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Adaptation to Climate Change by Rural Ethnic Communities of Northern Thailand

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Abstract: Northern Thailand has been experiencing the impact of climate change due to its fragile agro-ecosystem, inhabited by a resource-poor population. The study, conducted in a mountainous landscape of Doi Mae Salong area in Northern Thailand, explores the farmers' perceptions of climate change, its impact on farming, and adaptation measures undertaken by the two ethnic communities in the area for coping with climate change impacts. The data were collected through a structured questionnaire survey of ninety farm households using the recall approach for the past twenty years. The findings suggest that the farmers have perceived the change in climate pattern of the study area, and its negative impact on farming. Farm households have been trying to cope with the impacts by adapting to alternate farming options and practices using traditional techniques. The impact was perceived to be higher in the community living at higher elevation compared to those at lower elevation. Although autonomous adaptation is occurring in the area, the vulnerability of farm households to the impact of climate change still exists in terms of the lack of knowledge and financial resources.

Keywords: climate change impact; adaptation; farming; ethnic communities; Northern Thailand

1. Introduction

Southeast Asian countries, including Thailand, are experiencing climate change, and the increased frequency of climate-related hazards has resulted in substantial negative impacts in many areas [1]. Thailand has experienced climate fluctuation, particularly in rainfall patterns and temperature. Between 1955 and 2009, the average annual temperatures in Thailand have significantly increased—by 0.95 °C—while the rainfall trend is observed to fluctuate in different regions of the country [2]. Thailand has been facing tremendous damage due to droughts [3] and floods [4]. Thailand has nearly 55% of its total area under different forms of agricultural use, and any change in climate condition can destabilize agricultural productivity with important indirect collateral effects on farmers´ income, health and educational status [5–7]. Northern Thailand is dominated by mountainous landscape with a fragile agro-ecosystem, where resource-poor populations practicing subsistence agriculture are highly vulnerable from a climate perspective [8], and thus rural poverty could be exacerbated due to the negative impacts of climate change on agricultural production and a general increase in food prices and the cost of living [9].

Under these circumstances, adaptation strategies at farm level are essential to mitigate the impacts of climate change. Adaptation is a means of reducing risks posed by scarcity of resources, environmental change and increasingly by climate change [10]. Adaptation can be autonomous, i.e., adaptation happening without intervention, or can be a planned adaptation with deliberate intervention [11,12]. Autonomous adaptation might not occur spontaneously; rather, it depends on how climate change impact influences the livelihoods of people; for example practicing water conservation during water scarcity as the impact of climate change [13] to offset negative climate change impacts. Numerous adaptation studies have been conducted on assessing the impacts of climate change on crop yield [14,15] and the empirical evidence proves that climate change adaptation enables a reduction in impacts and prevents possible damage to farmers and their livelihood [16].

The studies suggest that farmers' adaptation to climate change are affected by socioeconomic factors, such as farmers' adaptive capacity and traditional practices [17,18]. The study conducted in northern Thailand found that the farmers' agricultural experience, farm income, training, social capital, and effective climate adaptation communication significantly increased the probability of adaptation by the farmers [16]. Thus, understanding how climate change is perceived, experienced and responded to by the farmers at a household level is important for devising appropriate adaptation strategies and support policies for addressing the expected changes.

Lack of appropriate adaptation practices further worsens the vulnerability of the farmers, who are vulnerable and in need of a response to extreme events [19]. The farm-level adaptation strategy appropriate to different farming conditions is still an area to explore due to lack of baseline information [20], and hence a better understanding of farmers' perceptions of climate change, ongoing adaptation measures, and the decision-making process is important for developing well-targeted adaptation policies [21]. Therefore, this paper presents a study of adaptation to climate change at farm level by the ethnic communities in Northern Thailand by understanding farmers' perception of climate change and adaptation measures.

2. Study Area

The study was conducted in the Doi Mae Salong area covering part of Mae Fah Luang and Mae Chan district of Chiang Rai province in northern Thailand (Figure 1). Located in a mountainous region with an elevation ranging from 900 to 1300 m above sea level, the temperature in the area ranges from 12 °C to 35 °C, and an annual rainfall of 1556 mm. Two main seasons of the year are the wet season (May to October) and the dry season (November to April).

Doi Mae Salong, which lies close to the Myanmar border, is inhabited by mostly hill tribes of Chinese origin, who were displaced during the Chinese civil war, and direct descendants of the Kuomintang regiment from Myanmar. Besides *Chinese*, other dominant ethnic groups are *Akha*, *Yao*, *Thai*, *Yai*, *Lawa*, and *Lahu*. The area is part of the golden triangle—famously known for growing opium in the past—and hence farming was not the main business in the area until the Thai Government created a crop-substitution program to encourage hill tribes to cultivate corn, rice, tea, coffee and fruit trees during the 1980s.

The study villages included Anglor and Lohyo, inhabited by the *Akha* ethnic group, and HeaKo village, inhabited by the *Lisu* ethnic group. The *Akha* are closely related to the *Hani* of China's Yunnan province, and they are usually settled on the saddle-back of a mountain range and occasionally in lowland villages, whereas the *Lisu* are settled at lower elevations with relatively better soil conditions and water availability. Despite the fact that these groups were involved in opium cultivation in the past, agriculture is presently the main activity and source of livelihood in both areas. The *Akha* mainly grow rice, corn and fruit trees as the dominant crop, whereas the *Lisu* grow rice, corn and beans.

The forest covers about 69% of the study area, and agriculture (rice, corn, bean, coffee, orchard, and tea) covers 31%. Traditionally grown agricultural crops, such as upland rice, which gives lower income, are being converted to commercial crops, such as tea, coffee, and fruit plantations recently, but mostly by the larger growers in the area, and not by the smaller ethnic households.

In the past, the weather in DMS used to be cold almost all year round, except in April and May. Heavier rainfall over short durations, leading to landslides in September and October, are increasingly observed due to steep slopes in the area. In winter (November to January), increased temperature affects the productivity of upland crops negatively by affecting the flowering and seeding stage of the crops. An increasing range of temperatures between day and night has been observed implying the higher extremes [22]. The area grows the finest quality of Ooulong tea, compared to other parts of Thailand, but tea cultivation is in the hands of big capitalists, whereas ethnic hill tribe farmers only work on tea estates as labor occasionally, and do small-scale farming of upland crops and fruit trees in the limited lands they own. Additionally, changing climate conditions are creating pressure on farming activities, crop patterns, and resources in DMS [23] despite an eminent lack of knowledge and support services in the area.

