Asian Journal of Crop Science

ISSN 1994-7879

science alert
http://www.scialert.net

ANSInet
an open access publisher
http://ansinet.com

Asian Journal of Crop Science 6 (3): 262-272, 2014
ISSN 1994-7879 / DOI: 10.3923/ajcs.2014.262.272

Impact of Climate Change on Rice-based Cropping Systems and Farmers' Adaptation Strategies in Northeast Thailand

Anan Polthanee and Arunee Promkhambut
Program on System Approaches in Agriculture, Faculty of Agriculture, Khon Kaen University, Khon Kaen, 40002, Thailand

Corresponding Author: Anan Polthanee, Program on System Approaches in Agriculture, Faculty of Agriculture, Khon Kaen University, Khon Kaen, 40002, Thailand

ABSTRACT

Climate is the primary important factor for agricultural production. The objectives of this research were to studied the temperature and rainfall under past climate (1981-1996) and recent climate (1997-2012) in Northeast Thailand and examine the existing rice-based cropping systems under past climate on the trend of climate changes, as well as examine farmers' coping with adaptation strategies to the related climate changes. The result showed that the areas where peanut grown after rice in post-rainy season with non-irrigation in Surin province, the mean maximum and minimum temperature increased about 0.53 and 0.84°C, respectively during the growing period under recent climate. This enhances potential evaporation and reduces the availability of soil moisture, thus causing peanut failure of production. Farmer's coping adaptation strategies including changes in crop species, changes in land allocation and supplement irrigation. The areas where sesame and kenaf grown before rice in Buriram and Chaiyaphum province, respectively as pre-rice crop with initial growth using soil moisture by summer rain. Sesame and kenaf fail of production under recent climate, due to shifts in the monthly distribution of rainfall within the summer season one to two months. This caused delay planting and consequently interferes with normal rice planting. Farmers' coping adaptation strategies including use of irrigation and changes land allocation. For overall climate changes in Northeast Thailand, the annual mean maximum temperature increased by 0.21°C, while mean minimum temperature increased by 0.51°C. The annual mean rainfall intensity increased by 67 mm with the number of rainy day in recent climate greater than the past climate about 2 days.

Key words: Climate change, rice-based cropping system, peanut, sesame, kenaf, adaptation

INTRODUCTION

Climate change is caused by the release of "greenhouse gases" into the atmosphere. These gases accumulate in the atmosphere, which result global warming. The changes in global climate related parameters such as temperature, precipitation, soil moisture and sea level (Aydinalp and Cresser, 2008).

Changes in temperature as well as changes in rainfall patterns will have important effects on agricultural production. Over the past 150 years, the average surface temperature of earth has increased by 0.76°C (CAPSA, 2011). Rising in maximum and minimum temperature was notice since last 49 years over Kerala, India. The day maxima increase was 0.64°C while the night minimum 0.23°C. Increase in mean annual surface air temperature over Kerala was 0.44°C (Prasada Rao *et al*., 2009). Annual rainfall has declined in Nigeria over both time and space while

reduction of 100-313 mm occurred, depending on topography and location (ITA, 1992). In the humid tropics of India indicate cyclic trend in annual rainfall with a declining trend in annual and southwest monsoon rainfall during the past 60 years. In contrast, there was an increasing trend in post monsoon rainfall (Prasada Rao *et al*., 2009). Higher temperatures may shorten growing periods and threaten yields if exposure occurs during important development stages such as flowering and grain filling (Wheeler *et al*., 2000; Wollenweber *et al*., 2003). Shifts in the monthly distribution of rainfall within the main rainy season may delay planting as early planting becomes increasingly risky. Delayed onset of rains has also tended to shorten the growing season (ITA, 1992).

Existing cropping systems in Northeast Thailand of growing peanut after rice, sesame or kenaf before rice in rainfed riceland have been practiced by farmers in certain areas for many years ago (Polthanee, 1986). Climate changes is expected to affects on crops and cropping pattern in Northeast Thailand under recent climate.

