Rice Production and Climate Change in Monsoon Asia: Problem in the 21st Century

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1. INTRODUCTION

During the recent years, studies on the relationship between climate change and rice production have been carried out in connection with the global environmental change. On the other hands, food security problems have been discussed, because population will increase with great rate in the 21st century. Not only the scientists but also the politicians and decision makes have been considering their importance.

Rice production and climate conditions have been studied from the stand points of agricultural meteorology and climatology for long years. Main subjects, however, include problems of human societies in a few decades to hundred decades period; historical and archeological periods. For example, dry conditions during the longer periods have been taken into consideration in a historical study in Southeast Asia (Fukui, 1999).

Food conditions are one of the most important environmental factors for migration of peoples for the historical and archeological periods. The climatic change should be cyclic, abrupt or occurred with certain tendencies, but our knowledge is very limited. Generally speaking, it is not enough to consider quantitatively the impacts of these conditions or factors on the subjects for the anthropological, historical or archeological studies.

In this paper, impacts of climatic change, mainly drought, on agricultural production in Thailand and Indonesia are dealt with, putting focus onto the 1994 and 1997 El Niño years. This must be a first step to analyze the human activities as man-environmental systems during the longer periods. Similar approach has been tried for Indonesian examples in the El Niño years in 1970's and 1980's (Yoshino et al., 2000). To know, how the impacts in Monsoon Asia in the 1990's were, is one of the aims of the present study. Did they occur in the regions in Monsoon Asia in parallel, in a opposite way or independently? These consideration is quite important to the food security in a regional scale such as Monsoon Asia.

2. IMPACT OF CLIMATE

2.1. Thailand

In Monsoon Asia, Thailand is situated roughly on the northeastern border of developed SW monsoon in South Asia in northern summer. On the contrary, it is located on the southwestern border of developed NE monsoon in Southeast Asia in northern winter. So, Thailand locates in the most sensitive region for year-to-year change of the monsoons (Yoshino, 1971, 1976).

According to a recent report by IPCC (Intergovernmental Panel for Climate Change), annual rainfall in Thailand has increased in the last decade (Thanawat, 1998) and may continue increasing in the future, especially in the areas situated on the windward side in the monsoon season (Runyailokraja et al., 1990). Increasing of precipitation in the dry season has become clear in Northeast Thailand during the last two decades, as shown in figure 1. A thorough work on El Niño and La Niña has been published recently (Allan et al., 1996). According to their maps, temperature anomalies, as given in table 1, were about +0.7ºC and precipitation anomalies were about –12% in the El Niño years. Contrary, air temperature is lower (about –7ºC) and precipitation is higher (about +14%) in the La Niña years.

Rainy season in Thailand has been generally recognized from May to September and the dry season from November to March. Of course, it fluctuates year-to-year and region to region. The earlier study on the period from 1906 to 1925 shows that the mean onset date of rainy season was 25 April and the terminated on 12 December. The longest rainy season was 236 days and the shortest 174 days. According to a recent study on the ten-days amount, the rainy season in Bangkok starts in the first ten-days of May and ends in the 3rd ten-days period of October.

In northern summer, SW monsoon, causing the rainy season, prevails over South Asia including Southeast Asia. On the other hand, in northern winter, NE monsoon that causes the dry season predominates over South Asia including some parts of Southeast Asia. Of course, SW monsoon reaches East Asia including South China and Southwest Japan on the extreme boundaries. Similarly, NE monsoon reaches South Asia including Sri Lanka and the surrounding tropical seas on the extreme boundary (Webster et al., 1998).

Sea surface temperature (SST) and monsoon conditions over Southeast Asia in the El Niño years are different from those in the western Equatorial Pacific

