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Original Article

Forest Conservation for Climate Change Mitigation by Karen Ethnic Group at Khun Saab Village, Samoeng District, Chiang Mai Province, Thailand

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ABSTRACT

This study aimed to assess forest ecosystem and biodiversity, carbon sequestration from biomass of the watershed forest, analyze the roles of Karen ethnic group in forest conservation and climate change recognitions by the villagers. The total forest area in Huai Hok sub-watershed was 1.88 km^2 whereas the hill evergreen forest (HEF) was 1.4 km^2, so there were 2 quadrats set up and each of which was 40 x 40 m^2 for tree measurement. Species diversity was assessed, based on the formula of Shannon-Weiner Index (SWI). Allometric equations were applied for calculating carbon content of living biomass. The climate change recognition by the villagers was studied, based on in-depth interviews and observations with 4 target groups, including 1) informal and formal village leaders, 2) respectful elderly people, 3) folk medicine men, and 4) saviors. The results showed that the Karen villagers utilized natural resources optimally according to their traditional livelihoods and practiced forest conservation. Huai Hok watershed forest was in good condition with 59 tree species in 33 families. Muead Lode (*Aporosa villosa*) was the species with the highest importance value index (IVI), while the most dominant species was Mang Tan (*Schima wallichii*). The SWI was 5.02, considering as high value. The average carbon sequestration of the sub-watershed was 18,804.34 ton C km^{-2}. Total HEF carbon dioxide absorption was 96.35 Gigagram CO_2, at the average value of 68.82 Gigagram CO_2 km^{-2} which was considered high. The Karen ethnic people recognized the climate change, although the impacts were yet apparent to their livelihoods. Thus, carbon sequestration in the watershed forest of Karen ethnic group could help mitigate climate change.

Keywords: climate change, hill evergreen forest, forest conservation, carbon sequestration, Karen ethnic group

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INTRODUCTION

Climate change is the global problem affecting all organisms, particularly human beings. The climate change is very critical in this century, and the impacts include global temperature increase, seasonal fluctuation, changes in precipitation patterns, more droughts and heat waves, storm intensity, and sea level rising (IPCC, 2000). The main cause of climate change problem has been the increase of greenhouse gas (GHG) emissions which have been accelerated by human activities. From 2000 to 2010, annual GHG emissions increased approximately 1.0 gigaton carbon dioxide equivalent (Gt CO_2 eq) or 2.2% which was higher than that of the period between 1970 and 2000 (0.4 Gt CO_2 eq or 1.3% per year). Fossil fuel combustion and industrial processes emitted about 78% of total GHG emissions (IPCC, 2015). Carbon dioxide uptake has been in terrestrial ecosystems, both vegetation and soil, but the CO_2 amount has also been released from forest clearing and wildfire at high and middle latitudes in tropical countries (IPCC, 2000). Forests are considered as one of the largest reservoirs (sinks) of carbon, as they help balance with CO_2 emissions which it, in turn, mitigate climate change (Stone and León, 2010).

The forest area of Thailand is 31.68% of total area (163,967.74 km^2) (Royal Forest Department, 2018) which is categorized as protected area of 65.44% of the total forest area (107,300.49 km^2) (Department of National Parks, Wildlife and Plant Conservation, 2018). Annual average household income from trade in non-timber forest products (NTFPs) has made up to more than 50% of annual income of forest-dependent people, and were particularly important in poorer households (Satian-Thai, 1999). The development of non-timber forest product based interventions may contribute positively to improve the future of the forestry sector and the rural poor in Thailand. (Jintana *et al.*, 2000). Forest conservation could help protect and enhance forest carbon stocks. Sustainable forest management can maintain or enhance forest carbon stocks, and maintain forest carbon sinks, including transferring carbon to wood products, thus addressing the issue of sink saturation (IPCC, 2020). Several thousands of indigenous people in the world live in forest areas, based on their traditional linkages to the lands. The indigenous people are both users and managers of forestlands and other natural resources for their livelihoods. Moreover, the forests are also the great cultural and spiritual significance to them (IUCN, 2010). In Thailand, indigenous people are known as ethnic groups, while Karen is the major ethnic group which population is 438,131 or 7.18% of total ethnic population (Ministry of Social Development and Human Security, 2014). Karen people live in/or near the forests and depend on them, based on their cultural traditions. Karen indigenous knowledge had a potential to help the biodiversity of the forest and ecological systems in the long-term (Wongvarn and Amnuay-ngerntra, 2018). Karen livelihood is based on a subsistence-oriented production system that is underpinned by a rich body of local environmental wisdom, vigorous communal orientation and consistently non-commercial values (Walker, 2001). Walker (2001) also found that Karen regulations over the lands were in consistent with the forest ecosystem conservation and protect long lasting systems of production.

This study aims to understand the roles of Karen ethnic group in forest conservation, assess forest ecosystem and biodiversity, calculate carbon sequestration from living biomass of the conserved watershed forest, analyze climate change recognitions by the villagers, and draw a link between Karen forest conservation and climate change mitigation.

MATERIALS AND METHODS

1. Study area

This study was conducted at Khun Saab village which located in the upper part of Mae Saab watershed. Its elevation ranged between 700 – 1,500 m above mean sea level (m a.s.l.) and the area was 20.21 km^2 or 12,631.25 rai (Figure 1 and 2). The case studied area was Huai Hok sub-watershed, locating in the upper part of Khun Saab village which total area was 1.88 km^2 (1,175 rai). The preliminary survey of forest ecosystems and GIS application showed that there were 3 types of plant communities, including hill evergreen forest (HEF) of 1.4 km^2 (875 rai), dry evergreen forest (DEF) of 0.33 km^2 (206.25 rai) and pine forest (PF) of 0.15 km^2 (93.75 rai). Thus, two sample plots of the HEF considered as the watershed forest were set up and assessed.

