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Potential of Biofuel Crop Production in the Philippines: A Preliminary Analysis

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This paper examines the potential of biofuel crop production in the Philippines, in which the renewed interest in biofuel is reshaping the energy policies. The analyses presented here rely mainly on secondary data. Some of its salient findings point to strong public and private efforts to promote biofuels in the Philippines, sugarcane as a more feasible energy crop for bioethanol than corn and cassava, and coconut as a viable option for biodiesel. It warns, however, that reliance only on sugarcane to further the country's bioethanol policy will not be enough since the current level of sugarcane production will not be is not sufficient to meet future demand.

1. Introduction

The renewed interest in biofuel is reshaping the energy policies of many Asian developing countries. This interest is fueled by at least three major global developments, the impacts of which are felt domestically in these countries. First, the largely unabated increase in global price of fossil-based fuel has made these countries, most of which being petroleum-dependent, rethink seriously their short and long-term energy securities. Next, since some countries are thought to have the comparative advantage in producing energy crops, they also recognize that biofuels may not only make them less energy insecure but also may be a source of extra earnings. Lastly, the Kyoto Protocol, which is an amendment to the international treaty on climate change and assigning mandatory limitations for the reduction of greenhouse gas to the signatory nations[1)], brought to the forefront an unprecedented global awareness of and concern over the impact of greenhouse gases on climate change. Nations all over the world, therefore, are seeking for "cleaner and greener" options that do not compromise their development goals.

Biofuels are renewable and carbon neutral[2)] so that they are considered sustainable in contrast to the majority of liquid and gas fuels, which are fossil based with limited world reserves. As is generally known, there are two kinds of biofuels: biodiesel and bioethanol. Biodiesel is a fuel extracted typically from oils of coconut and oil palm. It is a natural hydrocarbon with little sulfur content, and can be used in diesel engines with very little or without any need for engine modification [1]. Bioethanol, on the other hand, is a form of ethanol, a light alcohol, produced by fermenting carbohydrates, such as starch or sugar, in vegetable matter. Sources of bioethanol being explored are corn, sugarcane, cassava, and sweet sorghum[3)].

Although the potential benefits of biofuel could be large, the literature shows vigorous and unresolved debates in terms of the energy efficiency, the land-use competition with food and the environmental impacts of expanding cropping into the forest [5, 7, 18, 19, 21]. Braun [6] states that biofuel is a win-win solution for developed and developing countries while Vordermayr [20] opines that it is not as green as it seems. In recent years, some specialists insist to shift to the second-generation biofuels, which are made from nonfood feedstock, like jatropha, and wood chips. However, the viability, or profitability, of these alternatives has not been fully established yet. Notwithstanding the ongoing debate, both developed and developing countries have made it a national resolve to anchor their respective energy policies on biofuels. Hence, evidences from rigorous studies need be accumulated to highlight the comprehensive impact of food-based biofuel on the state and future of our society. As a start, one can examine whether or not biofuel is sustainable alternative by analyzing the production structure and potential of energy crops in a country.

The field of the study is the Philippines. The country has just passed the Biofuel Act of 2007 that seeks to promote both bioethanol and biodiesel. It has a large potential of energy crop production for biofuels. Moreover, by considering the Philippines, we are emphasizing the fact that opportunities for biofuel development exist also in countries other than fairly established markets like Brazil and the United States. In this paper, we focus on the domestic balance of biofuel demand and supply, setting aside international trade, because it is enough as a preliminary approach to examine the production potential of the nation.

The rest of this paper first describes the data and method used in the study. Then the current production structure of possible energy crops is analyzed to examine the reserve of production. In section 4, it discusses, as backgrounds, the national or private financial programs as well as the national promotion policies. Section 5 examines the potential of energy crop production using fuel consumption data simulated by spline function. Conclusion and remarks are given in the last section of the paper.

2. Data and Models

The study relied mainly on secondary statistics[4]. Sugarcane, corn and cassava are chosen for the analysis on bioethanol while coconuts are done for biodiesel. The crop production data were collected from production statistics published annually by the Philippine Bureau of Agricultural Statistics. Real GDP (2000 base) and fuel demand data were obtained from the World Bank (World Development Indicators) and APEC Energy Database (http://www.ieej.or.jp/egeda/database/), respectively. The period covered varied depending on the availability of data. The APEC Energy Data, though updated only in 2003 were used since these are not only accessible but also credible enough. In addition, government biofuel targets are adopted from the policy or program documents of the Philippine government.

