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Farmers' perceptions of impacts of climate variability on agriculture and adaptation strategies in Songkhla Lake basin

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ABSTRACT

In the past decade, there have been signs of climate variability that might have already affected certain aspects of the Songkhla Lake basin. This research was conducted to 1) identify the key problems of climate variability on the agricultural activities of farmers, 2) assess farmers' perceptions of the negative impacts of climate variability on agricultural activities, and 3) propose a set of adaptation strategies for agricultural development in the Songkhla Lake basin. Data were collected using structured interviews from a total sample of 271 farmers selected using the purposive and snowball techniques. The arithmetic mean was applied for data analysis. It was found that the key problem of climate variability on the agricultural activities of farmers in the Songkhla Lake basin was a reduction in crop yields. Farmers involved in fruit production, and fisheries suffered the most negative impacts of climate variability. The negative impacts of climate variability on para-rubber production, rice production, and oil palm production were at a high level. Five adaptation strategies for agricultural development were identified: 1) enhancement of capacity in impact assessment, 2) prevention and avoidance of negative impacts, 3) mitigation of negative impacts, 4) reduction of loss from negative impacts, and 5) rehabilitation of devastated areas and other losses. Furthermore, relevant agencies should campaign to raise awareness and understanding by farmers in terms of climate variability.

Introduction

Climate variability has become a global concern since it can adversely affect elements of various systems and sectors that threaten human wellbeing. The fifth assessment report of the Intergovernmental Panel on Climate Change (IPCC, 2013) provided clear evidence of changes in climate due to human activities. Recently, climate variability has had obvious impacts on agriculture in many areas of Thailand, which tends to be prone to more severe natural disasters with a higher frequency, particularly in southern Thailand including the Songkhla Lake basin. There are increasing concerns about possible climate variability and its impacts on the Songkhla Lake basin. Major concerns relate to temperature increases, irregular rainfall patterns, abnormal tropical storms, and severe flooding which directly affect the phonological cycle, agricultural productivity, and pest and disease incidences (Solomon & Shugart,

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1993 quoted by Apiratikorn, Sdoodee, Lerslerwong, & Rongsawat, 2012).

Most agricultural production in Thailand relies on rain-fed conditions. Economic crop production is inherently sensitive to climatic variability, and crop yields are predicted to decrease from the negative impacts of climate change (Marks, 2011). Craufurd and Wheeler (2009) reported that a key factor affecting the rate of plant development is temperature. Under warmer climate conditions, crop development stages shorten and this leads to a reduction in mean crop yields. Limsakul, Limjirakan, and Sriburi (2010) noted that fluctuations in rainfall have considerable agricultural impacts, especially in southern Thailand where the strong influence of the southwest monsoon often causes heavy rainfall events and severe flooding. Changes in rainfall will aggravate problems related to water resource management for farmers who use 70 percent of the country's water supply (Marks, 2011).

Proactive preparation with due understanding and adaptation capacity are considered vital to cope with possible climate extremes and their impacts. Furthermore, the proactive preparation regarding climate variability and adaptation has already been raised in international mandates which Thailand must plan for and abide by. Important international agreements are: 1) The Cancun Adaptation Framework, 2) The Strategic Plan for Biodiversity 2011–2020 and the Aichi Biodiversity Targets, 3) The Ramsar Convention on Wetlands, and 4) The Convention Concerning the Protection of the World Cultural and Natural Heritage, all of which can be used to guide the preparation for part of the Songkhla Lake basin.

Climate variability is anticipated to significantly affect agriculture because crop production is highly influenced by climatic conditions (Attavanich & McCarl, 2014; Deschenes & Greenstone, 2007; McCarl, Villavicencio, & Wu, 2008). Moreover, Attavanich (2013) found climatic parameters, such as summer temperature and winter temperature statistically significantly affected farmland values. Individual farmers may adapt in different ways to climate variability based on their capability. This research attempted to: 1) identify the key problems of climate variability on the agricultural activities of farmers, 2) assess farmers' perceptions of the negative impacts of climate variability on agricultural activities, and 3) propose a set of adaptation strategies for agricultural development in the Songkhla Lake basin. The results aimed to identify needs in terms of adaptation; in addition, they would be of some use, particularly for farming communities and responsible authorities in the region in learning and preparing to adapt better to climate uncertainty and risks, related natural disasters, and their impacts.