Local hill tripe of Karen lives in the watershed area, total population was 417 people of 99 households. The village was divided into 3 hamlets: Baan Khun Saab Nuea (56 households in northern hamlet), Khun Saab Klang (9 households in central hamlet) and Khun Saab Tai (34 households in southern hamlet). The Karen villagers of Khun Saab village were in close connection to their natural environment. Many Karen people possessed cultural values of non-violence and non-interference with other beings. They have their own marriage system and language. Elderly Karen is respected by younger generations, as well as teachers, pastors, priests, and those with higher education. They mostly knew about traditional medicine and native food collected from the forest.

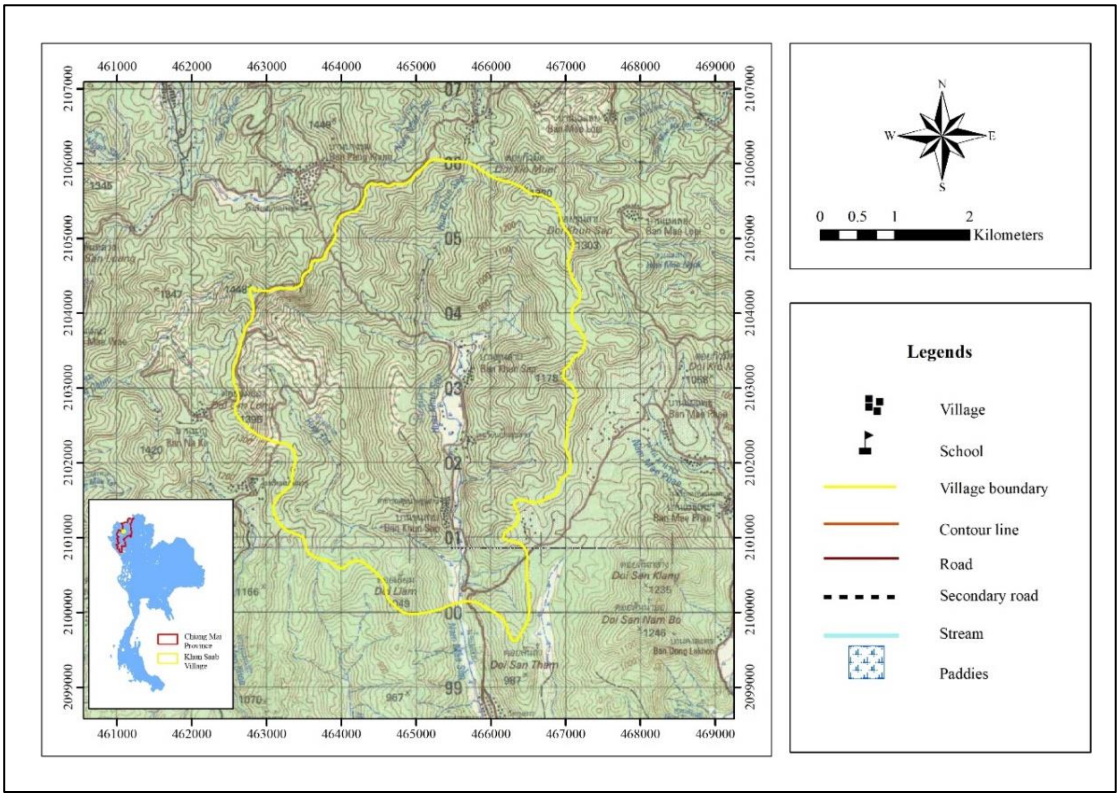

Figure 1. Location and boundary of Khun Saab village, Samoeng district, Chiang Mai rovince

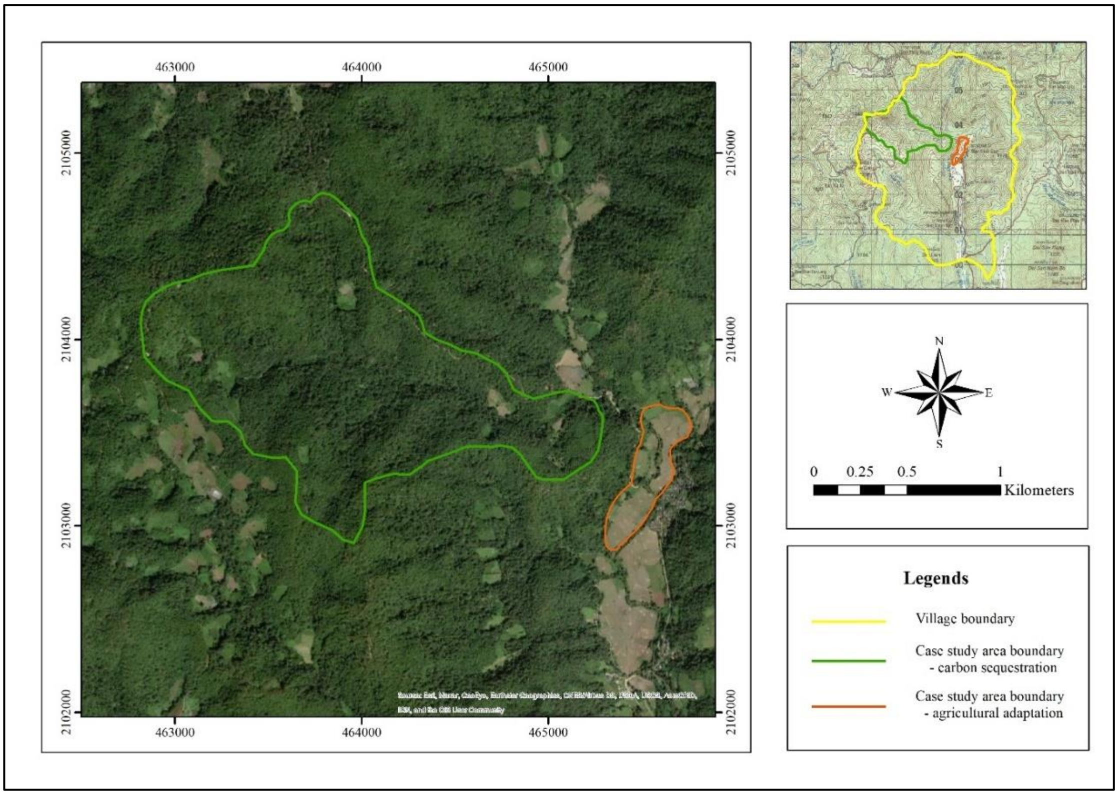

Figure 2. Huai Hok watershed boundary and agricultural adaptation case study areas at Khun Saab village, Samoeng district, Chiang Mai provinc

