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Analysis of climate scenarios and their impacts upon rice production in main rice production areas of Java, Indonesia

Análisis de escenarios de Cambio Climático y sus impactos en el cultivo de arroz en la región arrocera de Java Indonesia.

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Resumen

La disponibilidad de arroz en Indonesia, como alimento de primera necesidad es un gran problema. La gran dependencia por este alimento ha hecho que el gobierno estimule la producción nacional de arroz. La condición climática actual se ha convertido, en países como Indonesia, en un obstáculo para la producción de arroz, por estar fuertemente influenciada por las variaciones de precipitaciones anuales e inter-anuales. El exceso de precipitaciones durante la temporada de lluvias incrementa el riesgo de inundación y el aumento en la temperatura creará sequías durante la estación seca. Más del 60% de toda la población de Indonesia se concentra en la isla de Java. Como las principales zonas productoras de arroz se concentran en esta isla la sobrepoblación llega a ser un problema. Por lo tanto, el papel del gobierno es importante para hacer frente a los impactos del cambio climático, no sólo a la producción de arroz, sino también en términos de precio del arroz. El gobierno está aplicando políticas de "precio mínimo" para los agricultores y de "precio tope" para los consumidores a través de BULOG a lo largo de los años. Además, el Gobierno hizo un plan para dar subsidios directos a los agricultores a pequeña escala a partir de 2011, cuyo objetivo es estimular a los agricultores para incrementar la producción de arroz y, supuestamente, aumentar el bienestar de los agricultores. Los escenarios más factibles SRES (A2historial y B2 historial) en este estudio parecen tener poca diferencia. Con gestión integrada de la agricultura y el programa de intensificación en ambos escenarios, la producción de arroz aumentará probablemente hasta 2030. Sin embargo, debido a la falta de disponibilidad de campos de arroz, especialmente en la isla de Java, donde el crecimiento de la población sigue aumentando, y existe poco conocimiento del pronóstico meteorológico por parte de los agricultores, Indonesia podriá sufrir una gran pérdida de la producción de arroz y el riesgo de la seguridad alimentaria porque el arroz es todavía un alimento de primera necesidad.

Palabras clave: Arroz, isla de Java, Escenarios climáticos, Producción de arroz, Políticas gubernamentales

Abstract

As main staple food, the availability of rice is always a great issue in Indonesia. The large dependence on rice has made the Government boost rice production in the country. Meanwhile, the current climate condition has become a constraint for rice production, as Indonesia is strongly influenced by annual and inters annual variations in precipitation. Excessive rainfall during wet season will likely create flood risk and increase temperature will also create drought during dry season. More than 60% of the whole population of Indonesia concentrates on Java Island. The resulting over-population is likely become a problem, as the main rice production areas concentrate on this island. Therefore, the role of Government is important in order to cope with the impacts of climate change, not merely to rice production but also in terms of rice price. Policy implementation of "floor price" for farmers and "ceiling price" for consumers are being done by the Government through BULOG over the years. In addition, the Government has made a plan to give direct subsidy to small scale farmers starting 2011, which aimed to stimulate farmers to increase rice production and supposedly increase the welfare of farmers as well. The most feasible SRES scenarios (storyline A2 and B2) in this study seem to have slightly difference. With integrated agricultural management and intensification program in both scenarios, rice production will likely increase until 2030. However, due to lack of rice field availability, especially in Java Island where the population growth is still increasing, and low dissemination of climate forecast information to the farmers, Indonesia will suffer a great loss of rice production and risk of food security as rice is still as main staple food.

Keywords: Rice, Java Island, Climate Scenarios, Rice Production, Government Policies

INTRODUCTION

In Indonesia, the need of rice is becoming a great issue, as rice is not just as staple food but also as an agriculture product. However, the current climate condition has become a constraint for rice production and limits the capacity of farmers to grow rice. The changes in atmospheric condition due to anthropogenic activities accelerate the fragile balance between demographic condition and food production. Meanwhile, the agriculture production in Indonesia is influenced strongly by annual and inters annual variations in precipitation which caused by the Austral-Asia monsoon and El Niño-Southern Oscillation (ENSO) dynamics, with significant consequences for agricultural output, rural incomes, and staple food prices (Naylor et al., 2007).

Inter-Panel Climate Change (IPCC) has introduced four climate scenarios to four different greenhouse emission pathways as defined in the preliminary Special Report on Emission Scenarios (SRES), which are called B1, B2, A1, and A2. The impact of climate changes supposedly affect the social-economy of the agriculture sector which leads to changes of rice price and this issue will likely affects the food security issue in the national level.