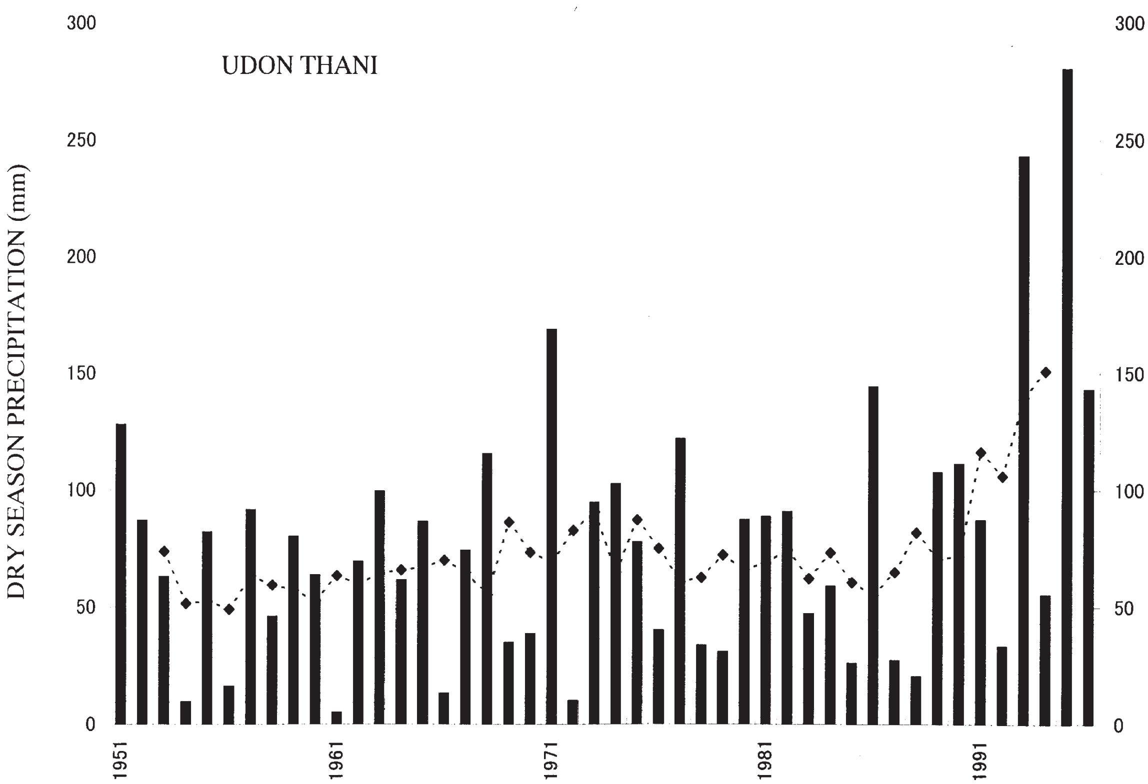

Fig.1. Secular variation of dry season precipitation at Udon Thani, NE Thailand. from 1951 to 1996

and Indian Oceans respectively. As has been well understood, in the El Niño years, SST is higher and the easterly trade wind is weaker in the eastern Equatorial Pacific region and the SW monsoon in northern summer is weaker in South and Southeast Asia. In contrast, SST is higher after the La Niña years, or before the El Niño years. In the La Niña years, SST is lower and the easterly trade wind is stronger in the eastern Equatorial Pacific region. In the western Equatorial Pacific region, SST is lower after the period of El Niño years. These situation results in the difference that the SW monsoon is weak in the El Niño years and strong in the La Niña years. These conditions provide the year to year difference of precipitation in Thailand.

2.2. Indonesia

National mean annual precipitation in Indonesia, 2,620mm, is the largest in the Asian monsoon region. But rainfall changes seasonally and regionally with a wide range (Yoshino, 1976). Also, it varies year to year in accordance with the monsoon circulation anomalies in the El Niño years and La Niña years. Monsoon circulations yield a distinctive dry season and wet season. Rainfall depends upon the monsoon circulations, which are affected by ENSO (El Niño-Southern Oscillation) events. During the northern summer, almost all parts of Indonesia are governed by an easterly monsoon current.

In Indonesia, it is generally accepted by the people that the dry season is the months from June to September and the wet season from October to March, but there are no generally accepted scientific definitions on the beginning of the seasons. For example, there is a definition that the date by which 350 mm of rainfall had accumulated as the beginning of the first day of the wet season and interpolated for the day of the month. Another one used 200 mm instead of the 350 mm. According to the data observed at Yogyakarta from 1879 to 1941, the beginning of the rainy season varied from Oct.2 to Dec.28 and the end date was April 27. This period can be defined as the wet season.

The previous study (Yoshino et al., 2000) showed that the dry season lasts longer in El Niño years and shorter in the La Niña years. Difference in rainfall between the El Niño years and the La Niña years is clear: In the El Niño years, 0% of forecast regions of Indonesia have above normal rainfall in contrast to 92.6% of regions with below normal during the dry season. The opposite was occurred in the La Niña years. During the wet season, however, clear contrasts with smaller deviation were observed.