2. Data collection and analysis

2.1 Assessments of forest ecosystem and biodiversity

Forest ecological assessments of this study applied Participatory Ecological Investigation Methodology (PEIM) , developed by Lakanavichian and Pintana (2002). PEIM is a method for natural resource assessments which integrated participatory approach and techniques into the processes. The methods and procedures were following:

1) To select research sites for studying quantitative forest ecology and biodiversity. The criteria for site selection included: (a) sub-watershed with forest abundance and all-year-round water, (b) watershed forest in the upper part of a village case study, and (c) water resource dependence by the villagers.

2) To undertake a preliminary survey of the entire watershed forest to classify the forest types as forest strata and conduct the stratified random sampling by applying PEIM (Lakanavichian and Pintana, 2002; Lakanavichian, 2014). PEIM included 4 steps: (1) building rapport with the target villagers and secondary data analysis, (2) preliminary field survey of the entire forest with key informants who are local experts on their forests, (3) participatory assessment of the village and planning of the field study, and (4) actual forest assessment with local forest experts. The researchers worked with the local forest experts of the village in classifying the forest types and identifying the trees. In the research team, there was a forest ecologist who has worked in the forests of Thailand and some Southeast Asian countries for almost three decades. If

the local forest experts could not identify some species, the forest ecologist would help identify the species by collecting botanical characteristics of the trees and using a manual namely, "A Field Guide to Forest Trees of Northern Thailand" (Gardner *et al.*, 2000). The area of the watershed forest was estimated for calculating a number of sample plots, using a specific formula by Avery (1975): a sample plot size of 0.2 hectare (ha) or a quadrat of 40 m x 40 m can represent 1 km^2 of a forest area (Lakanavichian, 2014).

3) To set up a sample plot for tree measurement, based on a simple random sampling technique and representativeness of each forest stratum, which the hill evergreen forest was selected in this case as of its best watershed forest quality. Each sample plot was a quadrat as mentioned. Tree measurement of 3 variables included (a) Girth at breast height (GBH), in order to calculate diameter at breast height (DBH), (b) tree height, and (c) tree canopy (2 axes: width and length) to estimate the crown cover of that particular forest (Lakanavichian, 2014).

Analyses of plant community included density, frequency and dominance, which relative values were calculated and accumulated resulting in an importance value index (IVI) of the sample plots. The formulae for calculating quantitative ecology were according to Krebs (1985). Plant species diversity index is also calculated, based on the Shannon – Wiener Index (SWI) formula (Shannon, 1949) as follows:

$$H' = -\sum_{i=1}^{s}(pi)(ln(pi))$$

where H´= Shannon-Wiener Index (SWI)

s = Number of species

p_i = Proportion of the sample belonging to the i^{th} species

ln = Natural logarithmic

2.2 Assessment of carbon sequestration in the watershed area

Above-ground carbon sequestration was estimated by non-destructive sampling in order to conserve carbon sinks. Generally, forest carbon estimate is based on stock-based approach by destructive sampling method which is to cut a tree into parts and pieces, collect all tree parts (leave, branch, stem and root), dry all tree parts for calculating biomass, and then estimate carbon content. Carbon sequestration in a perennial tree is about a half of its dry weight. However, this study estimated carbon sequestration by allometric equations for above ground biomass. Variables included DBH and tree height (Wattayakorn and Diloksumpun, 2011). Below-ground carbon sequestration was estimated by multiplying the standard constant of 0.37 with the above-ground carbon sequestration (IPCC, 2006).

Analyses of carbon content from biomass varied according to the forest types. The allometric equations for calculation in this case study were as follows.

1) To calculate dry weights and carbon contents of the trees in the hill evergreen forest (HEF) which was the main forest type in watershed area by the formulae below (Tsutsumi *et al.*, 1983).

$$W_S = 0.0509\ (DBH^2h)^{0.919} \quad (1)$$

$$W_B = 0.00893\ (DBH^2h)^{0.977} \quad (2)$$

$$W_L = 0.014\ (DBH^2h)^{0.669} \quad (3)$$

$$W_T = W_S + W_B + W_L \quad (4)$$

where W_S = dry weight of stem (kilogram: kg)

W_B = dry weight of branch (kg)

W_L = dry weight of leaf (kg)

W_T = dry weight of tree (kg)

DBH = diameter at breast height (cm) at 1.3 m. above surface; (DBH = GBH/π)

h = tree height (m)

2) To calculate above-ground (AG) carbon content of each tree by multiplying the dry weight of tree (W_T) with

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the standard constant of 0.48 (IPCC, 2015), while estimating 20% of the total dry weight as understory. Below-ground (BG) carbon content was calculated by multiplying the standard constant of 0.37 with the AG carbon content (IPCC, 2006).

AG tree carbon content (kg.) = Total dry weight of tree (kg.) x 0.48 (5)

AG understory carbon content (kg.) = Total dry weight of tree (kg.) x 0.20 (6)

AG carbon content (kg.) = Tree carbon content + Understory carbon content (7)

BG carbon content (kg.) = AG carbon content (kg.) x 0.37 (8)

Then, the carbon sink of the entire HEF was done by multiplying total carbon content with the HEF area, while, the carbon dioxide absorption calculation based on multiplying the constant of 3.66 (1.0 g carbon = 3.66 g CO_2) with the carbon content of the HEF.