The Indonesian Government's policies which combined price intervention and economic incentives through subsidized input, substantial investment in irrigation, and rice marketing activities in outer islands is to encourage agricultural production, especially for the staple crops (WTO, 2003). Therefore, the role of Government is necessary to maintain rice crop production as staple food and to assure food security for the people of Indonesian. The objectives of the study are to evaluate the climate scenarios in main rice production areas of Java, Indonesia, and to analyze the changes of rice price as an economic impact on national level.

Importance of Rice in Indonesia

According to FAO (2004), Indonesia is considered as one of the world's leading rice producers, with paddy production in 2003 of more than 50 million tonnes and more than 11.5 million hectares cultivated areas. However, Indonesia is also a big consumer of rice, averaging more than 200 kg per person every year.

The high yielding of rice varieties and improvement in traditional techniques has been introduced to increase rice production. Indonesia even attained rice self sufficiency in 1984 when 25.9 x 106 tons of rice is being produced and had exported 11,000 tons of rice (Amien et al., 1999), but due to the increase of population that led to a decrease in the availability of land for agriculture, especially for Java as the most populated island in the country, Indonesia had started to import rice.

Indonesia has almost imported rice since 1945. During the time of former President Soekarno (1945-1965), excess demand of rice was always become an issue despite the Government's effort to increase rice production. Then, during the time of former President Soeharto (1966-1998), Indonesia was one of the biggest rice-importing countries in the world, although in 1984, Indonesia was achieving rice-selfsufficiency (Masyhuri et al., 2002).

Considering the high need of rice crop, the Government of Indonesia has tried to launch many programs to increase rice production, in terms of fulfilling rice crop demand in order not to dependent on imported rice.

Rice Farming System in Indonesia

Generally, there are two major systems of rice farming in Indonesia, e.g. lowland and upland farming systems. In lowland system, rice is commonly as a single crop which provides the staple food for most of the population of Indonesia. This farming is not only as a source of food, but it is also as wealth and opportunities for the people who live in rural areas. The high use of fertilizers and improved crop protection practices has contributed to the high yields of rice. However, the low price of rice during the harvest season has caused this rice farming is less attractive in the recent years, and this leads to a decrease of farmer's income and considerable amounts of imported rice is being done.

Meanwhile, upland farming system is dominated by highly weathered acid soils, due to practice under rain fed conditions in outer islands. Upland areas are abundant in the country and have a high potential for agriculture development. Below is the comparison between lowland and upland areas generally in Indonesia.

Problems with Natural Hazards in Indonesia

Monsoon plays an important role in precipitation distribution and seasonality of rainfall in Indonesia. The peak of wet season is typically occurs in December-January, when the north-west monsoon sweep across Java-Bali towards Australia, and the largest absolute variation in rainfall occurs at the end of the dry season during monsoon onset which is on September until November (Hendon H.H, 2003 in Oh-e, 2007).

According to Irianto and Suciantini (2006), there were nine dry years from 1982 until 2007 i.e. 1982, 1987, 1991, 1994, 1997, 2002, 2003, 2004, 2006. The rice fields along north-coast road in Java Island are the most vulnerable areas.

Therefore, climate anomaly can give an existent impact to rice production and productivity. For example, in 1994 and 1997, the climate anomaly has caused a sere problem on irrigation of rice field in West Java which decreases the rice production.

Rice Policy's Issues in Indonesia

In the decade from 1975 to 1985, the Government promoted rice through combination of output price support and input subsidies, and production increased by about seven percent annually on average. In the second half of 1990s, unexpected shortages made large imports necessary to keep price below ceiling level. During the 1998-1999 large imports reflected decrease production as a part of the drought of El-Niño (Thomas et al, 2004).

Still according to Thomas et al (2004), during the financial crisis, the Soeharto's Government stabilized domestic prices of rice by a combination of a price band (guaranteed floor price for producers and a ceiling price for consumers) and a monopoly on international trade by state-owned Food Logistic Agency (BULOG). BULOG would purchase domestic rice to prevent the price from falling below the ceiling price, and release stocks or import rice to keep the price below the ceiling. In addition, the Government promoted production through the development of new rice varieties, which required investment in irrigation and subsidized fertilizers.

