SUSTAINABLE BIOENERGY DEVELOPMENT UNDER A CHANGING CLIMATE

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Abstrak

Pertanian dan perubahan iklim adalah dua hal yang saling berkaitan, diindikasikan oleh peranan nyata pertanian dalam menyumbang emisi gas rumah kaca dan pertanian merupakan salah satu sektor yang dipengaruhi oleh perubahan iklim. Emisi gas rumah kaca terutama karena penggunaan energi fosil dan peningkatan biaya bahan bakar fosil diakibatkan oleh peningkatan permintaan bahan bakar global, hal ini mendorong banyak negara berkembang mencari sumber bioenergi baru. Paper ini bertujuan untuk mendiskusikan bagaimana mengembangkan bioenergi di bawah kondisi perubahan iklim tanpa mengganggu ketahanan pangan. Analisis deskriptif terhadap data sekunder yang diperoleh dari berbagai sumber digunakan untuk mendiskusikan masalah tersebut. Bioenergi, yang diproduksi dari biomasa dapat dibakar langsung atau diproses lebih lanjut menjadi bahan bakar padat, cair atau gas. Pengembangan bioenergi dapat merevitalisasi sektor pertanian, menciptakan lapangan kerja dan menyediakan sumber pendapatan bagi kehidupan perdesaan, meningkatkan akses perdesaan terhadap energi secara kontinu, meningkatkan panen terhadap tanaman pangan dan penghasil energi, dan secara nyata berkontribusi positif terhadap pemecahan masalah iklim. Tetapi, bila tidak dikelola secara berkelanjutan, pengembangan bioenergi dapat mengancam ketahanan pangan. Mengingat peluang yang diberikan dan resiko yang ditimbulkan, maka kriteria keberlanjutan untuk industri bioenergi perlu ditetapkan dengan jelas.

Kata kunci: *keberlanjutan, bioenergi, ketahanan pangan, perubahan iklim.*

1. Introduction

In current century, there are many issues facing agriculture, i.e. population growth, climate change and impacts, agricultural price fluctuations and high correlation with energy prices, food security and safety, and environment sustainability. Climate changes can affect temperatures, precipitation, and weather events which can in turn impact: rainfall, drought, storms, pests and disease, irrigation demands, crop growth and yields (Siregar, 2010). The global feature of temperature change is depicted in Figure 1.

Agriculture accounts for an estimated 70-80 percent of the global use of water (Sagar and Kartha 2007). Changes in rainfall, drought or floods would therefore affect agriculture and food productions. More irrigation would then be demanded. Figure 2 illustrated the global competition of water usage. Climate change and agriculture are interrelated and climate change over the next century may have significant effects on crop production and food availability (Gahukar, 2009). Von Witzke (2008) stated that the interrelationship between the two is at least three ways. *First*, agriculture is a victim of climate change. *Second*, agriculture in many countries is subsidized in order to produce bioenergy, considered by many to be very climate friendly. And *third*,

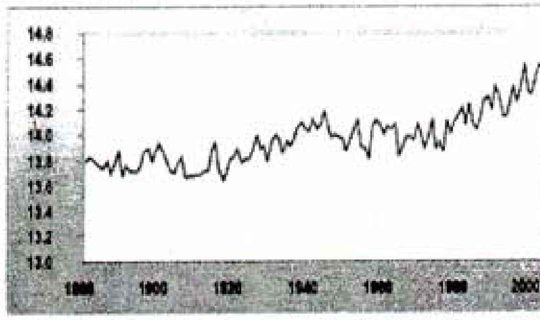

Figure 1. Changes in average global temperature (Siregar, 2010)

agriculture is the most important source of greenhouse gas (GHG) emissions; that is world agriculture contributes more than any other industry to global warming at the sometime that it suffers from the very same more than virtually all other industries.