Therefore, the objectives of this research were (1) To study the temperature and rainfall in Northeast Thailand under past and recent climate in the areas where farmers practiced rice-based cropping systems and overall Northeast Thailand, (2) To examine the existing rice-based cropping system on the trend of climate change in Northeast Thailand and (3) To examine farmers' existing coping with adaptation strategies to the related climate changes.

MATERIALS AND METHODS

Study areas: This study was carried out in Surin, Buriram and Chaiyaphum provinces where peanut after rice, sesame before rice and kenaf before rice cropping patterns practiced by the farmers under past climate, respectively. These three provinces located in Northeast region of Thailand which consists of twenty provinces in total (Fig. 1).

Observed climate trends in the study area: Rainfall and temperature data for the period from 1981-1996 and 1997-2012 were utilized for the study. Data analysis was carried out to find out long period changes in rainfall and temperature from 1981-1996 (past climate) in comparison with 1997-2012 (recent climate), by divided into three seasons of rainy season (May-October), winter season (November-January) and summer season (February-April). The climate data was analyzed to understand climate change or climate variability not only in certain areas where the rice-based cropping systems practiced by the farmers but also the overall northeast region. The rainfall and temperature data employed from the twenty seven meteorological stations where located in Northeast Thailand. Climate shift worked out using different mean and t-test analysis.

Data collection: Existing rice-based cropping systems practiced by the farmers of peanut grown after rice in Prasat District of Surin Province, Sesame grown before rice in Satuk District of Buriram Province and kenaf grown before rice in Khonsawan District of Chaiyaphum Province under past climate was literature reviewed, especially the technical report published by the Farming System Project, Faculty of Agriculture, Khon Kaen University (FSP, 1984; 1986, 1987). Preliminary survey and initial interviews were conducted with key informants in several villages to obtain information's on peanut, sesame and kenaf cultivation under recent climate.

The results of preliminary survey found that most of the farmers stop to cultivate peanut, sesame and kenaf under recent climate. Then the village that has the largest planting areas of