Table 1. Comparison between lowland and upland of rice farming system in Indonesia (Sri Adiningsih et al., 1992, Swastika D.K.S et al., 2007, FAO, 2005)

Parameter	Lowland	Upland
Water use	Mostly are irrigated	Predominantly based on rain fed
Labour	Hired labour and families (subsistence farming); lands are mostly owned by landlords	Subsistence farming
Input	High rates of fertilizer use and modern input (machineries, etc), however land is limited	Low use of fertilizer and modern input
Harvest time	Two times per year, however a very good irrigation system permits a third harvest	One or two times per year
Production	45.2 million tonnes (2002)	2.6 million tonnes (2002)
Average wide area	4 million hectares	2 million hectares
Soil	Sedimentation due to washed materials from upland, however integrated crop management practices are being emphasized	High weathered soils that deplete soil nutrients
Household	19 million households (1993)	10 million households (1993)
Market access	Developed access to the market	Limited due to lack of Government service
Perspective in growing rice	Rice as commercial commodity	Rice will be sell merely if there is a surplus over consumption
Yield	15.9 tonnes/hectares (West, Central and East Java, 2004)	9.2 tonnes/hectares (West, Central and East Java, 2004)

METHODOLOGY

Based on the availability data, there are three provinces in Java Island that become main rice production areas, they are West, Central and East Java, and in each province happens to have three main districts that have the highest rice production and main harvested area among other districts in the provinces. The location of each district is shown in Figure 1.

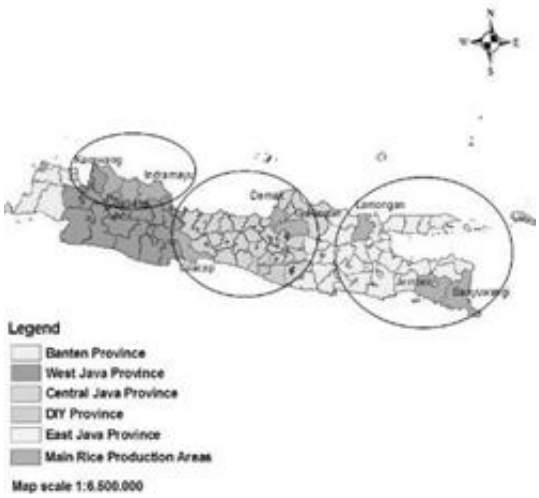


Figure 1. Main Rice Production Areas in Java Island (Drawn from Ministry of Forestry, 2003)

The figure 1shows that the study areas. There are three districts in each province, that are Karawang, Indramayu, and Subang in West Java Province, Cilacap, Demak, and Grobogan in Central Java, and Lamongan, Jember, and Banyuwangi in East Java Province. Below are the general geographic and socio economic condition in each district as the study area.

Impacts to Rice Production and Rice Price

The impact that will be discussed in this study is how the rice production in main rice production areas has been affected by the changes of climate variability e.g., monthly temperature and rainfall from 2003 to 2006. It is also important to note the changes of rainfall pattern during the dry season (Apr-Sept or May-Oct) and wet season (Oct-Mar or Nov-Apr), and how the delay of onset will affect the rice production. The impacts are being related with the two scenarios, i.e. scenario A2 and B2 like it is shown in Figure 1. The change in the price of rice is also being noted, how it is fluctuate during the years and whether it is related with the current situation which will likely affect the national rice supply as well. In addition, the government policies will likely play an important role as well, in terms of giving the subsidy and rice price protection to the local farmers.

Obtained Data

In this study, the climate data that are obtained are merely daily temperature and rainfall from Subang (West Java Province), Cilacap (Central Java Province), and Banyuwangi (East Java Province) from Climate, which are being converted into monthly data. Furthermore, administrative and land use map from Ministry of Forestry with scale 1:100,000 year 2003 are being used as well. In order to obtain wide rice field area in the respective districts, ArcGIS 9.3 is being used to overlay administrative and land use map.

Nevertheless, literature study plays an important role in order to add more information that is necessary. It is also necessary to analyze what are the impacts of the changes in rice prices to the government's policy. What are the current and future government's policies to cope with these changes. Below (Figure 2) is the flowchart of the methodology.

RESULTS AND DISCUSSION

Production

Due to the lack of data, the results that have been obtained are merely from 2003 to 2006. Meanwhile, average monthly rainfall and temperature are merely from one district in each province. Therefore, it is being assumed that the available temperature able to represent other districts. Although, the available rainfall data is not be able to represent other districts, due to its local characteristic. Below are the results for each province.

West Java Province

In West Java Province, there is a trend from each district that in 2004 there was a decrease of rice productivity, as shown in Figure 3. The rice productivity is obtained by dividing rice production and harvested area per year.