Literature Review

Bio-Physical Characteristics of Songkhla Lake Basin

Faculty of Environmental Management, Prince of Songkla University (2015) states that the Songkhla Lake basin has been considered a unique ecosystem covering three provinces in southern Thailand, that is, the whole of Phatthalung province, twelve districts in Songkhla province, and parts of the Hua Sai and Cha Uat districts in Nakhon Si Thammarat province.

On the west is the north-south lying Ban That mountain range while in the south, the basin is bound to the San Kala Khiri mountain range. Both mountainous areas are still covered by natural rainforests forming a vital part of its riverine ecosystem though an increasing portion has been invaded continuously by para-rubber and other economic crops which have caused surface erosion and landslides along with sedimentation in the lagoon and surface waterways. Next to the hilly terrain is a large flood plain that surrounds the whole Songkhla lagoon, and is used mainly for agriculture and paddy rice. On the northeastern side of the basin, there is a large wetlands complex—the Tale Noi wildlife sanctuary and the Khuan Kreng peat swamp that are related to the Tale Noi fresh water lake ecosystem and the Pak Phanang river basin in Nakhon Si Thammarat province. Parts of these wetlands are, however, degrading and being invaded by oil palm plantation, while the basin's northeastern coastal zone on the Gulf of Thailand has recently suffered from coastal erosion.

The Songkhla lagoon itself, also known as the three-water ecosystem, has long been an important multi-functional reservoir acting as natural pool for fresh, brackish, and saline water, and as natural drainage that links the lagoon and the open sea. The lagoon is thus naturally endowed with rich bioresources and biodiversity of both fauna and flora.

Climate Variability and Its Impacts on Agricultural Activities

Ramamasy and Baas (2007) documented that climate variability refers to variations in the mean state and other climate statistics (such as standard deviations and the occurrence of extremes) on all temporal and spatial scales beyond those of individual weather events. Variability may result from natural internal processes within the climate system (internal variability) or from variations in natural or anthropogenic forces (external variability). Climate change refers to any change in climate over time, whether due to natural variability or anthropogenic forces.

Agriculture is potentially the most sensitive economic sector to climate variability. Changes in climate can have direct effects on crop yields and production costs, as well as indirect effects on relative crop prices (Attavanich, Rashford, Adams, & McCarl, 2014). In addition, Attavanich and McCarl (2014) found that average climate conditions and climate variability contributed in a statistically significant way to average crop yields and their variability. Some early researchers have addressed the negative impacts of changing climate on para-rubber production; for example, Kositsup, Kasemsap, Thaler, and Ameglio (2007) reported that temperatures above 38 °C affected the photosynthesis rate of para-rubber leaves; nonetheless, growth rates were reduced when the average temperature rose above 28 °C (Isarangkool Na Ayutthaya, Dongsansuk, Teapongsorut, & Nakdaeng, 2007) Jacob and Satheesh (2010 quoted by Sdoodee & Rongsawat, 2012) reported that climate change as a result of global warming could influence the growth and yield of para-rubber trees in various direct and indirect ways. Satheesh and Jacob (2011) showed that as both

maximum and minimum temperatures increased by 1 °C, the para-rubber yield would decrease by 9–10 percent under agro-climatic conditions. Sdoodee and Rongsawat (2012) revealed that high rainfall tended to decrease the number of tapping days per year and the latex yield. Ruangsri, Makkaew, and Sdoodee (2015) illustrated that increasing rainfall amounts with a higher number of rainy days caused decreases in the number of tapping days per year and in the para-rubber yield.