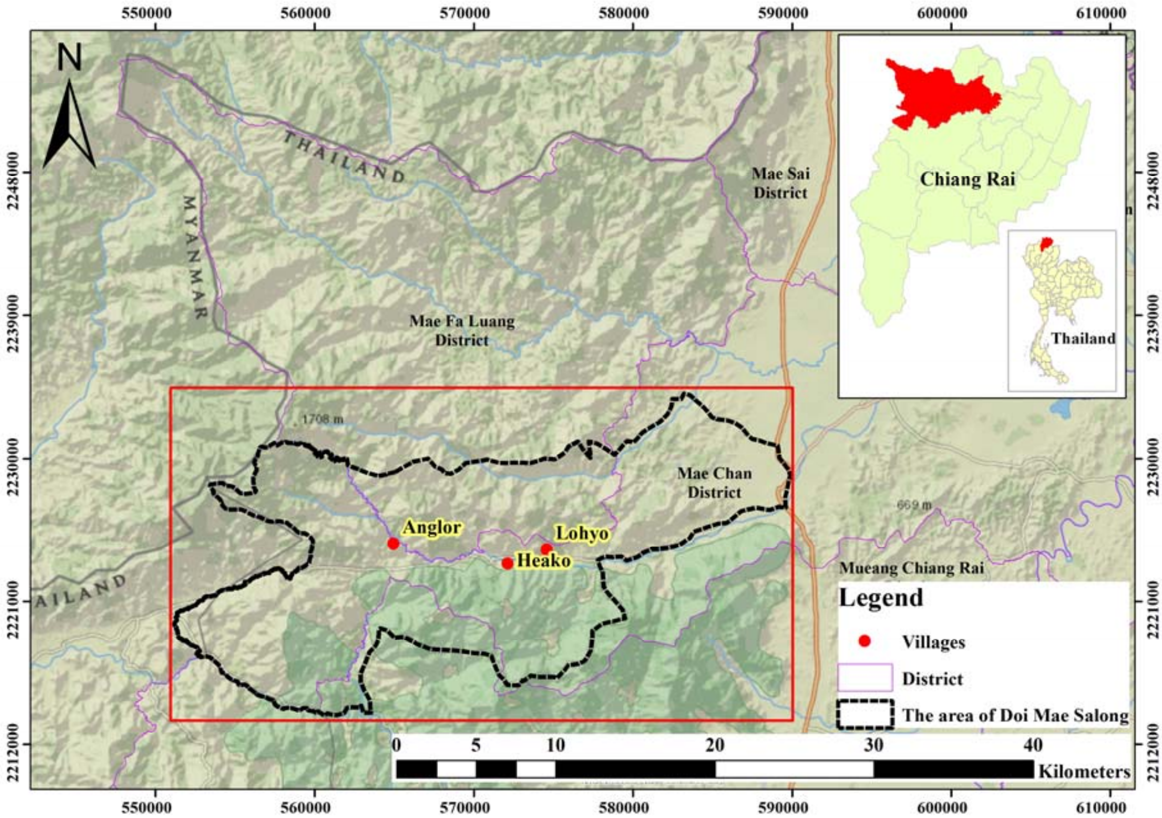

Figure 1. Location map of Doi Mae Salong area, Chiang Rai.

3. Methodology

3.1. Data Collection

The data were collected through key informant interviews, household questionnaire surveys, focus group discussions, and field observation. The key informant interviews were conducted to gain an understanding about climate trends in the area, upland crop- and land-use patterns, farmers' adaptation practices, and support provided by local government and other agencies during climate change-related disasters. Three heads of villages under study, three other elderly persons, and officers from the Sub-district Administrative Organization served as the key informants.

The questionnaire for the household survey contained both open- and close-ended questions to collect data on farmers' opinions, and was administered to 90 farmer households (60 households in *Akha* and 30 households in *Lisu* communities) between October and December 2012. The data from the survey consisted of household characteristics, socio-economic profiles, farming practices, land-use information, household income, perception of climate change and its impacts, and adaptation practices. Questions related to perception of climate change included trends in climate patterns; for instance, questions on whether there had been an increase, a decrease, or no change in temperature, rainfall, cold/heat wave, drought/flood, forest fire, or landslides in different seasons, as perceived by the respondents. Local people often have their own indicators (appearance, disappearance, or change in certain plants and animals) to base their perception about changes in climate pattern. Additional questions were asked on the impact of climate change on crop yield, weed/insect problems, soil productivity, water availability, and their coping practices with those perceived impacts.

Focus group discussion helps to gain information on issues of common interest or problems within a community. Two focus group discussions of about ten farmers per group were held to gather information on farmers' perceptions on climate trends, farmers' traditional practices of farming, and adaptation practices. Field observation was also conducted during the visits to households for the questionnaire interviews, as it is useful to complement the data from the household survey, key informant interview, and focus group discussion. Information about local physical context, such as farmers' livelihoods, housing/dwelling condition and assets, and crops grown was consistently observed.

Secondary data were collected from sub-district level government agencies and available published sources. There is no weather station in the area and hence, rainfall and temperature data were collected for a nearby Mae Chan Hill tribe Development station of the Thai Meteorological Department.

3.2. Data Analysis

The data from the household questionnaire survey was analyzed using descriptive statistics and statistical tests. A *t*-test was used to measure the difference between the means of two groups. Crosstab was used to describe characteristic of primary data in separate ethnic group and Chi-square to study the relation between farmer characteristics and respective responses. Similarly, Likert scale ranking or weighting index was used to prioritize among the responses of farmers on satisfaction level, impact severity of climate change and priority of the required support.

Climate data for 30 years were summarized by using simple statistics, such as sum, mean, relative frequency and a simple trend analysis was done to check whether such observed data relate with farmers' perception.

4. Results and Discussion

4.1. Respondents' Profile and Their Perception on Climate Change

The average age of *Akha* and *Lisu* respondents was 47 and 43 years, respectively (Table 1). Almost all the respondents were illiterate in both cases. Family size was slightly larger in *Akha* families, with six members in *Akha* and five in *Lisu*. The farm land owned by *Akha* communities was of an upland type, and by *Lisu* was a lowland type. Rice and corn are two major crops in the area, however fruit trees were also grown by *Akha* communities, and beans by *Lisu*.