The onset of the dry season was earlier in 69.4% of the total forecast region of Indonesia in the El Niño years, while it was later in the La Niña years.

This is reexamined by the other data from 1993 to 1999. Table 1 shows percentage of number of forecast regions for onset date of wet season in Indonesia. Onset date was the earliest in 1996 and 1998 among the recent six years. These coincide with the La Niña years. On the other hand, the latest was occurred in 1994 and 1997, which were the El Niño years. Table 2 presents percentage of number of regions for onset date of dry season in Indonesia. The relatively early onset was occurred in March and April in 1993, 1994 and 1995, which were the weak El Niño years. The relatively late onset was seen in May in 1996 and 1997, which were the La Niña years.

As a general view, it can be concluded that the wet season begins later and the dry season starts earlier in the El Niño years. In contrast, the wet season begins earlier and the dry season starts later in the La Niña years.

Table 1: Percentage of number of regions for onset date of wet season in Indonesia

	Sept.	*Oct.*	*Nov.*	*Dec.*	*Number of regions*
1993/1994	8%	43%	33%	16%	93
1994/1995	1	34	48	17	93
1995/1996	12	39	38	11	104
1996/1997	22	28	40	10	102
1997/1998	1	34	54	11	102
1998/1999	23	43	32	2	102

[*Data source:* Prakiraan Musim Hujan Di Indonesia, Departemen Perhubungen, Badan Meteorologi Dan Geofisika]

Table 2: Percentage of number of regions for onset date of dry season in Indonesia

	Mar.	*Apr.*	*May*	*June*	*July*	*Number of regions*
1993	0%	31%	29%	32%	8%	93
1994	0	31	30	29	10	93
1995	3	26	40	28	3	93
1996	1	22	45	28	4	102
1997	0	20	44	32	4	102
1998	0	21	42	30	7	102

[*Data source:* Prakiraan Musim Kemaru Di Indonesia, Departemen Perhubungen, Badan Meteorologi: Dan Geofisika]

3. RICE PRODUCTION

3.1. Thailand

Rice production area in Northeast Thailand occupies about 56% (5.12 million ha) of the total rice areas of Thailand. However, irrigated area is only 17% (0.79 million ha) of the total Thailand. The year-to-year variations of rice yield and zero harvest areas show different trend from the other major regions. The rice cultivation in Northeast Thailand has been studied for long years (Fukui et al., 2000). Its change in accordance with irrigation technique has been made clear. In this part of present study, rice production in the rainy season and the dry season in Northeast Thailand is analyzed for the El Niño years and La Niña years.

In the rainy season eight prefectures among ten are negative, which means that rice yield are less in the El Niño years than the La Niña years. On the other hand, six La Niña cases among ten were negative in the dry season. These differences of exceptional case between the rainy and dry seasons can be attributable to the facts that rice cultivation in the dry season weakly depends to precipitation amount; in other words, precipitation more locally falls in the dry season than the rainy season. The differences of precipitation between 1992 (dry year) and 1994 (wet year) were negative, but the rice yield in the dry season was positive. This was considered as a result of rapid technological development in the provinces of NE Thailand in the early 1990's, excepting the provinces of the surrounding mountainous region. As has been made clear by Konchan et al. (1996), the accelerated economic growth attracted Northeastern Thai farmers to Bangkok and its suburbs, and this resulted in the introduction of labor-saving techniques, for example, direct seeding, during the early 1990s.

Table 3 shows harvested areas of major rice and second rice in Northern Region of Thailand. It is very clear that the areas were minimum crop year of 1990/91, the El Niño year. In contrast, maximum in 1994/95, the La Niña years. However, sharp increasing tendencies are striking since 1995/96.

Table 4 shows yield of major rice and second rice in Northern Region of Thailand. Minimum in 1990/91 and maximum in 1995/96, were same tendency to harvested area mentioned above. Only one exception was found in the case of second rice.

