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THE IMPACT OF CLIMATE CHANGE ON FOOD PRODUCTION AND SECURITY AND ITS ADAPTATION PROGRAMS IN INDONESIA

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ABSTRACT

The increased intensity and frequency of storms, drought and flooding, altered hydrological cycles and precipitation variance have implications for future food availability. Many developing countries, in fact, already contend with chronic food problems. Climate change presents yet another significant challenge to be met. While overall food production may not be threatened, those least able to cope will likely bear additional adverse impacts. As a consequence, climate change has threatened food security in many developing countries, including Indonesia. While the adverse impacts of climate change will affect the poor, actual impacts will depend on socio-economic conditions as on the biophysical processes involved. Managing these risks is an imperative necessity for Indonesia. Policies and investments supporting sustainable agricultural practices and technological progress can help mitigate the effects of climate change on agriculture and food security while increasing the capacity of people and societies to adapt. Simulation based on climate data from 1971 to 2006 indicated that Indonesia agricultural production is more sensitive to temperature increase rather than rainfall decrease. A combination of these two climate components has significant impact on the country's food balance by 2050. It is estimated that the deficit will be 90 million tons of husked rice by 2050. This rice deficit can not be met only with a single effort, by improving cropping areas, crop productivity, cropping intensity or consumption alone. Only multiple adaptation programs could save Indonesia from this rice deficit. The feasible adaptation programs include improvement in cropping areas, crop productivity, cropping intensity and consumption.

Keywords: temperature increase, rainfall decrease, rice production, food balance

INTRODUCTION

Indonesia is the largest and widest archipelago country in the world which is prone to earthquakes and tidal waves. This is due to its position on two shelves, the Sunda Shelf, which is a continuation of the Asian mainland, and the Sahul Shelf, which is part of the foundation of Australia and New Guinea. Due to its location which is in the tropics and at the cross road between two oceans, The Indian and The Pacific, and two continents, Asia and Australia, Indonesia experiences a generally tropical climate with moderate temperature and very high humidity, even during dry months. In addition, the country is predominantly mountainous with approximately 400 volcanoes, of which 100 are active. The country is also influenced by the monsoonal winds, where the prevailing winds during each season are opposite.

Indonesia is also one of the world's most vulnerable regions to climate change, due to its long coastlines, high concentration of population and economic activity in coastal areas, and heavy reliance on agriculture, fisheries, forestry and other natural resources. Consequently, Indonesia is subject to many climate-related hazards, including floods, droughts, storms, landslides and wild-land fires, as presented in Figure 1 (UNDP Indonesia, 2007). Now these will become more frequent or more severe thus, there will be, among others, health risks, water shortages, forest fires, loss of biodiversity, coastal degradation and loss of land, and constrained agricultural production.