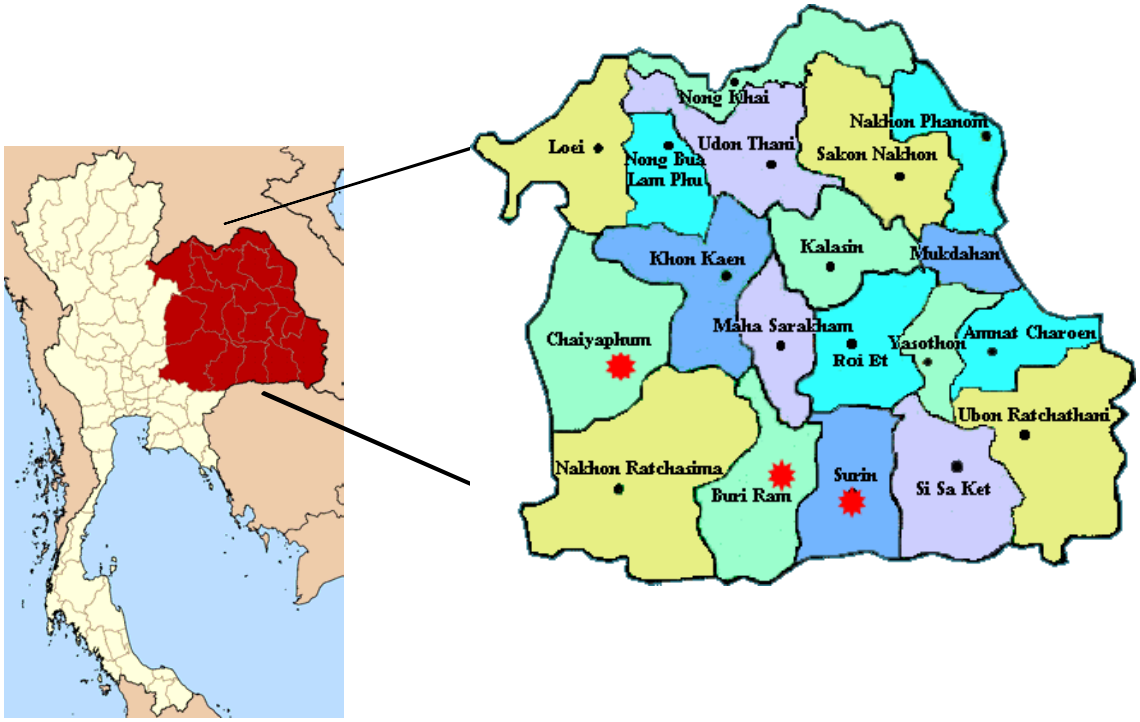

Fig. 1: Study sites

peanut, sesame and selected, based on the statistical data for the years 1984 (peanut), 1986 (sesame) and 1987 (kenaf) with reported by the Farming System Project. The farmers who cultivated peanut, sesame and kenaf under past climate were randomly selected within the village for focus group (10-15 people) discussion. The sub-topic guidelines focused on why their stop to grow crops before or after rice and knowledge of climate change, as well as their coping adaptation strategies to the related hazards was developed. Individual farmers who still continue practiced crop before or after rice were purposively selected for interviewing and crop cutting samples was done to determine the yield and yield components.

RESULTS

Observed climate change in Surin province: There was significantly increased mean maximum temperature in Surin Province between the time period 1981-1996 and 1997-2012 in the rainy season (0.29°C), winter season (0.53°C) but it was significantly decreased (0.31°C) in summer season (Table 1).

However, the mean maximum temperature was not significantly difference for annual in Surin province (Table 1).

Similar trend was noticed in the case of mean minimum temperature. It was significantly increased mean minimum temperature in the rainy season (0.26°C), winter season (0.84°C) but it was not significantly difference in the summer season (Table 1). However, the mean minimum temperature was significantly increased (0.39°C) for annual in Surin province (Table 1).

The rainfall intensity was significantly increased (30.4 mm) in the rainy season between the time period 1981-1996 and 1997-2012 but it was not showed any significant difference in winter

Table 1: Mean maximum and minimum temperature in rainy, winter, summer season and annual between the time period 1981-1996 and 1997-2012 in Surin province

Temperature/Time period	Rainy (May-Oct)	Winter (Nov-Jan)	Summer (Feb-Apr)	Annual
Maximum (°C)				
1981-1996	32.54	30.43	35.15	32.66
1997-2012	32.83	30.96	34.84	32.86
T-test	*	**	*	ns
Minimum (°C)				
1981-1996	24.29	18.48	22.58	22.41
1997-2012	24.55	19.32	22.80	22.80
T-test	*	**	ns	*

*,**Significant probability at level 95 and 99% respectively, ns: Not significant

Table 2: Mean rainfall intensity and the No. of rainy days in rainy, winter, summer season and annual between the time period 1981-1996 and 1997-2012 in Surin province

Rainfall/Time period	Rainy (May-Oct)	Winter (Nov-Jan)	Summer (Feb-Apr)	Annual
Rainfall (mm)				
1981-1996	1145.9	22.6	194.1	1326.7
1997-2012	1176.3	28.6	252.0	1456.9
T-test	**	ns	ns	*
Rainy day (No.)				
1981-1996	98	4	13	115
1997-2012	93	4	14	112
T-test	*	ns	ns	ns

*,**Significant probability at level 95 and 99% respectively, ns: Not significant

and summer seasons (Table 2). However, rainfall intensity was significantly increased for annual (94.3 mm) in Surin province.

In case of the number of rainy day, it was significantly decreased (5 days) of the number of the rainy day in rainy season but it did not show any significant difference in winter and summer season (Table 2). However, the number of the rainy day was significantly decreased for annual (3 days) in Surin province.