Table 1. Socioeconomic characteristics of each village.

Socio-Economic Variable	*Akha*	*Lisu*
Ethnic group	*Akha*	*Lisu*
Total Households	91	46
Population	565	220
Average age of respondent (year)	47	43
Family size (people)	6	5
Education	Illiterate	Illiterate
Average Landholding size (ha)	1.1	1.3
Land type	Upland	Lowland
Dominant crop	Rice and Corn, and fruit trees	Rice, corn and bean

A substantial majority of 95% and 90% respondents from *Akha* and *Lisu* communities, respectively, perceived that they were experiencing variation in climate variables at present compared to some 10 or

20 years ago. 56% and 51% of respondents belonged to the 40- to 60-year age category in *Akha* and *Lisu*, respectively, indicating that they had experienced the changing climatic condition over the years (Table 2). 81 to 85% of respondents who had perceived such change were engaged in agriculture, and hence the perceived change could be based on the impact they had observed in farming. Similarly, 74% and 71% of farmer households who had perceived climate change were usually small holders who had less than 1.3 ha of farm size.

Table 2. Characteristics of respondents who perceived climate change.

Variable	*Akha*	*Lisu*	Variable	*Akha*	*Lisu*
	% HH			% HH	
			Land holding (Rai)		
Age (year)			<4	49.1	14.8
20–30	19.3	11.1	4–8	24.6	55.6
30–40	24.6	37.0	8–12	15.8	18.5
40–50	31.6	25.9	12–16	–	3.7
50–60	31.6	25.9	16–20	8.8	3.7
60–66	12.3	–	20–22	1.8	3.7
Education			Occupation		
Illiterate	75.4	66.7	Farming	80.7	85.1
Primary	17.5	29.6	Off-farm	14.0	3.7
Middle	7.0	3.7	No work	5.3	11.1
Gender			Land use		
Male	64.9	59.3	Changed	2.1	29.6
Female	35.1	40.7	Not changed	57.9	70.4

1 Rai = 0.16 ha.

As a measure to cope with climate change, 42% and 30% respondents from *Akha* and *Lisu*, respectively, of those who had perceived climate change had changed their land use types. There was no specific difference observed between the two communities with regard to gender and education level influencing their perception of climate change and eventual land use change. However, respondents' age, occupation and land holdings showed some influence. The perception of *Lisu* respondents as influenced by age category was found to be significant at 95% confidence level, with a lower proportion of elderly or retired (older age) respondents perceiving climate change. The perception of *Akha* farmers was also found to associate with occupation and total land holding size significantly at 95% confidence level.

4.2. Climate Trend

The climate trend, as perceived by farmers based on various climate variables in the last 20 years was based on a recall approach of the respondents, as we asked them during the interview to compare the current situation with 10 and 20 years ago. In Table 3, most respondents (76.3% *Akha* and 81.5% *Lisu*) perceived an increase in temperature in the area compared to 10 years ago. This coincides with the increase in heat wave since 66.7% *Akha* and 51.9% *Lisu* believed there have been an increase in heat waves compared to 10 or 20 years ago. This was also true for drought, which had increased in the last 10 years, as perceived by 42.1% *Akha* and 66.7% *Lisu* respondents. On the contrary, cold waves had decreased in the same period, as perceived by both groups. The rainfall amount was perceived to have increased by the majority of *Akha* respondents, whereas it was perceived to have decreased by *Lisu*. It is worth noting that the forest conditions at higher elevations or the head watershed region are better at present than in the past, and the *Akha* are living at higher elevation. The difference in opinion about rainfall patterns could be partly due to better forest condition in the head watershed; however, no specific analysis was done to verify this. There was no specific trend perceived by the respondents in case of rainfall intensity.

Table 3. Perceived trend of climate by respondents.

Climate Variable	*Akha*					*Lisu*				
	Increase		Decrease		No Change	Increase		Decrease		No Change
	10	20	10	20		10	20	10	20	
	% Respondents					% Respondents				
Temperature	<u>76.3</u>	9.7	1.75	-	12.25	<u>81.5</u>	11.1	–	–	7.4
Cold wave	7.0	-	<u>61.4</u>	17.5	14.0	3.7	-	<u>59.3</u>	29.6	7.4
Heat wave	<u>66.7</u>	17.5	–	–	15.8	37	<u>51.9</u>	–	–	11.1
Drought	42.1	5.3	–	–	<u>52.6</u>	<u>66.7</u>	11.1	–	–	22.2
Amount of rainfall	<u>52.6</u>	8.8	17.5	–	21.1	29.6	–	<u>48.1</u>	7.4	14.8
Rainfall intensity	24.6	10.5	26.3	3.5	<u>35.1</u>	33.3	–	<u>44.4</u>	3.7	18.6

Note: 10 and 20 represent 10 and 20 years ago, or approximately 2004 and 1994, respectively. "–" denotes no response in that category.

There is no weather station in the study area, and the Mae Chan Hill tribe Development station located outside the study area is the nearest weather station. We compared monthly minimum and maximum temperatures during 1980 to those in 2012 using the data recorded at this station. As the weather station is not located inside the study area, the purpose of this examination was to have a simple comparison of respondents' perceptions with empirically observed data for validation, hoping that the station would somehow represent the climate of the study area in the absence of other, better, sources of information. In Figure 2, temperature did not show any significant change in terms of decrease or increase; however, a trend of slight increase in minimum temperature is generally observed. The trend shown by the observed data is generally in line with what the farmers perceived, particularly for the dry season.

Time series data on annual rainfall and monthly rainfall amount from 1980 to 2012 recorded at the weather station are presented in Figures 3 and 4, respectively. Polynomial order 2 relation shows a slightly declining trend of rainfall in the recent past (Figure 3). The year-wise comparison of rainfall amount for each month since 1982 to 2012 showed a highly variable trend, and thus did not show any trend in particular in the months of February, April, August and December (Figure 4). A very slight increasing trend was observed in January and March, whereas a very slightly decreasing trend was observed between May and July, and between September and November. However, none of these trends were statistically significant. Regarding farmers' perception of rainfall, the responses of *Lisu* farmers, as shown in Table 3, were somehow in line with the observed empirical data from the weather station; however, the response of the *Akha* community located at comparatively higher elevation was different. In the study area, the farmers were more concerned with shorter term events, such as irregular rainfall patterns and/or drought due to extreme temperature, than the longer-term shifts in climate variables, and this is in line with the findings of other perception-based studies in the region [24], and can be explained by the fact that such shorter-term events are more easily perceived than the longer ones.