A few researchers have addressed the negative impacts of changing climate on rice production. For example, Wassmann and Dobermann (2007) showed that increased temperature caused increased spikelet sterility in rice and a reduction in the yield. Chaowiwat and Likitdecharote (2008 quoted by Marks, 2011) reported that increases in minimum and maximum temperatures, and a decrease in relative humidity caused more water to evaporate from paddy fields. Such an increase affected the run-off, soil moisture, water in reservoirs and the groundwater table, and would result in either a decrease in irrigated yield or an increase in the demand for water to maintain past production levels. Kawasaki and Herath (2011) revealed that as solar radiation and temperature increased, the rice yield would decrease. Nara, Mao, and Yen (2014) illustrated that a flooding phenomenon caused decreases in paddy field area and in the quantity of rice in 2011.

Some researchers have addressed the negative impacts of changing climate on fruit production. For example, Sdoodee (2007 quoted by Sdoodee & Rongsawat, 2012) found that there had been increasing trends of maximum and minimum temperatures during the last decade, whereas there had been a decrease in rainfall, causing changes in flowering and the fruit development period of mangosteen, which led to low yields and poor fruit quality. Apiratikorn et al. (2012) found that climatic variability affected phonological change, fruit yield, and the fruit quality of mangosteen.

Other researchers have addressed the negative impacts of changing climate on fisheries. For example, the United Nations Development Programme (UNDP, 2010) showed that freshwater fish populations were predicted to shrink because of reductions in wetlands and changes in migration patterns. Fluctuations in water levels disrupted fish migration. Local fishermen reported fewer and smaller fish and a disappearance of some species (Ellgee, 2010 quoted by Marks, 2011). Shelton (2014) reported that climate change affected fisheries via acidification, changes in sea temperatures and circulation patterns, the frequency and severity of extreme events, and a rising sea level, with associated ecological changes. Both direct and indirect impacts include impacts on the targeted population's range, habitats, and food webs, as well as impacts on the costs of fisheries and aquaculture, productivity, and fishing community livelihoods and safety (Badjeck, Allison, Halls, & Dulvy, 2010).

The negative impacts of changing climate on oil palm production were addressed by Nantaworrakarn and Tianma (2010) who found that climate change affected the growth and yield of oil palm trees. A decrease in the number of rainy days caused a change in the fruit development period of the oil palm trees, which led to low yields and poor fruit quality.

Research Methodology

The study design used a cross-sectional survey in 2012. Primary data were collected using structured interviews from a total sample of 271 farmers who could be classified into five major agricultural activities: 1) para-rubber production, 2) rice production, 3) fruit production, 4) fishery production, and 5) oil palm production, as shown in Table 1. These agricultural activities are the main occupations for the people in the Songkhla Lake basin. The research sites consisted of 12 areas which were defined as climatically sensitive areas, and are now considered at risk of being subjected to adverse impact from climate variability.

All of these samples were selected using the purposive and snowball sampling techniques which were based on the agricultural experience of the farmers and their suffering through the adverse consequences of climate variability. Respondents had more than five years of agricultural experience and had suffered the negative impacts of climate variability on their agricultural activities.

The data were analyzed using the arithmetic mean. Respondents were asked to express their perceptions of the negative impacts of climate variability on agricultural activities using a categorical, rank-order scale of 3 (high), 2 (moderate), 1 (less), and 0 (never). A weighted scale was used for interpretation, namely, 0.76–1.00 (mean = 2.26–3.00), 0.51–0.75 (mean = 1.51–2.25), 0.26–0.50 (mean = 0.76 –1.50), and 0.00–0.25 (mean = 0.00–0.75) representing the most, high, moderate, and less impact levels, respectively.

Research Findings

Key Problems of Climate Variability on Agricultural Activities of Farmers and Their Perceptions of the Negative Impacts in Songkhla Lake Basin

Para-Rubber Production

Para-rubber has been known as the most important economic crop in southern Thailand and particularly in the Songkhla Lake basin. Key problems of climate variability with regard to para-rubber production at the research sites comprised three aspects: 1) para-rubber plantation has continued to expand into hilly terrain owing to poor enforcement of relevant laws and economic incentives, triggering more landslides and unexpected damage to the para-rubber farmers themselves, 2) insufficient attention has been paid to the selections of plantation techniques, farm management, and fitting para-rubber species to hilly terrain, and 3) existing conservation groups were not easily capable of helping protect hilly terrain and upstream forest areas.