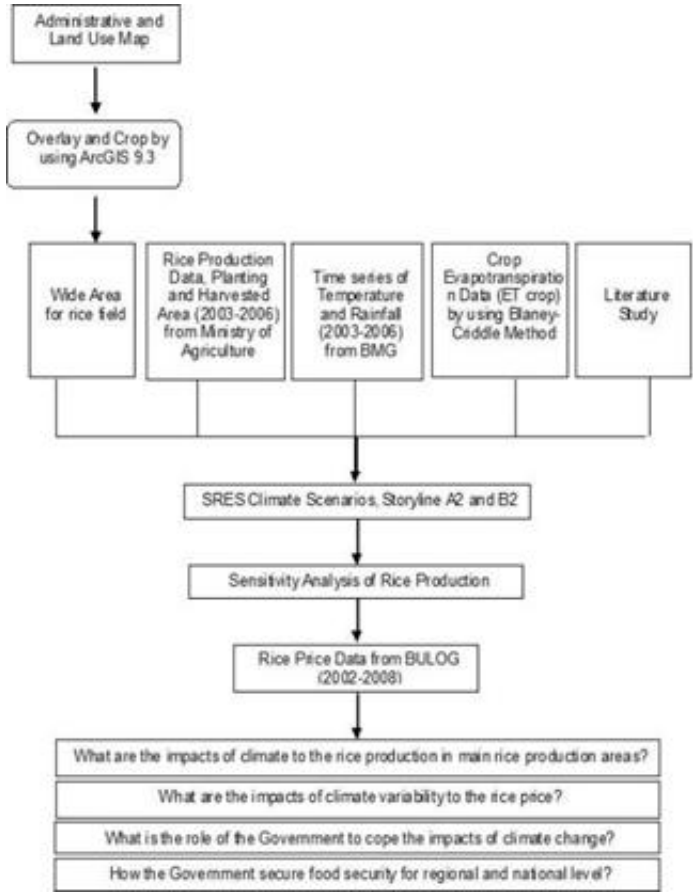


Figure 2. Flowchart of Methodology

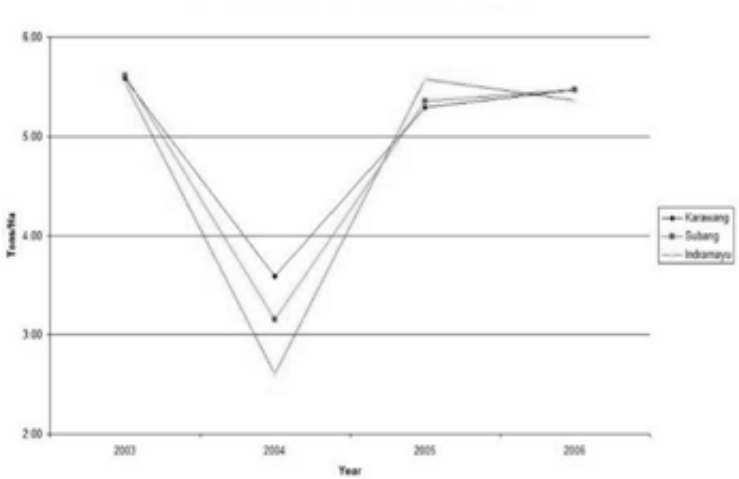


Figure 3. Rice Productivity in West Java Province (2003-2006) (Drawn from Centre Data and Information, Ministry of Agriculture, 2008)

The Figure 4 shows although there was a significant decrease in 2004, the rice productivity in the respective districts show an increase in 2005. The rainfall as one of an important climate variability for rice plant shows there was also a decrease during the dry season, especially in 2004 and 2006. Below is a Figure of monthly temperature and rainfall in Subang as one of the main rice production areas in West Java Province.

According to above graph, the rainfall is normally increasing during the wet season (Jan-Apr) and decreasing in the dry season (Jun-Aug). The temperature during wet season varies between 25-28^{0}C, meanwhile during the dry season the temperature varies between 28-34^{0}C.

In this study, the cropping area with the administrative map in each district is also being carried out in order to have wide area for rice field and the result is shown in figure 5.

According to above graph, the rainfall is normally increasing during the wet season (Jan-Apr) and decreasing in the dry season (Jun-Aug). The temperature during wet season varies between 25-28^{0}C, meanwhile during the dry season the temperature varies between 28-34^{0}C.

In this study, the cropping area with the administrative map in each district is also being carried out in order to have wide area for rice field and the result is shown below.

The graph 6 shows that the rice field is dominating most of the areas of these districts, as rice crop become the most important for the residents. In comparison with other province, West Java indeed has the widest area for the rice field. Based on the calculation with ArcGIS 9.3, it is founded that, Karawang has 129,031 hectares of rice field, Subang has 119,648 hectares, and Indramayu has 134,863 hectares respectively.

Central Java

In Central Java Province, rice productivity seems low in 2003 until 2005. However, in 2006 rice productivity is significantly increasing.

The monthly average temperature in Cilacap shows an increase during the wet season (Jan-May) and decrease during the dry season. Likewise, the rainfall is also showing the same condition as shown in below Figure 7.

