Long-term Change and Short-term Fluctuation of Production of Wetland Paddy in Java, Indonesia - Precipitation Change and Farmer's Response -

Long-term Change and Short-term Fluctuation of Production of Wetland Paddy in Java, Indonesia —— Precipitation Change and Farmers' Response ——

Yoshiyuki MURAYAMA*, Kiyotaka SAKAIDA*, Nao ENDO and Toshikazu TAMURA*****

Abstract We examined the wetland paddy production and its change in Java and Bali based on the statistics prepared by BPS-Statistics Indonesia (Badan Pusat Statistik) from 1976 to 2000 in units of province (propinsi) and district (kabupaten). The short-term fluctuation and the long-term change were separated from the yearly data of rice production. As for the long-term change, the yield rates increased in about first ten years of the period by injecting the chemical fertilizers and introducing new varieties, the harvested areas also increased by the development of irrigation systems and so on, and the production grew remarkably. On the other hand, the growth rate of those indices decreased in the latter half of the period, and short-term fluctuation responding with ENSO cycle came to be recognized clearly. Though the influence of small precipitation caused by the El Niño hardly appears in the yield rate, the fall of the harvested area is remarkable, which causes a decrease in production.

The influence is obvious in the area with an annual precipitation of around 2,000 mm and clear in the years with small rainfall in the early rainy season, especially until November or December. The areas affected most severely by the fluctuation of precipitation are neither the areas with small precipitation with irrigation facilities, nor the area of a large precipitation of over 3,000 mm. It is suggested that the influence of drought is represented by giving up growing rice at the field of poor condition or by reducing the time of cropping.

Field investigation was carried out on a farm village in West Java located on the north foot of Volcano Salak, to figure out the manner of the farmers' response to small rainfall. The survey confirmed the above hypothesis. Some farmers have experienced substituting some upland crops for wetland paddy due to small rainfall. On the other hand, the farmers who have large rice fields do not have even that experience. The fact suggests that the upper farmers are less affected by drought ; in other words, the sensitivity to environmental fluctuation is different by social classes.

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1. Introduction

The present amount of production of rice in Indonesia is about 50 million tons a year and is the third largest after China and India. Indonesia, as well as other tropical monsoon countries in Asia, experienced a rapid growth of rice production due to "green revolution" in the 1970s, and achieved self-sufficiency of rice in 1984. However, an unstable condition in rice production in Indonesia followed, requiring large quantities of imports at the time of poor harvest after 1994. Indonesia is one of the countries that hold the key to food supply and demand in the world (Surayama and Nurmalina, 2000). One of such unstable factors can be the change in precipitation that relates to ENSO (El Niño Southern Oscillation). The analyses of rainfall and agricultural production in El Niño years such as 1994 and 1997 have been proceeding (Yoshino *et al.*, 2000).

The ratio of production of rice in Java to the whole country is 60.3% in 1976 and 56.1% in 2000, and 97.6% and 96.6% of the rice production in Java are wetland paddy in 1976 and 2000, respectively. Figure 1 shows the distribution map of the production and the yield rate of a wetland paddy in province units in Indonesia in 1976 and 2000. Java is clear to occupy the leading position of the wetland paddy production in Indonesia still now in terms of not only the amount of production but also the yield rate, although that relative position was a little lowered due to a rise in production in other islands such as Sumatra and Sulawesi. A change in production of rice in Java in the El Niño determines domestic rice supply and demand.

This paper aims to clarify the change and distribution of production of a wetland paddy in Java (including Bali) that is the core of the rice production in Indonesia and to analyze the relationship among those and precipitation and ENSO, based on data in the period ranging from 1976 to 2000 in units of province (propinsi) and district (kabupaten) that is the lower governmental body than the province. Although the Indonesian precipitation data had been prepared in considerable density since the beginning of the 20th century until around 1975, after the 1980s the collection and arrangement of the data do not proceed through fully (Yamanaka, 1998). Therefore, the analysis of the relations between the amount of agricultural production and the actual precipitation is delayed in comparison with the relations with ENSO. Both the relations were to be examined by the data of wetland paddy production and the monthly precipitation, which the authors collected in Jakarta.

Furthermore, the second purpose is to figure out the manner of the farmers' response to small rainfall, by hearing investigation to the farmers in a village of Java.

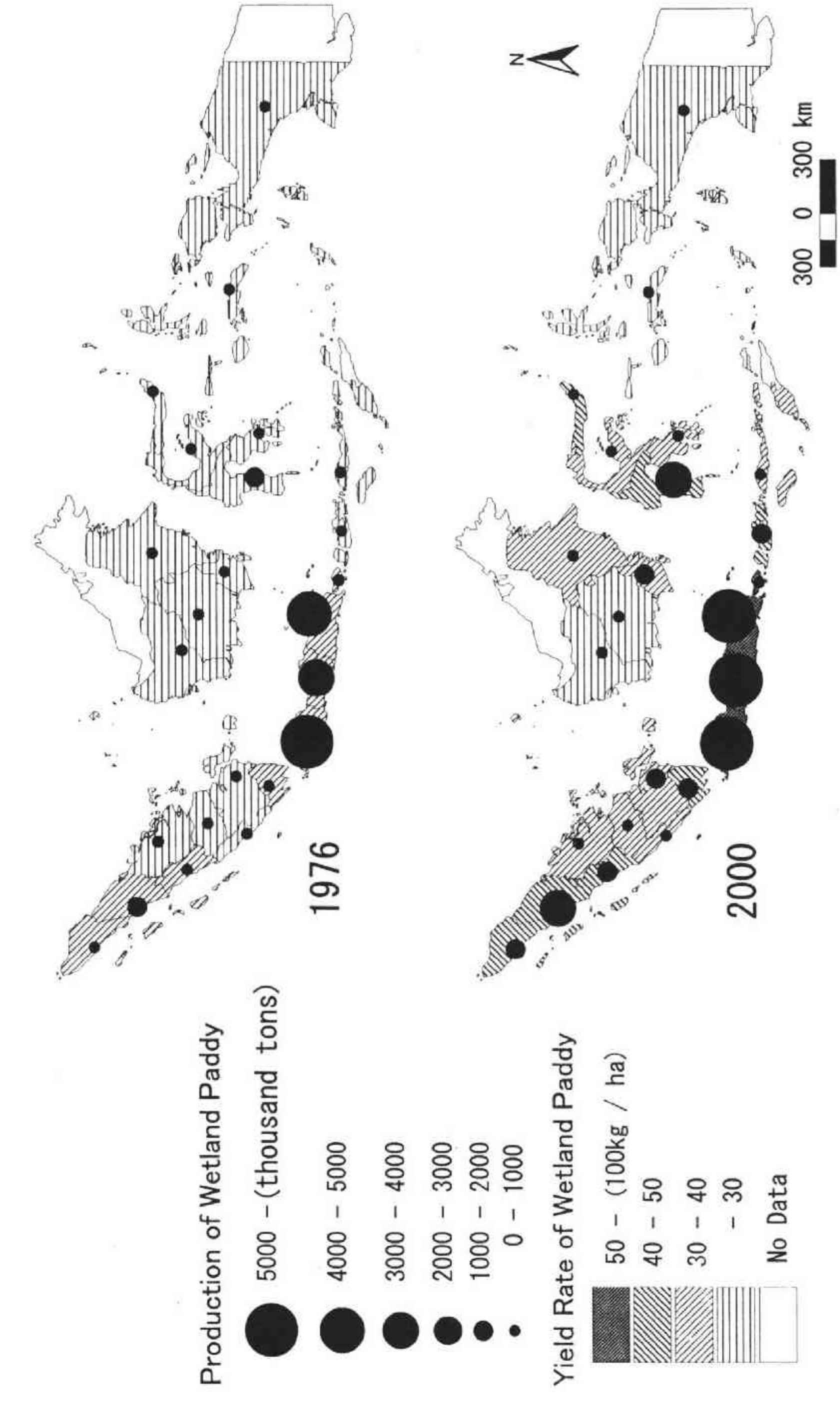

Figure 1. Production and yield rate of wetland paddy in Indonesia
Source : Agricultural Survey by BPS-Statistics Indonesia.

2. Change in wetland paddy production with time — analysis of statistics —

2.1. Data

All the data on a wetland paddy used in the study are based on the agriculture statistics reports named as Statistik Pertanian or Survei Pertanian issued by BPS-Statistics Indonesia (Badan Pusat Statistik)[1]. Analysis was made to the amount of production, harvested area, and yield rate (production per unit area) totaled up by calendar years (January-December). The form of the production and the yield rate are based on the weight of the unhusked dry rice (gabah kering giling). The agriculture statistics had been written in the form of the weight of dry stalk (padi gagang kering) until 1975. A method for calculating a harvested area had been also changed before 1975 (Kano, 1988). To avoid errors due to these changes, analysis was made based on data from 1976 to 2000 in this study.

