research and educational purposes from *ex situ* collections than from *in situ* reserves. Priority for *ex situ* conservation should be given to species that are at high risk of becoming extinct or are predicted to be critically endangered under future climatic change conditions, or to those species, which have high CI values. For these purposes, botanical gardens play an important role in *ex situ* conservation programs. These can also be applied to rescue threatened medicinal plants, store plant seeds, produce materials for reinforcement of the species, as well as to support systems of habitat restoration and management. Moreover, the cultivation of some medicinal plants in the home-gardens or fields of the Karen people may be an effective strategy that would help to mitigate the impacts of climate change on these plant species. Srithi et al., (2012) revealed that home-gardens have also been important sites for the domestication of plant species especially for those of medicinal plants and these gardens make a valuable contribution to the conservation of rare, endangered, or overexploited species.

Regard to objective of this study, it was aimed to consider potential adaptation strategies for mitigating the impact of climate change on medicinal plants used by Karen in the study area. However, author was not able to make a fully achievement on this goal due to some limitations. In order to make a coorperation between scientists and government authorities, this step might be time-consuming especially for establishing new protected area and introducing a forestry law that prohibits the collection of threatened medicinal plants from the wild. Moreover, there is limitation of funding. However, the most effective migiation strategies which author can be done are raising awareness of climate change and conservation of medicinal plants to the Karen, promoting sustainable use of medicinal plants and also promoting cultivation of some medicinal plants in the home-gardens or fields of the Karen.

Overall, the conservation of the medicinal plants of the Karen people would not only benefit their livelihood, but would also provide certain advantages to all people who reside in Chiang Mai Province and northern Thailand by helping to maintain plant biodiversity, plant ecosystems, indigenous plant genetics and all regional forest resources.