The farmers highly suffered the eight negative impacts of climate variability on para-rubber production (Table 2). The three most negative impacts of climate variability on para-rubber production were: 1) reductions in the number of tapping days and in the latex yield due to rainfall interference, 2) labor movement from para-rubber plantation to non-agricultural areas, and 3) the high tapping frequency has led to an adverse impact with a shorter lifespan for tapping. The four high negative impacts of climate variability on para-rubber production were: 1) change in the defoliation period due to infection by powdery mildew

Table 1
Sample numbers used in the study by agricultural activity Unit: household

Research site	Para-rubber production	Rice production	Fruit production	Fishery production	Oil palm production	Total
1. Bang Kaeo district, Phatthalung province	8	12	–	–	8	28
2. Tamot district, Phatthalung province	14	6	6	–	–	26
3. Khaochaison district, Phatthalung province	9	8	–	–	–	17
4. Ranot district, Songkhla province	–	15	–	9	–	24
5. Rattaphum district, Songkhla province	7	–	18	–	–	25
6. Sathingphra district and Singhanakhon district, district, Songkhla province	–	11	–	17	–	28
7. Khlonghoykhong district, Songkhla province	8	–	6	–	–	14
8. Muang district and Hatyai district, Songkhla province	10	–	–	21	–	31
9. Bangklam district, Songkhla province	6	10	–	–	–	16
10. Khuanniang district, Songkhla province	8	12	–	–	–	20
11. Hua Sai district, Nakhon Si Thammarat province	–	12	–	–	11	23
12. Nayong district, Trang province	19	–	–	–	–	19
Total	89	86	30	47	19	271

disease, 2) heavy rains and strong winds reportedly brought about violent flooding and water-related landslides in para-rubber plantation areas on hilly terrain resulting in the loss of the para-rubber trees and their yield, 3) poor health status of farmers because of more chemical substances applied, and 4) deterioration of soil fertility because of leaching by heavy rain in addition to reduction of biodiversity in para-rubber plantation areas. The single moderate negative impact of climate variability on para-rubber production was the reduction in forest area due to invading agricultural land use.

Rice Production

There were five key problems of climate variability on rice production in the Songkhla Lake basin comprising: 1) increased temperatures and rainfall with higher frequency and intensity with changes in the distribution pattern, and storms with strong winds causing flooding. This may have been due to limited drainage systems, 2) inefficient collaboration and sharing among rice farmers and related authorities regarding suitable rice species, and inefficient paddy field management that can help adapt to prolonged flooding and salinity variation, 3) poorly prepared price assurance for rice, along with the insurance plan and compensation for farmers affected by climate variability, 4) there has been insufficient agricultural promotion regarding climate variability and its impacts, for example, providing low cost quality factors of production and suitable rice species, and 5) rice farmers and the younger generation in the study area were not well prepared for climate variability and the adaptation required of them and their societies to survive and sustain their rice-farming culture.

Farmers highly suffered from nine negative impacts of climate variability on rice production (Table 3). The five most negative impacts of climate variability on rice production were: 1) succession in paddy field with the next generation has reduced; as a result, knowledge of rice production will not be transferred from generation to generation, 2) reduced rice traditions, 3) reduced yield, 4) labor movement from paddy field to non-agricultural areas, and 5) loss of local wisdom. The two high negative impacts of climate variability on rice production were: 1) reduction in the number of local varieties of rice because new varieties of rice adapted to climate variability will be recommended, and 2) change of method of rice planting. The two moderate negative impacts of climate variability on rice production were: 1) reduction of paddy field area owing to transformation to areas under oil palm and para-rubber plantations, and 2) the influx of seawater from storm surges into paddy fields leading to a reduced area of suitable paddy fields.