The statistical unit areas are provinces and districts. There are 95 districts in Java and Bali Islands, and most of those are about 1,000 square kilometers in area. Merged and renamed districts are totaled in the latest district unit again, and obvious mistakes are corrected. Data on the city (kotamadya) at the same administrative grade as a district are added to the data on the district including the city.

As for precipitation, the authors use the monthly rainfall data (1975-1999) of about 200 points in Java acquired by Bureau of Meteorology and Geophysics (Badan Meteorologi dan Geofisika) in Jakarta. Though many precipitation observation points mainly for agricultural use exist in Java Island, these are moved or abolished very often, and do not supply the data without interruption for a long time. Probably based on such observations, there are statistics reports including average precipitation of each district without mentioning the source. This study is not based on such data due to its unclear source but on that of Bureau of Meteorology and Geophysics. Because the data of the bureau also have many missing periods and the observation points tend to be unevenly distributed, the data are arranged in district units. Namely, annual precipitation is standardized by the average and the standard deviation for the observation point which had a record for 15 years or more, and these are averaged in units of district. The number of districts having average precipitation derived in this manner reaches 32, which is 37% of the whole of Java.

Though there had been a few missing records before early 1980s in Java, the missing records increased rapidly thereafter, and the missing rate becomes more than 70%, for example, in 1989, 1994, and 1998. The missing is ignored in case of a dry season. In case that the missing lasts one or two months in the rainy season, an average year value was assigned. Also, in case of the missing over three months, annual precipitation is not calculated for the following analysis. A dry season lasts from July to September at most of the observation points in Java (Yamanaka, 1998). Taking into consideration of the dry season and the growing period of a wetland paddy (Yoshino, 1999), annual precipitation is totaled from September of the preceding year until August this year, and this annual precipitation is analyzed in relation to the annual production of a wetland paddy from January to December of this year.

The monthly SOIs (Southern Oscillation Indexes) by the Australian Bureau of Meteorology from the preceding year September until this year August are also annually averaged as indices of ENSO[2]. When a year is given on annual precipitation or SOI in the following, it indicates one year from September of preceding year of the indicated year to August of this year.

2.2. Long-term change in wetland paddy production and short-term fluctuation

Figure 2 shows a change in production of a wetland paddy in three provinces of Java. Although the growth of wetland paddy production reaches about 2.3 times in whole Indonesia and about 2.0 times in Java in 25 years from 1976 to 2000, the increase during the period is not constant. The long-term change shows a remarkable trend that the production increased greatly in the first half and slowed down in the latter half of the period. The trend is commonly recognized in three provinces. In addition, a short-term fluctuation that repeats increase and decrease in several years became clear in the latter half. This fluctuation can be seen to correspond to SOI.

The amount of production is the product of the yield rate and the harvested area. As for the transition of the yield rate (Figure 3), it increased gently through the period

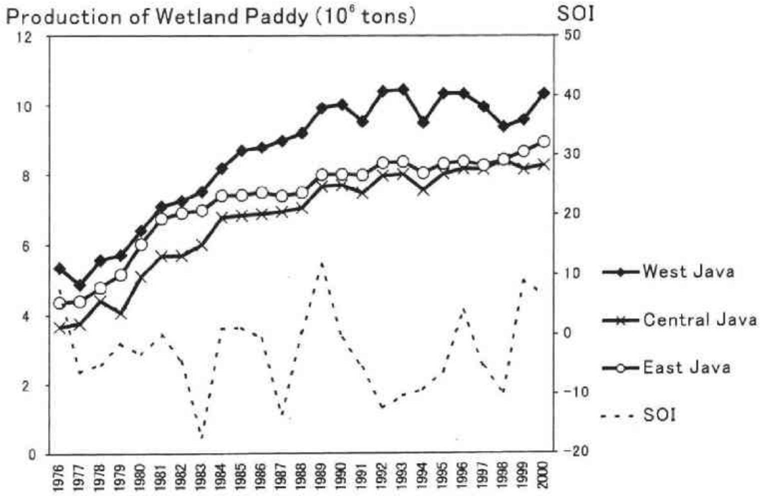

Figure 2. Change of production of wetland paddy in three provinces of Java and SOI
Source: the same as Figure 1 as for wetland paddy.
SOI is by the Australian Meteorological Agency.

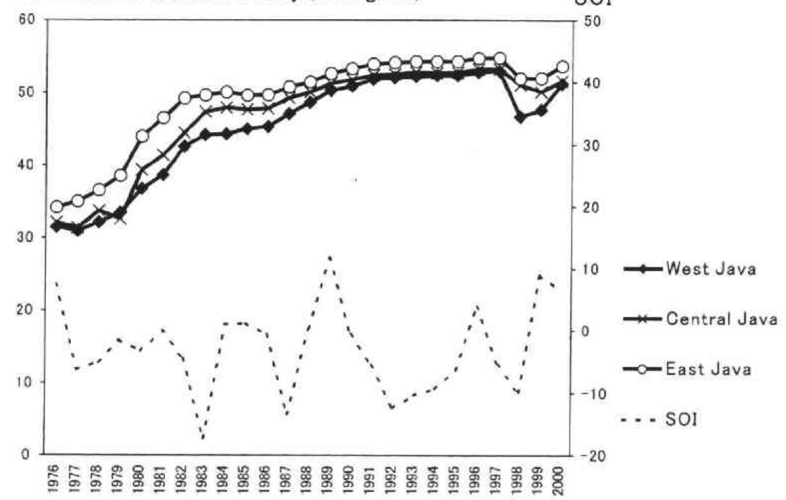

Figure 3. Yield rate of wetland paddy in three provinces of Java and SOI
Source: same as Figure 2.

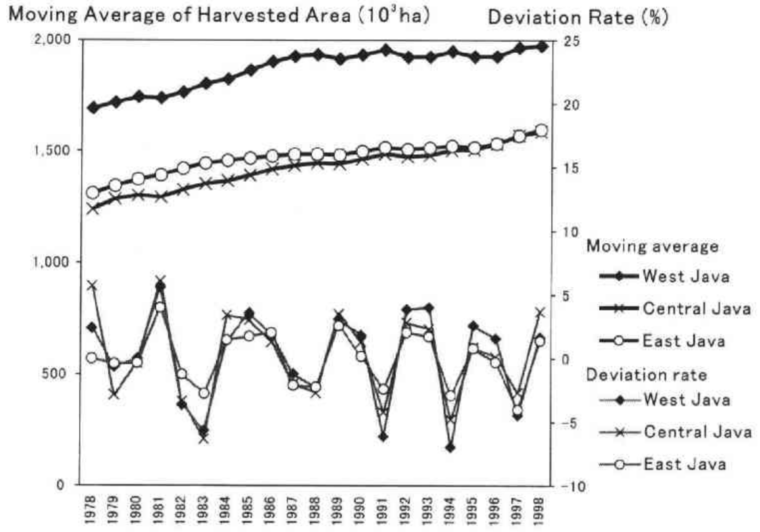

Figure 4. Five-year moving average and deviation rate of harvested area of wetland paddy in three provinces of Java
deviation rate=((value of indicated year−5-year moving average)/5-year moving average)×100
Source: same as Figure 1.

except a drastic fall in 1998 and 1999, including a rapid rise until the early 1980s, but the short-term fluctuation corresponding to SOI cannot be seen. Figure 4 shows the 5-year moving average of the harvested area with the deviation rate (rate of the deviation from the 5-year moving average to the average). The tendency of the rise in the first half and the slowness in the latter half are recognized as seen in the two previous indices. The deviation rate is also greatly changing in the period of several years. Figure 5 suggests that the fluctuation (deviation rate) of the harvested area and SOI work together, which has brought about a change in the amount of production. Then, it is noteworthy that the short-term fluctuation in the harvested area and the amount of production has already existed as early as the 1970s.