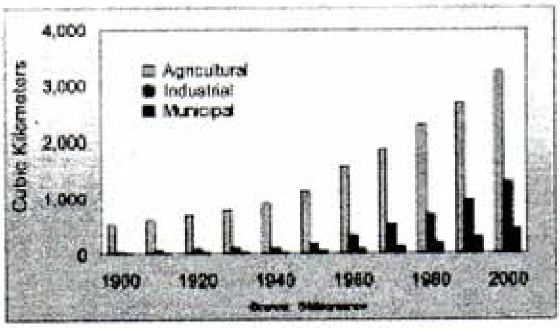

Figure 2. Global water usage competition (Siregar, 2010)

Facing climate change and higher fluctuation of agricultural commodity price, global ending stock of rice has been relatively low. Similarly, stock to use ratio has been only around 20 percent (Figure 3). Global import of rice has tended to exhibit increasing trend (Figure 4), with the Philippines being the largest importer by around 2.5 million tons followed by Nigeria almost two million tons (Hatcho, 2008; Siregar, 2010).

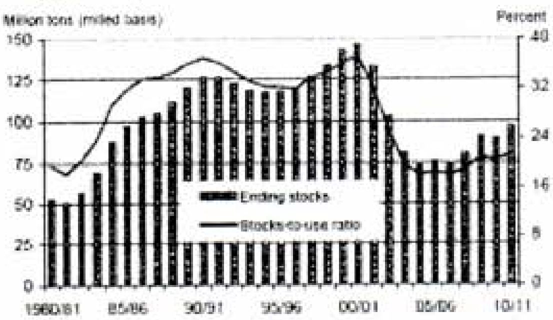

Figure 3. Global ending stock of rice and stock to use ratio (Hatcho, 2008)

Gahukar (2009) indicated that wheat production, in Haryana, has declined from 4,106 kg/ha in 2000–01 to 3,937 kg/ha in 2003–04, with maximum temperature rising by about 3°C during February–March in the last seven years. In Indonesia, during 1995-2005 flooded paddy field amounted to 1.93 million ha and drought paddy field amounted to 2.13 million ha where 0.33 million ha could not be harvested. In 2006 itself, flooded and drought paddy field was around 577 thousand ha (190 thousand ha could not be harvested). With an average yield of five tons dried husk paddy per ha, this is a loss of around 0.95 million tons (Siregar, 2010). The UN Intergovernmental Panel on Climate Change (IPCC) report indicated that an overall increase of 2°C in temperature and seven percent in rainfall would lead to an almost eight percent loss in farm level net revenue (Gahukar, 2009). The IPCC also estimated that GDP in the developing and less developed countries would decline by 1.4–3.0 percent due to climate change. Thus, the direct impact of climate change on agriculture and food supply includes shortage in grain production resulting in less availability of food items, especially to the economically poor people, changes in agricultural inputs such as fertilizers and pesticides, shift in planting dates of agricultural crops, preference of crop genotypes due to adaptation to changing climate, soil erosion, soil drainage and lower fertility level. Additionally, the incidence of pests, weeds and diseases in food crops will be more pronounced.

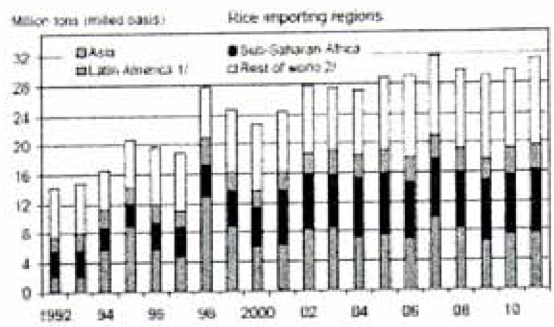

Figure 4. Global import of rice (Siregar, 2010)

Gahukar (2009) also stated that Agriculture is the main contributor to increasing methane and nitrous oxide concentration in the earth's atmosphere. These gases prevent and absorb radiation from the earth, thereby increasing the temperature of earth's surface as well as the lower layers of the atmosphere. The IPCC has predicted that GHGs will cause temperature to increase from 1.5 to 5.8°C and precipitation patterns to shift resulting in the increase of sea water level by 15– 95 cm by 2100. Concentration of GHGs such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), etc. has been rising at a fairly rapid rate. With regard to CO_2, Von Witzke (2008) indicated that agriculture's impact on climate change is usually fairly small. The studied showed around 60 percent of GHGs emission come from fossil energy utilization (Widodo and Rahmarestia, 2008). Although agriculture is an emitter of CO_2 through the use of fossil fuels in tractors, combine harvested and other farm machinery or the use of synthetic nitrogen fertilizer, agriculture may also sequester considerable amounts of CO_2 in the soil. The main culprits are as laughing gas (N_2O) and methane (CH_4). Globally, agriculture accounts for about 50 percent of all CH_4 emissions and 70 percent of all N_2O emission. CH_4 is 21 times as powerful as CO_2 and N_2O even 310 times as powerful as CO_2. Adding to the 18 percent of climate effect was caused by deforestation, the 14 percent of global warming resulting from farming on the present agricultural acreage makes agriculture by far the single most important source of global GHG emissions (Von Witzke, 2008).