2.2 The roles of Karen ethic group in forest conservation and climate change recognition

The roles of Karen in forest conservation were collected from preliminary field surveys and informal interviews with key informants, in-depth interviews and observation. Role is a set of connected behavior, rights, obligations, beliefs, and norms as conceptualized by people in a social situation. It is an expected or free or continuously changing behavior and may have a given social status or social position to individuals. The variables for primary data collection included culture, tradition, livelihood, agriculture, natural resource utilization and forest conservation. In addition, the secondary data were collected from relevant documents, reports and research articles. The secondary data included climate, population, history, culture and tradition.

Data of climate change recognition by the villagers were collected by interviewing the target villagers from four target groups including 1) informal and formal village leaders, 2) respectful elderly people, 3) folk medicine men, and 4) saviors. The researchers aimed for a sample size of at least 30% of the total population, while the population was 39 people. In fact, the total samples of this study were 26 people, accounting for 66.67 % of the total population. The target villagers were current dwellers who resided in Khun Saab village for a long time (at least 20 years) so they were able to recognize the climate change or variation occurring in their village. The target villagers were interviewed on five issues comprising (1) changes of temperature and climate conditions that they recognized, (2) seasonal characteristics and duration, (3) disaster related to water resource, (4) pest epidemic, and (5) change of species and seasons of non-timber forest products (NTFPs) collection. Then, the data were analyzed by descriptive statistics and t-test to assess the recognition and awareness of the target villagers on climate change.

RESULTS AND DISCUSSIONS

1. Forest ecosystem and biodiversity of Huai Hok sub-watershed

Total 462 tree individuals were observed and identified species of 59 species in 47 genera and 33 families existed in the HEF of Huai Hok sub-watershed. In addition, five tree species was awaited for identification (Appendix Table 1). Tree density and basal area were 1,443.75 individuals.ha^{-1} and 9.857 m^2.ha^{-1}, respectively. While, tree diversity based on Shannon-Weiner index (H$^/$) showed the intermediate diversity (H$^/$ = 3.48). Considering to each plot result, the elevation of first and second plot had almost similar (1,032 – 1,041 and 1,067 – 1,088 m a.s.l., respectively). However, the higher slope was detected in first plot (ranged from 30 – 60%) than second plot (ranged from 11 - 15 %). Because the second plot was laid down on the mountain ridge which provided large flat areas. This condition could be supported tree establishment in which high tree density almost two times was found in the second plot, 17,875 individuals.ha^{-1} or 286 individuals.rai^{-1} (Table 1). Indicating second plot was under the recovery phase after some utilizations (personal observation) and revealed with small individual trees.

The most dominance tree species based on their IVI was Muead Lode (*Aporosa villosa*), 20.61 % which is a shrubby tree species, and followed by Kang Kok (*Nyssa javanica*), Ko Paen (*Castanopsis diversifolia*), Mangtan (*Schima wallichii*), Siam Benzoin (*Styrax benzoides*), Tiew Khon (*Cratoxylum formusum*), Indian Walnut (*Albizia lebbeck*), and Kra Phi Khao Kwai (*Dalbergia cultrata*), with value of 16.04, 13.21, 13.12, 12.78, 12.40, 10.83, and 10.73 %, respectively. Some dominance species of HEF in the family of Fagaceae such as Ko Dueai (*Castanopsis acuminatissima*), Ko Daeng (*C. hystix*), and Ko Dam (*Lithocarpus truncata*) can be found with less abundance. Many pioneer species such as Liang (*Berrya mollis*), Yab Bai Yao (*Colona flagrocarpa*), Yab Bai Yai (*Colona flagrocarpa*), Po Daeng (*Sterculia guttata*), and Po Taen (*Colona elobata*). Many species of shrubby trees such as Mountain Ebony Tree (*Bauhinia variegata*), Kaao San (*Phyllanthus columnaris*), Man Pla (*Glochidion sphaerogynum*), Mao Soi (*Antidesma acidum*), and Mao Sai (*Antidesma sootepense*) also found. Indicating, the study areas were disturbed and created the open areas which suitable environments, particular high light conditions, for their establishment. (Appendix Table 1).

Low species diversity (59 species) was found compare to other reports in the natural HEF or montane evergreen forest in Thailand which ranged from 140 - 210 species (Khamyong and Seramethakul,1998; Marod et al., 2015; Sri-ngernyuang et al., 2003). In addition, we had no found the species in family of Lauraceae, and also less species of Fagaceae, even though, these were the dominance family in HEF (Marod and Duengkae, 2019). It may be caused from the previous anthropogenic disturbances based on converted forest areas into agriculture areas. Recently, the villagers' understanding of the watershed forest importance, then, practice of forest conservation and less utilization of the watershed area had been promoted to increase plant biodiversity.

2. Carbon sequestration in the watershed forest

Forest carbon sink in HEF of Huai Hok sub-watershed area was 26,326.08 ton C in the forest area of 1.4 km^2 and the average carbon sequestration was 18,804.34 ton C km^{-2}, including AG carbon sequestration of 13,725.80 ton C km^{-2} and BG carbon sequestration of 5,078.54 ton C km^{-2}. Carbon stock in the first plot was higher than second plot, 20,262.52 and 17,346.16 ton C km^{-2}, respectively. It was negative correlation with tree density in the plot. In addition, the total carbon dioxide absorption and its rate were 96.35 Gigagram CO_2 and 68.82 Gigagram CO_2 km^{-2}. The carbon dioxide absorption rate was higher than the standard rate (41.85 Gigagram CO_2 km^{-2}). It could be based on they were under recovery phase which needed more food supply through the photosynthesis.