Impacts of observed climate change on peanut after rice: In general, peanuts are planted from the last week of November to the second week of December after rice harvesting (Polthanee, 1986). Because this is the post-rainy season, the peanuts must start their initial growth on residual soil moisture remaining in the soil after the rice harvesting.

In the past climate, residual soil moisture it sufficient for growth and pegging of the peanuts during their first two months (December-January) and receiving additional winter rain for the late growth stage. The peanut gave satisfactory yields (1.2-2.0 ton ha^{-1}) even if there is slightly of winter rain during growing season (Polthanee, 1991).

In the recent climate, information obtained by focus group and household interview stated that the farmers who grown peanut after rice stop to grow peanut year after year since 10 years ago. They observed changes in temperature in the last decades. The day temperature seems to increase and warming in recent climate as compared to the past climate, especially in December and January. The peanut crop early subjected to drought and could not be survive due to severe water stress. In some year, the peanut yield can be obtained but it is relatively low. Crop cutting in the

Table 3: Mean maximum and minimum temperature in rainy, winter, summer season and annual between the time period 1981-1996 and 1997-2012 in Buriram province

Temperature/Time period	Rainy (May-Oct)	Winter (Nov-Jan)	Summer (Feb-Apr)	Annual
Maximum (°C)				
1981-1996	32.90	30.00	35.30	32.77
1997-2012	33.21	30.93	35.19	33.13
T-test	**	**	ns	**
Minimum (°C)				
1981-1996	23.73	18.22	21.90	21.90
1997-2012	24.14	19.04	22.30	22.41
T-test	*	**	**	*

*,**Significant probability at level 95 and 99% respectively, ns: Not significant

Table 4: Mean rainfall intensity and the No. of rainy days in rainy, winter, summer season and annual between the time period 1981-1996 and 1997-2012 in Buriram province

Rainfall/Time period	Rainy (May-Oct)	Winter (Nov-Jan)	Summer (Feb-Apr)	Annual
Rainfall (mm)				
1981-1996	893.9	41.0	125.4	1060.4
1997-2012	1078.4	46.3	156.8	1281.5
T-test	*	ns	ns	*
Rainy day (No.)				
1981-1996	93	5	15	113
1997-2012	92	6	16	114
T-test	ns	ns	ns	ns

*Significant probability at level 95 and 99% respectively, ns: Not significant

farmer's field in 2012 showed that peanut produced yield only 488 kg ha^{-1} which declined 64% in comparison with peanut yield 1,345 kg ha^{-1} (average three samples from the farmer's fields at the same village) obtained in 1983 (FSP, 1984). The farmers also mentioned that supplemental of winter rain during the growing season had been frequently delayed in recent climate.

Farmer's adaptation strategies: Peanut grow after rice produced low yield or unable to survive due to inadequate soil moisture under recent climate. This indicated that soil moisture shortening available for crop growth. The farmers employ coping adaptation strategies which replacing peanut by growing early maturing crops such as pumpkin, cowpea and squash, as well as cassava a drought resistant crop. Some farmers change land use pattern by shift rice-peanut double cropping pattern to sugarcane single cropping pattern.

Observed climate change in Buriram province: There was significantly increased mean maximum temperature in Buriram province between the time period 1981-1996 and 1997-2012 in the rainy season (0.31°C), winter season (0.93°C) but it was not significantly difference in summer season (Table 3). However, the mean maximum temperature was significantly increased (0.36°C) for annual in Buriram province (Table 3).

In case of minimum temperature, it was significantly increased mean minimum temperature in the rainy season (0.41°C), winter season (0.82°C), summer season (0.40°C) and annual (0.51°C) in Buriram province between the time period 1981-1996 and 1997-2012 (Table 3).

The rainfall intensity was significantly increased in the rainy season (184 mm) but it was not showed any significant difference in winter season and summer season (Table 4). However, rainfall intensity was significantly increased for annual in Buriram province (Table 4).

In case of the number of the rainy day, it did not show any significant difference of the rainy day in the rainy season, winter season, summer season and annual in Buriram province.