Table 3: Harvested area (× rai) major rice and second rice in Northern Region of Thailand

Crop year	*Total rice*	*Major rice*	*Second rice*
1988/89	14.7	13.6	1.0
1989/90	14.0	12.8	1.1
1990/91	11.6	11.0	0.6
1991/92	12.2	11.1	1.0
1992/93	12.3	11.5	0.8
1993/94	11.2	10.7	0.5
1994/95	12.1	11.2	0.9
1995/96	11.8	10.1	1.7
1996/97	13.2	11.1	2.0
1997/98	14.8	12.1	2.6

[*Data source:* Statistical Reports of Region, Northern Region 1999, National Statistical Office, Office of the Prime Minister, Thailand] (1rai=0.16ha)

It is noteworthy that the harvested area of second rice is about one sixth of major rice, but yield of second rice is 1.5 times greater than that of major rice. This means that the second rice is cultivated under the better condition (irrigation and others), even the area is small.

3.2. Indonesia

Rice production change in the El Niño year from the preceding years is negative, because of drought: –6,190 x 1,000 t in average of five typical El Niño years in South Asia and –34 x 1,000 t in Southeast Asia. On the other hand, it was positive in La Niña years; +4,893 x 1,000 t in average of five typical La Niña years in South Asia, and +1,779 x 1,000 t in Southeast Asia.

In wetland paddy production for the respective three cultivation seasons shows a clear relation to the four-month-mean SOI (Southern Oscillation Index, defined by difference of sea level pressure between Dawin and Tahiti). The production was higher during positive SOI period (El Niño year) than negative SOI period (La Niña year). But, the relationships are not significant because of scatter distribution of points in the range of the four-month-mean SOI from +5 to –10, as shown in figure 2. In the first period (January to April) of the year, production is the largest and the differences between the El Niño years and La Niña years are largest. In the third period, it is the smallest.

In table 5, harvested area of wetland paddy and dryland paddy in Java and the outside of Java from 1992 to 1998 is given. Harvested area of wetland paddy in Java was almost half of the total wetland paddy of Indonesia and more than 12 times of dryland paddy. But it fluctuates with wide range: from 8,166 (×1,000ha) in 1993 to 4,830 (×1,000ha) in 1994. This is worthy to note that the first period to

Table 4: Yield (kg/rai) of major rice and second rice in Northern Region of Thailand

Crop year	*Total rice*	*Major rice*	*Second rice*
1988/89	431	415	643
1989/90	446	424	685
1990/91	384	366	702
1991/92	435	409	726
1992/93	400	379	688
1993/94	402	389	672
1994/95	464	444	704
1995/96	495	453	736
1996/97	479	435	724
1997/98	451	403	671

[*Data source:* Same to Table 3] (1rai=0.16ha)

second period harvests occupy the tendencies of the year in Indonesia as mentioned above. The maximum of 1993 was occurred in the weak El Niño year and the minimum of 1994 in the La Niña year. Also, as concluded above, the dry season starts earlier in Indonesia in the El Niño year, which means dry condition dominants in Java in dry season in general, but the first and second period harvest, which is mainly cultivated in the wet season is better in Java in the El Niño years. The reverse tendencies are true in the La Niña years as shown in 1994 and 1997.

These will be summarized as shown in table 6. This general view of the conclusion was drawn from the results in the previous Chapter 2 on climate impacts and Chapter 3 on rice production. Important facts are: (1) The rice harvest depends upon the El Niño and La Niña conditions. The impacts are parallel in Thailand and Indonesia; namely, they are maximum in the El Niño years and minimum in the La Niña years in the northern

Table 5: Harvested area of wetland paddy and dryland paddy in Indonesia (×1,000 ha)

	Java	*Outside of JAVA*	*Total*
Wetland paddy			
1992	5,158	4,640	9,799
1993	8,166	4,640	9,806
1994	4,830	4,663	9,493
1995	5,128	4,952	10,081
1996	5,125	5,125	10,251
1997	5,018	4,863	9,881
1998	5,380	5,095	10,475
Dryland paddy			
1992	393	910	1,304
1993	348	857	1,205
1994	345	894	1,239
1995	351	1,006	1,357
1996	363	955	1,318
1997	362	896	1,258
1998	371	883	1,254

[*Data source*: Statistik Indonesia]