Table 2
Farmers' perceptions of negative impacts of climate variability on para-rubber production in Songkhla Lake basin

Negative impacts of climate variability	Mean	Level of impact
1. Reduction in number of tapping days	0.78	Most
2. Labor movement to non-agricultural areas	0.77	Most
3. High tapping frequency	0.76	Most
4. Change in defoliation period	0.75	High
5. Landslides in para-rubber plantation areas	0.70	High
6. Poor health status of farmers	0.69	High
7. Deterioration of soil fertility and reduction in biodiversity	0.56	High
8. Reduction in forest area	0.27	Moderate
Average negative impacts of climate variability	0.66	High

Source: Interviews, 2012

Table 3
Farmers' perceptions of negative impacts of climate variability on rice production in Songkhla Lake basin

Negative impacts of climate variability	Mean	Level of impact
1. Reduction of succession in paddy field on the next generation	0.86	Most
2. Reduction in rice traditions	0.85	Most
3. Reduced yield	0.80	Most
4. Labor movement to non-agricultural areas	0.78	Most
5. Loss of local wisdom	0.77	Most
6. Reduction of local varieties of rice	0.73	High
7. Change of method of rice planting	0.72	High
8. Reduction of paddy field area	0.49	Moderate
9. Influx of seawater	0.43	Moderate
Average negative impacts of climate variability	0.71	High

Source: Interviews, 2012

Fruit Production

There were five key problems of climate variability on fruit production in the Songkhla Lake basin: 1) most fruit orchards in the research area were not well equipped with climatic coping mechanisms, such as flood prevention and mitigation structures including farm drainage and irrigation systems, 2) there had been little research into fruit species selection that would lead to new species more tolerant of the changing environment associated with factors regarding rain intensity, flooding, and droughts, 3) fruit farmers paid little attention to knowledge and learning about climate variability, its impacts, and any adaptation needed, 4) no preparation of comprehensive price assurance and compensation plans for fruit farmers who might be affected by the threats of climate alteration, and 5) authorities were not well prepared for the risks and rehabilitation measures probably required for those farmers once disturbed by the disasters—preparing for low cost production factors, for instance.

Farmers most suffered from five negative impacts of climate variability on fruit production (Table 4). The three most negative impacts of climate variability on fruit production were: 1) change in the flowering period due to phonological change, 2) deterioration of soil fertility because of leaching by heavy rains in addition to the reduction in fruit orchard biodiversity, and 3) reduced yield. There were two high negative impacts of climate variability on fruit production: 1) reduced fruit orchard area owing to transformation to oil palm and para-rubber plantations, and 2) heavy rainfall and strong winds that caused floods and water-related landslides in sloping fruit orchards, leading to tree destruction.

Fisheries

Changes in the water level, salinity, temperature, and other qualities could affect aquatic ecosystems including fresh water, brackish water, marine fauna, and especially fish. The changing amount of rainfall, a rising sea level, and storm patterns recently experienced in many areas of the Songkhla Lake basin could well affect fisheries and the fishing communities. The three key problems of climate variability on fisheries in the research area were: 1) ineffective legislated action regarding environmentally protected areas, the coastal city master plan, and building codes, along with mangrove conservation strategies—some were not implemented or fully enforced, 2) fishers in the research area were not well prepared for climate variability and the adaptation required by them and their communities to survive and sustain the fisheries, and 3) existing community networks among fishers were not readily capable of sharing information and undertaking common action regarding climate variability and its impacts.

Fishing communities most suffered from seven negative impacts of climate variability on fisheries (Table 5). The six most negative impacts of climate variability on fisheries were: 1) poor water quality which could affect the fisheries, 2) reduced fish numbers, 3) loss of biodiversity in aquatic ecosystem and fishery areas, 4) conflict among the groups wanting to exploit and those wanting to conserve the resources, 5) reduced mangrove area due to rising sea level, and 6) influx of seawater into freshwater ecosystems. The single high negative impact of climate variability on fisheries was the possible outbreak of disease that could affect the fisheries and all those in the dependent communities.