Figure 6 is the year-to-year changes of the annual standardized precipitation averaged by province. Though dispersion is recognized among provinces, fluctuation

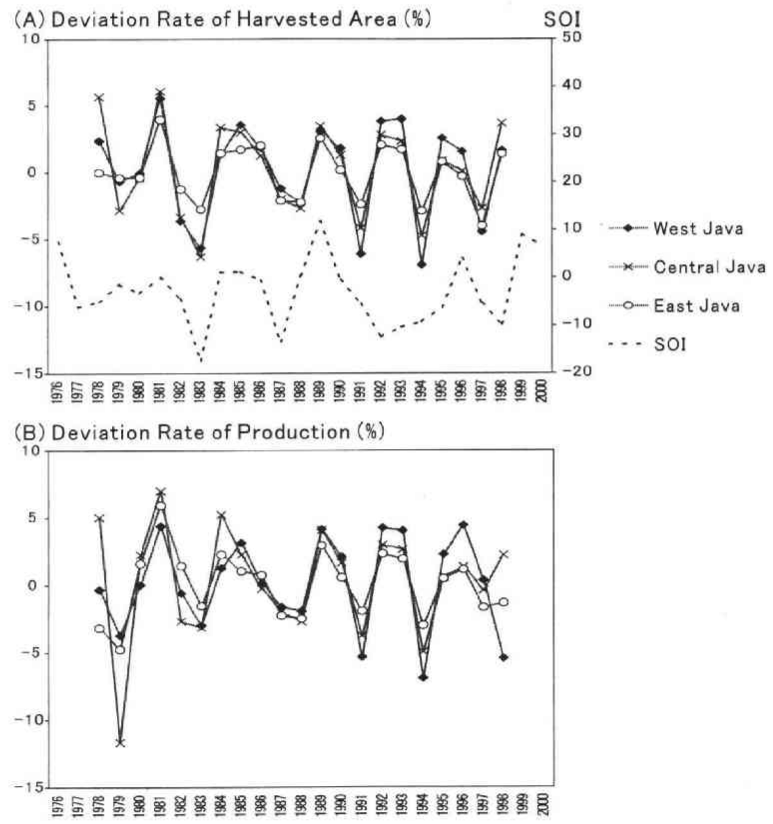

Figure 5. Deviation rate of harvested area and production of wetland paddy in three provinces of Java and SOI
Source : same as Figure 2.

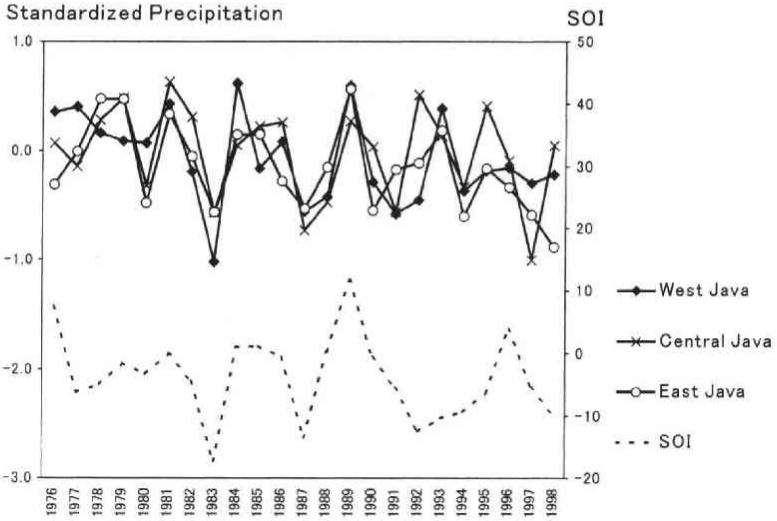

Figure 6. Deviation of precipitation deviation in three provinces of Java and SOI
deviation of precipitation = (indicated value − the mean of the period)/standard deviation of the period.
Source : q.v. the body.

with a period of several years predominates, and a fall in 1980, 1983, 1987, 1991, 1994, and 1997 corresponds to that of the harvested area and the amount of production recognized in Figures 4 and 5. It is clear that a small rainfall was caused by the El Niño in 1983, 87, 91, and 97 in comparison with SOI. Small precipitation, however, did not last during the long El Niño period from 1991 to 1995 except for 1991 and 1994. Though there are many missing observations in this period as mentioned above and only the precipitation data are not so reliable, drought damage seems to be limited to 1991 and 1994 from the wetland paddy data as well.

As a result, the transition of the amount of wetland paddy production comprises (i) long-term change originated from the rapid rise of both of the yield rate and the harvested area in the first half of the period and from the slow increase in the latter half, and (ii) short-term fluctuation caused by the change with a period of several years of the harvested area due to ENSO-precipitation change. Though the short-term fluctuation was offset by the high-rise tendency of the yield rate and the harvested area until the 1980s, it came to be recognized clearly because the rise of the production slowed down since then.

The following chapter will indicate the regional difference of the long-term change and the short-term fluctuation from the district data in Java and Bali.

3. Distribution of wetland paddy production and its change

3.1. Long-term change

Figure 7 shows the distribution of production and a yield rate at the beginning and the end of the period (1976 and 2000) in district units. Both of the production and the yield rate grew drastically in almost the whole area. The yield rate in 2000 exceeds 5 (tons/ha.) in most of the districts, except for some at the western tip of Java. Figure 8 shows the distribution of the long-term change (the change from 1978 to 1988 and the change from 1988 to 1998) of the production, the yield rate, and the harvested area. The long-term change is derived from the rate (percent) of the value at the end of the period to that of the beginning, using the values of 5-year moving average in order to remove the short-term fluctuation.

As for the earlier half (the change from 1978 to 1988), the production change rate from the central part to the eastern part of Java grew greatly, and that of the northern coast and that of the western tip of west Java increased as well. The distribution tendency of the yield rate change considerably corresponds with that of the production, and the increase in the yield rate contributes specially to the growth of the production. Though harvested areas also show a tendency to increase overall, they decrease in the district including Jakarta, Bandung, Surabaya, and so on. The decrease even in production is recognized in Jakarta. On the other hand, because of the high increase rate in both of the yield rate and the harvested area, the production grows extremely in the western tip of Java. The increase in the yield rate proceeded rapidly after 1970s by introducing new high yield varieties (or bred traditional ones) and brown-planthopper (Nilaparvata lugens)-resistant varieties under the government leadership, and by injecting the chemical fertilizer, and the increase in the harvested area advanced by introducing new varieties of short growth period and by developing irrigation systems (Kano, 1988; Research Institute for International Investment and Development of Japan Bank for International Cooperation, 1999).

As for the latter half (change from 1988 to 1998), the production is confined to less than 120% in most districts, and it decreases in the circumference of Jakarta, Bandung, Surabaya, Bali Island, and so on, though it shows a tendency to increase. The harvested areas decreased greatly, and the production is made to decrease in all these districts. Most of the districts with production decrease are those with remarkable urbanization and industrialization. Generally, the growth in the yield rate slowed down overall, and some districts shifted to the decrease. The whole of Java is dotted with districts showing yield rate decrease, and the districts showing yield rate decrease are distributed in a zone within the western part of East Java. Most of these with a yield rate decrease are the districts with a large yield rate.

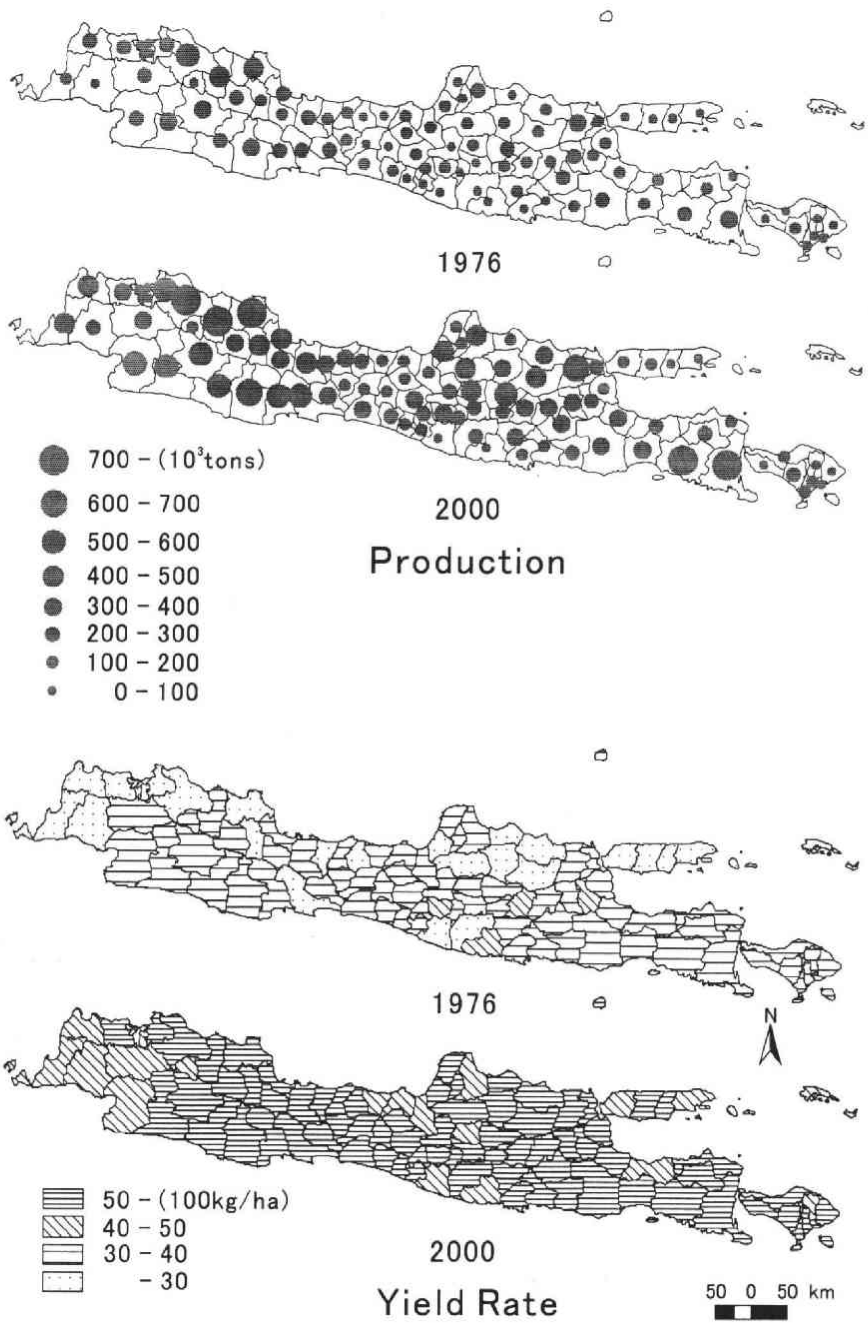

Figure 7. Distribution of production and yield rate of wetland paddy by districts in Java
Source: the same as Figure 1.