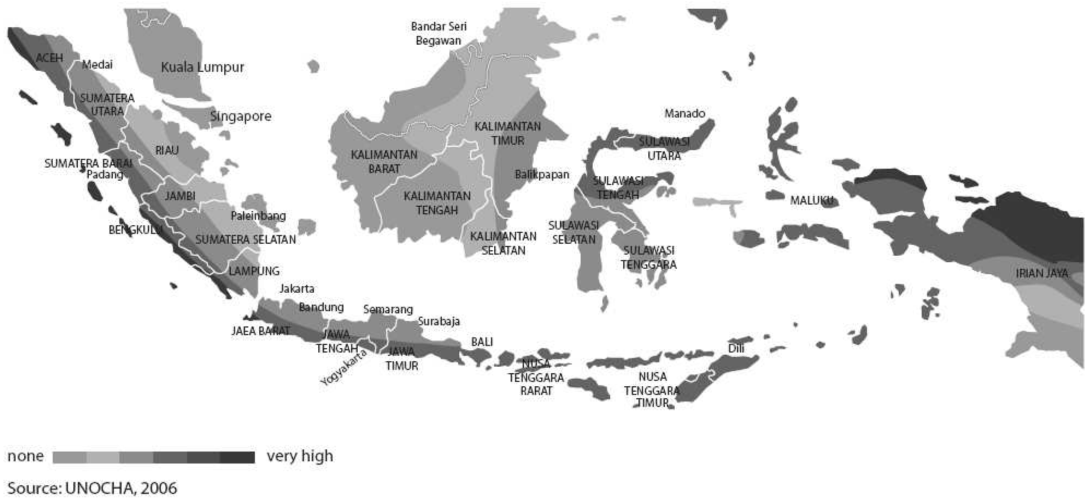

Fig. 1. Degree of exposure to natural hazards in Indonesia

Climate change represents abnormal climatic situations that can affect agricultural production through their impact on temperature changes and water availability. Agriculture in developing countries, including Indonesia, has received considerable attention recently with regard to climate change because of the high dependence of agriculture on the climate. Those countries already contend with chronic food problems, and climate change will intensify the existing hunger and food insecurity problems, since it can greatly increase the risk of crop failure and the loss of livestock.

Climate change has caused changes in seasons and rainfall of Indonesia. UNDP Indonesia (2007) reported that for several years now, farmers in the villages of Java and Sumatera have been talking about the abnormal seasons., Comparing the periods 1961-1990 and 1991-2003, the onset of the wet season is now 10 to 20 days later and the onset of the dry season is now 10 to 60 days earlier in most of Sumatra. Similar shifts have been seen in most of Java. These patterns seem likely to continue. In the future, some parts of Indonesia, particularly in regions located south of the equator, could have longer dry seasons and shorter but more intense wet seasons with the kind of changes in the rainfall pattern. In addition, the climate is also likely to become more variable, with more erratic rainfall. Higher temperatures will also dry out the soil, reducing groundwater resources, degrading the land and in some cases leading to desertification.

There are two objectives of this paper: (1) to review the relationship and potential impact of climate change on food production and food security; and (2) to evaluate some adaptation programs required by Indonesia to meet and maintain its food security.

Climate Change and Food Production and Trade

a) Climate Change and Food Production

Complex relationships between crops, atmospheric composition and temperature, combined with the complexities of world agricultural policies and trade, make it difficult to predict the future impacts of climate change on agriculture. Many studies indicate that the increased intensity and frequency of storms, drought and flooding certainly have implications on agricultural production, particularly food. FAO (2007) indicated that climate change impacts on agriculture can be roughly divided into two groups: biophysical and socio-economic impacts. Recent research has focused on regional and national assessments of the potential effects of climate change on agriculture. Sensitivity studies of world agriculture to potential climate changes have indicated that the effect of moderate climate change on world and domestic economies may be small, as reduced production in some areas is balanced by gains in others (Tobey *et al*., 1992). However, there has to date been no integrated (combined biophysical and economic) assessment of the potential effects of climate change on world agriculture.

Fischer and co-workers (2005) project that global cereal production could continue to increase up to 3.7 - 4.8 billion tons by 2080 under the basic conditions i.e., without climate change. When it is factored in, global cereal production could be within 2% of reference scenarios, but with potentially large regional variations, with temperate regions on the northern hemisphere benefiting from increased temperatures and longer growing periods for moderate degrees of warming; while tropical regions will loose agricultural production potential, reflecting both declining potential land available for crop cultivation and changes in productivity. A similar study, modeled the impacts of climate change on agricultural production and demonstrated that there will be negative effects on crop yields over the next century, particularly in developing countries where people are already at risk (Ludi *et al.* 2007).

Despite technological advances such as improved crop varieties and irrigation systems, weather and climate are still key factors in determining agricultural productivity. Kasryno *et al*. (2001) stated that there were six drought incidence in Indonesia in the last 30 years i.e., 1972, 1976, 1982, 1991, 1994 dan 1997. Before 1991, drought incidence has decreased the harvest areas of paddy by 3.2% but, has not reduced total rice production. This occurred since decrease in harvest area could be compensated by increase in rice productivity.