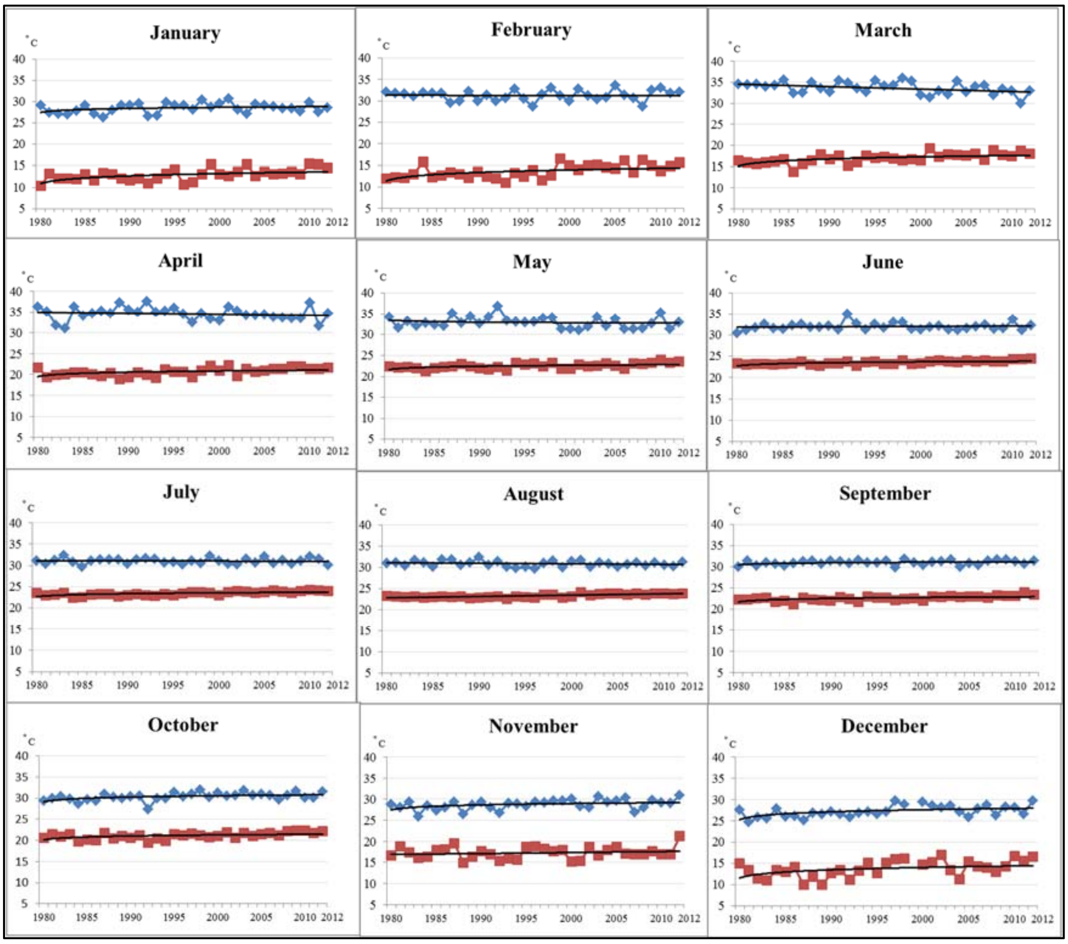

Figure 2. Monthly minimum and maximum temperature recorded at Mae Chan Hill tribe Development station in Chiangrai province.

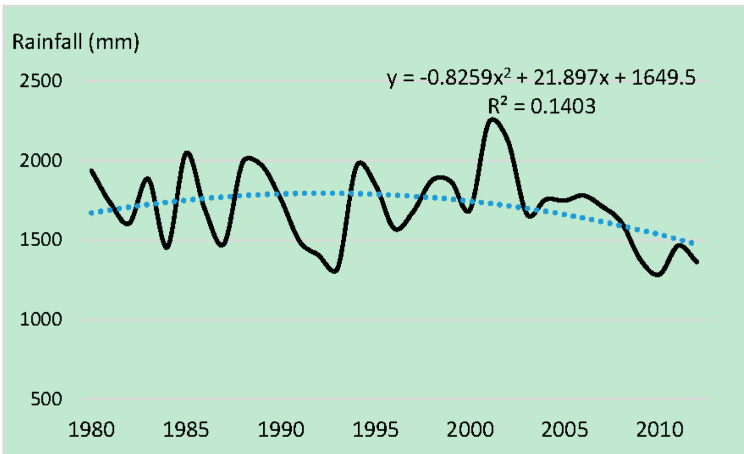

Figure 3. Annual rainfall of 1980–2012 at Mae Chan Hill tribe Development station.

The length of growing period (LGP) is the period (in days) during a year when precipitation exceeds half the potential evapotranspiration [25]. The plot of total decadal rainfall and evapotranspiration data observed at the Mae Chan Hill tribe development weather station, however, shows that the monthly rainfall during 2008–2012 had decreased compared to the past, and had no significant effect on LGP (Figure 5). Although there is no irrigation in the area, in the particular case of the *Akha* community, there was adequate soil moisture in their lands between May and September for cultivating annual crops in rainfed condition. The annual rainfall was also enough for perennial crops and fruit trees. The majority of rainfall occurs from July to September, with excess moisture, and thus there is risk of landslides, as the study area is mountainous countryside. The average annual rainfall amount of 1684, 1671, and 1666 mm for the three periods (1980–1990, 1991–2000, and 2001–2012) calculated from weather station data, however, shows a decreasing trend, although the decrease was not significant.