Impacts of observed climate change on sesame before rice: In general, sesame is planted when the summer rain come during the period of February to March under past climate (Polthanee, 1986). Because this is the summer season, the sesames must start their growth using soil moisture by the first month rain of the summer season, followed by a proportional increased in the second month. In recent climate, the respondents mentioned that there are often shifts in the monthly distribution of rainfall within the summer season. There is frequently no rain on the first month or the second month of the season under recent climate. Delayed onset of rains for planting tended to shorten the growing season and interfere with normal rice planting. Therefore, they did not planting sesame even enough rainfall intensity comes later. In some years, onset of rains comes early similar to the past climate but it was frequently occurred the second rain come late after seeding, resulted to crop failure due to prolong drought e.g. in year 2012. This indicated that increasing risky under recent climate, therefore most of the farmers stop to grow sesame before rice in Buriram province.

Farmer's adaptation strategies: Some farmers who still practiced sesame before rice under recent climate mentioned that they use water available in farm pond or reservoir where located nearby their paddy fields irrigated to the crop for planting and initial growth in the first month in summer season if enough rainfall intensity comes late. This indicated that the farmers who had only water resources available in summer season are able to grow sesame before rice. However, even the crops can be planted in the first month; the crop may failure if the second rain or third rain comes late. Since, water in farm pond is insufficient to irrigate the crop before the second rain come, especially in the year with low rainfall intensity during the rainy season like year 2012. Other coping adaptation strategy, farmers change land allocation by shift sesame-rice double cropping pattern to rubber tree single cropping pattern.

Observed climate change in Chaiyaphum province: There was significantly increased mean maximum temperature in Chaiyaphum province between the time period 1981-1996 and 1997-2012 in the winter season (1.05°C) but it did not show any significant difference in the rainy and summer season (Table 5).

In case of minimum temperature, it was significantly increased mean minimum temperature in the rainy (0.33°C), winter (0.88°C), summer season (0.34°C) and annual (0.47°C) in Chaiyaphum province (Table 5).

The rainfall intensity was significantly increased (86 mm) in the rainy season but it was not show any significant difference in the winter and summer season (Table 6). However, rainfall intensity was significantly increased for annual (96 mm) in Chaiyaphum province (Table 6).

In case of the number of the rainy day, there is not significant difference of the number of the rainy day in the rainy, winter, summer season and annual in Chaiyaphum province (Table 6).

Table 5: Mean maximum and minimum temperature in rainy, winter, summer season and annual between the time period 1981-1996 and 1997-2012 in Chaiyaphum province

Temperature/Time period	Rainy (May-Oct)	Winter (Nov-Jan)	Summer (Feb-Apr)	Annual
Maximum (°C)				
1981-1996	32.62	30.18	35.05	32.62
1997-2012	32.78	31.23	35.07	32.97
T-test	ns	**	ns	*
Minimum (°C)				
1981-1996	24.16	19.05	22.71	22.52
1997-2012	24.49	19.93	23.05	22.99
T-test	*	**	*	*

*,**Significant probability at level 95 and 99% respectively, ns: Not significant

Table 6: Mean rainfall intensity and the No.of rainy days in rainy, winter, summer season and annual between the time period 1981-1996 and 1997-2012 in Chaiyaphum province

Rainfall/Time period	Rainy (May-Oct)	Winter (Nov-Jan)	Summer (Feb-Apr)	Annual
Rainfall (mm)				
1981-1996	913.6	30.8	143.9	1088.3
1997-2012	999.2	23.2	162.0	1184.4
T-test	*	ns	ns	*
Rainy day (No.)				
1981-1996	86	4	11	101
1997-2012	83	4	15	102
T-test	ns	ns	ns	ns

*Significant probability at level 95 and 99% respectively, ns: Not significant

Impacts of observed climate change on kenaf before rice: Kenaf is planted when the rain comes in the onset of summer season during February-March similarly to in case of sesame before rice cropping pattern. The respondents gave the reason why their stop growing kenaf the same as in case of sesame under recent climate.