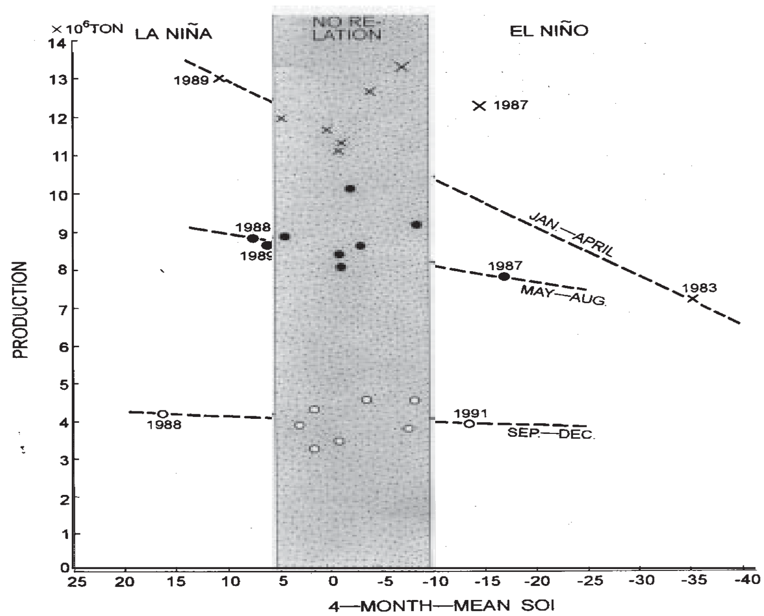

Fig. 2. Wetland paddy production in Java and SOI in the three periods of years (January-April, May-August and September-December). Data: 1983-1991 (Yoshino et al., 2000)

winter monsoon period. 1996 was an exception. (2) Onset date of dry season and wet season is clearly depended upon the El Niño and La Niña conditions, but maximum or minimum of harvested area are not affected clearly by them. (3) Maximum or minimum of harvested area appears differently between the northern winter monsoon season and the northern summer monsoon season. Therefore, interannual fluctuation by annual total of harvested area (and yield) of course leads some times wrong conclusions. We should analyze the impacts separately for the cultivation periods in the northern summer and winter monsoon seasons.

4. DISASTER TYPES IN THE 21ST CENTURY

4.1. A Viewpoint

Due to the inadequate or incomplete program-

Table 6: Climate impact and rice harvest in Thailand and Indonesia by season and year from 1993 to 1998: A summary

	J F M	*A M J*	*J A S*	*O N D*
1993	**H.A. Second Rice, N.Thail. decrease (negative), NE, Thail. min.** **H.A.Wetl.Rice, Indon. max., Java max.**	Dry Season onset, Indon. Earliest.	H.A. Major Rice, Thail. min.	Wet Season onset, Indon. earlist.
1994	H.A. Second Rice, N.Thail min. H.A.Wetl.Rice, Indon. min., Java min.	Dry Season onset, Indon. earliest/late.	H.A. Major Rice, Thail. max.	**Wet Season onset, Indon. earlist.**
1995	**H.A. Second Rice, N.Thail. increase.** H.A.Wetl.Rice, Indon. Max.	**Dry Season onset, Indon. Early.**	H.A. Major Rice, Thail. min.	Wet Season onset, Indon. early.
1996	H.A. Second Rice, N.Thail max. H.A.Wetl.Rice, Indon. max.	Dry Season onset, Indon. late.	H.A. Major Rice, Thail. increase.	Wet Season onset, Indon. earlist.
1997	H.A. Second Rice, N.Thail min. H.A.Wetl.Rice, Java, increase.	Dry Season onset, Indon. late.	**H.A. Major Rice, Thail. increase.**	**Wet Season onset, Indon. late.**
1998	**H.A. Second Rice, N.Thail. max (increase).**	Dry Season onset, Indon. latest.		Wet Season onset, Indon. earliest.