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Table 1. Forest carbon sequestration in HEF of Huai Hok sub-watershed, Khun Saab village

HEF	Tree density (individuals.ha^{-1})	Carbon sequestration (ton C km^{-2})			
		Above-ground		Below-ground	Total
		Tree	Understory		
Plot 1	110,000	12,325.13	2,465.03	5,472.36	20,262.52
Plot 2	178,750	10,551.19	2,110.24	4,684.73	17,346.16
Average	144,375	11,438.16	2,287.63	5,078.54	18,804.34

Many researchers reported that the carbon storages varied among the forest types and conditions. For instant, Khamyong (2009) showed that the lowest carbon sequestration in natural forest at Doi-Suthep Pui National Park was found in the deciduous dipterocarp forest, DDF, (12,707 ton C km^{2}), and followed by the mixed deciduous forest, MDF, and hill evergreen forest (21,689 and 28,177 ton C km^{-2}, respectively. Because the deciduous forests, DDF and MDF, had low tree density (Bunyavejchewin, 1983; Marod et al., 1999) compared to the evergreen forests as HEF (Sri-ngernyuang et al., 2003; Marod and Duengkae, 2019). While, in the community forest (CF) which mostly applied for local utilization also varied among CF, such as, at Huai Hin Lad village was 21,200 ton C km^{-2} (Asia Indigenous Peoples Pact *et al*., 2011), at Nhong Tao village was 12,688 ton C km^{-2}, and at Huai Tong village was 14,185 ton C km^{-2} (Seeloy-ounkeaw, 2014). Indicating the carbon sequestration varied among forest types and some disturbances as resource utilization. In this study, we found the average carbon sequestration (18,804.34 ton C km^{-2}) was higher than the default value of the evergreen forest in Thailand, 11,435 ton C km^{-2} (LEAF, 2015), and its was the intermediate value between natural MDF and HEF based on Khamyong (2029). Thus, recently conservation forest management, particular sustained utilization of the villagers might be increased the carbon storage in the recovery forest areas.

3. Roles of Karen ethnic group in forest conservation and climate change recognition

There were 4 categories of land uses classified by Mae Saab Subdistrict Administrative Organization (2015) including: (1) agricultural area of 1.032 km^{2} (645 rai), (2) homestead of 0.16 km^{2} (99 rai), (3) forest area of 18.89 km^{2} (11,807.25 rai), and (4) other land uses, such as, temple, school, public land, village spirit area for traditional ceremonies, equal to 0.128 km^{2} (80 rai). The villagers were mostly farmers. The upland cultivation was practiced about 2 to 3 years, and then abandoned for 5 to 10 years, which was considered to be rotational cultivation. The villagers also collected NTFPs from the forest for food and medicine.

Khun Saab villagers were Sgaw Karen or white Karen who called themselves as Pa-Ka-Koe-Yo (Presson, 2005). There were 3 groups of leaders in the village including (1) traditional leaders, who were mostly elected as the official village head, (2) ancestral leader (female), and (3) the elderly or senior leaders. The religions were animism, Buddhism and Christianity. The Karen believed that the spirit lived everywhere in their village territory. There were several spirit types, such as, land spirit, house spirit, water spirit, weir-canal spirit, forest spirit, which protected them from bad lucks or unfortunate situations. Thus, they paid respect to the nature via the spirit regularly. The cultural calendar is shown below as Table 2.

Table 2. Cultural calendar of Khun Saab village, Mae Saab sub-district, Samoeng district, Chiang Mai province

Month	Activities
January	Village rituals (getting rid of bad lucks from the households)
February	Select land for utilization, new rice cooking and giving to the shaman, and blessing wrist tying
March	Prepare the land for cultivation
April	Offer sacrifices to the land spirit
May	Sow the rice, blessing wrist tying and wish for good products
June – July	Offer sacrifices to the land spirit and wish for good products
August – September	Maintain their crops
October	Harvest upland rice
November	Harvest paddy rice
December	Threshing, drying, and keeping the rice in their barns

The Karen people of Khun Saab village played the important roles in forest conservation by applying their traditional and cultural knowledge. They managed and protected their natural resources and biodiversity which could be seen from 97.88% of the entire watershed area was watershed forest, and allowed only 2.12% as agricultural area in the lowland of Huai Hok watershed. It was also based on the fact that 84.62% of the total population in this case study understood and followed the forest regulations set up by the villagers so their watershed forests had become into the good conditions and the perennial stream yielded water all-year-round. Karen people at Huai Hin Lad village also followed the rules and regulations for natural resource management while undertaking forest conservation activities, such as, wildfire control and patrol, forest protection, and reforestation (Asia Indigenous Peoples Pact *et al.*, 2011).

The results showed that the villagers recognized climate change in the area significantly ($t=2.51$, $p<0.05$). All respondents recognized pest epidemics, and followed by change of temperature and climate conditions (88%). Some of them recognized seasonal changes and duration (34.62%), and species and seasonal changes of NTFPs collection (6.25%). None of them recognized disaster related to water resource. Some of the samples were the elderly people who were not concerned with climate change impacts. The details can be seen in table 3.

Table 3. Recognition of climate change by Khun Saab villagers, Mae Saab sub-district, Samoeng district, Chiang Mai province

Climate change impacts	Number of sample	Number of respondent[1]	Recognition		t	p
			Number of people	Percentage (%)		
Temperature and climate conditions	26	25	22	88.00	2.51	0.02*
Seasonal characteristics and duration	26	26	9	34.62		
Disaster related to water resource	26	26	0	0.00		
Pest epidemics	26	16	16	100.00		
Species and seasons of NTFPs	26	16	1	6.25		
Average	**26**	**22**				

Remark: [1] the respondents meant the samples which knew about the situations and could reply.
* Significantly with $p < 0.05$

The pest epidemics were very high, since all of the respondents found that insect pests increased (100% of the respondents). Increase of plant diseases was 31.25%, while animal pest increase was 6.25% of total respondents respectively. The villagers recognized the temperature and climate conditions changes mostly (88%). They felt warmer with stronger sunshine in the summer (100%). Less rainfall in the rainy season was obvious, and they felt warmer in the winter as well (62.50%). For instance, the average temperature during 1981-2010 was 25.8 ˚C, whilst it was 27.6 ˚C during the 2 year of field study. The average rainfall in the rainy season (May – October) was 972.6 mm/year, while it was low during the research period (1981-2010), 587.5 mm/year and 967.5 mm/year respectively (Northern Meteorological Center, 2016). Regarding the impacts of climate change upon their livelihoods, some respondents found that agricultural crops were affected highly (57.14%), and followed by the impacts upon people livelihoods (42.86%) causing the villagers to be sick more often. Although the villagers recognized the climate change, they did not take any actions yet because their livelihoods were still quite normal according to their opinions.