Irawan (2002) estimated the impact of climate change, in term rainfall decrease and temperature increase, on crop production in Indonesia. He concluded that in the future, El Nino events (decrease in rainfall) will be a more serious climatic anomaly than La Nina (increase in rainfall), due to its increasing frequency, duration and magnitude. El Nino events that occurred from 1968 - 2000 (seven events) have, on average, caused food production losses of 3.06 per cent, whereas La Nina (five events) resulted in food production increases of 0.64 per cent at the national level. Four provinces experienced significant decreases in food production (production losses of 5.4 per cent to 12.5 per cent) during El Nino events, they are the provinces of South Sumatera, Lampung, East Kalimantan and Irian Jaya. Five other provinces with food production quite sensitive to El Nino events (production losses of 3.2 to 4.9 per cent) are Riau, Jambi, West Java, Central Java and Yogyakarta. In general, there are two major factors that cause variations in production loss in the various provinces, i.e. geographical position of the province and social capacity in anticipating possible production decreases due to drought. Geographical position of the province determines the magnitude of the El Nino impact on rainfall decreases in the related province, whereas social capacity determines the magnitude of production loss which can be reduced through mitigation efforts performed by farmers.

b) Food Production and Trade

Currently, fewer countries have the possibility to feed themselves (even if this is desirable) and, hence, that there will be greater reliance on markets and trade. Some developing countries are particularly vulnerable to additional impacts of climate change on their ability to attain food security, due to their unfavourable positioning in international trade, compounded by poor development of domestic and regional markets. Being able to balance growing differences between food demand and production will mean paying greater attention to develop policies supporting trade, and putting in place the necessary infrastructure and institutions.

With the increasing trend in the international food trade, the effects of climate change on agriculture in individual countries cannot be considered in isolation. Food trade has grown dramatically in recent decades and now provides significant increments of national food supplies to major importing nations and substantial income for major exporting nations (Rosenzweig, 1993). This emphasizes the close links between agriculture and climate, the international nature of food trade and food security, and the need to consider the impacts of climate change in a global context.

c) Climate Change, Food Production and Food Security: the Linkages

FAO (2003) reported that food security as a concept originated only in the mid-1970s, in the discussions of international food problems at a time of global food crisis. The initial focus of attention was primarily on food supply problems. Following the events of global food crisis in the mid 1970s, the issues of famine, hunger and food crisis were also being extensively examined. The outcome was a redefinition of food security, which recognized that the behavior of potentially vulnerable and affected people was a critical aspect. Based on The State of Food Insecurity 2001 (FAO, 2002), food security is defined as "a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life". This new definition emphasizes on the consumption, demand side and issues of access by vulnerable people to food. Household food security is the application of this concept to the family level, with individuals within households as the focus of concern. To achieve food security, all four of its components: availability, stability, accessibility and utilization, must be adequate. Food insecurity exists when people do not have adequate physical, social or economic access to food as defined above.

Significant changes in climatic conditions will affect food security through their impacts on all components of global, national and local food system i.e., a set of dynamic interactions between and within bio-geophysical and human environments that influences both activities and outcomes all along the food chain: production, storage and processing, distribution, exchange, preparation and consumption (FAO, 2007). Food security is the outcome of food system performance at global, national and local levels. It is often directly or indirectly dependent on agricultural and forest ecosystem services, e.g., soil and water conservation, watershed management, combating land degradation, protection of coastal areas and mangroves, and biodiversity conservation. Nutritional status of the population is the consequence of the food security status (Figure 2).