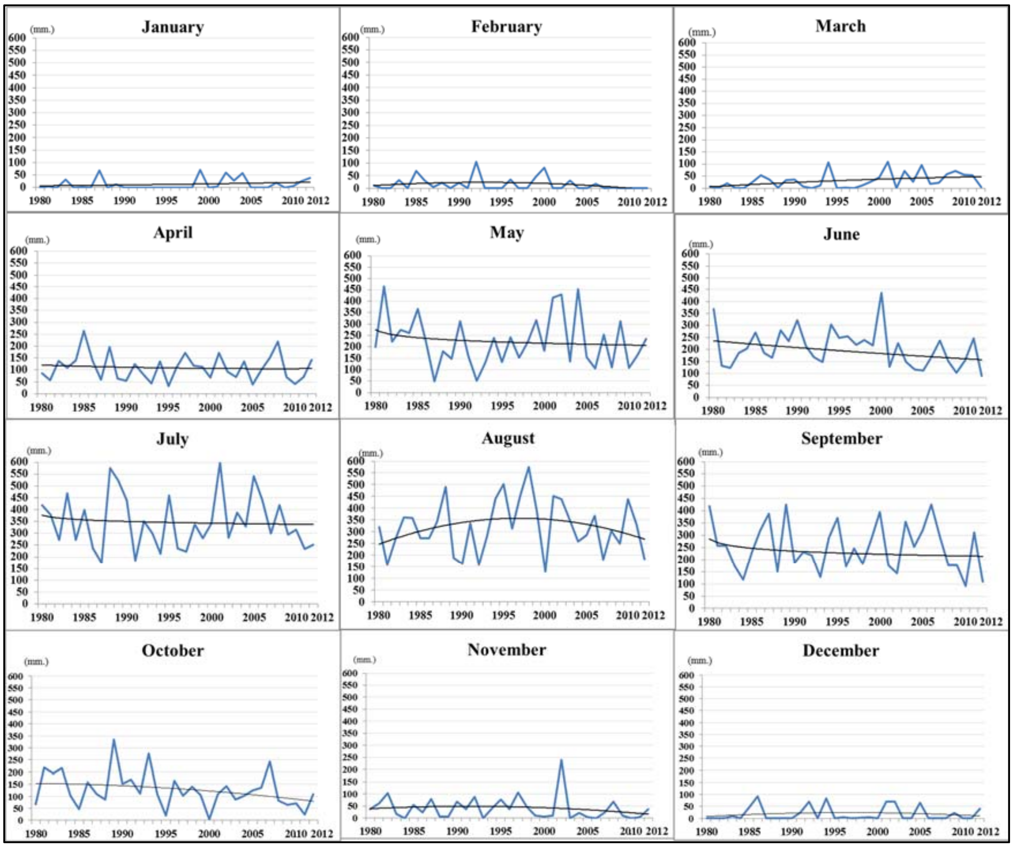

Figure 4. Monthly rainfall for 1980–2012 at Mae Chan Hill tribe Development station in Chiangrai province.

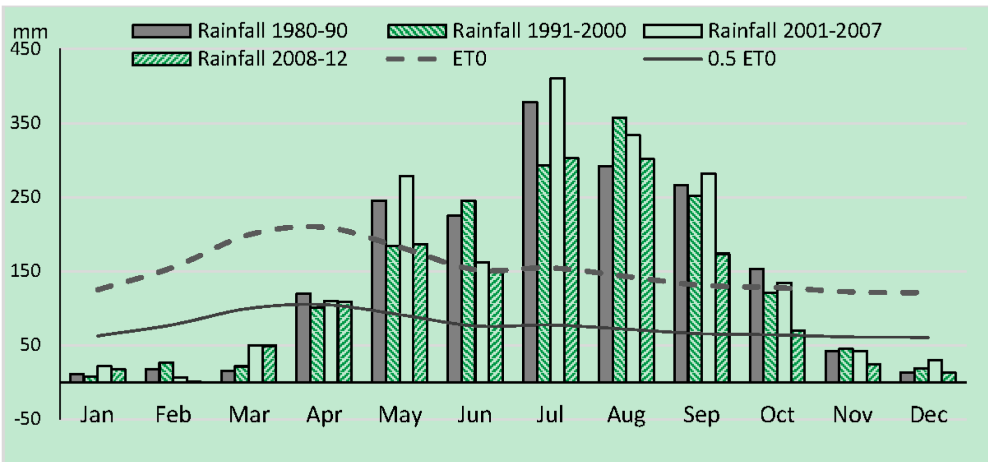

Figure 5. Length of Growing Period calculated from the data recorded at Mae Chan station.

4.3. Impact of Climate Change

Despite agriculture being a main source of livelihood for many social groups in developing countries, this sector is severely impacted by climate change through impacts on reduced soil carbon, land degradation, water scarcity, and biodiversity loss [26]. Besides the direct physical damage due to increased rainfall, temperature and drought, the phenological behavior of agriculture crops is also changed due to changing climatic condition. The effects of climate change impact can also be seen in agricultural practices, quality of products and yields, among other problems [7].

We examined farmers' perceived experience of the impact of climate change. Of three different climate variables, namely temperature, rainfall and drought, farmers perceived various impacts on farming due to the change in these climate variables. There are impacts on major crops of the area due to changes in those climate variables. Increases in temperature and drought had a major impact on fruit and rice crops, as shown by WAI in both communities. The major impact cited by *Akha* respondents due to increased temperature was less or no flowering in Lychee (WAI 0.39) and Cherry (0.23), whereas it was reduced yields in rice (0.35) and corn (0.26) for *Lisu* respondents (Table 4). Increased rainfall negatively affected rice (0.28) and corn production (0.19) through physical damage, such as lodging. Decreased rainfall reduced rice yield, as perceived by both communities, but this was more strongly perceived by *Lisu* (0.31) than *Akha* (0.28).

The increase in drought duration not only led to an inability to cultivate rice, but also caused field crops to be stunted and eventually to die. The respondents perceived the drought impacts to be more severe. The major impact of drought was that both groups of farmers could not cultivate rice due to the lack of water. The perceived severity was higher in the case of the *Akha* community.

Table 4. Major impacts of climate change on crops.