Only 34.62 % of the respondents realized changes of seasonal characteristics and duration. The highest recognition of the villagers was the changes of summer (46.15 % of the respondents), the winter (34.62%) and the rainy season (30.77%). The duration of summer was longer and it was warmer than in the past, while the beginning came earlier and the ending was later. The respondents felt that the rainfalls fluctuated more than those before. The winter was warmer and shorter than the past.

Some villagers who recognized the changes in species and seasons of NTFPs collections was 6.25% of the respondents. The species and seasons of NTFPs have not changed so far, while the villagers recognized that quantity of NTFPs were changed. The villagers stressed that most bamboo plants died last year so the quantity of bamboo shoots was decreased. However, most respondents collected NTFPs for consumption only. They tended to collect NTFPs less these days, comparing with the past. The NTFPs included mushrooms, bamboo shoots, tree shoots, and medicinal plants.

The disaster related to water resource has never occurred in the case-study area. There were flash floods in the rainy season, however it was still normal in their opinions. Flooding caused several aquatic species to increase, such as, fishes, frogs, crabs and others, which were caught by the villagers for food. Nevertheless, flooding never occurred since the stream was dredged during the research.

The villagers participated in activities related to forest conservation at a rate of 61.54 % of the total samples. The activities included setting up forest fire lines (56.25% of respondents), planting trees in the forest (31.25% of respondents), and undertaking forest patrols (6.25% of respondents). Most elderly people (38.46% of the samples) who could not undertake the demanding activities did not participate in those activities

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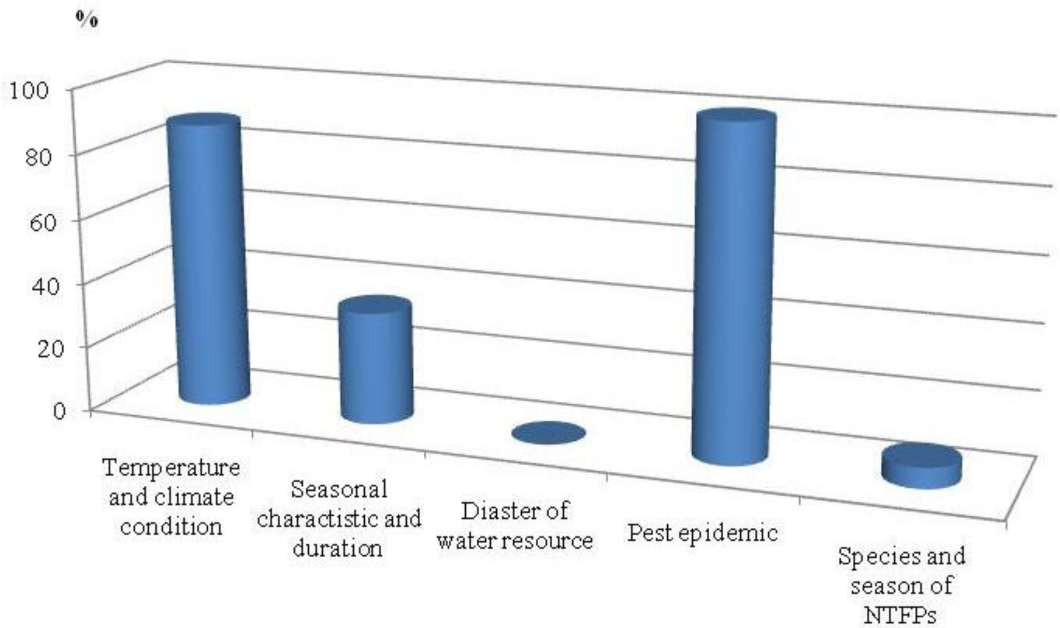

Figure 3 Climate change recognition by Karen ethnic group of Khun Saab village, Samoeng district, Chiang Mai province

It obviously shown that Khun Saab villagers recognized some climate change factors, such as, pest epidemics, temperature and climate conditions, and seasonal characteristics and duration, as it showed statistical significance. However, the villagers have maintained their current livelihoods mostly, as the climate change impacts were not yet severe. The elderly Karen was still able to cope with the incremental changes as they have seen some fluctuations in the weather patterns for many years. The rainfalls indeed affected the villagers' livelihoods because most villagers were farmers. Asia Indigenous Peoples Pact *et al.* (2011) found that traditional livelihood practices of Huai Hin Lad villagers were helping to balance the ecosystems, mitigate adverse impacts of climate change effectively, and maintain food security sustainably. It was also drawn that consumption pattern of the community was low, which was properly managed through their beliefs, wisdom and community regulations. Wongvan and Amnuay-ngerntra (2018) analyzed that the type of Karen farming relied highly on Karen knowledge of soil selection and watershed preservation which was paramount to the Karen wellbeing. And that could be considered as the Karen philosophical concept of human-forest relationship or the livelihood-based forest management of the Karen. Ministry of Natural Resources and Environment (2014) concluded that local villagers who were living in or nearby the forests in Thailand, were utilizing forest biodiversity, based on their belief, culture, tradition including their local knowledge which were compiled, tested and passed on from their ancestors.