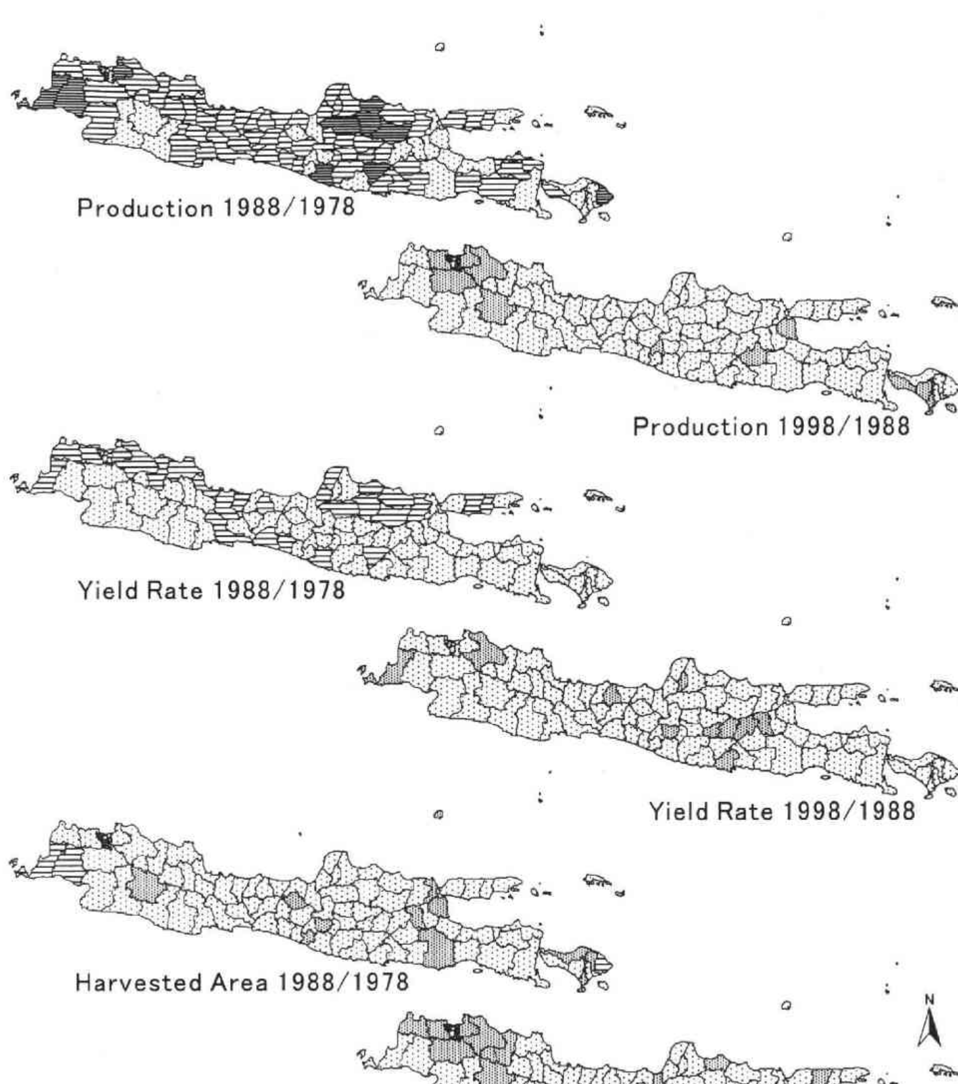

Figure 8. Distribution of changing tendency of production, yield rate and harvested area of wetland paddy by districts in Java
It is shown in the ratio between 5-year moving average of the indicated years.
Source : same as Figure 1.

3.2. Short-term fluctuation

Figure 9(A) shows the areal distribution of the correlation coefficient between the annual precipitation change and the short-term fluctuation (deviation rate from the 5-year moving average) of the amount of wetland paddy production in every distirict. A clear distribution tendency is not recognized in 32 targeted districts in the map. As for the precipitation and the amount of production, negative correlation is shown in about one third of the 32 districts. Most of the districts with negative correlation, such as Situbondo at the end of the northeast Java, and Kediri in the eastern inland areas, are characterized as small precipitation (less than 1,800 mm), a high yield rate (equal to or more than 4.8 ton/ha), and small fluctuation in the production. These districts do not seem to have suffered from drought severely, because of the effect of irrigation facilities.

Figure 10 shows the relationship between this correlation coefficient and the annual precipitation. The correlation is higher in the districts with annual precipitation of about 2,000 mm than in the districts with smaller or larger precipitation. The area that has annual precipitation of around 2,000 mm is said to be sensitive to the fluctuation of precipitation.

Figure 11 shows the distribution maps of the deviation rate of the wetland paddy production in 1994 and 1997, which are recent drought years. Almost whole of Java experienced the decrease in production in 1994, especially the western part suffered severely. Districts Karawang and Subang located on the northern coast of western Java do not decrease, as well as some districts at the end of the northeast and the eastern inland areas mentioned in the above. On the other hand, in 1997, though a larger decrease occurred in the eastern part than in 1994, there were many districts with increase located in the western and central part of Java, especially on the northern coast and western tip of western Java.

The distribution of fluctuation in precipitation and production is different in places, and also different in each El Niño year.

3.3. Factors of short-term fluctuation in harvested area

Though "correlation between production and annual precipitation" was seen in Figure 9(A), there are many districts which show intense positive "correlation between harvested area and annual precipitation" than "correlation between production and annual precipitation", and there are also many districts which show negative "correlation between a yield rate and annual precipitation (Figures 9(B) and (C)). In other words, annual precipitation is considered to correlate positively with production, parameterized by the harvested area.

The process in which precipitation fluctuation influences the harvested area is considered as follows; farmers who are conscious of small rainfall take action by