Factors		***Akha***		***Lisu***	
		Major Impact	**WAI**	**Major Impact**	**WAI**
Temperature	*Increased*	Less or no flowering in Lychee	0.39	Reduced rice yield	0.35
		Less or no flowering in Cherry	0.23	Reduced corn yield due to wilting/drying	0.26
Rainfall	*Increased*	Increase rice production	0.19	Lodging rice plant before harvest	0.28
		Damage to corns and yield decrease	0.13	Damage to corns and low production	0.19
	Decreased	Reduced rice yield	0.28	Reduced rice yield	0.31
		Reduced corn yield due to wilting/drying	0.21	Reduced corn yield due to wilting/drying	0.20
Drought	*Increased*	Rice cultivation not possible	0.54	Rice cultivation not possible	0.39
		Stunted growth of field crops and eventually die	0.22	Stunted growth of field crops and eventually die	0.28

With changing climatic conditions, farmers are required to change their agricultural practices to adapt to the changing context [27]. In DMS, such a phenomenon has been perceived by the respondents as discussed above. All *Lisu* respondents and 70% of *Akha* respondents answered that they had changed their cultivation practices to adapt to changing climatic conditions. Of those who had changed, the majority of them (66% *Akha* and 70% *Lisu*) had changed the crop calendar. 63% of *Lisu* and 14% of *Akha* had started cultivating new crops, replacing traditionally grown crops, and 43% of *Akha* and 30% of *Lisu* respondents had changed their cultivation methods. There was significant difference between the impacts perceived by the two communities. Unlike *Akha*, who have orchards, *Lisu* mostly grow annual crops, and hence change in crop type and crop calendar was relatively easier for the *Lisu* community, whereas the *Akha* had adopted change in cultivation practices, as replacing perennial crops requires a long time and is relatively difficult.

Rainfall pattern influences crop cultivation by influencing the length of the growing period [28], and it was opined by both groups of respondents that crop growing periods for rice and corn had been influenced, requiring the adjustment of growing periods in the study area. Crop calendars for rice and corn in both areas are quite similar in terms of duration of cultivation, but the *Lisu* community start planting about two to three weeks earlier than the *Akha* do. However, compared to 10 or 20 years ago, the start of rice cultivation at present is indeed delayed by about three weeks, as perceived by *Akha*, and by one week as perceived by *Lisu*. In general, there had been a shift of between one and four weeks (delay) in the crop calendars in the area (Figure 6).

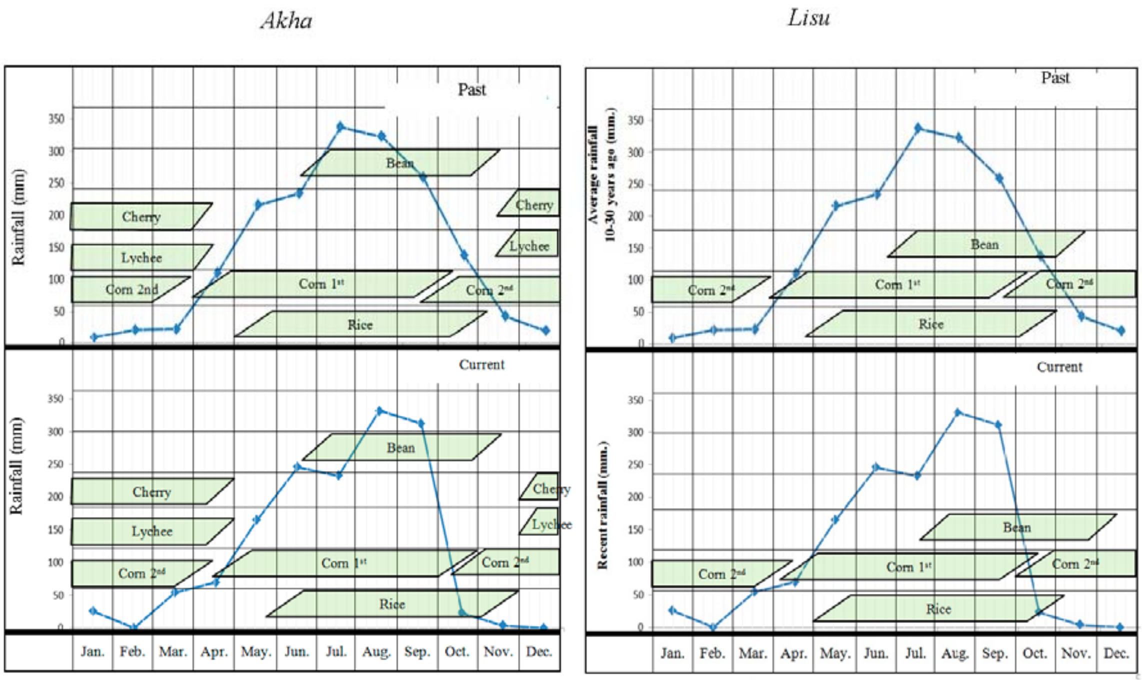

Figure 6. Current and past crop calendars of *Akha* and *Lisu* communities. Note: Current refers to the year of survey and past refers to 10–20 years ago.

Normally, corn is cultivated with the onset of rain, whereas rice cultivation has to wait for about two to three weeks after the onset of rain. Corn planting had been delayed by a week compared to the past for both crops in the study area. Rice planting starts in last week of May to the whole month of June, and harvesting starts five to six months after planting, depending on rice varieties. Fruits, Cherry, and Lychee, in particular, start flowering in December, and are harvested in April, but nowadays it is delayed by two to four weeks because of warmer temperatures and a late winter, as perceived by the *Akha* community. Beans can be cultivated the whole year round, but local farmers mostly cultivate it between June and December. Similar trends of delay in planting by three weeks in bean cultivation were perceived by the *Lisu*.

We examined other related climate change impacts, such as water unavailability, soil fertility and crop yield decline, and increase incidence of weed, insect and crop disease. Based on the perceived impact by the respondents, the *Akha* community increasingly faced three major problems as severe impacts, as shown by WAI, and these problems were lack of water, soil fertility and crop yield decline (Figure 7). The *Lisu* community perceived lack of water as a moderate impact of climate change. Except for disease problems, all other problems were perceived to be more serious by the *Akha* community compared to *Lisu*. The problem of water scarcity had increased in the area; however, it was higher in the *Akha* community, as more than 70% of *Akha* respondents, compared to 40% of *Lisu* respondents, felt that water scarcity had increased at the present compared to 10 or 20 years ago, probably because the *Lisu* community is situated at lower elevation, with relatively higher access to water availability.