Bioenergy has been politically promoted as a means to mitigate air pollution, climate change, and scarcity of fossil energy sources (Schneider *et al.*, 2008). Bioenergy also has a variety of benefits including rural infrastructure development, employment, diversification of biofuel feedstock, beside as a climate change mitigation (Siregar and Thompson, 2007). However, the rapid expansion of global biofuel has potential impact on food security. Trade off between food shortages or increased food prices and biofuel production could be occurred.

This paper aims to discuss how to develop bioenergy under the climate change condition without weighing heavily in food security. Secondary data from appropriate sources were used to write it. Furthermore, descriptive analysis was used to discuss the problem.

2. Sustainable Bio-energy Development and Food Security

2.1 A brief concept on sustainable agriculture

Essentially, sustainable agriculture is an extended of conventional agricultural development and also a critical remark to the Green Revolution that only focused on how to produce large quantities of food for the current year. Since 1987, sustainable development has become a subject of discussion and debate, internationally. In 1990s, sustainability has become a significant issue in the United States and internationally since a number of scientists and laymen have persistently asserted their concern about conservation and the environment (Brady, 1990). Some concern with the dangers of excessive inorganic fertilizer and pesticide use mainly its application during the Green Revolution; other focus on the problems of soil and water conservation (Brady, 1990) and the health risks due to environmental damages (Satin in Clancy, 1990).

Sustainability can be defined differently but every one agrees that it considers the human needs of the future generations. In accordance with FAO Council (Kwaschik *et al.*, 1996), sustainable development is "the management and conservation of the natural resource base and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations". Such sustainable development (in agriculture, forestry, and fisheries sectors) conserves land, water, plant, and animal genetic resources, are environmentally non-degrading, technically appropriate, economically viable and socially acceptable. SEARCA (1995) defined sustainable agricultural system as a holistic farming system which economically viable, ecologically sound and friendly, socially just equity and acceptable, and culturally and technically appropriate. Basic principles of sustainable agriculture are (1) eliminating industrial production method and finding the effective, productive and inexpensive of external input system; (2) including more farmers, recognizing and understanding to indigenous knowledge for agricultural and natural resources management; and (3) conserving the active resources that integrated into production framework (Shepherd, 1998).

SEARCA (1995) also identified sustainable agriculture criteria, involves (a) economically viable agricultural systems have a reasonable return on investment of labor and cost involved and ensures a decent livelihood for the farm family; (b) ecologically sound agricultural systems are well integrated into the wider ecological system and the focus is on maintenance and enhancement of the natural resource base; (c) socially just agricultural systems respect the dignity and rights of individuals and groups and treat them fairly; (d) culturally appropriate agricultural systems give due consideration to cultural values, including religious belief and traditions in the development of the agricultural system, plans and programs; and (e) agricultural systems based on holistic science view agriculture in terms of farming systems and system approach and their relationships - biophysical, social, economic, cultural and political factors.

Criteria for evaluating sustainability of agricultural system are also introduced by Virmani and Eswaran (Maji, 1991). These include assessment of risks, assess-ment of production technology performance, stability of the system, impact of the farming system on the degradation of natural resources, particularly soil and water and the profitability of the system.