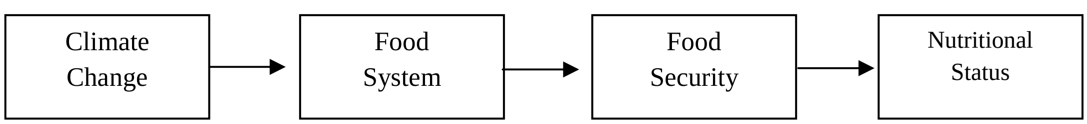

Fig. 2. The impacts of climate change on food security

Currently, more frequent and more intense extreme weather events and droughts, rising sea levels, and increasing irregularities in rainy season patterns are already having immediate impacts on food production, food distribution infrastructure, incidence of food emergencies, livelihood assets and opportunities and human health, in both rural and urban areas. FAO (2007) reported that the impacts of gradual changes in mean temperatures and rainfall are likely to be disruptive, whether positive and negative, and may include:

- Changes in the suitability of land for different types of crops and pasture,

- Changes in the health and productivity of forests,
- Changes in the distribution, productivity and community composition of marine resources,
- Changes in the incidence and vectors of different types of pests and diseases, loss of biodiversity and ecosystem functioning of natural habitats,
- Changes in the distribution of good quality water for crop, livestock and inland fish production,
- Loss of arable land due to increased aridity and associated salinity, groundwater depletion and the rise in sea level,
- Changes in livelihood opportunities,
- Changes in health risks, and internal and international migration.

Changes in agricultural production patterns will affect food security in two ways (FAO, 2007):

- Impacts on the production of food will affect food supply at both global and local levels. Globally, higher yields in temperate regions could offset lower yields in tropical regions. However, in many low-income countries that have limited financial capacity to trade, and that rely heavily on their own production to cover their food requirements, it may not be possible to offset declines in local supply without increased reliance on food aid.
- Impacts on all forms of agricultural production will affect livelihoods and ability to access food. Producer groups less able to deal with climate change, such as the rural poor in developing countries, risk having their safety and welfare compromised.

Currently, trade in food products is the norm, since very few countries aim for food self sufficiency. Hence, the supply of food within a country is a function of: the volumes produced domestically, the price of imports, and the price of the exports used to generate foreign exchange. Climate change could affect all three of these variables (Ludi *et al*., 2007). According to Fischer *et al.* (2005), about 768 million people are estimated to be undernourished in 2080. Regional differences between developed countries (where are generally benefiting from climate change) and developing countries (where crop production is projected to decline considerably) are likely to grow stronger through time, leading to significant polarization with a substantial increase in risk of hunger among the poorest countries, especially in sub-Saharan Africa and South Asia, where a large portion of the population will depend on agriculture, and where capacities (e.g. technologies, finances, investments, etc.), both at national and farm level to adapt to climate change, are lowest.

Slater *et al.* (2007) tried to trace the likely impacts of climate change through changes in the quality of the physical asset base, access to assets, and impacts on grain production and on agricultural growth. At moderate degrees of warming, impacts are likely to be negative in some regions, but positive in others, making it important to understand the possible implications for trade between the regions. The short term impacts of climate change, particularly changes in the frequency and severity of adverse weather events, remain uncertain, but their impacts on many developing countries are likely to be negative. However, there is likely to be time to make appropriate policy responses to some of the longer-term impacts.

Slater *et al.* (2007) also indicated that climate change may slow down rates of improvement in food security, although the projections are highly uncertain due to limitations in the number of crop and economic models available and simplification of the definition of food *security* to food *availability*. However, Parry *et al.* (2005) projected that in 2080, around 1300 million people could be at risk of hunger under the most extreme scenarios, with the poorest countries worse affected. General modelling studies on food security rarely consider how it could be disrupted by more extreme weather events. Under more moderate scenarios, climate change appears to have a negligible effect on the numbers of people at risk of hunger.