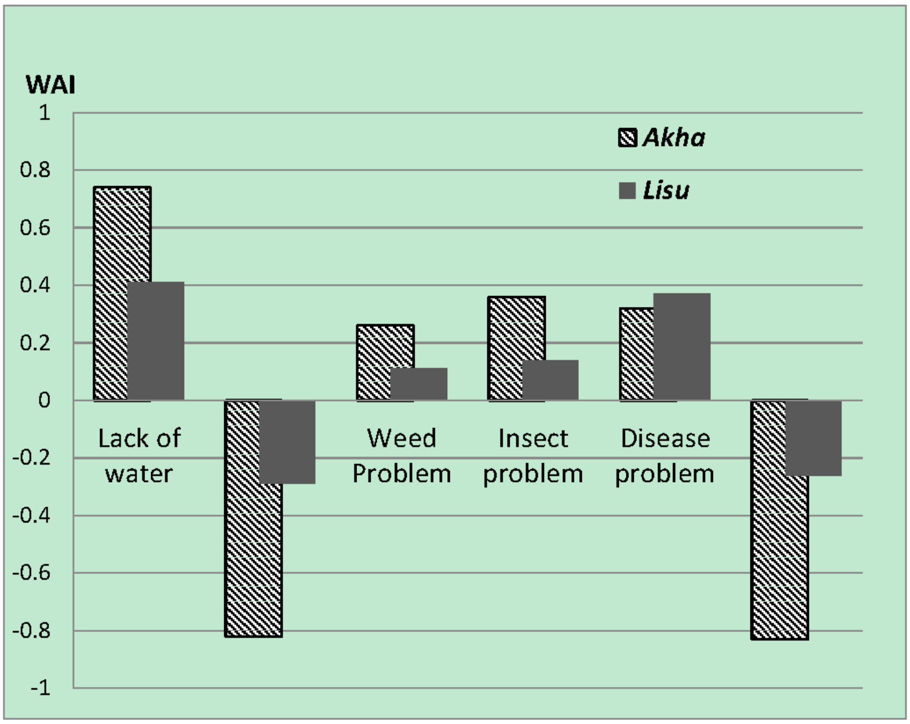

Figure 7. Perceived impacts of climate change.

Although the perception of trends in climate change was found to be not much different between the two communities, as discussed in the above section, the perception of climate change impacts was different between the two groups, as shown by the perceived change in crop cultivation practices and associated attributes, and production resources, such as soil fertility and water availability. The *Lisu* community has access to community forests and possesses relatively fertile agricultural farm land compared to the *Akha* community, who mostly have less fertile upland areas in highly leached hilly landscape. No significant impact on weed, insect and disease infestation in the crops was perceived, as 65–75% *Akha* and 63–90% *Lisu* respondents opined that these problems were as usual, and they saw no significant difference. The decline of crop yield as an impact of climate change was reported by a high majority (85% of *Akha* and 53% of *Lisu*). 85% *Akha* and 37% *Lisu* respondents opined that there had been soil fertility decline, and they regarded it to be an impact of climate change.

4.4. Farmers' Adaptation to Climate Change Impacts

Farmers try to adapt to the changing climatic condition and its impacts by bringing changes in their cultivation practices, mostly as autonomous adaptation led by community leaders. Farmers follow several adaptation practices depending on the suitability of that practice in particular circumstances in any given year. The adaptation practices in the study area were of common adaptation techniques in the agriculture sector of Thailand and Southeast Asia [29].

The adaptation measures for dealing with climate change impacts were significantly different between the two communities (Chi-square value −26.09). Change in cultivation time (73.3%) and growing new crops (63.1%) were found to be the two major adaptation measures in the case of the *Lisu* (Table 5). Only 23% of *Lisu* respondents had changed their cultivation practices. Not many *Akha* respondents, compared to *Lisu*, were found to have adapted new measures. It was 46.7% of

Akha who changed cultivation practices and 35% who changed cultivation time. 28.3% of *Akha* respondents mentioned that they had grown new crops to cope with changes in climatic conditions. Change in cultivation practices included increasing rate of fertilizer applications and practicing mixed-cropping. Doing nothing or following the way it had always been, changing occupation from farming to something else, and setting aside the cultivation area were other measures that had been taken was mentioned by about 28% of *Akha* respondents, whereas none of *Lisu* respondents were found to have done these as adaptation measures.

Table 5. Adaptation measures practiced by the respondents.

Adaptation Measures	***Akha***	***Lisu***
	% Respondents	
Change cultivation time	35.0	73.3
Grow new crop	28.3	63.1
Change cultivation/agronomic practice	46.7	23.3
Change occupation to another business	16.7	-
Do nothing (no change)	10.0	-
Set aside area and cultivate again after 4–5 years	1.7	-

It was learned during the focus group discussions that change in practice as adaptation measures also depends on the type of crop being cultivaed. The major adaptation practice in case of rice cropping was to change the rice growing time itself, as shown by the majority of farmers, who had changed the cultivation and harvesting time. A similar practice had been adopted for corn cultivation, given its similar growing period to rice, but in upland areas. Coffee cultivation began in the area very recently under the recommendation of local government agencies, and hence no specific adaptation measures had been implemented in the case of coffee thus far. Some change in agronomic practices in fruit trees, like lychee and cherry, were mentioned by *Akha* respondents.

The coping measures practiced by the farmers as a response to various problems, such as the impact of climate change, are summarized in Table 6. The farmers' satisfaction ranking of the coping measures practiced showed that the farmers' satisfaction level was very low in the study area. With regard to the water scarcity problem, constructing water harvesting structures in the catchment, use of water from streams, rationing of water use, protecting the forest and not cultivating the agricultural lands were some of the measures practiced in the area; however, these were not the major choices. The majority of *Akha* respondents had not implemented any interventions, as shown by WAI of 0.4, when there had been problems of water scarcity, as they depend on rainfall only for cultivation. Consumption demand of water was fulfilled with limited allocation of water supply in the catchment. Some respondents adopted catchment management and used stream water, particularly the *Lisu* community, but many farmers did not practice this due to the lack of financial resources.

Table 6. Adaptation measures to climate change impact.

Impact	**Coping Measures**	***Akha***	***Lisu***
		WAI	WAI
Water scarcity	Do nothing	0.40	0.22
	Build water harvesting in catchment	0.09	0.27
	Use stream water	0.07	0.03
	Rationing water use	0.06	0.05
	No cultivation that year	0.02	0.00
	Protect forest	0.00	0.05

Table 6. *Cont.*

Impact	Coping Measures	*Akha*	*Lisu*
Water scarcity	Do nothing	0.40	0.22
	Build water harvesting in catchment	0.09	0.27
	Use stream water	0.07	0.03
	Rationing water use	0.06	0.05
	No cultivation that year	0.02	0.00
	Protect forest	0.00	0.05

Satisfaction rank of coping measures, WAI 1 = very high, 0.8 = high, 0.6 = moderate, 0.4 = low, 0.2 = very low.