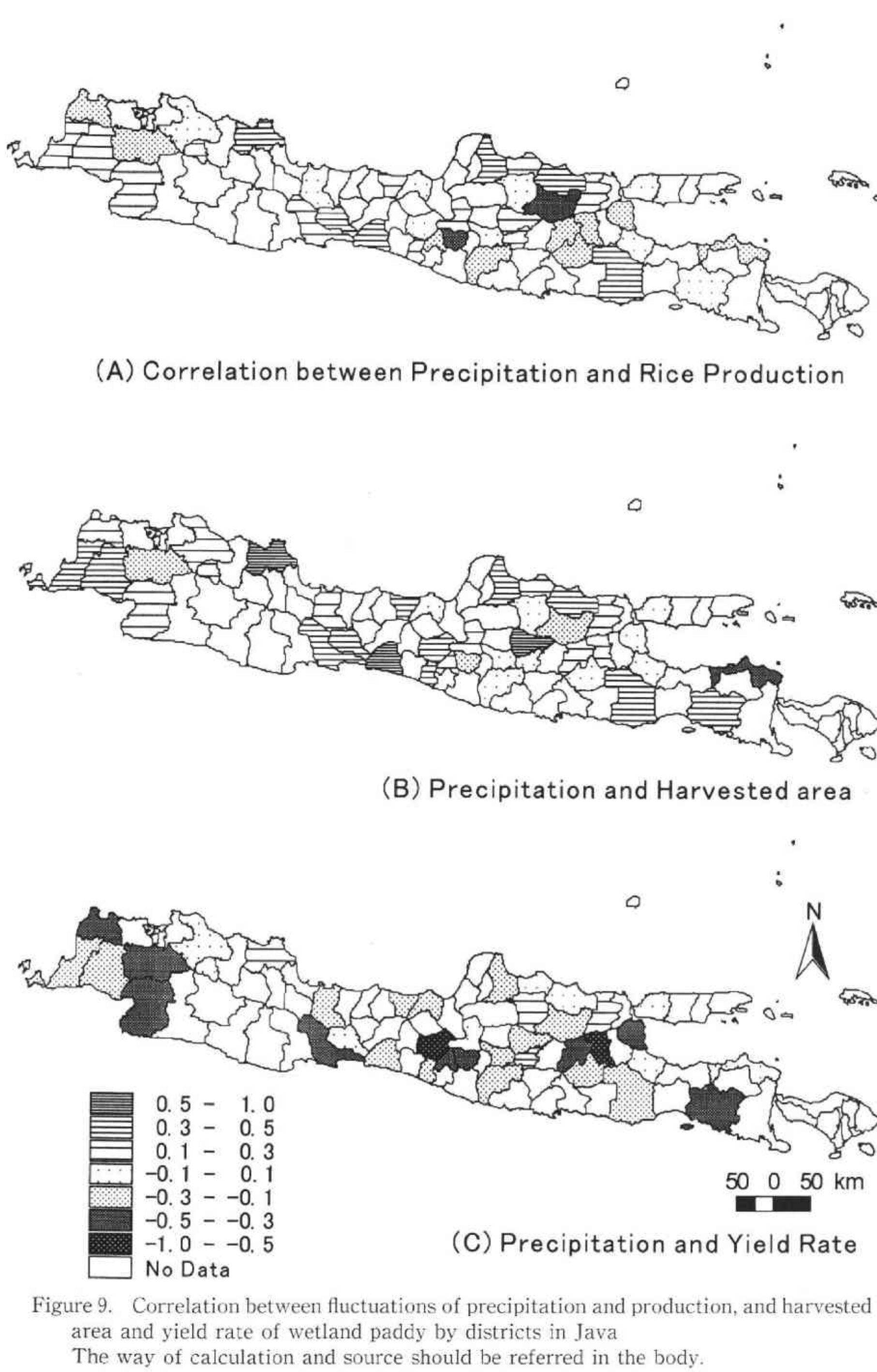

Figure 9. Correlation between fluctuations of precipitation and production, and harvested area and yield rate of wetland paddy by districts in Java
The way of calculation and source should be referred in the body.

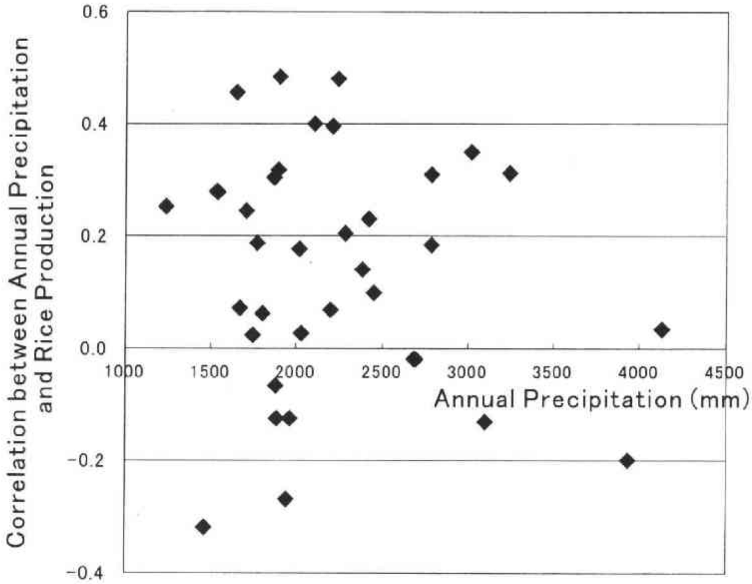

Figure 10. Relation between "the correlation coefficient between production of wetland paddy and annual precipitation" and "annual precipitation" by districts
The former is based on Figure 9.
Source: q.v. the body.

giving up seeding and planting in paddy fields without irrigation facilities or the fields of poor conditions, or by reducing the number of cultivation times. Those farmers are considered to decide seeding and planting only in rice fields in good conditions, conversely. The hypothesis is supported by the fact that there are many districts where precipitation and yield rate show negative correlation. If this hypothesis is correct, it is considered that the precipitation in the beginning or the early stage of the rainy season, instead of annual precipitation, strongly affects the decrease in the harvested area. In the four districts, where the correlation between harvested area and annual precipitation is high and precipitation data are satisfactory, an examination was made of the ratio of the monthly precipitation to the annual precipitation in 1988, 1991, 1994, and 1997, that were recent drought years (Figure 12). As illustrated in the case of Indramayu of West Java, the decrease in harvested area is the severest in 1991, when precipitation until the preceding December is extremely small, while the decrease is slight in 1997 when the precipitation of the same season is large. In the case of Jember of East Java, where precipitation until November of the preceding year is small, the decrease in harvested area is the largest in 1997 in Jember. The difference in the decrease in harvested area is small in Kendal where the difference in the precipitation of that period is not so much. In other words, it is suggested that a

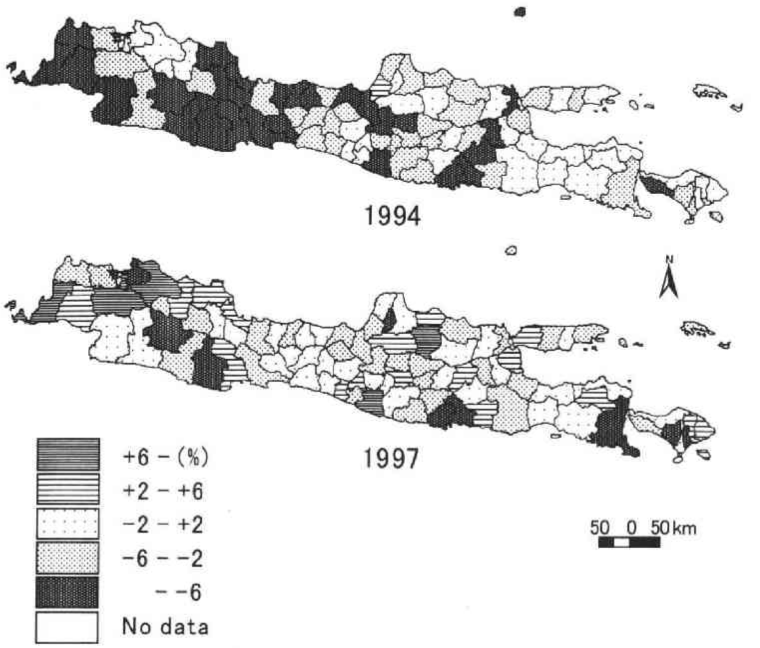

Figure 11. Distribution of deviation rate of production of wetland paddy of drought years by districts in Java
Source : same as Figure 1.

farmers' action to the rice field depends on the rainfall until November or December in the first half of the rainy season. This can be true, because cultivation starts in between December and January in most cases in Java (Yoshino, 1999), though the cultivation calendar in a wetland paddy of Java is complex. The correlation between precipitation fluctuation and harvested area is weak in the districts with improved irrigation systems, and is strong in districts with annual precipitation of around 2,000 mm as mentioned above. This can also suggest the condition of precipitation influencing such a farmers' action to the small rainfall.

4. Regional characters of wetland paddy production in Java and Bali

Regional characters of wetland paddy production in Java and Bali are examined by the principal component analysis using the variables of actual numbers, long-term changes and short-term fluctuations of the amount of the production, the yield rate and the harvested area. Table 1 shows the principal components with a varimax rotation. As a result, the amount of production and the harvested area show the same trend and each component is clearly labeled as follows, those sizes (Component 1), those long-