H.A. :Harvested Area
Bold :El Niño
Light :La Niña

ming, activities of computers will suffer from unpredictable or unprepared trouble in the 21st century. By such trouble, loss of people, and number of destroyed houses and destruction of buildings will be small or nothing. However, the areas affected are quite broad and the economic loss of human societies and inconvenient every day life of people will reach an immense amount and extend to many kinds of human activities, if it will be able to be calculated. In this sense, such trouble should be developed to disaster in our activities indispensably. Such types of disasters in the 21st century have been found in the case of power stoppage occurred in the western part of the United States in summer of 1996 and in Auckland in January of 1998. It was estimated that the total amount of economic damage was equivalent to 0.25-0.35% decrease of GDP in New Zealand. As the second example of damage, we are able to see traffic jam in big cities. In Tokyo, it was calculated that the total economic loss for users of the urban super-high ways reached to 327,100 million Japanese Yen (about 3,000 million US-Dollar) per one year. Thirdly, problems are found in amount of insurance as indicated by "net claims paid". The five-year mean ratio ($\times 10^{-2}$) of "net claims paid" to GNP in Japan increased three times during the last 40 years. It should be stressed that such tendencies will be more accelerated in the coming century. How play the role the damages of agriculture by severe drought on human societies in the 21st century. Drought as well as flood is considered as the old type disasters, which are originated by direct effects, without any computer trouble. However, agricultural insurance today should cover in some occasions huge amount of money for disasters caused by such as drought, flood, severe typhoon and cyclone, front by cold waves etc. Reinsurance system will not work rightly, if these new type disaster in some regions occurs simultaneously with the old type disaster in remote regions in the world.

This means that the agriculture in the regions will be suffered seriously. In other words, it results in an avoidable problem in food security.

4.2. Discussion on Climate Change and Rice-production in Monsoon Asia

In order to assess the climate change caused by global warming in the 21st century and its impacts on the rice-production in Monsoon Asia, previous researches were reviewed (Yoshino, 1998). It is indicated that there were many studies on regional geographies of Monsoon Asia described mainly by European and American geographers, demographers, agricultural economists and sociologists since the 1920's. They concluded that the rice-producing societies can only sustain high-density population in Monsoon Asia. In other words, the high-density population is a result of rice cultivation. After the II War, regional geography (Dobby, 1970; Fryer, 1970) synthetic studies on some special topics by scientists from many fields have been carried on (Brookfield et al., 1993). Examples are rice cultivating societies in Thailand, agricultural cultivation forms in Monsoon Asia and so on (Fukui, 1993, 1996). From the 1970's, international symposium/meeting have been held, in particular, on the theme on rice and climate and from the 1980's, on the relation with global change.

From 1990's, food security problems of the world or in the nation scale have come to one of the main topics. Based on cultivation, production and yield of rice, Monsoon Asia, in where physical conditions (vegetation, soil and climate) and human societies, based on rice production, are similar, should be studied as a unit of region. In particular, homogeneities of historical, anthropological, and cultural backgrounds are taken into consideration. The boundaries of Monsoon Asia are shown elsewhere (Yoshino, 1998).

The important points in Monsoon Asia will be as follows: 1) The recent trends in consumption, self-sufficiency, and demand for rice; 2) rice production in relation to El Niño and La Niña; 3) the rice cropping calendar in relation to environment change; and 4) the historical development of paddy cultivation. Three topics are the most urgent subjects: 1) urbanization/industrialization and rice-producing societies in Monsoon Asia; 2) assessment of the impact of climatic fluctuations/changes on paddy production potential; and 3) influence of arid or humid climate tendencies on regional/cultural development.

5. CONCLUSION

The early studies concluded that the high density of population in Monsoon Asia could be supported only by agricultural societies based on rice production. This conclusion has been generally accepted and is still written in textbooks today. Is this conclusion being applicable for the 21st century?

Food security has been considered individually on each (nation) basis. On the other hand, world food security is discussed as a global scale problem from a long-term viewpoint. In the future, however, food security should be considered in a relatively broad region, which can be considered by geographical unit, such as Monsoon Asia, which is composed of countries connected by similar physical and human characteristics.

Adaptations of agricultural societies to the environmental change due to the global warming is also important in the 21st century, where (1) Change of sensivity / deviation / range of anomaly, according to period (e.g. type of agriculture, life style, stage of infrastructure), (2) Change of relationship between yield and climatic elements, and (3) Change of human impacts, according to development stages of societies. (4) Changes of correlated regions or changes of parallel and opposite trends between regions. These are closely related to monsoon circulations.

Differences of precipitation and rice production between the El Niño years and the La Niña years were dealt with. It is shown that decreasing in the El Niño years and, in contrast, increasing are striking in the La Niña years. In NE Thailand, it is interesting to note that the differences of precipitation between 1992 (dry year) and 1994 (wet year) were negative, but the rice yield in the dry season was positive. This was considered as a result of rapid technological development in early 1990's, excepting the provinces of the surrounding mountainous region.

Maximum or minimum of harvested area appears differently between the northern winter monsoon season and the northern summer monsoon season. We should discuss the impact problems together with the regionally parallel or independent changes separately for these two seasons. From the viewpoint of food security, this must be important. Indirect disaster caused by the computer trouble, which happened simultaneously in other remote regions in the world, should be considered in the case of reinsurance for the catastrophic agricultural damages in the 21st century.