Oil Palm Production

Oil-palm is another important economic crop in the Songkhla Lake basin. The three key problems of climate variability on oil palm production in the Songkhla Lake basin comprised: 1) oil palm plantation has continued to expand into non-productive paddy fields, peat swamps, and wetlands that provide ground and sanctuary for various bio-resources and help absorb greenhouse gases. Such practices then destroy these natural pollution sinks and reduce their pollution assimilative capacity making the Songkhla Lake basin more vulnerable to future loss of biodiversity, 2) not enough attention has been paid to agricultural promotion and research regarding plantation techniques, land preparation and farm management, and species selection that may help reduce the negative impacts on carbon sequestration, bio-resources, and bio-diversity, and 3) there has been little attention paid to helping maintain rice farmers and their traditional ways of living and intensive oil palm plantation expansion has disturbed or even replaced them making the farmers more vulnerable in the future.

Farmers highly suffered from nine negative impacts of climate variability on oil palm production (Table 6). The three most negative impacts of climate variability on oil palm production were: 1) deterioration of soil fertility and reduced biodiversity, 2) the high cost of fertilizer because of heavy rains and intense flooding that caused run-off over the soil surface and leached away fertilizer despite the high levels of fertilizer applied in oil palm production, and 3)

Table 4
Farmers' perceptions of negative impacts of climate variability on fruit production in Songkhla Lake basin

Negative impacts of variability	Mean	Level of impact
1. Change in flowering period	0.93	Most
2. Deterioration of soil fertility and reduced biodiversity	0.88	Most
3. Reduced yield	0.85	Most
4. Reduced fruit orchard area	0.75	High
5. Landslides in fruit orchards	0.71	High
Average negative impacts of climate variability	0.82	Most

Source: Interviews, 2012

Table 5
Farmers' perceptions of negative impacts of climate variability on fishery in Songkhla Lake basin

Negative impacts of climate variability	Mean	Level of impact
1. Poor water quality	0.92	Most
2. Reduced fish numbers	0.85	Most
3. Loss of biodiversity	0.84	Most
4. Conflicts among groups	0.83	Most
5. Reduced mangrove area	0.78	Most
6. Influx of seawater	0.77	Most
7. Disease outbreak	0.74	High
Average negative impacts of climate variability	0.82	Most

Source: Interviews, 2012

Table 6
Farmers' perceptions of negative impacts of climate variability on oil palm production in Songkhla Lake basin

Negative impacts of climate variability	Mean	Level of impact
1. Deterioration of soil fertility and reduced biodiversity	0.93	Most
2. High cost of fertilizer	0.89	Most
3. Adverse impacts on water reservoir	0.85	Most
4. Landslides in oil palm plantation areas	0.75	High
5. Reduced yield	0.60	High
6. Poor health status of farmers	0.55	High
7. Labor movement to outside the study area	0.34	Moderate
8. Influx of seawater	0.31	Moderate
9. Reduction in food security	0.24	less
Average negative impacts of climate variability	0.61	High

Source: Interviews, 2012

adverse impacts on water reservoirs due to higher chemical pollution from oil palm production. The three high negative impacts of climate variability on oil palm production were: 1) water-related landslides occurring on sloping oil palm plantation areas had caused trees to fall over, 2) heavy rains and flooding had caused damage to oil palm farmers through reduced and fluctuating yields, and 3) poor health status of farmers due to more chemical substances being applied. The two moderate negative impacts of climate variability on oil palm production were: 1) labor movement from oil palm plantation to outside the basin, and 2) seawater intrusion in lowland areas. The single less negative impact of climate variability on oil palm production was the reduction in food security owing to the transformation from paddy fields to oil palm plantation.