The dissemination of rice field in Central Java apparently is not as big as West Java Province as shown in below Figure. Grobogan however has the widest area of rice field in comparison with other districts in Central Java. Based on the calculation, the wide area for rice field in Cilacap is 60,550 hectares, Grobogan has 83,008 hectares, and Demak has 67,861 hectares respectively. Although Central Java has smaller harvested area, however the rice productivity from 2003 to 2006 is slightly bigger than West Java Province. This condition shows that intensification of rice crop is being emphasized in Central Java.

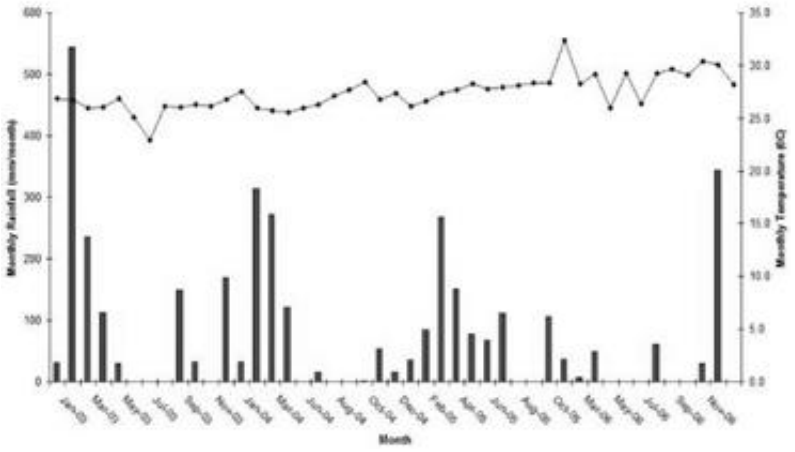


Figure 4. Monthly Average Temperature and Rainfall in Subang, West Java (2003-2006) (Drawn from BMG)

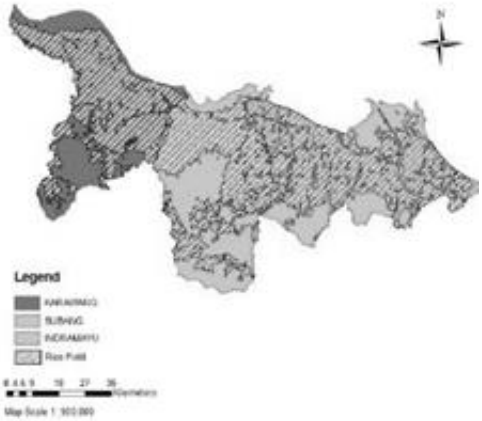


Figure 5. Rice Field in Karawang, Subang, and Indramayu (Drawn from Ministry of Forestry, 2003)

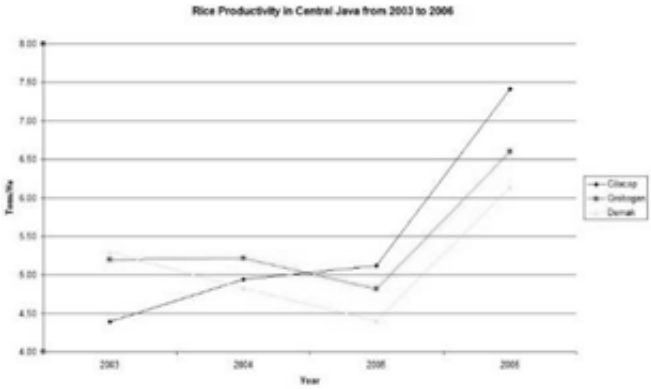


Figure 6. Rice Production and Harvested Area in Main Rice Production Areas, Central Java (Drawn from Centre Data and Information, Ministry of Agriculture, 2008)

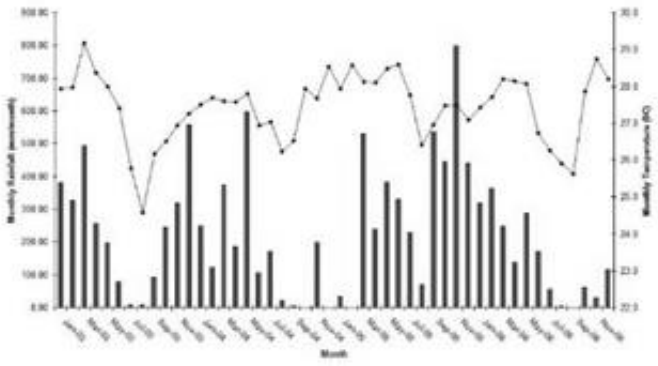


Figure 7. Monthly Average Temperature and Rainfall in Cilacap (Drawn from BMG)