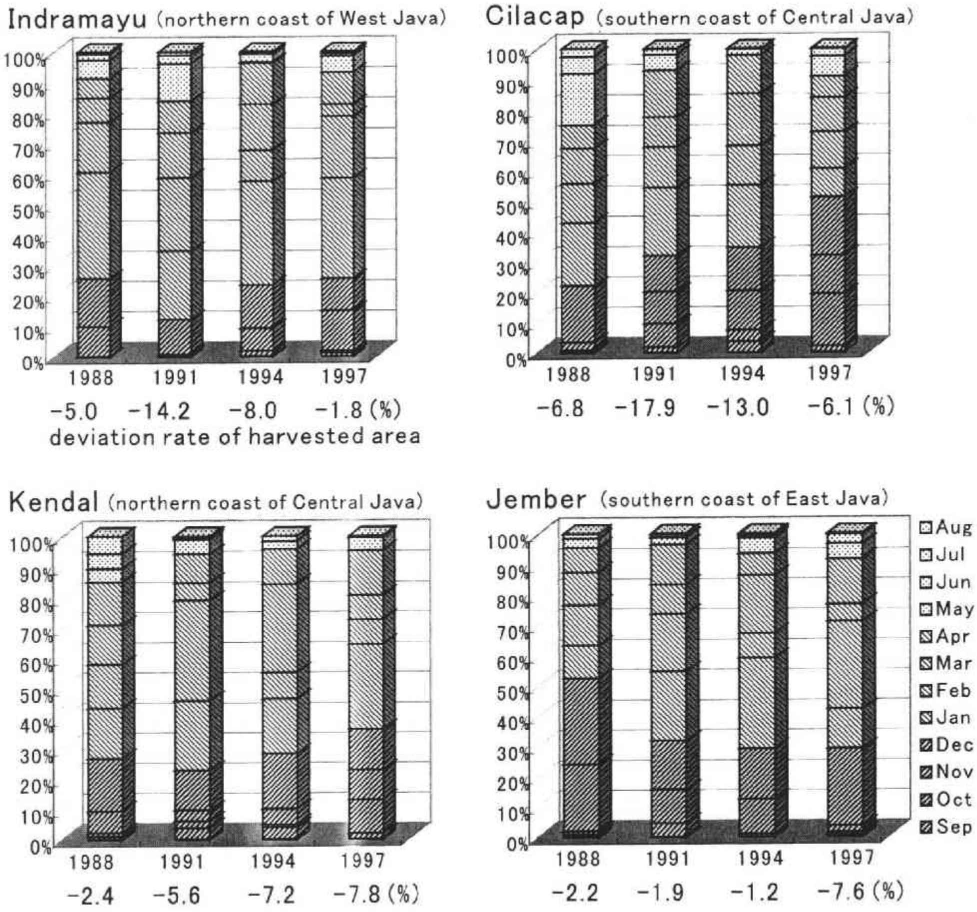

Figure 12. Distribution of precipitation by month in drought years in four districts in Java

Distribution by month is shown in rate to annual precipitation.

Source : q.v. the body.

term changes (Component 2) and those short-term fluctuations (Component 5), the size of the yield rate (Component 3), and the short-term fluctuation of the yield rate (Component 4).

Figure 13 is the score distribution of these five components. Component 1 shows especially high scores (both the production and the harvested area are large) at the western part (especially, the northern coast) and the eastern tip of Java including so-called a granary. The score of Component 2 is high (the rate of increase in production and a harvested area is high) in the central part and the western tip of Java. That of Component 3 is particularly high (the yield rate is large) in the area from the

Table 1. Rotated Component Matrix

		Component 1	Component 2	Component 3	Component 4	Component 5
1978PM	(a) moving average of production 1978	0.95	−0.08	0.15	0.01	−0.19
1988PM	(b) moving average of production 1988	0.96	0.03	0.12	0.15	−0.15
1998PM	(c) moving average of production 1998	0.96	0.13	0.09	0.13	−0.13
PM88/78	change rate 1988/78 (b/a×100)	0.12	0.79	−0.08	0.39	0.13
PM98/88	change rate 1998/88 (c/b×100)	0.03	0.87	−0.15	−0.13	−0.19
STDVDP	fluctuation of production 1*	0.93	0.09	0.06	0.12	0.20
STDVDRP	fluctuation of production 2**	−0.17	−0.09	−0.17	0.32	0.85
1978YM	(d) moving average of yield rate 1978	−0.05	−0.01	0.74	−0.48	−0.32
1988YM	(e) moving average of yield rate 1988	0.12	−0.03	0.97	−0.03	−0.09
1998YM	(f) moving average of yield rate 1998	0.01	−0.03	0.77	−0.21	−0.21
YM88/78	change rate 1988/78 (e/d×100)	0.15	−0.08	−0.19	0.65	0.39
YM98/88	change rate 1998/88 (f/e×100)	−0.21	0.05	−0.77	−0.21	−0.12
STDVDY	fluctuation of yield rate 1*	0.22	0.07	0.12	0.88	0.03
STDVDRY	fluctuation of yield rate 2**	0.08	0.11	−0.17	0.91	0.09
1978AM	(g) moving average of harvested area 1978	0.97	−0.05	0.05	0.09	−0.15
1988AM	(h) moving average of harvested area 1988	0.97	0.05	0.03	0.13	−0.14
1998AM	(i) moving average of harvested area 1998	0.96	0.14	0.02	0.13	−0.12
AM88/78	change rate 1988/78 (h/g×100)	0.04	0.88	−0.01	0.09	−0.03
AM98/88	change rate 1998/88 (i/h×100)	0.08	0.89	0.10	−0.07	−0.15
STDVDA	fluctuation of harvested area 1*	0.85	0.13	−0.04	−0.08	0.37
STDVDRA	fluctuation of harvested area 2**	−0.18	−0.19	−0.12	0.07	0.92

principal component analysis with a varimax rotation
moving average: 5-year moving average
*: standard deviation of deviation from the moving average
**: standard deviation of deviation rate from the moving average

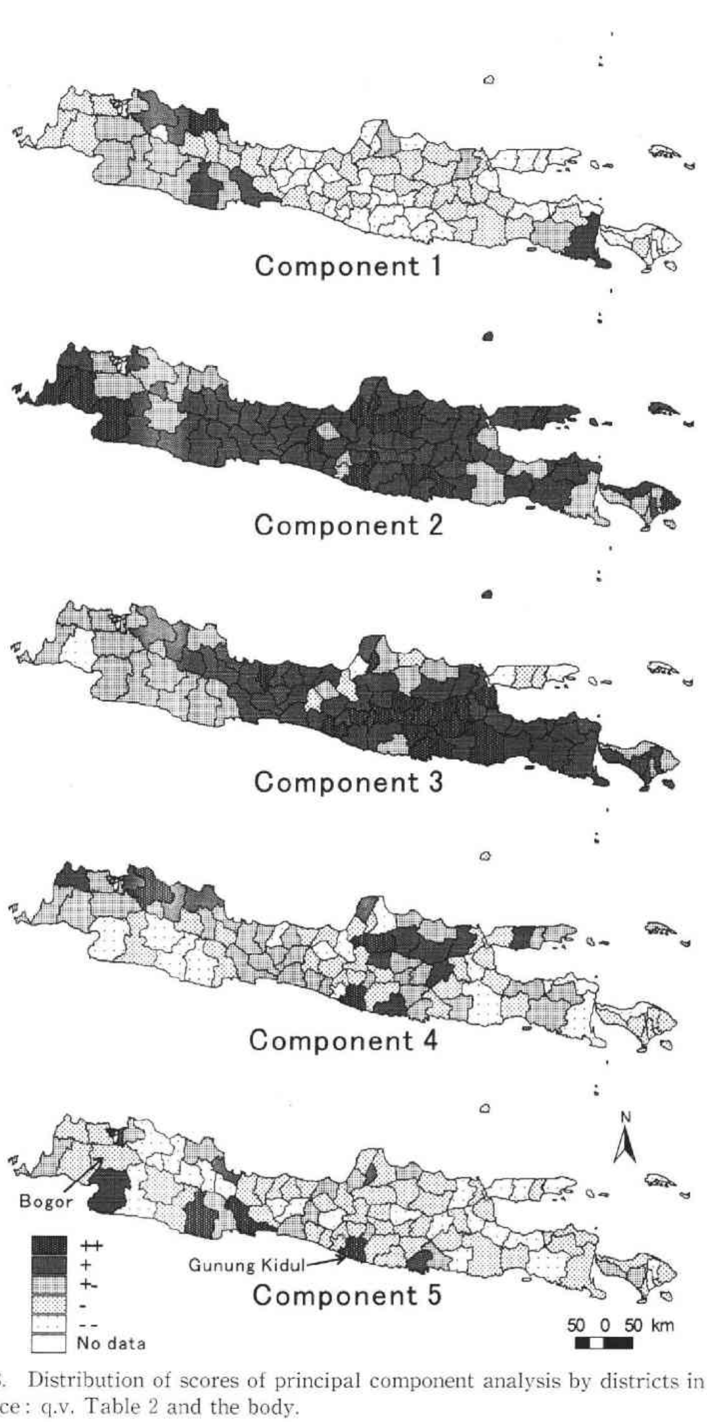

Figure 13. Distribution of scores of principal component analysis by districts in Java.
Source: q.v. Table 2 and the body.

southern coast of Central Java to the East Java. That of component 4 is high (the short-term fluctuation of a yield rate is large) in the area surrounding that with high score of Component 3, northern coast of West Java and Madula. That of Component 5 is high (the short-term fluctuation of production and a harvested area is large) in Jakarta and at several places in Java.

Kano (1988) examined the regional structure of wetland paddy production based on the data of the wetland paddy and the population by district in 1920 and 1977, and extracted four main rice-producing areas. He explained that both the northern coastal area of west Java and east end part of Java are relatively new rice bowl in history. Our result supports it as that the score of Component 1 is high in the two areas. It is different from Kano (1988), however, the fluctuation in the yield rate is large in the northern West Java while it is small in the east end of Java (Component 4). Moreover, areas from the southern coast of Central Java to the Solo River basin and the Brantas River basin, which are old rice bowls in history (especially, the former), have an extremely high yield rate as shown in Component 3 scores at present also. The main rice-producing areas pointed out by Kano are thus considered to fit generally at present.