The overall goal of sustainable agriculture is to improve the quality of life. This can be achieved through: (a) economic development, (b) prioritizing food security, (c) placing high value on human resources development and fulfillment, (d) farmer empowerment and liberation, (e) ensuring a stable environment (safe, clean, balanced, renewable), and (f) focusing on long-term productivity goals (SEARCA, 1995). However, the success of sustainable agricultural development is strongly determined by two important factors, i.e. best management practices in agriculture and the government intervention (Sugino, 2003). Some of them are nutrient management by application of organic or biological fertilizer, integrated pest management, multiple cropping for reducing the crop damage and also producing different products, minimum or zero tillage, conserving soil and water management (Indradewa, 1996). Better use of local resources and natural processes as well as appropriate use of irrigation technologies could make farming more profitable, sustainable, and safe environment.

Dixon and de Los Reyes (Widodo, 1993) asserted the sustainability as constrained optimization to maximize benefit subject to natural resource base maintenance. Farming system research is very helpful and useful in achieving the goals of sustainable agriculture (Widodo, 1993). Farming system research can use the optimization farming system development model by using linear programming (LP) analysis. The LP model is based on input-output relationship for each crop and livestock subject to the availability and maintenance of natural resources. Linear programming models can be used to test the on-farm efficiency of resource use (Standen, 1972).

2.2 Bioenergy development and food security

Globally, 80 percent of total primary energy supply depends on fossil fuels—coal, gas, and oil (Kimble *et al.*, 2008). The world is currently burning about 85 million barrels of oil per day. The demand for high-speed diesel will increase to 66.9 mt by 2011–12, which is 1.6 times higher than that of the current demand. With increasing number of vehicles and industries, the demand would further increase (Gahukar, 2009). Indonesia, as an oil producer, holds proven oil reserves as 4.7 billion barrels. However, as the oil demand is increased, Indonesia has become a net oil importer since 2004 as described in Figure 5 (Widodo and Rahmarestia, 2008). Rising costs of fossil fuels compromise the ability of many developing countries to broaden access to energy, even as the use of such fuels worsens global climate change (Kimble *et al.*, 2008). Therefore, it is now imperative to search for new sources of bioenergy that would act as renewable energy.

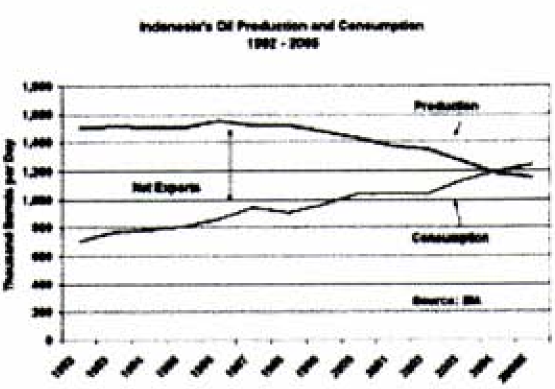

Figure 5. Oil production and consumption of Indonesia 1992-2005

Bioenergy is energy produced from organic matter or biomass. It can come from biomass that is burned directly or further processed into solid, liquid, or gaseous fuels (Siregar and Thompson, 2007). A number of agricultural crops can serve as feed stocks for bioenergy production. Cassava, cashew nuts, maize, sorghum, sugar beet and sugarcane are among the list of crops that are to be utilized for bioenergy due to sucrose accumulation and may offer an excellent alternative for ethanol production, while cotton seeds, rapeseed, soybean, sunflower, safflower, groundnuts, palm oil, jatropha, and ricin for biodiesel (Kimble *et al.*, 2008; Gahukar, 2009). But again, these are major agricultural crops. Of course, these crops can be supplementary or complementary. If food crops are used for bioenergy, the price of foods will be determined by their value as feedstock for biofuel, rather than their importance as human food or livestock feed (Siregar and Thompson, 2007; Gahukar, 2009).

Key facts are identified by FAO (2007) includes (a) bioenergy meets approximately 10 percent of global energy demand, around 80 percent of it as solid biomass for heating and cooking; (b) liquid biofuels account for less than two percent of road transport fuels worldwide; this is projected to rise to nearly five percent by 2030. Biofuels are already a small but rapidly growing contributor to the transport fuels market. In 2005, global fuel ethanol production was approximately 36,000 million liters and biodiesel approximately 4,000 million liters. This is sufficient to displace roughly two percent of global gasoline consumption and 0.3 percent of global diesel consumption. These amounts are modest but growing rapidly (ethanol at more than 10 percent per year and biodiesel at more than 25 percent per year) in the period 2000-2004. The world's top producers are Brazil and the United States for ethanol and Germany for biodiesel (Sagar and Kartha, 2007).