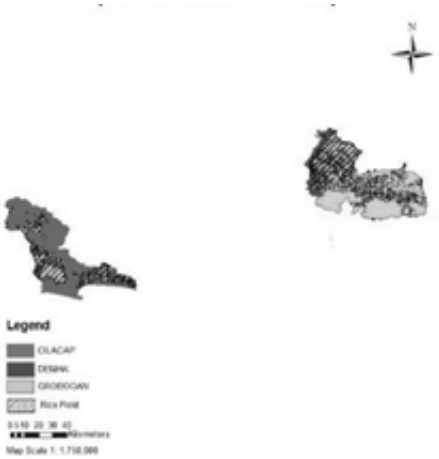


Figure 8. Rice Field in Cilacap, Grobogan, and Demak (Drawn from Ministry of Forestry, 2003)

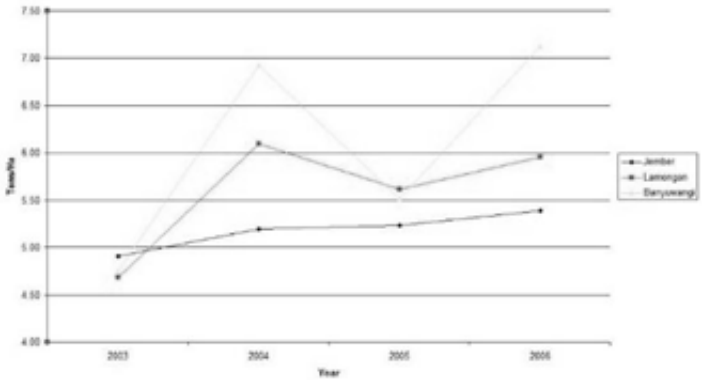
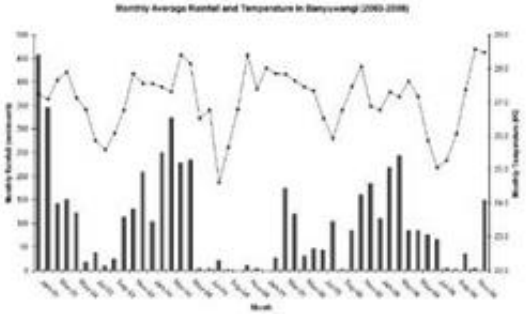


Figure 9. Rice Production and Harvested Area in Main Rice Production Areas, East Java (Drawn from Centre and Data Information, Ministry of Agriculture, 2008)

East Java Province

Unlike other provinces, rice productivity in three districts in East Java Province is increasing in 2004 and decrease in 2005. However it is increasing again in 2006. The monthly average temperature and rainfall in Banyuwangi shows a significant decrease during the dry season in 2004 and early 2005. Meanwhile, rainfall is merely high during wet season in 2004 and 2005 as shown in Figure below. ETo in Banyuwangi also shows that there is increase during wet season and decrease in dry season. This condition leads to high use of irrigation which likely caused low productivity during 2005. The high population growth in the areas which caused many rice fields change function into settlement or housing is possibly becoming one of the areas for low rice productivity.

The rice field cover in East Java Province is also not as big as in the West Java Province as shown in Figure below. Based on the calculation, wide area of rice field of Jember is 84,760 hectares, Lamongan has 64,465 hectares, and Banyuwangi has 35,117 hectares of rice fields. It is seems that Jember is the widest area of rice field in comparison with other district in East Java. The high intensification of rice planting is likely being emphasized due to high population in the area.



Impacts to Seasonal Changes and Rice Price

Seasonal Changes

Changes in rainfall pattern and length of wet season will have serious implications for agricultural sector especially rice crops. The current cropping pattern might not be practicable in the future. Currently, the cropping pattern that being used most in main rice production areas is rice-rice. The second planting depends heavily on irrigation water. The vulnerability of rice productivity due to the uncertainties of climate variability may expose Indonesian rice farmers to have more frequent crop failures. Thus, in area where the rainfall pattern changes into direction farmers should alter their cropping pattern from rice-rice into rice-non rice (Indonesia Country Report for IPCC, 2007).

In West Java Province for instance, the big amount of rice productivity decrease in 2004, which was considered as one of the dry period, is likely because of there was a lack of rainfall during the years. This would cause the switch of planting season of rice crop. Nevertheless, the distribution of rice field in West Java Province indeed is the widest among other main rice production areas.