The impact of climate change on food trade can be divided into two. In cases where a country exports agricultural goods, the net impact of climate change will result from a combination of the impact on their production of exported crops and demand for these in the world. For example, if an exported crop product is less susceptible to the adverse production effects of climate change in a particular country than those products destined for domestic consumption, the decline in domestically produced food supply may be offset by an increased ability to import (especially if world prices for the export crop also rise). By contrast, if the export crop is affected to the same (or a greater) extent than is domestic food production, the two adverse effects will reinforce each other. Finally, where a country imports agricultural goods, there is a range of potential indirect effects of climate change on exports that could result from the policy responses of different governments.

Status of Food Production and Security in Indonesia

Food production is one of important factors of food security. Indonesia achieved self sufficiency in rice – staple food of the majority of Indonesians – in 1984, though in 2007 still imported 4% of rice (Table 1). It was a very successful achievement for Indonesia, since Indonesia was previously known as the biggest rice importer country for a few decades. Volume of rice traded in the international market is in fact relatively small i.e., about 20 million tons, which is known as "thin market". In the past, Indonesia was highly depended on the imported rice. Thus, fluctuation in production and price of rice in the international market will affect Indonesia's food security status. The highest level of rice imports occurred in 2002, when Indonesia imported about 3.25 million tons of rice from the world market, equivalent to 10.2% of the total rice traded in the world market, which was only 25.8 million tons. Indonesia is still imported some food commodities from the international market, including: wheat, soybean and maize which are, in fact, very important food crops in the Indonesian diet. Importation levels vary from 8 to 100 percents of the total commodity's demands.

Table 1. Total production and percentages of import of main commodities in Indonesia, 2007

Commodity	Production (million tons)	Percentage of Import from the Total Supply
Palm Oil (CPO)	17.40	0
Rice	32.37	4.0
Maize	13.30	8.1
Sugar	2.45	13.5
Beef Meat	0.36	28.0
Soybean	0.59	61.8
Wheat	0	100

Source: Department of Agriculture *in* Suryana (2008)

Based on the 8th National Workshop on Food and Nutrition Criteria, Indonesia is, in general, in "food security" status. Based on this criteria, the recommended energy (calorie) consumption is 2000 calorie capita^{-1} day^{-1}, with its recommended availability (at national level) at 2200 calorie capita^{-1} day^{-1}. For protein, the recommended protein consumption is 52 gram capita^{-1} day^{-1}, with its recommended availability at 57 gram capita^{-1} day^{-1}. Based on BPS data (2007), the average real energy and protein consumption are higher than their recommended levels. These conditions reflect that food consumption has been sufficient or secure. However, at the micro level, about 20% of the households consume less than those of the recommended levels (Suryana, 2008); implying that the food security is still a significant problem to be solved in Indonesia. This is due to the problems of accessibility (of households and individuals to appropriate foods for a nutritious diet) and affordability (of individuals and/or households to consume food according to their respective socio-economic conditions, cultural backgrounds, and preferences), since these two aspects are highly correlated with poverty problems.

The people with food insecurity status usually have correlation with those with poverty problem. The poor people of Indonesia reached 32.53 million persons in 2009, equivalent to 14.15% of the total population of the country (BPS, 2009). Based on their locations, urban poor is lower than those of rural areas i.e., 11.91 million compared to 20.62 million persons. Ironically, most of the rural poor are working in the agricultural sector, indicating the inability of the agricultural sector in the country to improve the livelihood of its community. Since the agricultural sector is significantly affected by the climate change, it is estimated that the degree of poverty and food insecurity could be worse in the future. To anticipate these potential problems, adaptation to climate change is required by the country which is subject to many climate-related hazards.

Agricultural Adaptation for Food Security and Sustainable Development

Dependence of agriculture on the climate condition implies that agriculture has an important role to play in adaptation to climate change. To make agricultural adaptation most effective, particularly for the developing countries, adaptation plans and strategies need to be integrated into sustainable development planning and risk reduction planning at community, local and national levels (United Nations Framework Convention on Climate Change, 2007). Crucially there has been little work to integrate adaptation into development plans or within existing poverty alleviation frameworks.