Bioenergy presents both opportunities and risks for food security (FAO, 2007). It could revitalize the agriculture sector, foster rural development, and alleviate poverty, not least by improving rural access to sustainable energy. It can generate employment and raise incomes in farming communities and spur rural development by providing a sustainable source of energy that is an affordable substitute for imported fossil fuels. Investments in bioenergy can increase harvests for both food and fuel crops. Bioenergy production may generate additional income and employment opportunities in the agricultural sector (Schneider *et al.*, 2008). A large scale expansion of biofuel for transport has the potential to make a significant positive contribution to the climate problem and to provide a source of income to support rural livelihoods (Sagar and Kartha, 2007). Sugarcane biofuel in Brazil accounts for 4.2 million jobs and palm oil in Indonesia is expected to create 2.5 million jobs next few years (Siregar and Thompson, 2007). The growing national and international demand of bioenergy is particular interest to developing countries for seeking opportunities on economic development (Widodo and Rahmarestia, 2008). In international bioenergy platform (FAO 2007) noted that bioenergy main benefits, i,e. impacts food security, improves livelihoods, reduces poverty, promotes employments and rural infrastructure, stimulates the double role of agriculture and forestry that includes reducing in carbon emissions, and producing in biofuel. But, if not managed sustainably, it could seriously threaten food security, hindering access to food for some of the most vulnerable. Figure 6 illustrates the relationship among bioenergy development, food security, and economic development.

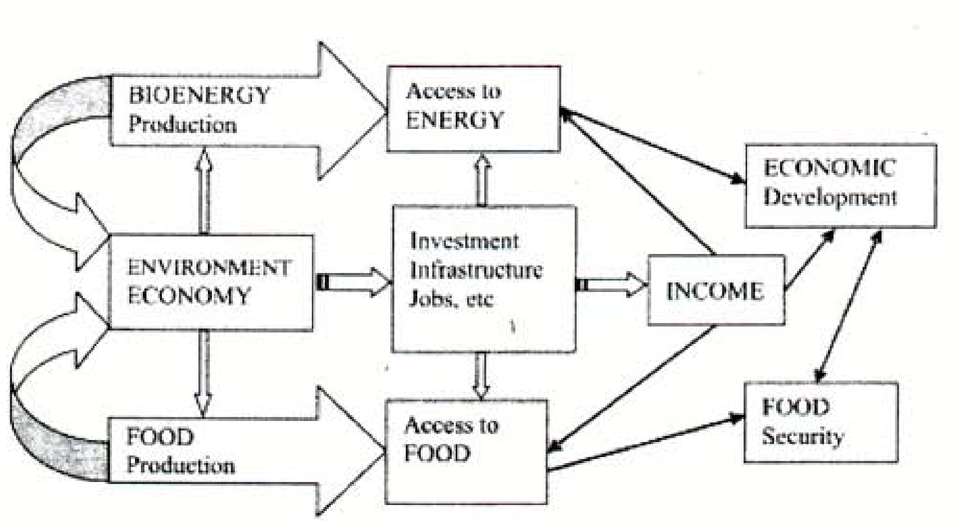

Figure 6. Bio-energy development and food security framework

On the other hand, Cassman and Liska (Siregar and Thompson, 2007) stated that the use of food crops for biofuels could lead to an increase in food prices and consequent undernourishment of the poor, particularly in those countries which are net food importers or experience regular food shortage. The growing bioenergy production allocates agricultural land and other inputs away from food production. Hence, the price of food increases even further. This aggravates the global problem of malnutrition. In fact, this is not the reality, as about 10 percent of the population in the world is still undernourished. Undernourishment is defined as having less than 9,200 kJ of food energy per day (Gahukar, 2009). Bioenergy also acts to increase the incentives for the rural poor in developing countries to burn forests in an attempt to claim additional land for food production (Von Witzke, 2008). Already today deforestation is the second most important source of GHG emission in the world, contributing about 18 percent to the anthropogenic global warming. The precise impacts of biofuels on food security are not clear and the relationship between the two requires further illumination. The effects of increased bioenergy production have particular bearing on food availability, and access to food. The extended to which biofuel production could threaten the availability of food supplies depends on the extended of land, water, and other production resources diverted away from food production. However, there are four dimension of food security (includes availability, accessibility, stability, and utilization) that needs to be considered. Given the opportunities and risks, criteria for the sustainable development of the bioenergy industry should be clearly established in both international and national regulatory frameworks.