Forecast is a necessary process to examine the potential of energy crop production. For the sake of it, we apply smoothing spline technique to fuel consumption data. We know that GDP is typically correlated with fuel demand. On the other hand, understanding the comprehensive structure of demand is a bit difficult due to data limitation. Spline method is very useful in this case. A smoothing spline function $f(x)$ is obtained by minimizing the following formula.

$$\sum\left(y_i - f(x_i)\right)^2 + \lambda \int f''(x)^2 dx$$

The variables of y and x are a response (i.e., fuel demand) and a predictor (i.e., real GDP), respectively. Lambda (λ) is called a smoothing parameter and is standardized to fall within the range of 0 to 1. The first term of the formula measures the fitness to data, while the second penalizes the roughness of the spline function. To determine the degree of smoothing, the equivalent number of degree of freedom (hereafter, df) is specified[5] or determined by cross-validation (hereafter, cv), which is a model evaluation method based on the re-sampling.

3. Production Potential of Energy Crops

The objective of this section is to examine the supply potential of energy crop by using data that reflect the current production in the Philippines. There are no data on how much volume of crops is used only for energy production. The Philippines is eyeing four crops as sources of bioethanol, namely: sugarcane, corn, cassava and sorghum. The first-three crops are traditionally grown in the country, sorghum is not. Sorghum is, in fact, cultivated on a limited scale at field trial sites being of Northern Luzon. On the other hand, commercial production of biodiesel may rely on two main energy crops, coconut and jatropha, an indigenous shrub found in the country. The technology of refining diesel from coconuts is well established but not so for jatropha. In fact, there is no commercial manufacture of biodiesel from jatropha, to date. There are now nurseries propagating jatropha seedlings for the planned commercial production as an energy crop. No production statistics are available for sorghum and jatropha and therefore, are excluded in this paper.

Fig. 1 shows the historical performance of sugarcane in the Philippines in terms of the harvested area, the volume of production and the land productivity for the period of 1981 though 2005. The output of the production was highly volatile. The average was calculated at 21.2 million tons with the maximum of 25.6 million in 2004 as well as with the minimum of 13.8 million in 1987. As to area harvested, the maximum hectare was 416.5 thousand hectare in 1982, but the period of 1984 through 1992 saw the plummeting to the lowest level recorded at 215.6 thousand in 1988. The period is chronicled in Philippine sugar history as the worst crisis that hit the sugar-producing provinces. The crisis was brought about by a combination of world sugar price falling, severe drought in 1984 and two destructive typhoons after that. The trend of per hectare yield, however, was observed at almost flat level except for the crisis period, which means there is little technological change or little intensive input use in general. If the data of 1988-1992 were excluded in the computation, the average per hectare yield is 57.8 tons with the coefficient variation of 7.5% in contrast to 62.3 tons with the coefficient variation of 16% in entire period. This shows that the sugar crisis gave greater damage on marginal or low productivity area. The high level of per hectare yield for 1988-1992, such as 80.1 tones, might be considered as the Philippines sugarcane production frontiers.

Table 1 summarizes per hectare yield and harvested area of specific

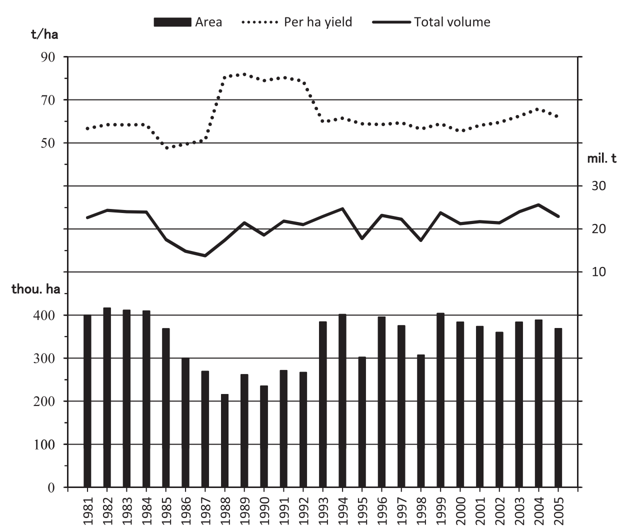


Fig 1. Sugarcane production, harvested area and per hectare yield, Philippines 1981-2005
Source: Bureau of Agricultural Statistics, the Philippines

Table 1. Mean values of per hectare yield (ton/ha) and harvested area (thou. ha) by specific countries, averaged for 2000-05

Countries	Sugar cane		Corn		Cassava		Coconut	
	Per ha yield	Area harvested	Per ha yield	Area harvested	Per ha yield	Area harvested	Per ha yield	Area harvested
Philippines	66.2	385	1.94	2,462	7.96	209	4.37	3,194
Indonesia	71.7	361	2.94	3,376	14.2	1,265	6.03	2,690
Malaysia	75.2	17	3.94	24	10.0	38	3.74	177
Thailand	57.8	1,015	4.94	1,125	18.0	1,039	5.37	307
India	65.8	4,178	6.94	6,874	26.9	230	4.93	1,888
Brazil	71.5	5,285	7.94	12,104	13.6	1,726	9.65	278
USA	74.2	401	8.94	29,018				
Japan	58.0	23						