Table 7
Adaptation strategies for agricultural development in Songkhla Lake basin

Type of agriculture	Adaptation guideline	Adaptation strategy				
		1	2	3	4	5
1. Para-rubber production	1.1 Enable law enforcement and economic incentives to remove para-rubber plantation in hilly terrain.		√	√	√	
	1.2 Select plantation techniques, farm management and suitable para-rubber species, e.g. direct seeding in hilly terrain to hold ground.		√	√	√	√
	1.3 Strengthen conservation groups to protect upstream forests.		√	√	√	
2. Rice production	2.1 Improve irrigation and drainage systems for mitigating flooding and salt water intrusion in vulnerable areas.		√	√	√	
	2.2 Enhance collaboration and sharing among rice farmers and related authorities regarding suitable rice species, paddy field management, and adaptation through capacity building in risk areas.		√	√	√	√
	2.3 Establish a proper price assurance scheme, along with insurance planning and compensation for rice farmers who might be affected by climate-related disasters.				√	√
	2.4 Provide agricultural promotion regarding climate variability and its impacts, e.g. providing low cost quality factors of production and suitable rice species.			√	√	√
	2.5 Enable rice farmers and the younger generation to be well-prepared for climate variability and any adaptation required for their communities to sustain their rice farming culture.		√	√	√	√
3. Fruit production	3.1 Equip fruit orchards with climate-coping mechanisms, e.g. flood prevention and mitigation structures including farm drainage and irrigation systems.		√	√	√	√
	3.2 Promote research into fruit species selection and assorted orchards that would lead to new species and farms more tolerant to changing environmental factors, such as rain intensity, flooding, and droughts.		√	√	√	√
	3.3 Provide fruit farmers with due knowledge and learning ability regarding climate variability, its impacts, and adaptation needed.	√	√	√	√	√
	3.4 Establish a price assurance scheme, an impartial market, and a compensation plan for fruit farmers who might be affected by the threats of climate alteration.				√	√
	3.5 Provide low cost factors of production including suitable fruit species for fruit farmers who might be affected by climate-related disasters.			√	√	√
4. Fishery	4.1 Develop and enforce relevant laws and regulations to conserve and regulate fisheries and related eco-systems in climate risk fishery areas with greater community participation.		√	√		
	4.2 Develop and enable fishing community learning to help these communities become aware of and understand climate uncertainty and the risks involved.	√	√	√	√	√
	4.3 Strengthen community networks among fishing communities to share, learn, and help each other against unwanted change and threats.		√	√	√	√
5. Oil palm production	5.1 Enable stringent law enforcement and economic incentives to cut back oil palm plantation expansion into non-productive paddy fields, peat swamps, and wetlands that provide ground and sanctuary for bio-resources and help absorb greenhouse gases.		√	√	√	
	5.2 Provide knowledge and facilities for and promote research into plantation techniques, land preparation, and farm management, and oil palm species selection that could maintain carbon sequestration, bio-resources, and biodiversity.		√	√	√	
	5.3 Provide alternatives for rice farmers so their traditional ways of living are not disturbed or even replaced by intensive oil palm plantation.			√	√	√

Remark: Five adaptation strategies: 1) enhancement of capacity in impact assessment, 2) prevention and avoidance of negative impacts, 3) mitigation of negative impacts, 4) reduction of loss from negative impacts, and 5) rehabilitation of devastated areas and other losses

Adaptation Strategies for Agricultural Development in Songkhla Lake Basin

The results of this research and focus group discussions with the farmers led to adaptation strategies for agricultural development in the research area as shown in Table 7.

Conclusions and Recommendation

At present, climate variability in the Songkhla Lake basin is evident. It could exert negative impacts on agricultural activities, such as para-rubber production, rice production, fruit production, fishery production, and oil palm production. Therefore, the negative impacts of climate variability on agriculture were investigated. Farmers clearly suffered from the negative impacts of climate variability, namely decreased agricultural and fishery yields, high costs of production, land erosion on sloping agricultural land, labor movement from the agricultural sector to the non-agricultural sector, and health-related issues. These negative impacts will become more serious during the next few decades. The results of the research support the need for awareness and adaptation programs towards climate variability, leading to adaptation strategies through which farmers and relevant agencies should focus on agricultural development to cope with the serious consequences of climate variability.

Conflict of Interest

There is no conflict of interest.

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