FAO (2007) suggests two main types of adaptation for agriculture: autonomous and planned adaptation. Autonomous adaptation is the reaction of, for example, a farmer to changing precipitation patterns, in that crops or planting dates are changed. Planned adaptation measures are conscious policy options or response strategies, often multisectoral in nature, aimed at altering the adaptive capacity of the agricultural system or facilitating specific adaptations. For example, deliberate crops selection and distribution strategies across different agriclimatic zones, substitution of new crops for old ones and resource substitution induced by scarcity.

Following FAO (2007), to achieve food security status, a country should make a planned adaptation measure at the national level, the second type of FAO’s suggestions, which include conscious policy options and response strategies, in altering the adaptive capacity of the agricultural system or facilitating specific adaptations. The planned adaptation measures should include four main components:

a) Integration of climate change mitigation and adaptation strategies into the economic and social development policy framework
b) Cooperation on the implementation of adaptation and mitigation measures
c) Strengthening of national and regional knowledge sharing, communication and networking on climate change and food security
d) Developing a more comprehensive multi-sectoral strategic framework and a roadmap for implementation.

Research Methods

The model used in this research is taken from “Sistem Informasi Perubahan Iklim dan Ketahanan Pangan Strategis” (*Climate Change and Food Security Information System*) developed by Handoko, Sugiarto and Syaukat (2008). The objective of the model is to estimate the food balance situation in Indonesia by 2050 with and without climate change. The food balance is measured as the difference between food production and food consumption with and without climate change in 2050.

The framework to estimate food balance is presented in Figure 3. There are two climate components included in the model i.e., temperature and rainfall. These two factors, whether individually or collectively, will determine cropping areas, cropping intensity and crop productivities, which then result in crop (food) production. On the other hand, the demand for food is determined by the total population and average food consumption.

Rainfall data was taken from 174 climate stations in four main provinces in producing food crops in Indonesia i.e., West Java, East Java, North Sumatera and South Sumatera. Rainfall varies from 501 to 6,400 mm per annum in the period of 1971 to 2002, with 1 to 10 months of wet season and 1 to 11 months of dry season. Moving-average data on these four provinces indicate that there is tendency for declining rainfall. In this model it is assumed that the rainfall will decline by 246 mm/year. Based on the same database, temperature increased from 1^{o}C to 4^{o}C. In this model, temperature is assumed to increase by an average, 2^{o}C.

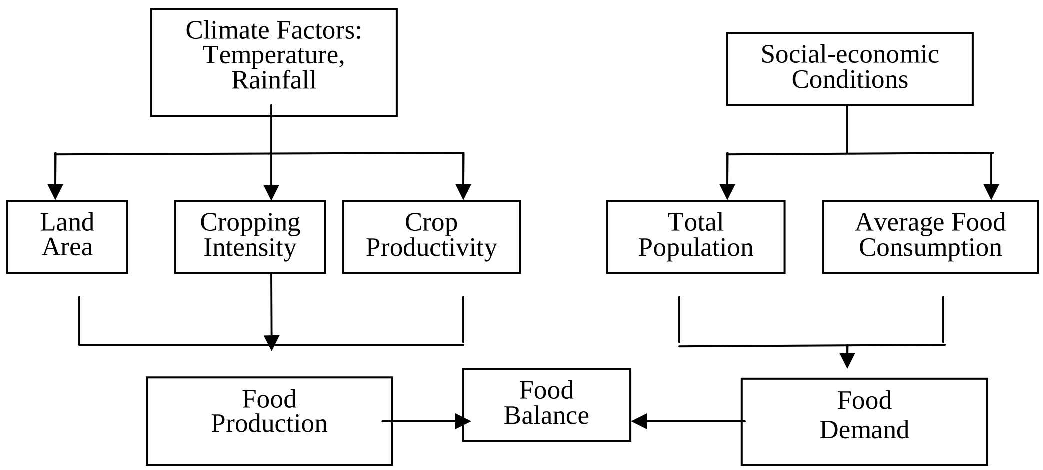

Fig. 3. Framework to estimate the impact of climate change on food balance

Adaptation programs included in the model include four main components: (1) increase crop planting areas, (2) increase cropping intensity, (3) increase crop productivity, and (4) decrease average food consumption, particularly for rice.