Source: FAOSTAT

countries[6]. The area of the Philippines accounts only for seven percent of Brazil's, which is a world-leading country of sugar cane production and bioethanol production using sugarcane. This does not mean that the Philippines is insignificant to the biofuel crop market in the future. The possible increase of domestic and international demand for bioethanol will be large and therefore, even energy crop production of a minor producing country will definitely be counted.

The time series data show that output volume and per hectare yield of corn production exhibited a positive trend over the past two decades (Fig. 2). In fact, the average annual growth rates of output volume and per hectare yield are 1.8% and 3.3%, respectively. Such a change was mainly due to the tremendous growth of yellow corn with 6.6% per year. The Philippines planted mostly white corn prior to 1980, so that white corn contributed at 77% of total production in the period of 1981 to 1985. The share, however, was reduced to a mere 42% in the period

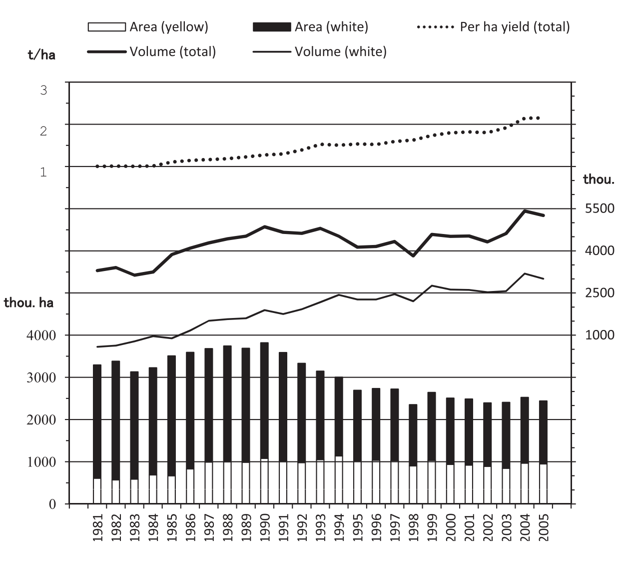


Fig 2. Corn production, harvested area and per hectare yield, Philippines 1981-2005
Source: Bureau of Agricultural Statistics, the Philippines

of 2001 to 2005. On the other hand, while there was sustained increase in total production, a declining trend happened in area harvested. Corn harvested area reached its plateau in the late 1980s and started to go downhill from 1990. This was mainly due to the continued decline in white corn, which was not a preferred feed ingredient. It should be noticed, however, that even though the performance of yellow corn is superior to that of white corn, the importance of white corn could not be overemphasized given the fact that 63% of the total area of corn production came from white corn during the period of 2001 to 2005. This shows that there will be a large potential of a switchover to yellow corn, preferred for bioethanol as well as feed, if bioethanol is demanded more in the energy market. However, there is a significant disadvantage since the productivity of corn farming is rather low as compared to other countries listed in Table 1, and this may reflect that the low technical efficiency of corn production in the Philippines [3].

For cassava, the average annual production hovers around 1.7 million metric tons planted in 210 thousand hectares that yielded 8.2 metric tons per hectare, on average during the period 1981-2005. The production of cassava is generally stable in terms of total production, harvested area and per hectare yield (Fig. 3). The entire size of production itself, however, is rather small and low yielding compared to the other counties in Table 1. All these facts seem to suggest that the current production is not enough apparently to satisfy the increased demand for ethanol production.

Coconut is a crop widely planted in the entire Philippines and is a major agricultural source of foreign exchange. For the period 1981-2005, average annual nut production was slightly less than 13 million tons. As shown in Fig. 4, while there were slight ups and downs in production throughout the 25-year period, the last period of 2001 to 2005 saw an upsurge in production which exceeded the 14-million level, reflecting the upward trend of bio-diesel demand. Although the land area devoted to coconut fell during the 1991 to 1995, 2001-2005 levels are