Farmer's adaptation strategies: Since, the farmers practiced kenaf before rice similar to in case of sesame. The farmers who still continue growing kenaf they use water available in farm pond or reservoir where located near by their paddy fields. Therefore, this cropping pattern limits the number of farmers who practiced under recent climate.

Observed climate change in Northeast Thailand: The Northeast region consists of twenty provinces which included Surin, Buriram and Chaiyaphum. There are about twenty seven meteorological stations situated in the northeast region.

There was significantly increased mean maximum temperature in the northeast between the time period 1981-2012 in the rainy season (0.25°C) and winter season (0.89°C) but it was significant decreased in summer season (0.53°C) (Table 7). However, the mean maximum temperature was significantly increased (0.21°C) for annual in the northeast (Table 7).

In case of minimum temperature, it was significantly increased mean minimum temperature in the rainy (0.33°C) and winter season (1.33°C) but it did not show any significant difference in summer season (Table 7). The annual mean minimum temperature was significantly increased by 0.51°C in the region (Table 7).

Table 7: Mean maximum and minimum temperature in rainy, winter, summer season and annual between the time period 1981-1996 and 1997-2012 in Northeast Thailand

Temperature/Time period	Rainy (May-Oct)	Winter (Nov-Jan)	Summer (Feb-Apr)	Annual
Maximum (°C)				
1981-1996	32.30	29.91	34.60	32.28
1997-2012	32.55	30.80	34.07	32.49
T-test	*	**	*	*
Minimum (°C)				
1981-1996	23.85	17.36	21.55	21.66
1997-2012	24.18	18.69	21.63	22.17
T-test	*	**	ns	*

*,**Significant probability at level 95 and 99% respectively, ns: Not significant

Table 8: Mean rainfall intensity and the No. of rainy days in rainy, winter, summer season and annual between the time period 1981-1996 and 1997-2012 in northeast Thailand

Rainfall/Time period	Rainy (May-Oct)	Winter (Nov-Jan)	Summer (Feb-Apr)	Annual
Rainfall (mm)				
1981-1996	1204.3	27.8	141.1	1373.3
1997-2012	1245.2	35.1	158.5	1438.8
T-test	*	ns	ns	*
Rainy day (No.)				
1981-1996	96	4	14	115
1997-2012	96	5	16	117
T-test	ns	ns	ns	ns

*Sgnificant probability at level 95 and 99% respectively, ns: Not significant

The rainfall intensity was significantly increased (41 mm) in the rainy season, it was not show any significant difference in winter and summer season (Table 8). However, the rainfall intensity was significantly increased for annual (66 mm) in the Northeast Thailand (Table 8).

In case of the number of the rainy day, there is not significantly difference of the number of the rainy day in the rainy, winter, summer season and for annual in the Northeast Thailand (Table 8).

DISCUSSION

Temperature: In recent study, overall increase in annual of mean maximum and minimum temperature between the time periods 1981-1996 and 1997-2012 was ranged 0.20-0.36°C and 0.39-0.51°C respectively, depending on locations. This indicating that means minimum temperature increased higher than that of maximum temperature. The mean annual maximum and minimum temperature during 1996-2010 has increased 0.6 and 0.7°C, in comparison with the time period 1975-2010 in the areas of district Pishin of Pakistan (Ashraf and Routray, 2013). There was an increase in maximum temperature over Kerdlo, India by 0.64°C during the period of 1956-2004 (Prasada Rao *et al*., 2009).