Impact of climate change on food production

Table 2 represents the projected status quo condition by 2050. In this case, planting area, cropping intensity and crop productivity are assumed to evolve at the current rates up to 2050. With these assumptions, crop production will decline by 7.6% to 27.1%. Upland rice will decrease at the highest rate, while sugar cane at the lowest level.

Table 2. Projected food crop production by 2050, without climate change.

No	Commodity	Production (2006 - base)	Decrease in Production by 2050	
		(ton)	(tons)	(%)
1	Wetland rice	51,647,490	10,473,764	20.3
2	Upland rice	2,807,447	761,522	27.1
3	Maize	11,609,463	1,574,966	13.6
4	Soybean	747,611	92,503	12.4
5	Cane sugar	1,279,070	97,453	7.6

Table 3 shows that the impact of a 2°C increase in temperature has a higher impact on crop production compared to a 246 mm decrease in rainfall. This occurs for all considered crops. Decrease in crop productions due to a 2°C increase in temperature is 7 to 22 times higher than those of a 246 mm decrease in rainfall, indicating that change in temperature has more significant impact on crop production than that of declining in rainfall. Baseline condition indicates crop surplus (deficit) when productions system is under the current condition (status quo) and with climate changes, while projected demand is increasing overtime due to population growth. Both production and consumption levels are measured by 2050. This condition is becoming a benchmark whether our food situation is improving or worsening with various adaptation programs. Even for palm oil, which is currently surplus of 7 million tons, it will be changed into deficit 17 million tons by 2050 if the climate changes were occurred, *ceteris paribus*.

Table 3. Impacts of a 2°C increase in temperature, a 246 mm decline in rainfall, and combination among the two climate changes on food production while keeping the cropping area constant (in million tons)

Commodity	Baseline	2°C Increase in Temperature		246 mm Decline in Rainfall		2°C Increase in Temperature and 246 mm Decline in Rainfall	
		Food Balance	Percentage of Change	Food Balance	Percentage of Change	Food Balance	Percentage of Change
Husked rice	-65.0	-89.0	-36.9%	-68.0	-4.6%	-90.0	-38%
Maize	-5.0	-27.0	-440.0%	-6.0	-20.0%	-27.5	-450%
Soybean	-3.0	-23.0	-285.7%	-3.8	-65.2%	-25.2	-952%
Cane sugar	-7.0	-28.0	-300.0%	-8.2	-17.1%	-30.0	-328%
Palm oil	+7.0	-15.0	-314.2%	+5.5	-21.4%	-17.0	-343%

There are seven options considered in this research, as presented in Table 4, which can be classified into two categories. Options 1), 2), 3) and 4) are considered as single (individual) efforts, representing the impact of a certain adaptation measure (increase land area, crop productivity, cropping intensity, or decrease average consumption level) on Indonesia's rice balance by 2050. These individual programs could improve rice balance from 11.1 to 50.0%. These are quite significant achievements, but Indonesia constantly faces rice deficit by 2050. An effort to increase rice cropping area by 100,000 ha per year (equivalent to 1% of the current total rice planting areas) (Option 1) could reduce rice deficit by 42.2%, but still result in 52 million tons of rice deficit. Another example, a reduction in the average rice consumption by 10% (Option 4 - through food diversification programs) could reduce the deficit by only 11%.