Both communities had experienced continuing soil fertility decline. Several measures, such as increasing fertilizer application to compensate yield decline, planting new crops, practicing crop rotation, and reducing chemical fertilizer application for restoring soil fertility had been practiced in the study area to deal with soil fertility decline, but the farmers were not so satisfied with these measures. Except for an increase in fertilizer application by some farmers (WAI 0.32 and 0.33 in *Akha* and *Lisu*, respectively), which were still found to have a low level of satisfaction, other measures were found to give significantly less satisfaction.

Adaptation measures practiced by the farmers in any given circumstances can be influenced by a number of climate factors (temperature, rainfall, seasonal frequency and climate variability), social factors (socio-economic, demographic characteristic, market factor, suitability of technology), and economic factors (financial resources, product price and investment, the support from government agency) [30]. The rural area generally has high vulnerability or less capacity for adaptation. In the study area, the major barrier for adaptation was lack of adequate finance according to 37% of *Lisu* and 27% of *Akha* respondents, as shown in Figure 8, resulting in inability to invest in adaptation. The other barrier was inadequate support from the agencies as indicated by 18.3% of *Akha* and 6.7% of *Lisu* respondents. Lack of knowledge, inadequate farm land for cultivation, and lack of labor were also cited as other barriers. 46.6% of *Lisu* and 36.7% of *Akha* respondents mentioned not having any barriers to adaptation, as has also been reported by other researchers in Nigeria [31]. To increase the adaptation capacity of the farmers, such barriers have to be addressed by providing greater assistance and support from the relevant agencies, as the respondents in the area are not capable, either financially or in terms of skill.

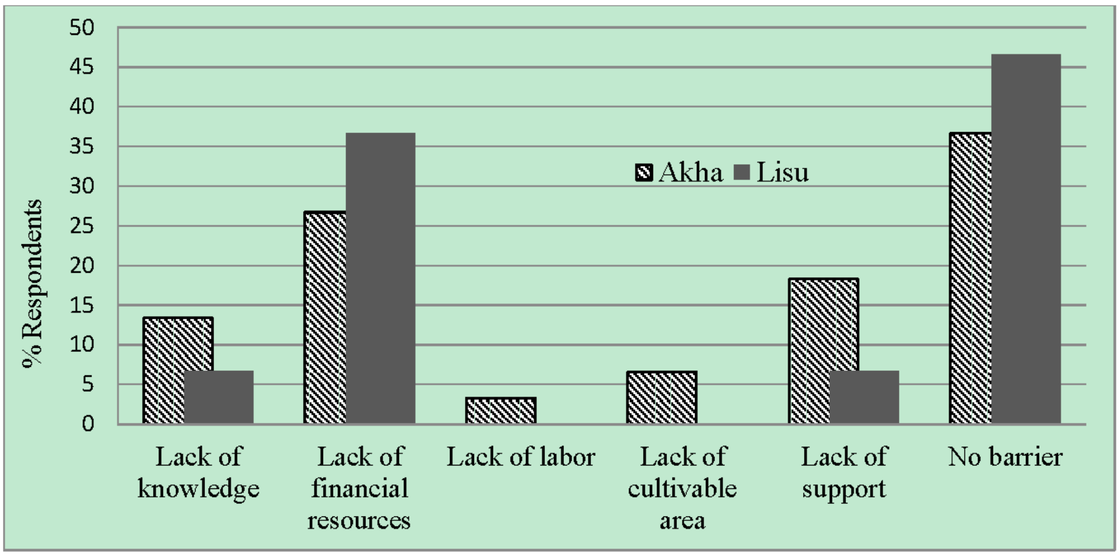

Figure 8. Barriers for adaptation to climate change.

5. Conclusions

The farmers, particularly the older age respondents, had perceived the occurrence of climate change in Doi Mae Salong, Thailand, as they had experienced variation in temperatures and rainfall compared to one or two decades ago. No specific difference in their perception was found due to household characteristics, such as ethnic groups, gender, education, occupation, or land holding. The main changes perceived by the farmers were an increase in temperatures and heat waves, leading to increasing frequency of drought in summer, increasing variability of rainfall in rainy season, and a shorter length of growing period. At present, the amount of rainfall had decreased compared to the past, with shorter rainfall duration and high uncertainty.

Climate change impacts of direct and indirect nature were noticeable on upland agriculture dominated by the *Akha* ethnic community in the area. Decreasing rainfall, in particular due to climate change, had a major impact on rice yield decline, whereas temperature increase affected fruit crops, like cherry and lychee. Decline in crop yield, soil fertility and water availability were other impacts perceived by the respondents. These impacts had led the farmers to require autonomous adaptation to the changing conditions. Farmers had responded to the perceived impacts by changing agriculture practices depending upon crop types. Growing time adjustment by delayed planting of one to four weeks were found for rice, corn and beans, and even changing the crops in some cases. While few farmers had tried different agronomic practices in cherry, lychee and other fruit trees by increasing fertilizer application, practicing mixed cropping and delayed harvesting, constructing the water harvesting structures in catchment, water rationing, and forest protection had been some deliberate attempts of the farmers to cope with the problem of decreasing water availability. The adapted measures mostly address the problems of fertility and crop yield decline compared to water scarcity.

The impacts were higher in upland areas inhabited by the *Akha* community. Lack of knowledge and financial resources were two major barriers to practice adaptation measures. The government agencies were providing some materials and financial support, especially in the event of climate-induced disasters, but no significant planned adaptation programs are in place in the area. As reported in other places [32], adaptation is occurring locally based on traditional knowledge to deal with the impacts of climate change faced by the farmers in the study area. However, such autonomous adaptation may not adequately reduce vulnerability and improve the livelihood of the resource-poor hill tribe farmers, because agriculture is vulnerable to climate change and adaptation is crucial to minimizing the impacts [33]. Hence, community capacity should be reinforced with some sort of planned adaptation, particularly the adaptation knowledge and financial resources.

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