In the present study, the temperature change among the three seasons. The mean maximum temperature increased by 0.16-0.31°C and 0.53-1.05°C in rainy season and winter season, respectively between the time period 1981-1996 and 1997-2012, depending on locations, while, the

mean maximum temperature decreased 0.53 and 0.11°C in summer season in Surin and Buriram provincs, respectively. On the other hand, the mean maximum temperature is slightly increased 0.02°C in summer season in Chaiyaphum province. In case of minimum temperature, the mean minimum temperature increased by 0.26-0.4°C, 0.82-0.88°C and 0.22-0.40°C in rainy, winter and summer seasons, respectively, depending on the locations. It is noticed that temperature are increasing more in winter than in rainy and summer season, in this study. In contrast, the maximum temperature in all the season winter and summer was decreased trend during the period of 1956-2004 in Palakkad and Ambalavayal, India. Such trend was noticed in decreasing mean minimum temperature in Trivandrum and Pampadumpara, India (Prasada Rao *et al*., 2009). However, the maximum and minimum temperature was increasing at some locations in Kerala state in India (Prasada Rao *et al*., 2009).

Rainfall: In the present study, overall increase in annual of rainfall intensity was ranged from 94-221 mm between the time periods 1981-1996 and 1997-2012, depending on locations. In contrast, annual rainfall has declined 100-313 mm in Nigeria over 30 years period of 1961-1990 depend on topography and location (ITA, 1992). It is observed also that there was high annual rainfall variability during 1996-2004, reduction as much as 10-151 and 81-167 mm below the annual average of Kach and Qaetta in India, respectively (Prasada Rao *et al*., 2009). Similar trend was noticed of annual rainfall in China during the last 50 years of 1951-2009, there was a slight decrease in precipitation within China, varying in different regions (Wheeler *et al*., 2002).

Among the three seasons in the present study, rainfall intensity increased range from 30-184, 5-7 and 18-58 mm in rainy, winter and summer seasons, respectively, depending on locations. There was a reduction of 27.3 mm in autumn and an increase of 20.6 mm in spring of rainfall intensity during the past 100 years in China (Yu *et al*., 2011). In case of the number of rainy day, overall increase or decrease was observed in annual of the number of rainy day, depending on locations. However, difference of the number of rainy days was slightly between the time period 1981-1996 and 1997-2012. Among the three seasons, the number of rainy day decreased range from 1-5 days in the rainy season but tend to slightly increased in the winter range from 0-1 days and summer range from 1-4 days. Similar trend was noticed in fewer wet days in rainy season in Nigeria (ITA, 1992).

In case of rainfall pattern, summer rain plays an important role for growing crops before rice in the past climate. In the recent study, although, rainfall intensity shows slightly increased in summer season, there were high variations among years rain come of the beginning in summer season (data not shown). In Northeast Thailand, the beginning of rainy season has changed markedly in the last 10 years and has increased variability, particularly during 2006-2010 (Atichart *et al*., 2013). The greatest changes also occurred in the onset of the rainy season and the extension of early rainfall was noticed in Nigeria (ITA, 1992).

Peanut after rice cropping pattern: Peanut grown after rice in the post-rainy season with non-irrigation fail of production under recent climate. This was due to high evapotranspiration caused by rising of both maximum and minimum temperature. Farmer's coping adaptation strategies include changes in crop species (autonomous adaptation or short-term adjustments) by replacing of peanut with pumpkin, cowpea and squash. This means substitution of crop with long growth duration by crops with early maturity. Some farmers replaced peanut by cassava a drought resistant crop. Other currently observed, some farmers changes in the land allocation

(planed adaptation or long-term adaptations) by replacing of rice-peanut double cropping pattern with sugarcane single cropping pattern. In general, rice-peanut double cropping practiced in upper paddy fields. Such paddy fields which have the lowest water availability with standing water depth due to their located in the top position of toposequence landform. Therefore, rice yield, generally, low where drought causes frequent problems. This means substitution of crops with high inter-annual yield variability by crop (rice) with more stable yields (sugarcane).