The decrease of rainfall during the dry season period in 2004 also affects other provinces like Central and East Java. Although rice productivity in East Java in 2004 is increasing but it is decreasing again in 2005. According to the study of Soemarno et al. (2008), there was an anomaly in raining pattern during 2006/07 period in those main rice production areas. In the normal years, wet season should start in October or early November, meanwhile in 2006/07 it started on December as shown in Table below. An erratic wet season was shown with a two or three weeks of dry season on January 2007 in most of the main rice production areas, like Karawang, Grobogan, and Lamongan..

Rice Price

According to BULOG, there is a trend of increasing of national rice price in the market from 2002 to 2007 as shown in Figure 11.

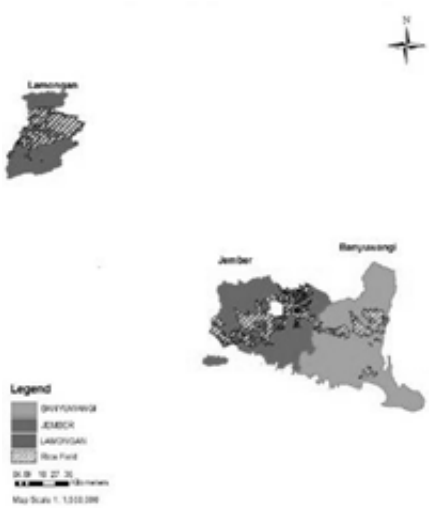


Figure 10. Rice Field in Jember, Lamongan, and Banyuwangi (Drawn from Ministry of Forestry, 2003)

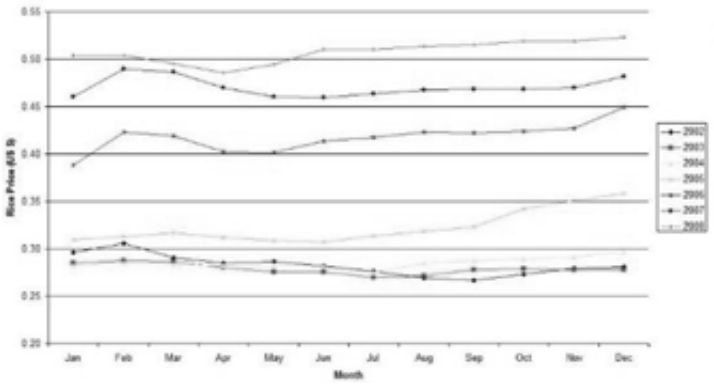


Figure 11. National Rice Price in 2000-2008 (Drawn from BULOG)

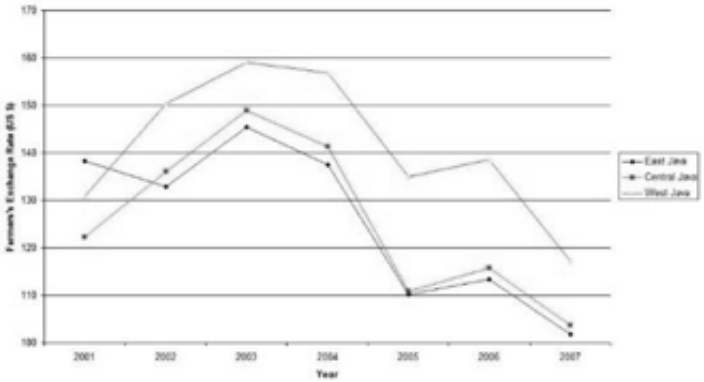


Figure 12. Total Farmer's Exchange Rate in West, Central, and East Java (2001-2007) (Drawn from Ministry of Trade and Trading, 2007)

Although the fluctuation in a year is not visibly seen, however the national rice price is significantly increasing from year 2002 to 2007. This condition is likely due to the reduction of fertilizer subsidy for the farmers. Robinson et al. (1997) mentioned that since the late 1960's fertilizer subsidies have been given to farmers by setting the wholesale prices of urea, triple super phosphate (TSP), and ammonia. Villages cooperative (KUD) and traders are allowed to distribute fertilizers to farmers at the official retail price level.

According to Sugiarto (2008), welfare of farmers is able to represent with farmer's exchange rate as a ratio between total farmer's income and total farmer's expenses.

From figure 13 it is clearly seen that the farmer's exchange rate is significantly decreasing in West, Central and East Java. It is likely that the increase of national rice price is not necessarily improves the welfare of farmers, because farmers have to pay more money for a high production cost.

Government Policies

The role of Government is important regarding to cope with the impact of climate change. Below are several strategies in order to improve rice independent and food security in year 2020.

SRES Climate Scenarios

Boer et al. (2007) formulates in his study that there is an increase of rice production from 2000 until 2030 in Indonesia by using two scenarios (A2 and B2) and slightly decline in the coming years as shown in Figure 14.