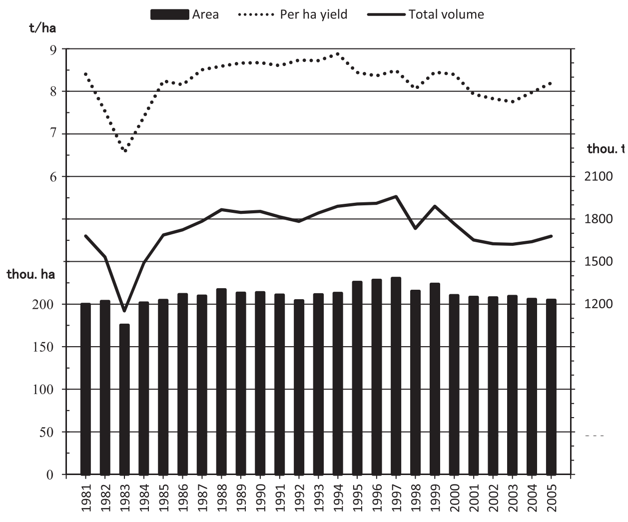


Fig 3. Cassava production, harvested area and per hectare yield, Philippines 1981-2005
Source: Bureau of Agricultural Statistics, the Philippines

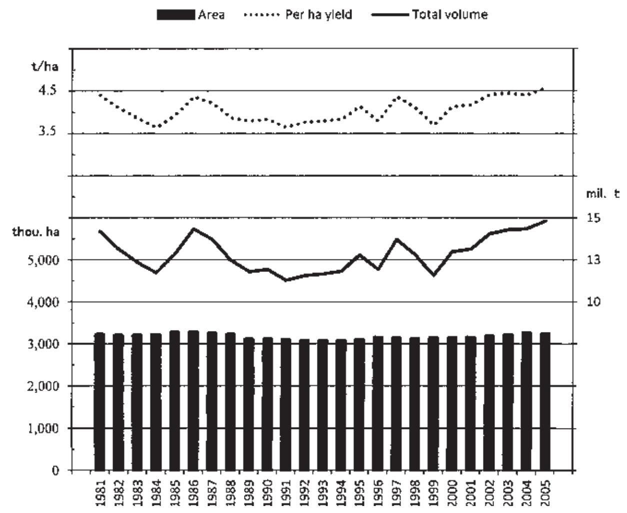


Fig 4. Coconuts production, harvested area and per hectare yield, Philippines 1981-2005
Source: Bureau of Agricultural Statistics, the Philippines

Table 2. Sugarcane production (thou. ton) by region, Philippines, 2005

Top five regions	Production	(%)	Top five regions	Production	(%)
[Sugarcane]			[Cassava]		
Philippines (total)	22,918	(100)	Philippines (total)	1,678	(100)
Central Luzon	1,202	(5.25)	Southern Tagalog	72	(4.26)
Southern Tagalog	1,766	(7.70)	Bicol Region	122	(7.28)
Western Visayas	13,072	(57.0)	Eastern Visayas	71	(4.21)
Central Visayas	2,080	(9.08)	Northern Mindanao	150	(8.96)
Northern Mindanao	2,875	(12.5)	ARMM	951	(56.6)
Top 5 total	20,995	(91.6)	Top 5 total	1,366	(81.4)
[Corn]			[Coconut]		
Philippines (total)	5,254	(100)	Philippines (total)	14,825	(100)
Ilocos Region	300	(5.71)	Southern Tagalog	1,484	(10.0)
Cagayan Valley	770	(14.6)	Eastern Visayas	1,765	(11.9)
Northern Mindanao	938	(17.9)	Zamboanga Peninsula	1,638	(11.0)
SOCCSKSARGEN	959	(18.3)	Northern Mindanao	1,549	(10.4)
ARMM	631	(12.0)	Davao Region	2,494	(16.8)
Top 5 total	3,598	(68.5)	Top 5 total	8,928	(60.2)

Source: Bureau of Agricultural Statistics, the Philippines

comparable with that of 1985-1990. Dwarf coconut, a height of at most thirty feet, bearing flowers after only three years and having higher productivity, has been widely disseminated even in the Philippines. However, nut yield per hectare seems to be pegged within the vicinity of 4 tons per hectare. In fact, this is barely on the international standard of land productivity (Table 1).

The regional distributions of crop production are summarized in Table 2[7]. The first column of the table shows the uneven distribution of sugarcane production in the country. While the regions of Central Luzon, Southern Tagalog, Western Visayas, Central Visayas and Northern Mindanao accounted for 92% of all domestic production in 2005, Western Visayas, especially Negros Occidental, was the most predominant area reaching half of the total output. As to corn, it came mainly from the regions of Ilocos Region, Cagayan Valley, Northern Mindanao, SOCCSKSARGEN and Autonomous Region of Muslim Mindanao (ARMM). The regional concentration of the corn production is fairly lower than that of the sugarcane production. The top producing regions contributed 68% to the total in 2005. Bukidnon (Northern Mindanao) and Isabela (Cagayan Valley) are traditionally considered corn-growing area. As for cassava, more than half of all Philippine output was produced in ARMM with the province of Lanao Sur accounting for almost 30% of the total production. The share of top five regions came to over 80% though it is not much of sugarcane. As to coconut, about 60% of all production came from five regions, namely: Southern Tagalog, Eastern Visayas, Zamboanaga Peninsula, Northern Mindanao and Davao Region. Coconut can be said most universal among the crops studied in this paper.