However, the rise rate of the yield rate (1988-1998) is clearly low in districts with high yield rate (Component 3 in Table 1), and the rate of growth in production is also relatively low in the northern coast of West Java and east end of Java (Component 3 in Figure 12). The facts demonstrate that the growth in yield rate almost reaches the upper limit, and the influence of urbanization is obvious particularly in the northern coast of West Java. It seems to be difficult for the rice bowls to keep holding the position in the future.

5. Response of wetland paddy cultivation farmers to drought
— A case of a village on the volcanic foot, Sukajadi Village, West Java —

This chapter examines how rice cultivation farmers are coping with drought, based on the result of the field investigation in a village in West Java.

5.1. Research area and method

The field investigation was carried out in Sukajadi Village (Desa Sukajadi) which belongs to Taman Sari County, Bogor District, Province of West Java (Kecamatan Taman Sari, Kabupaten Bogor, Propinsi Jawa Barat), located about 10 km to the southwest of Bogor City (Figure 14) and about 60 km to the south of Jakarta[3)], and has a population of 6,427 (in 2000). The village extends on the terrain, about 450 m-650 m above the sea level, consisting of a lahar plateau surface which leaned to the north as much as 10/1,000 and shallow valleys dissecting it at the north foot of Volcano Salak

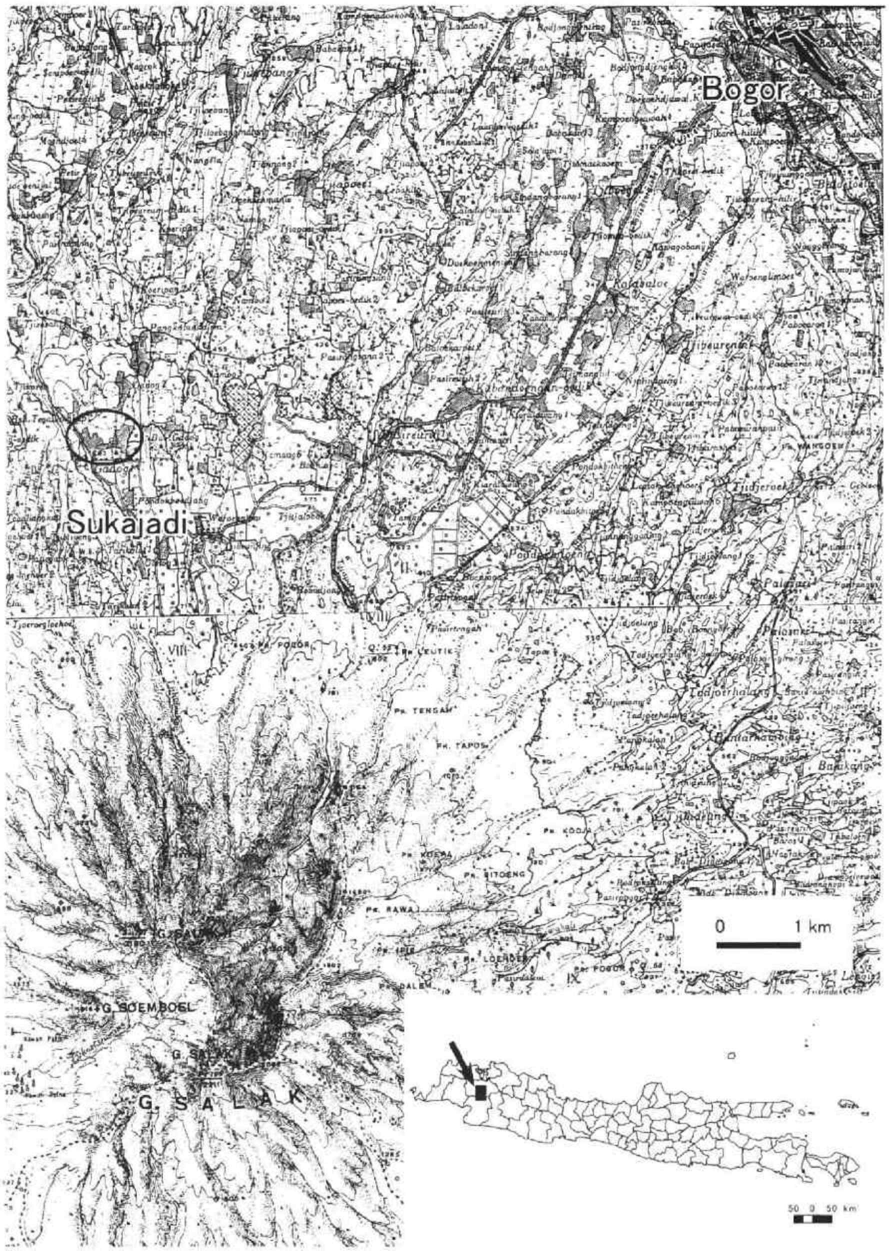

Figure 14. Index map of Sukajadi

An oval in the figure shows the investigated area.

Base map is a Gaihozu (topographical map of overseas) duplicated by former Survey Division of Japan Army from a topographical map produced by Dutch colonial government of East India in 1924.

(Gunung Salak, 2,211 m a.s.l.) (Tamura and Kitamura, 2001). Pekarangan, which is a type of home garden originated in Java and is paid attention in recent years as a prototype of agroforestry enabling intensive and sustainable land use in a humid tropical area, is popularly found in this village. Houses are hidden bellow in the woods of pekarangan, and rice fields and dry fields are spread out around the settlement. The rice fields are distributed in valleys and the irrigated areas on plateau surfaces in the north of the village, and the dry fields spread out on the plateau in the south of the village. The dry fields were tea plantation in a colonial period[4]. Most of the streams seen in the village are irrigation waterways. The irrigation system of the investigation area (to be mentioned later) is a non-technical system that is managed by farmers themselves.

Investigation was made by hearing with questionnaires about the contents such as the family composition, the income, the land use and the response to drought, for 85 households, almost equal to all the households in the areas (RT3 and RT4 in RW4) located in the center of the village[5]. The investigation period ranges from September to October in 2001. The area is near the upper limit (southern limit) of the rice field on the plateau at the foot of Mt. Salak, and the number of households managing a rice field is 19, or less than 1/4 of the total households in the investigation area. Sixteen households out of 19 are examined, about which a result of investigation has been acquired.

According to the statistics of wetland paddy of Bogor District since the late 1980s, the yield rate has a gentle peak around 1995, the harvested area is decreasing slowly through the period, and the production has a gentle peak around 1990 and then decreases as a result. Ciomas County (Kecamatan Ciomas) that formerly included the investigation area shows a similar tendency, too. It can be thought that agricultural land itself decreases due to the urbanization in the district as a whole and in the county. The decrease in agricultural land due to urbanization such as development of housing estates, however, does not extend to the village or the investigation area.

The short-term fluctuation of production of a wetland paddy in Bogor District is not so large (Component 5 in Figure 13). This may relate to the fact that the dry season is weak and short in western Java. Bogor City has an annual precipitation of about 4,000 mm due to much orographic rainfall, and has several tens mm even in the smallest rainfall month in non-El Niño year. Because Sukajadi Village is situated at the volcanic foot and also has much rainfall, streams in the dissection valleys never dry up. It is presumed that the area does not tend to suffer severely from drought. According to the analysis above on the data by district, precipitation is sufficient for 1997, and there is more production of a wetland paddy than usual in Bogor District, though the decrease was recognized in 1998 at the time of the Indonesian bad harvest for 1997-1998 (Figure 11).