Sesame and kenaf before rice cropping pattern: Sesame and kenaf grown before rice fail of production under recent climate. This was due to shifts in the monthly distribution of rainfall within the summer season. There has been less rainy in the first month (February) of the season. This means that the available crop growing period was generally shortened by nearly one month due to delayed rainfall and subsequently delayed planting. Delayed planting would interfere with normal rice planting. In some case, there is enough rain in the first month for planting but crops fail of production. This was due to the subsequent of second rain come late after planting. Sesame and kenaf are unable to survive at seedling growth stage due to water stress (e.g. in 2012). In the case of adaptation strategies, some farmers irrigated to the paddy fields for land preparation and planting in the first month of the summer season, using water available in farm pond and consequently irrigated to the crops until the next rain come. Therefore, the areas where planted of the two crops sharply reduction. Since, the farmers who had on farm-pond located in the paddy fields are limited.

CONCLUSION

Existing rice-based cropping systems practiced by the farmers under past climate has been affected under recent climate. This was due to rising in maximum and minimum temperature in the winter season and changing in rainfall pattern in the summer season. Farmers employ various coping adaptation strategies against climate changes which included changes crop species (autonomous adaptation), changes of land use (planed adaptation) and supplement irrigation.

REFERENCES

Ashraf, M. and J.K. Routray, 2013. Perception and understanding of drought and coping strategies of farming households in North-West Balochistan. Int. J. Disaster Risk Reduction, 5: 49-60.

Atichart, S., N. Worasatit, R. Srisathit and K.Thmma, 2013. Study on variation of the rainy season period in the Northeast of Thailand. Khon Kaen Agric. J., 1: 346-351.

Aydinalp, C. and M.S. Cresser, 2008. The effects of global climate change on agriculture. Am. Eurasian J. Agric. Environ. Sci., 3: 672-676.

CAPSA, 2011. The impact of climate change on crop productivity in South-East Asia. Centre for Alleviation of Poverty through Sustainable Agriculture. http:// www.uncapsa.org/publication/Fact-Sheet-Climate-Change-022011.pdf

FSP, 1984. Peanut after rice using residual soil moisture. Technical Report RRA Series 1, Faculty of Agriculture, Khon Kaen University, Thailand.

FSP, 1986. Sesame before rice cropping systems in Buriram province. Technical Report RRA Series 2, Faculty of Agriculture, Khon Kaen University, Thailand.

FSP, 1987. Kenaf before rice cropping systems in Chaiyaphum province. Technical Report RRA Series 3, Faculty of Agriculture, Khon Kaen University, Thailand.

ITA, 1992. Rainfall changes call for shifts in cropping practices: The case of Nigeria. International Tropical Agriculture, Annual Report for 1992, pp: 36-37.

Polthanee, A., 1986. Rainfed Cropping Systems in Northeast Thailand. In: Traditional Agriculture in Southeast Asia: A Human Ecology Perspective. Martin, G.G. (Ed.). Westview Press, Boulder and London, ISBN: 9780813370262, pp: 103-131.

Polthanee, A., 1991. Cultivation of peanuts after rice in rainfed areas of Northeast Thailand: Farmers' approach. J. Agric., 7: 70-76.

Prasada Rao, G.S.L.H.V., A.V.R. Kesava Rao, K.N. Khishnakuma and C.S. Gupakumar, 2009. Impact of Climate Change on Food and Plantation Crops in the Humid Tropics of India. In: Impact of Climate Change on Agriculture, Panigrahy, S., S.S. Ray and J.S. Parihar (Eds.). ISPRS Archives, Ahmedabad, India, pp: 127-130.

Wheeler, T.R., P.Q. Craufurd, R.H. Ellis, J.R. Porter and P.V.V. Prasad, 2000. Temperature variability and the yield of annual crops. Agric. Ecosyst. Environ., 82: 159-167.

Wollenweber, B., J.R. Porter and J. Schellberg, 2003. Lack of interaction between extreme high-temperature events at vegetative and reproductive growth stages in wheat. J. Agron. Crop Sci., 189: 142-150.

Yu, H.Y., S.H. Liu, N. Zhao, D. Li and Y.T. Yu, 2011. Characteristics of air temperature and precipitation in different regions of China from 1951 to 2009. J. Meteorol. Environ., 27: 1-11.