In order to assess the reserve of production, we need to review the balance of domestic supply and consumption for the specific crops (Table 3). In contrast to sugarcane, the production of which is fully sufficient for the current domestic demand, other crops, such as corn and cassava, depend somewhat on import. The quantity imported is not so large itself, but this suggests that those crops do not offer great reserve as potential suppliers of bio-ethanol feedstock. As for coconut, the export quantity largely exceeds the import. With a shift for food use to biofuel use on large scale in the country, the international market of coconut would be impacted since the Philippines is a major global exporter. Based on the discussions thus far, we conclude that sugarcane and coconuts offer better potential as biofuel feedstock of the Philippines than the other crops.

4. Biofuel promotion programs and production capacity

4.1 *Promotion programs*

The national government is steadfast in its promotion of biofuel as an alternative fuel source. In this section, we would like to provide an overview of the landmark biofuel law and other related policies, such as financial and credit support programs, and investments in biofuel infrastructure and facilities by the private sector in order to collect the basic data of demand projection and to assess the country's overall ability to launch the promotion of biofuels.

4.1.1. National Policies

The Biofuel Act of 2006 (also known as Republic Act 9367), signed into law in January 2007, laid out the national policy for the exploration of alternative sources especially energy crops for biofuel production and utilization. This biofuel law is integral to and a specific translation of the national government's Five-Point Energy Independence Agenda[8) [16]. The implementing rules and regulations (IRR) of the biofuel law mandate the transport sector of the country to have all amount of fuels consumed replaced with 5% (E5) and 10% (E10) blends in 2009 and 2011 for bioethanol , respectively and 1% (B1) and 2% (B2) blend for biodiesel in 2007 and 2009, respectively. The IRR also effectively established the National Biofuel Board (NBB)[9) and given the membership of key government ministries, the public sector involvement in the biofuel initiative is not only key but also strategic[10).

Two other biodiesel efforts of the government are worth mentioning. First is a memorandum from the Office of the President (Memorandum Circular No. 55) which directs all departments, bureaus, offices and instrumentalities of the government to incorporate the use of 1% by volume CME in diesel requirements. Second is the Jatropha initiative which aims to propagate Jatropha in 4 million hectares of denuded forestlands in the Philippines within 10 years as source of sustainable alternative fuel, establish pilot plantations of Jatropha, and a one-million metric ton biodiesel refinery amounting to P11.8 billion in Mindanao by 2010.

4.1.2. Financial supports and private sector investment

In November 2006, a one-billion peso Biofuel Fund was established, 50% of which came from the Philippine National Oil Company-Petrochemical Development Corporation (PNO-CPDC) and the National Development Company (NDC). The fund is earmarked for lands for marginalized landless farmers who wish to grow biofuel crops including but not limited to jatropha, sugarcane, corn and cassava. Also, the Land Bank of the Philippines, a government owned and controlled corporation, will be extending between five to ten billion pesos in financial assistance to finance the production and development of jatropha nurseries, plantation and the construction of refineries and other facilities for the biofuels development project [9].

While the government financial packages seem to be directed in stimulating the energy crop production, the private sector interest lies in the mainly in the downstream end of the supply chain like investments in distilleries and flexible fuel engine plants. Local and foreign firms have expressed their intent in establishing bioethanol plants in various

Table 3. Balance sheet of crops studied (thou. ton), 2003, Philippines

Items	Sugarcane	Corn	Cassava	Coconut Oil	Coconut (incl. Copra)
Production	30,000	4,478	1,622	1,473	14,122
Import	0	205	125	9	15
Export	0	0	5	1,233	694
Consumption					
Feed	900	3,375	65	0	42
Food	27,757	474	1,557	170	9,933
Others	1,343	833	120	78	3,468

Source: FAOSTAT

part of the country. For instance, Juan Miguel Zubiri, a Philippines Senator and a major author of the biofuel law, informed a recent new briefing that San Miguel Corporation planned to invest up to PHP 20 billion for the construction of 10 ethanol processing plants [15]. In addition, three prospective Filipino companies are expected to sign a contract with Nanning Yong Kai Industry Group, a Chinese firm that will invest USD 105 million for the construction of three bioethanol plants [4]. In December 2005, though going back a bit, Ford Philippines committed to invest PHP one billion to build a flexible fuel engine plant in Sta. Rosa, Laguna: this is a part of the commitment made by Ford Asia-Pacific and Africa to the President Gloria Macapagal-Arroyo to make the Philippines as its ASEAN Center of Excellence for Flexible Fuel Technology. These topics presented here show that the national and private actions to biofuels are positive and immediate[11].