Improving security of fuel supplies means producing more biofuel at home, but the biggest fuel consumers cannot produce biofuel as cheaply as some tropical countries (Banse, 2007). Indonesia has a comparative advantage for bioenergy production because of greater availability of land, favorable climatic conditions for agriculture and lower labor costs. However, Indonesia faces socio-economic and environmental implications affecting the potential to benefit from the increased local and global demand of bioenergy (Widodo and Rahmarestia, 2008).

In India, bioenergy development may be a solution to the energy security. In recent years, ethanol has emerged as the most important alternative source for biofuel due to increasing price, vulnerable supply and environmental pollution from petroleum fuel. Among non-edible oil sources, two forest trees, jatropha (*Jatropha curcas*) and pongam (*Pongamia pinnata*) have been selected for biofuel production in India. If plantation of jatropha is done on a large scale, the biodiversity of forest land will be reduced to a greater extent as most of the wasteland will be under these plantations. Under such a situation, pongam offers a better choice as biofuel because (a) it does not suppress any associated crop; (b) the tree supports the activity of microorganisms in rhizosphere since root nodules fix nitrogen; (c) it grows well in wasteland; (d) the tree has the ability to store carbon; (e) the tree parts do not contain allelo chemicals that have a harmful impact on the flora and fauna, and (f) seed contains 30–40 percent oil that can be converted to fatty acid methyl esters as biodiesel (Gahukar, 2009).

3. Conclusion and Implication

Climate change and agriculture are interrelated at least three ways, i.e.: (a) agriculture and land use change are significant contributors to GHGs emissions (mainly CO_2, CH_4, and N_2O); (b) agriculture is one of the first sectors to be affected by climate change; and (c) agriculture in many countries is develop in order to produce bioenergy that has important role as a climate change mitigation.

Rising costs of fossil fuels due to the increasing in the global oil demand compromise the ability of many developing countries to search for new sources of bioenergy that would act as renewable energy or affordable substitute for imported fossil fuels, even as the use of such fuels worsens global climate change. Bioenergy is energy produced from biomass that is burned directly or further processed into solid, liquid, or gaseous fuels. A number of agricultural crops can serve as feed stocks for bioenergy production. Among non-edible oil sources, two forest trees, jatropha (*Jatropha curcas*) and pongam (*Pongamia pinnata*) have been also selected for biofuels production. But, the major sources of the energy are agricultural crops. If food crops are used for bioenergy, the price of foods will be determined by their value as feedstock for biofuels, rather than their importance as human food or livestock feed.

Bioenergy presents both opportunities and risks for food security. Bioenergy development could revitalize the agriculture sector, foster rural development, generate employment and provide a source of income to support rural livelihoods (alleviate poverty), improve rural access to sustainable energy, increase harvests for both food and fuel crops, and make a significant positive contribution to the climate problem. But, if not managed sustainably, it could seriously threaten food security, hindering access to food for some of the most vulnerable.

Given the opportunities and risks, criteria for the sustainable development of the bioenergy industry should be clearly established in both international and national regulatory frameworks. The sustainable production and use of biofuels can increase energy security, foster economic development especially in rural areas, and reduce greenhouse gas emissions without weighing heavily on food prices.

Also, to minimize the potential trade-off between bioenergy development and food security, it is very important to develop a great research toward agricultural commodities with high yield potential for bioenergy production. The recommended biofuel crops can grow in difficult terrain (marginal land), need relatively little water, generates topsoil, help to stall soil erosion, and reduce GHGs emissions. And, as an incentive for effectiveness of bioenergy development, the policy implication is to reduce the fossil fuels subsidy and to increase bioenergy subsidy.

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