KEYWORDS Agricultural Production. Climate Change. El Niño Year. Monsoon Asia. Rice.

ABSTRACT Relationship between rice production and climate change was discussed taking an example of Monsoon Asia. In particular, Thailand, located at the central region of monsoons in the northern hemisphere and Indonesia, a region predominated wet and dry seasons corresponding monsoon circulations at the agricultural region, were selected as study regions. The analyzed years were mainly 1993 to 1998. The harvested area and yield of wet land paddy, dryland paddy, onset date of dry season and wet season were analyzed for every year. In the last part of the study, disaster types in the 21st century were pointed out: In the case that the disaster caused by computer trouble reaches to huge amounts of cost and reinsurance system does not work rightly, and the serious agricultural damage will happen in nations scale, it will result in a unaccountable problems from the stand point of food security. Parallel or indipendent changes in the two regions in Monsoon Asia are shown.

REFERENCES

Allan, R., Lindesay, J. and Parker, D.: El Naño, southern oscillation and climatic variation. Calling word. CSIRO Publishing, Australia (1996).

Brookfield, H. and Byron, Y.: *Southeast Asia's Environmental Future; The Search for Sustainability*. United Nations Univ. Press, Tokyo (1993).

Dobby, E. H. G.: *Monsoon Asia*: University of London Press, London (1970).

Fryer, D. W.: *Emerging Southeast Asia. A Study in Growth and Stagnation.* George Philip and Son, London (1970).

Fukui, H.: *Food and Population in a Northeast Thai Village*. University of Hawaii Press, Honolulu (1993).

Fukui, H.: Transformation of agriculture in Northeast Thailand. *Southeast Asian Studies*, **33(4):** 521-702 (1996).

Fukui, H.: *The Dry Areas in Southeast Asia: Harsh or Benign Environment?* Center for Southeast Asian Studies, Kyoto University, Kyoto (1999).

Fukui, H., Chumphon, N. and Hoshikaw, K.: Evolution of rainfed rice production in Northeast Thailand: Increased production with decreased stability. *Global Environ. Res*., **3(2)**: 145-154 (2000).

Konchan, S. and Kono, Y.: Spread of direct seeded lowland rice in Northeast Thailand: Farmers' adaptation to economic growth. *Southeast Asian Studies*, **3(4):** 523-546 (1996).

Runyailokraja, V. and Nimma, S.: The variation of annual rainfall and surface temperature over Thailand. In: *Workshop on the Global Changes, 16-17 August 1990*. National Research Council of Thailand, Bangkok (NRCT) (1990).

Tanawat, Jorupongsakul: The implications of sea-level rise and flooding for the Gulf of Thailand region. *Papers presented at IPCC Asian Regional Expert Meeting 21-23 June 1999, NIES, Tsukuba, Japan.* IPCC/AREM-Doc-3, 5-80 (1990).

Webster, P. J., Magana, V. O., Palmer, T. N., Shukla, J., Tomas, R.A., Yanai, M. and Yasunari, T. : Monsoons: processes, predictability, and the prospects for prediction. *Jour. Geophys. Research*, **103(7):** 14,451-14,510 (1998).

Yoshino, M.: Some aspects of the intertropical convergence zones and the polar frontal zones over Monsoon Asia. In: *Water balance of Monsoon Asia*, M. Yoshino, (Ed.). University of Tokyo Press, Tokyo and University of Hawaii Press, Honolulu, 87-108 (1971).

Yoshino, M.: Climatological and meteorological problems of precipitation in Monsoon Asia. *Ann. Rep., Inst. Geosci., Univ. of Tsukuba*, **(2):** 51-63 (1976).

Yoshino, M.: Impacts of ENSO on agricultural production, meteorological disasters and phenology in Asia: Some examples. *Journal Agricultural Meteorology*, **52(2):** 163-170 (1996).

Yoshino, M.: Climate and food security ? A view from Monsoon Asia. *Global Environmental Research*, **1(1/2):** 49-58 (1998).

Yoshino, M., Urushibara-Yoshino, K. and Suratman, W.: Agricultural production and climate change in Indonesia. *Global Environmental Research*, **3(2):** 187-197 (2000).

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