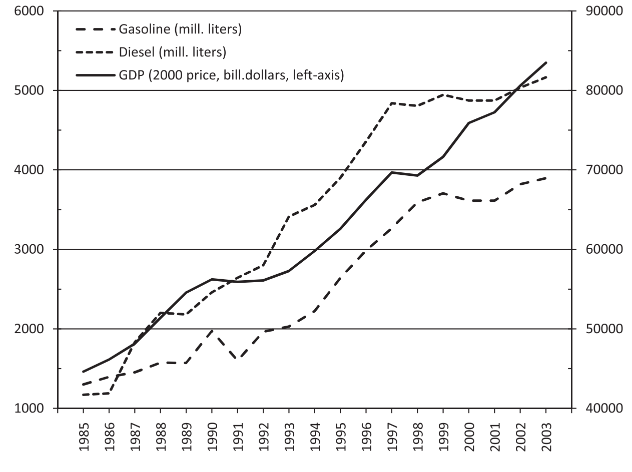


Fig 5. Trend of GDP and Fuel consumptions, 1985-2003, Philippines
Source: World Development Indicators and APEC Energy Database

4.2. *Production requirement for biofuel demand*

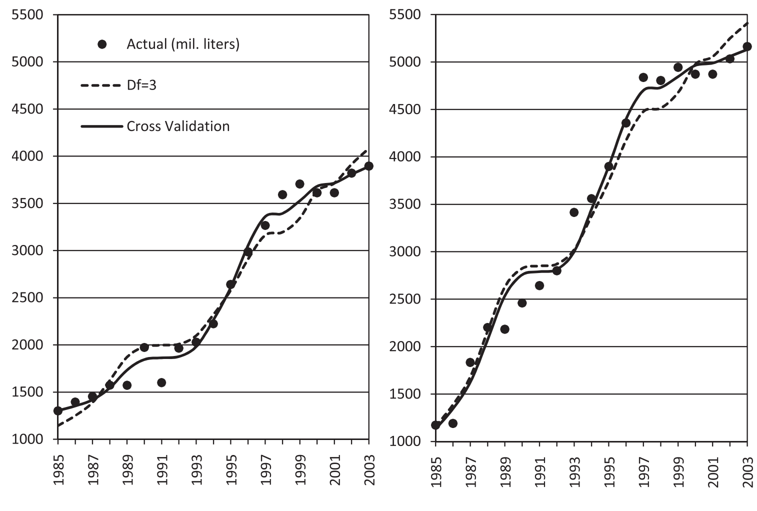
The Philippine wants to further its goals of biofuels. The movement is highly appreciated since biofuel is an environmentally friendly energy or contributes to global warming. Rapid and over expansion of biofuel production, however, would cause serious impacts on the environment and society. In this section, we try to estimate the harvested area of energy crops that is required to satisfy the projected increase of biofuel demand in order to examine the production capacity. The two crops, sugar and coconut, are the focus of the succeeding analysis.

The biofuel act requires the transport sector to replace all amount of vehicle fuels, gasoline and diesel, with blend ones. Fig. 5 shows the recent trends of vehicle fuel consumptions as well as real GDP, a possible regressor in spline function, of the Philippines. In the analysis, we use the total volume of consumption instead of per capita since the distribution of vehicle ownership in the Philippine is much distorted toward high-income classes, and therefore, average data, dividing the total volume by total population, will be misleading. The figure indicates that the amount of diesel consumption has outstripped that of gasoline for the most of the time-period studied, while both of them have almost parallel growth-pattern since the early 1990s. Real GDP grows more rapidly than the fuel consumptions, and especially, the difference becomes big for the recent several years. Although the power of real GDP to explain the variance of fuel consumption seems to decline with time, they are positively correlated to each other for the entire period, and therefore, we can confirm that the real GDP is one of good predictors of vehicle fuel consumption as a whole.

Forecasting future consumption of biofuel is difficult since the demand and supply structure is really complicated. We, however, tried it using an effective statistical method, such as a technique of smooth spline that is a kind of penalty regression and can make the best use of information that the data convey. The details of regression formula were described in the section 2. The estimated lines are drawn with actual values in Fig. 6. The two lines correspond to the different values of a smoothing parameter. The dash line denotes the case using a fixed value, df = 3, as a reference, while the solid lines do the case that the value is chosen based on cross validation, cv, in which the selected df is 5.30. The spline function using df = 3 exhibits more strongly long-run trend than using cross validation, which is sensitive to annual fluctuation.