CONCLUSION

The forest structure and species composition in this study could be classified as under the recovery phases. It was under the good process, even though, low species diversity (59 species) was found. However, high tree density was found 1,443.75 individuals.ha^{-1} with tree basal area of 9.857 m^2.ha^{-1}. Forest carbon sequestration of the HEF in Huai Hok sub-watershed was diverse, ranging from 17,346.16 to 20,262.52 ton C km^{-2}, while the average sequestration was 18,804.34 ton C km^{-2}. In addition, the carbon dioxide absorption was 96.35 Gigagram CO_2 with the rate of 68.82 Gigagram CO_2 km^{-2} which was higher than the standard value of 41.85 Gigagram CO_2 km^{-2}. Indicating the good-conditions of HEF were able to sequester large amount of carbon and mitigate climate change.

The watershed forests have been conserved by the Karen villagers effectively through various activities, such as, fire break setting up, forest patrol, planting trees. The forests yielded direct benefits, such as, wood, carbon sinks, food, as well as, good quality and all-year-round water. Most villagers were not yet affected by climate change, although they already recognized climate change. Thus, the indigenous knowledge of Karen could be potential included into the awareness policy for mitigation and adaptation on the climate changes.

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Appendices

Appendix Table 1 Quantitative ecology of the hill evergreen forest in Huai Hok sub-watershed, Khun Saab village, Samoeng district, Chiang Mai province. The abbreviates represented as; basal area (BA, m^2), density (Den, individual.ha^{-1}), relative density (RF, %), relative frequency (RF, %), relative dominance (RDo, %), and important value index (IVI, %), respectively.

No.	Local name	Botanical name	Family	BA	Den	RD	RF	RDo	IVI
1	Muead Lode	*Aporosa villosa* (Wall. ex Lindl.) Baill.	Euphorbiaceae	0.336	215.63	14.94	2.27	3.41	20.61
2	Kang Kok	*Nyssa javanica* (Blume) Wangerin	Cornaceae	0.509	140.63	9.74	1.14	5.16	16.04
3	Ko Paen	*Castanopsis diversifolia* (Kurz) King	Fagaceae	0.865	31.25	2.16	2.27	8.78	13.21
4	Mangtan	*Schima wallichii* (DC.) Korth.	Theaceae	0.898	25	1.73	2.27	9.11	13.12
5	Siam Benzoin	*Styrax benzoides* Craib	Styracaceae	0.459	84.38	5.84	2.27	4.66	12.78
6	Tiew Khon	*Cratoxylum formusum* (Jack) Dyer subsp. *pruniforum* (Kurtz) Gogel.	Guttiferae	0.55	65.63	4.55	2.27	5.58	12.4
7	Indian Walnut	*Albizia lebbeck* (L.) Benth.	Leguminosae-Mimosoideae	0.395	65.63	4.55	2.27	4.01	10.83
8	Kra Phi Khao Kwai	*Dalbergia cultrata* Graham ex Benth.	Leguminosae-Papilionoideae	0.407	62.5	4.33	2.27	4.13	10.73
9	Mountain Ebony Tree	*Bauhinia variegata* L.	Leguminosae-Caesalpinioideae	0.579	25	1.73	2.27	5.87	9.87
10	Ma Faen	*Protium serratum* Engl.	Burseraceae	0.492	31.25	2.16	2.27	4.99	9.43
11	Rosewood	*Dalbergia oliveri* Gamble	Leguminosae–Papilionoideae	0.294	71.88	4.98	1.14	2.99	9.1
12	Hoi Jan	*Engelhardtia serrata* Bl.	Juglandaceae	0.293	37.5	2.6	2.27	2.97	7.84
13	Kaao San	*Phyllanthus columnaris* Müll. Arg.	Euphorbiaceae	0.193	40.63	2.81	2.27	1.96	7.05
14	Man Pla	*Glochidion sphaerogynum* (Müll. Arg.) Kurz	Euphorbiaceae	0.155	37.5	2.6	2.27	1.57	6.44
15	Hai	*Ficus geniculata* Kurz. T	Moraceae	0.481	3.13	0.22	1.14	4.88	6.24
16	Ko Daeng	*Castanopsis hystrix* A.DC.	Fagaceae	0.198	25	1.73	2.27	2.01	6.01
17	Pa Yom	*Shorea roxburghii* G.Don	Dipterocarpaceae	0.108	37.5	2.6	2.27	1.09	5.96
18	Ko Dam	*Lithocarpus truncatus* (King) Rehder &Wilson	Fagaceae	0.251	31.25	2.16	1.14	2.55	5.85
19	Kra Phi Nang Nuan	*Dalbergia cana* Graham ex Kurz	Leguminosae-Papilionoideae	0.182	25	1.73	2.27	1.85	5.85
20	Cham Pi Pa	*Michelia floribunda* Finet & Gagnep.	Magnoiliaceae	0.24	12.5	0.87	2.27	2.43	5.57
21	Kai Daeng	*Ternstroemia gymnanthera* (Wight & Arn.) Bedd.	Theaceae	0.062	25	1.73	2.27	0.63	4.63
22	Makok Kleon	*Canarium subulatum* Guillaumin	Burseraceae	0.102	15.63	1.08	2.27	1.04	4.39
23	Tin Nok	*Vitex pinnata* L.	Labiatae	0.204	12.5	0.87	1.14	2.07	4.07
24	Khammok Luang	*Gardenia sootepensis* Hutch.	Rubiaceae	0.047	18.75	1.3	2.27	0.48	4.05
25	Indian Plum	*Flacourtia indica* (Burm.f.) Merr.	Flacourtiaceae	0.136	21.88	1.52	1.14	1.38	4.03
26	Rak Noi	*Gluta obovata* Craib	Anacardiaceae	0.012	21.88	1.52	2.27	0.12	3.91
27	Ma Ha	*Syzygium albiflorum* (Duthie & Kurz) Bahadur & R.C.Guar	Myrtaceae	0.087	25	1.73	1.14	0.88	3.75
28	Devil Tree	*Alstonia scholaris* (L.) R.Br.	Apocynaceae	0.075	6.25	0.43	2.27	0.76	3.46
29	Mao Soi	*Antidesma acidum* Retz.	Euphorbiaceae	0.012	12.5	0.87	2.27	0.12	3.26
30	Yo Pa	*Morinda coreia* Ham.	Rubiaceae	0.025	6.25	0.43	2.27	0.25	2.96
31	Sa Lhao Khao	*Lagerstroemia tomentosa* C.Presl	Lythraceae	0.048	18.75	1.3	1.14	0.48	2.92