Table 2. Response of wetland paddy cultivation farmers

No.	family composition (age and size)			occupations (income resources)	area of fields operated by the household (m^2)		other field
	head	wife	size		paddy field	dry field	
1	30	23	5	crop farming + rent for land	4,000	0	paddy field (4,200 m^2) for rent, kebun
2	40	35	4	crop farming	*3,900	3,500	
3	65	60	2	crop farming + rent for water buffalo	3,100	0	
4	50	40	10	crop farming + vegetable broker	3,000	0	kebun
5	31	26	4	crop farming + farm wage + rent for water buffalo + rent for land	500	500	paddy field (1,750 m^2) for rent
6	70	65	4	crop + farming + rent for land ?	1,000	0	paddy field (700 m^2) for rent to their son, kebun
7	48	45	4	driver + crop farming	1,500	0	
8	42	35	4	vegetable broker + crop farming + shopkeeper	1,500	0	
9	60	50	5	farm wage + crop farming	1,200	200	kebun
10	35	26	3	vegetable broker + farm croping	1,000	500	
11	55	45	5	crop farming + vegetable broker + shop keeper	1,000	0	
12	55	45	4	crop farming	600	1,500	
13	60	50	2	crop farming	500	0	
14	60	55	2	crop farming	500	0	kebun
15	45	35	6	farm wage + crop farming	500	500	
16	53	50	4	farm wage + crop farming	240	1,000	kebun

Source : field investigation by Nao Endo

* : including leased land (3,000 m^2)

Shaded households indicate those who have never given up seeding wetland paddy due to small to unusual small rainfall in Sukajadi Village, West Java

crops for one year (Aug. 2000-Jul. 2001)	variety of rice	at paddy fields, in case of little rain, the household experienced		alternative crops in case of little rain		
(cropping times of rice)		giving up seeding	non-harvest	maize	common bean	yard-long bean
rice(1)+cucumber, common bean, others : rice(2)+common bean, yard-long bean	Malos				✓	✓
rice(1)+maize : rice(2)+bitter cucumber	IR89			✓	✓	
rice(2)+sweet potato, maize	Cimandili	✓		✓		✓
rice(1)+maize, yard-long bean, common bean	Malos			✓	✓	
rice(1)+maize, yard-long bean	Malos		✓	✓		✓
rice(1)+sawah lettuce rice(3)	Malos					
rice(2)	Malos	✓		✓		
rice(1)+vegetables	IR64	✓		✓	✓	✓
rice(3)	?	✓	✓	✓		
rice(1)+yard-long bean, common bean, bittter cucumber	IR89	✓				✓
rice(2)+maiza	IR64	✓		✓		
rice(1)+tomato, maize	Cimandili	✓				
rice(1)+common bean, maize	IR64	✓		✓	✓	
rice(3)	IR64	✓		✓		
rice(2)+maize	Malos					
rice(2)+common bean	Brondol	✓		✓	✓	

rainfall.

5.2. Result of investigation and consideration

Table 2 shows the result of investigation. The managed area of rice fields is generally small. The hearing revealed that most of the harvested rice is for the consumption of families including relatives, and that for selling is a little. Rice is grown 1 to 3 times a year around the rainy season in a rice field. In case that rice is grown 1 or 2 times a year, cash crops such as vegetables are made as a secondary crop on the same field.

The households in Table 2 are arranged by the possessed or managed area (total managed area including leased land and rent for others) of a rice field. The terms "upper" and "lower" are used in the following as relative positions arranged by area of rice field as above in the village. Some upper farmers obtain income from the rent of farms or water buffalos, the second upper farmers obtain larger off-farm income than farms, and some lower farmers obtain the income from agrarian labor instead of farming. Namely, the income composition clearly depends on the area of a rice field. Though the uppers in the area have various sources of income except rice farming, the lowests do not obtain enough rice for captive consumption and must obtain income and food from agrarian labor, a dry field, kebun campuran[6], and so on.

Ten farm households out of sixteen answered to have "the experience where wetland paddy cultivation was given up because of small rainfall", while only two households have "the experience where wetland paddy harvest came to nothing because of small rainfall". Then, there are many cases that maize and other crops are grown instead of the wetland paddy in the occasion of small rainfall. As it was suggested with a statistical analysis above, it was quite different from the case of northeastern Japan where a yield rate went down in cold weather damage, and it was confirmed that the farmers in Java cope with drought by changing from a wetland paddy to other crop cultivation.

It is clear here that there are many upper households with no "experience where wetland paddy cultivation was given up because of small rainfall". Moreover, many farmers with no such experience choose Malos as a cultivation variety, and most of them are also the upper households. The variety Malos is evaluated by the farmers as less disease resistant, requiring much fertilizer, but has a short growing period and is delicious, compared with other varieties. They think that the variety Malos is poor at lack of rain. Moreover, upper farmers tend to cultivate rice for smaller number of times. In other words, the uppers may grow (delicious) rice only in the rainy season when the rice can be made securely because they have enough fields to obtain rice. They are influenced little by drought. It is also said that cash crop cultivation is taken seriously than rice. On the other hand, because the lowers tend to grow rice 2 or 3 times a year in a small field for securing more rice for captive consumption, they need to give up growing rice in case of drought. In addition to maize that the farmers generally grow as an alternative crop, the uppers grow cash crops such as a common bean and a yard-long bean also.

Though this area does not tend to be severely affected by drought because of its inherent conditions of climate and topography, there are farmers who have experience of giving up wetland paddy cultivation due to small rain and growing substitute crops at that time. However, the upper farmers do not have such an experience. Though the number of samples is limited, it is indicated that the influence of small rainfall to farmers in the area is differential by the classes. Yoshino et al. (2000) and Urushibara-Yoshino and Yoshino (2000) reported that working away from home increases rapidly, mortality rises, and population decreases in drought years of El Niño in a central Java karst area. The influence of unusual small rainfall in the investigated area is very much limited compared with the case of central Java. Figure 13 shows that wetland paddy production is very unstable though the production grew greatly in Gunung Kidul District (Kabupaten Gunung Kidul) of central Java, where Yoshino et al. (2000) made their investigation. Bogor District and Gunung Kidul District have very different characteristics about the wetland paddy production, and both may be placed on the counter situation as for the farmers' response to drought.

There are many farmers without managing any rice fields in Sukajadi Village, and those households purchase rice. Though there was no decrease in the amount of harvest in 1997 in this area, the retail price of rice jumped up to three times larger than the previous years at highest, together with currency Rupiah fall caused by the Indonesian economic failure, at the time of the bad harvest in 1997-1998 (Research Institute for International Investment and Development of Japan Bank for International Cooperation, 1999). There may be some upper farmers selling rice, and the influence of the rice price is presumed not to be simple even inside the village.

6. Concluding remarks

The wetland paddy production and its change in Java and Bali are examined based on the statistics from 1976 to 2000. First, the short-term fluctuation and the long-term change are separated from the yearly data of rice production. As for the long-term change, the yield rates increased in about first ten years of the period by increase in injection of the chemical fertilizers and introduction of new varieties, the harvested areas also increased by the development of irrigation systems and so on, and the production grew remarkably. However, the growth of those indices slowed down in the latter half of the period, and short-term fluctuation responding with ENSO cycle came to be recognized clearly. Though the influence of small precipitation caused by the El Niño hardly appears in the yield rate, the fall of the harvested area is remarkable, which causes a decrease in production. Moreover, the influence is obvious in the area with an annual precipitation of around 2,000 mm and clear in the year with small rainfall in the early rainy season, especially until November or December.

The areas affected most severely by the fluctuation of precipitation are neither the areas with small precipitation with irrigation facilities, nor the area of a large precipitation of over 3,000 mm. It is suggested that the influence of drought is represented by giving up growing rice at the field of bad condition or by reducing the time of cropping.

According to the field survey on a farm village in West Java, the above hypothesis is confirmed where farmers cope with unusual small rainfall by planting other crops instead of rice. The influence of drought to the farmers with a large rice field is small, in other words, the class difference is recognized in the sensitivity against fluctuation in natural environment.

We further need to collect data on precipitation and irrigation, analyze the relation between wetland paddy production and precipitation with irrigation at the district statistics level, and make another field investigation in a farm village in the various areas.

It is clear that the production fell due to the rapid decrease in the yield rate in 1998. It is the first time in the recent history of rice production in Indonesia under the possible influence of change in natural and social environment. This could be recognized as another phase of rice production in Indonesia, which needs more time to be correctly evaluated.

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Notes

1) Several change of the report-name is recognized as follows;
Produksi Tanaman Bahan Makanan di Indonesia, 1976-1983
Produksi Tanaman Bahan Makanan di Jawa & Madura, 1976-1980
Produksi Tanaman Bahan Makanan di Jawa, 1981-1983
Produksi Tanaman Padi dan Palawija di Jawa, 1984-1993

Produksi Tanaman Padi dan Palawija di Indonesia, 1984-1993
Produksi Tanaman Padi di Indonesia, 1994-1997
Produksi Tanaman Padi dan Palawija di Indonesia, 1998-1999
The reports for 1998-2000 editions do not include the data on the district (kabupaten) unit. The computer output of BPS is obtained.

2) SOI = 10 × [Pdiff − Pdiffav] / SD(Pdiff)
where
Pdiff = (average Tahiti MSLP for the month) − (average Darwin MSLP for the month),
Pdiffav = long term average of Pdiff for the month in question, and
SD(Pdiff) = long term standard deviation of Pdiff for the month in question.
By Australian Meteorological Agency.

3) The new county that includes Sukajadi was separated from Kecamatan Ciomas in 2001.

4) Though it is still presently possessed by the absentee landlords residing in such as Jakarta, local people use it as a field by free rent. Such a land system is named Tumpansari in the area (Endo, 2002).

5) Hearing investigation was carried out by Nao Endo. RW and RT are considered to be equivalent to Chonaikai and Tonarigumi in Japan, respectively.

6) A kind of agroforestry owned privately and located inside the village away a little from the house of an owner or located outside the village, predominated by perennial crops (Endo, 2002)

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