Based on the estimation results of spline function, the projected demand for gasoline and diesel in 2010 and 2015 are calculated by type of blend percentage and by GDP scenario, in which the growth rates of real GDP are assumed at 1% as a lower bound and at 6% as a reasonable expectation[12] (Table 4). Although the IRR of the biofuel law mandates the use E5 and E10 blend gasoline in 2009 and 2011, respectively and B1 and B2 blend diesel in 2007 and 2009, respectively, we show here all of the results corresponding to combinations between blend types and scenarios. The table also presents, as a reference, a projection conducted by the Philippine Council for Industry and Energy Research and Development (PCIERD).

In 2010, given the E5 blend, the country needs 200 to 330 million liters of bioethanol, while this is expected to double when the E10 blend becomes mandatory. The difference between the GDP scenarios of 1% and 6% comes in the range of 1.3 to 1.5 times. In addition, a spline function estimated using df = 3 gives larger estimates, 1.1 to 1.3 times, than that using cross validation. On the other hand, the country needs 50 to 150 million liters of biodiesel according to the scenarios. The projection of PCERD as to bioethanol is close to a maximum value of our estimates, while biodiesel projected is located below our lower bound. Although the detail assumption of PCIERD estimates cannot be traced fully, their projection is more positive on bioethanol as compared to our estimation. The projections of 2015 are almost the same levels as 2010 in case of 1% GDP growth and are as large as 1.2 to 1.4



a) Gasoline consumption b) Diesel consumption

Fig 6. Spline smoothing of fuel consumptions

Table 4. Demand projection of biofuels and production capacity of energy crops, Philippines

Scenarios (d	Gas (mil. liters)	Bioethanol (mil. liters) E5	E10	Sugarcane land requirement (thou. ha) (a,(c E5	(%)	E10	(%)	Diesel (mil. liters)	Biodiesel (mil. liters) B1	B2	Coconut land requirement (thou. ha) (b,(c B1	(%)	B2	(%)
[2010]														
1% growth														
cv	4068	203	407	48	(13)	97	(26)	5283	53	106	110	(3.4)	220	(6.9)
df=3	4435	222	443	53	(14)	106	(28)	5740	57	115	120	(3.7)	239	(7.5)
6% growth														
cv	5117	256	512	61	(16)	122	(32)	6188	62	124	129	(4.0)	258	(8.0)
df=3	6528	326	653	78	(21)	155	(41)	7722	77	154	161	(5.0)	322	(10.0)
PCIERD (e	5650	283	565	67	(18)	135	(36)	4586	46	92	96	(3.0)	191	(6.0)
[2015]														
1% growth														
cv	4201	210	420	50	(13)	100	(27)	5398	54	108	112	(3.5)	225	(7.0)
df=3	4700	235	470	56	(15)	112	(30)	5991	60	120	125	(3.9)	250	(7.8)
6% growth														
cv	6354	318	635	76	(20)	151	(40)	7255	73	145	151	(4.7)	302	(9.4)
df=3	8995	450	899	107	(29)	214	(57)	10058	101	201	210	(6.5)	419	(13.1)

a: The conversion ratio in Lotilla (2007), i.e., 4200 liter ethanol per hector, is adopted.
b: The conversion ratio in Lotilla (2007) and Agribusiness Lands Investments Center (2007), i.e., 480 liters per hector, is adopted.
c: Percentage of land area requirement to the harvested area averaged for 2001 to 2005.
d: 1% and 6% denote real GDP growth rates assumed. cv and df denote cross validation and degree of freedom using in estimation of spline function, respectively.
e: Adopted from PCIERD (2007) "Biofuel S&T Roadmap," Draft, 15 January.

times of 2010 for bioethanol and 1.2-1.3 times for biodiesel in case of 6% growth.

The column "Sugarcane land requirement" shows that the harvested areas will be required to provide the sugarcane as feedstock of bioethanol to satisfy the projected demands and the percentages of it to the actual harvested areas averaged for 2001 to 2005. This holds true for coconut. The conversion ratio of sugarcane to ethanol and of coconuts to diesel are adopted from of Lotilla [14], i.e., 4200 liter ethanol per hectare and 480 liters per hectare, respectively, which are consistent with other reports [2, 11]. As in Table 4, around a half of the current sugarcane production has to be used for producing ethanol to satisfy governmental goal, while it requires at most around 10% as to coconuts. This shows the possibly large influence of ethanol promotion policy on the society and the environment as well as the feasibility of the biodiesel policy. If the government develops the capacity of bioethanol production, multiple polices are required: for example, policies pertain to the production promotion of other feedstock, such as corn or cassava, as well as policies to improve the production efficiency of sugarcane through extending proper cropping practices and introducing new variety or to improve farmers' allocative efficiency. Moreover, we should consider sufficiently monitoring or controlling environmental damages since more input-intensive and extensive production impacts significantly on environmental sustainability. The cost for monitoring or controlling the environmental problems will be another issue of biofuel promotion scheme. Although the percentage values of land requirement are very sensitive to the values of conversion ratio adopted, the conclusion is mainly sustained [13].