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No.	Local name	Botanical name	Family	BA	Den	RD	RF	RDo	IVI
32	Kai Bai Yai	(awaited to confirm)		0.088	12.5	0.87	1.14	0.89	2.89
33	Kaao	*Tristaniopsis burmanica* (Griff.) Peter G. Wilson & J.T.Waterh var. rufescens (Hance) J.Parn. & Nic Lughadha	Myrtaceae	0.005	6.25	0.43	2.27	0.05	2.76
34	Sae Boh Au	(awaited to confirm)		0.087	9.38	0.65	1.14	0.89	2.67
35	Mamao Sai	*Antidesma sootepense* Craib	Euphorbiaceae	0.056	12.5	0.87	1.14	0.57	2.57
36	Ko Dueai	*Castanopsis acuminatissima* (Blume) A.DC.	Fagaceae	0.119	3.13	0.22	1.14	1.21	2.56
37	Sak Khi Gai	*Premna tomentosa* Willd.	Labiatae	0.054	12.5	0.87	1.14	0.55	2.55
38	Myrabolan Wood	*Terminalia chebula* Retz. var. chebula	Combretaceae	0.059	9.38	0.65	1.14	0.59	2.38
39	Viburnum	*Viburnum sambucinum* Blume var. *tomentosum* Hallier f.	Caprifoliaceae	0.036	12.5	0.87	1.14	0.36	2.37
40	Liang	*Berrya mollis* Wall. ex Kurz	Tiliaceae	0.075	3.13	0.22	1.14	0.76	2.11
41	Muead Khon Tua Phu	*Helicia nilagirica* Bedd.	Proteaceae	0.053	6.25	0.43	1.14	0.54	2.11
42	Saan Yai	*Dillenia obovata* (Blume) Hoogland	Dilleniaceae	0.049	6.25	0.43	1.14	0.5	2.07
43	Khun Mai	*Nageia wallichiana* (C.Presl) Kuntze	Podocarpaceae	0.068	3.13	0.22	1.14	0.69	2.04
44	Unidentified 2	(awaited to confirm)		0.021	9.38	0.65	1.14	0.21	2
45	Lamyai Pa	*Paranephelium xestophyllum* Miq.	Sapindaceae	0.019	9.38	0.65	1.14	0.19	1.98
46	So	*Gmelia arborea* Roxb.	Labiatae	0.041	6.25	0.43	1.14	0.41	1.98
47	Yab Bai Yao	*Colona flagrocarpa* (C.B.Clarke) Craib	Tiliaceae	0.035	6.25	0.43	1.14	0.36	1.93
48	Unidentified 1	(awaited to confirm)		0.035	6.25	0.43	1.14	0.35	1.92
49	Po Daeng	*Sterculia guttata* Roxb.	Sterculiaceae	0.029	6.25	0.43	1.14	0.29	1.86
50	Kluai Rue Si	*Diospyros glandulosa* Lace	Ebenaceae	0.037	3.13	0.22	1.14	0.38	1.73
51	Kai Sai	*Stereospermum neuranthum* Kurz	Bignoniaceae	0.037	3.13	0.22	1.14	0.37	1.72
52	Po Taeng	*Colona elobata* Craib	Tiliaceae	0.031	3.13	0.22	1.14	0.31	1.66
53	Sae Kha	(awaited to confirm)		0.004	6.25	0.43	1.14	0.04	1.61
54	Beleric Myrobalan	*Terminalia bellirica* (Gaertn.) Roxb.	Combretaceae	0.02	3.13	0.22	1.14	0.2	1.55
55	Mamao Luang	*Antidesma thwaitesianum* Müll. Arg.	Euphorbiaceae	0.017	3.13	0.22	1.14	0.18	1.53
56	Tabaek Na	*Lagerstroemia floribunda* Jack	Lythraceae	0.016	3.13	0.22	1.14	0.16	1.51
57	Ngiew Pa	*Bombax anceps* Pierre var. *anceps*	Bombacaceae	0.015	3.13	0.22	1.14	0.15	1.5
58	Khae Pa	*Markhamia pierrei* Dop	Bignoniaceae	0.013	3.13	0.22	1.14	0.13	1.49
59	Manod	*Ficus ribes* Reinw. ex Blume	Moraceae	0.01	3.13	0.22	1.14	0.1	1.46
60	Ma Kok Pran	*Turpinia pomifera* (Roxb.) DC.	Staphyleaceae	0.01	3.13	0.22	1.14	0.1	1.45
61	Ta Khram	*Garuga pinnata* Roxb.	Burseraceae	0.009	3.13	0.22	1.14	0.1	1.45
62	Hum Hok	*Pterospermum semisagittatum* Hum.	Sterculiaceae	0.006	3.13	0.22	1.14	0.07	1.42
63	Malacca Tree	*Phyllanthus emblica* L.	Euphorbiaceae	0.006	3.13	0.22	1.14	0.07	1.42
64	Dong Dam	*Alphonsea glabrifolia* Craib	Annonaceae	0.002	3.13	0.22	1.14	0.02	1.38
	Total			**9.857**	**1,443.75**	**100**	**100**	**100**	**300**