The second approach is called multi effort programs: combination of production and/or consumption improvement programs to reduce rice deficits. These include options 5), 6) and 7). Improvement of cropping areas and intensity at the same time (option 5) reduces the deficits significantly (by 91.1%), but Indonesia is still in rice deficit by 2050 (by 8.0 million tons of husked rice). Only option 6) and 7) could save Indonesia from rice deficits by 2050. These occur when the adaptation programs include improvement in cropping areas, crop productivity and cropping intensity and also consumption. A combination between increased cropping areas (by 100,000 ha yr^{-1}), increase crop productivity (by 50%) and increased cropping intensity (from 1.5 to 1.65) could increase rice balance by 104%, which result in a rice surplus condition by 3.7 million tons by 2050 (option 6). In addition, if those programs are followed by reduction in the average rice consumption by 10% whether from cereal or tubers (Option 7), it could result in 17 million tons of rice surplus by 2050. These two last options are feasible if we can maximize our efforts in doing such improvements consistently.

Table 4. The impact of adaptation programs on Indonesian rice balance by 2050.

Adaptation Program		With Climate Change	
		Food balance (Million tons)	**Percentage of change**
Baseline: With 2^0C increase in temperature and 246 mm decline in rainfall		**-90**	-
1) Cropping area	Cropping areas +100,000 ha yr^{-1}	-52.0	+42.2
2) Productivity	Productivity +25%	-68.0	+24.4
	Productivity + 50%	-45.0	+50.0
3) Cropping intensity	Cropping intensity from 1.5 to 1.8	-72.0	+20.0
	Cropping intensity from 1.5 to 2.0	-60.0	+33.3
4) Consumption	Consumption -10%	-80.0	+11.1
	Consumption -20%	-65.0	+28.8
5) Cropping areas and productivity	Cropping areas +100,000 ha yr^{-1} and productivity +50%	-8.0	+91.1
6) Cropping areas, productivity and cropping intensity	Cropping areas +100,000 ha/yr, productivity +50% and		
	• Cropping intensity from 1.5 to 1.65	+3.7	+104.1
	• Cropping intensity from 1.5 to 1.8	+8.0	+108.9
7) Cropping areas, productivity, cropping intensity and consumption	Cropping areas +100,000 ha yr^{-1}, productivity +50%, Consumption level -10% and		
	• Cropping intensity from 1.5 to 1.65	+17.0	+118.9
	• Cropping intensity from 1.5 to 1.8	+20.0	+122.2

CONCLUSIONS

Securing food supplies to meet the future food demand of the increasing population will be essential. This can be done by intensifying agricultural production i.e., obtaining more yields per unit of input – whether this be time, land, water, nutrient, plant or animal. Improved land management practices that contribute to soil moisture retention and maintain the amount of nutrients in the soil at appropriate levels can strengthen resilience as well as enhance productivity.

There are still large uncertainties as to when, how and where climate change will have an impact on agricultural production and food security, but it is generally agreed that agricultural impacts will be more adverse in tropical areas than in temperate areas (Stern, 2007). Climate change has threaten food security in Indonesia and other developing countries with its dimensions food availability, food accessibility, food utilization and stability, and thus impact the economic development.

From a food security perspective, the most immediate risks arising due to climate change are from extreme events: storms, floods and droughts. As they become more frequent and intense the magnitude of asset losses that impact on agricultural production and purchasing power of low-income consumers is also increasing. Policies and investments supporting sustainable agricultural practices and technological progress can help mitigate the effects of climate change on agriculture and food security while increasing the capacity of people and societies to adapt.

Based on the available data, Indonesia agricultural production is more sensitive to temperature increase rather than rainfall decrease. A combination of these two weather components has significant impact on Indonesia food production and food balance by 2050. For rice, it is estimated that the deficit will be 90 million tons of husked rice. This food deficit can not be met only with single effort, by improving cropping areas, productivity, cropping intensity or consumption alone. Only multiple effort adaptation programs could solve this food deficit. The feasible adaptation programs include integrated improvement in cropping areas and crop productivity, cropping intensity, and reduction in rice consumption through food diversification programs.

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