Strategy	Policies	Program	Target 2020
Research and Development	Support of human resources, facilities, research and fund	Integrated upstream and downstream research	Technology development to improve quality and quantity of production
Utilization of natural resources	Expansion of planting area	Integrated irrigation and mapping	1.5 million irrigated rice field areas in Sumatera, Java and Sulawesi; 1.5 million in southern Papua and Moluccas
Utilization of technology	Improve of productivity, consumption diversification	Early warning system, incentives, reduce rice consumption through socialization of non-rice as staple food	In every main rice production areas

Figure 13. Strategies to Improve Rice Independent and Food Security (Indonesian Agency for Agriculture Research and Development, 2008)

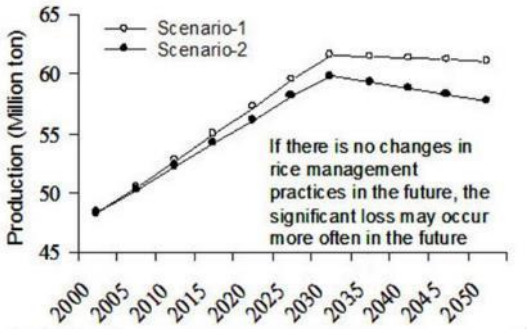


Figure 14. Implementation of Climate Scenario A2 (Scenario 1) and B2 (Scenario 2) to Rice Production in Indonesia (Boer, 2007)

Figure above shows that with two scenarios (A2 and B2), Indonesian rice production tends to increase in year 2000 to 2030. However, with the climate projection which will cause the increase of flood risk during the wet season and drought risk during the dry season. Boer also mentioned that with the climate projection and if there is no changes in rice management, rice production in Indonesia will decrease until year 2050.

These scenarios are with the assumption that there will be high decentralization of rice plantation migration to outside of Java Island and followed by technology inputs that will be introduced in Java Island and outside Java as well. This condition will likely boost the rice production. However, this condition will come to one point where there is no more potential lands outside Java Island that are suitable to grow rice crop. Therefore in 2030, the rice production will drop from 5-10% and 10-20% respectively in 2050.

CONCLUSION

Impacts on Rice Production

Java Island with more than 60% of population concentrated in the island has become over-populated. This condition is likely become a problem, as the main rice production areas are still concentrated in this island. West, Central, and East Java are considered as the main rice production areas as these provinces contributed more than 60% national rice production over the years. This is due to the supported topography and climate that is suitable to grow rice in comparison with other areas outside Java Island. However, nowadays the Government is providing technology transfer to support rice plantation outside Java Island in order to increase national rice supply.

The changes in temperature and rainfall pattern are indeed affecting the rice production. Excessive rainfall during the wet season will likely create

flood risk and increase of temperature will also create drought during the dry season. The current copping pattern that is commonly rice-rice is likely will be a problem for the farmers, not mention the uncertainties of climate variability may expose farmers to have more crop failures. Therefore, the farmers should alter the cropping pattern into rice-non rice, so that crop failure risk could be minimized.

Impacts to the Rice Price, Government's Policies and Climate Scenarios

The alteration of rain and drought season likely will affect the plantation and harvest time and leads to change or rice price in the market in terms of rice stock for national supply. During the time of rice scarcity, rice price will rise respectively. However, this condition seems not to improve farmer's income, due to high production cost for fertilizers and other infrastructures. The farmer's income is even decreasing from 2003 to 2007. Therefore, it is necessary to have policies that able to cope with this issue.

The role of Government is important in order to cope with the impacts of climate change. Provision of adequate climate forecast information to the farmers supposedly will help to reduce the risks. Development of more technologies and adequate mechanism to communicate climate forecast from the authorities to the farmers also plays an important role.

Rice support is being implemented by the Government through BULOG by giving "floor price" to farmers in order to support rice production. On the consumer's side, the "ceiling price" is being set-out in order to maintain price stability at affordable price, especially for the poor. After deregulation of rice trade with zero percent tariffs in 2000, domestic rice market is pressured. This condition has increased import significantly in 2000s. Recognizing this condition of liberalization of rice market, the Government made a concrete step to protect domestic farmers from the flood of imported rice by imposing tariffs at the level of approximately 30% of the world price (Sidik, 2004).

In terms of most feasible SRES scenarios that have been mentioned in the previous chapter, both scenarios are seems to have slightly difference. With integrated agricultural management and intensification program in both scenarios, rice production will likely increase until 2030. However, due to lack of rice field availability, especially in Java Island where the population growth is still increasing, and low dissemination climate forecast to the farmers, Indonesia will suffer a great loss of rice production and risk of food security as rice is still as main staple food.

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