5. Concluding Remarks

Based on our discussion so far, we believe that sugarcane has greater feasibility as an energy crop for bioethanol than corn and cassava. Although corn areas are extensive, its productivity is fairly low as compared to the international standard. A lot of resources is required to approximate global productivity benchmarks and improve competitiveness. Moreover, ethanol from corn generally consumes more energy than other crops [9]. These make corn not a feasible option. As to cassava, the current size of production is too small to cover the future increase of ethanol demand.

The government, however, cannot rely only on the current production of sugarcane in carrying out bio-ethanol policy. The level of production is not fully enough to satisfy the future demand projected. Therefore, it will require improving farmers' efficiency or expanding croplands as well as to promote the production of other crops, such as corn or cassava. It should also be noted that environmental damages would be likely occur by introducing productive agricultural practices or expanding the land. The Philippine sugarcane has a structure that the production is concentrated in one region such as Negros Occidental. Seizing it positively, the government can efficiently monitor and control the damages through a policy that calls for Negros Occidental to specialize in bio-ethanol production since the costs will become high when monitoring places lie scattered over the archipelago. As for biodiesel, coconut seems to be the most feasible option for the Philippines. We are unable to examine the impact on the trade market of coconut or coconut oil because it is beyond the scope of this paper. In general, however, there is a possibility that the market is stringent given additional large increase in the demand for the Philippine biodiesel domestically as well as internationally. The government should seriously promote productive yet environmentally friendly coconut cropping practices.

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1) As of December 12, 2006, the 177 countries and other governmental entities have ratified the agreement.
2) "Carbon neutral" means a property of energy that can remove as much carbon dioxide from the atmosphere as we put it in by using the energy.
3) Conversion efficiency of biofuel is changed by feedstock, and biodiesel has an advantage of efficiency over bioethanol [10].
4) Data of biofuel production and consumption in the Philippines are not generally open to the public at this moment.
5) There is a strict relationship between λ and df. For details, see Cantoni and Hastie [8].
6) Although the data of the Philippine Bureau of Agricultural Statistics used in this paper is not exactly the same as that of FAOSTAT, they give consistent conclusions in terms of long-run change.
7) You can confirm the entire six-teen regions of the Philippines at http://www.tourism.gov.ph/explore_phil/explore_main.asp#1
8) The agenda calls for the development and utilization of: indigenous sources, e.g., (1) coal, (2) alternative fuels, e.g., biofuel, (3) renewable energy resources while forging (4) strategic alliance with other countries, and (5) implementing efficiency and conservation measures.
9) According to the Department of Budget and Management (DBM), the NBB staffing and operations budget of 90 million pesos is incorporated in the operations budget of the Department of Energy [17].
10) For instance, the Department of Energy is responsible for providing leadership and coordination in the designing of the national biofuel program. On the other hand, the Department of Agriculture is tasked with ensuring the sufficient and stable supply of energy crops through its various crop production programs, and the Department of Science and Technology is mandated to ensure that appropriate research, and technology development and commercialization are done on the production and utilization of biofuels.
11) In our understanding, the Philippines government has no policies to import biofuels or to give direct financial support, either price or income subsidy, to farmers, though the productivity or competiveness of Philippine biofuels is fairly low as compared with countries like Brazil. However, some pilot research activities, like

jatropha seedling production, have received some grants from the government.

12) International Monetary Fund [12] forecasted that the Philippines economy of 2008 would grow by 5.8 percent in GDP.

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比国バイオ燃料作物の生産可能性に関する予備的分析

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摘　　要

本研究は，バイオ燃料によるエネルギー政策の推進に関心が高まっている比国において，バイオ燃料作物の生産ポテンシャルの現状を統計データに用いて検討したものである。分析結果は，政府や民間企業は共にバイオ燃料の普及に積極的であること，比国ではエタノールについてはサトウキビが，ディーゼルについてはココナッツが相対的に有力な原料作物であること，しかし，国が掲げるバイオエタノールの導入目標を達成するには，サトウキビのみに原料を頼ることは生産余力の観点から適当ではないことが明らかになった。