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Feasibility of Wild Grass Exploitation for Bio Fuel Production

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Abstract: Cultivating fuel crops is planned in Papua New Guinea. In order to evaluate the production potential, available land which is covered by grass was found by satellite image analysis. Comparing between the input of the energy to the project and reduced amount of CO_2 emission, ethanol fermentation process consumes a lot of energy and makes negative impact on CO_2 emission totally. Power generation with the local grass is suggested as alternative energy for it.

Keywords: CO_2 emission, Ethanol production, Grass land, Satellite image analysis

1. Introduction

Recent jump in crude oil price induces not only the focus on bio fuel, but also the food price rising. Present situation is the beginning of shifting to the new generation of energy, so that there are a lot of cases that the farmland for food crops are changed to that for energy crops because of easy obtainment. As a result, it has been said that bio fuel production causes the incident of the early food crisis on some occasions. However, strictly speaking, appropriate developments of bio fuel in marginal land such as grassland, which has not been cultivated for food crops or dense forest, surely contribute to that issue without the significant impact on local economics and environment.

Another discussion on bio fuel is energy input and CO_2 emission balance for that production; harvest, transport, process and feedstock. Some critics argue that bio fuels will demand more energy than they produce[A)]. Transportation of resource and products, agricultural activities and ethanol production processes consume a lot of fossil fuel in the conventional processes.

This study shows the feasibility of bio fuel project in the concrete site with the advanced exploitation of local resources. First, the available area in the study site was identified by the satellite image analysis, then candidate crops are defined and ethanol production potential was evaluated. The reduction of CO_2 emission was compared with the input energy to the project. Finally, the solution for the negative cases in the CO_2 emission was suggested.

2. Study Site

The study site is located in Papua New Guinea (PNG), one of South Pacific countries. The area of PNG is 462,840 km² (1.25times than Japan). The population is 6180,000, thus population density is 13person/km² (Japan 343/km²). This situation shows this country remaining undeveloped land for agriculture and high potential of new agricultural development. Current life style in PNG is Self-sufficiency. Because of the shortage of logistics, the farmers cannot access to the market and they only cultivate the food of their consuming amount without excess production irrespective of enough land for commercial agriculture under the adequate climate. These situations keep this country in low economical growth. The study site was defined on East Sepik Province whose capital is Wewak. North bank of Sepik River is a large vacant grass land.

3. Satellite Image Analysis for Finding Grassland and its Land Potential for Agriculture

Satellite image analysis is carried out focusing on the study site for finding the available grass land. Unsupervised categorization is applied using the parameters of bands 1–6 of the LANDSAT image of 16 September 2002. Comparing the ground truth survey, categorizing to eight groups clearly indicates the grassland (the black area in **Fig. 2**). There are flood plains along Sepik River. This area is considered to be unavailable for agriculture. Excluding the flood plains, the total available grassland is about 2,000 km^2.

Shuttle Radar Topographic Mission (SRTM) data is downloaded and overlaid on the map. There is

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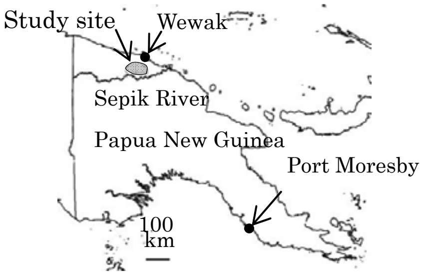

Fig. 1. Location of the study site.

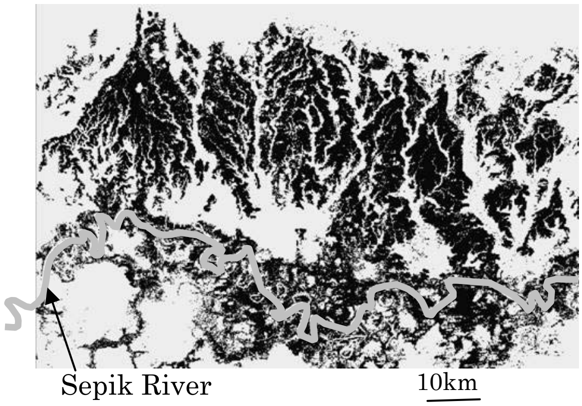

Fig. 2. Finding the grass land by the satellite image analysis of unsupervised classification. Black area shows the grass land.

a gentle slope from the north to the Sepik River, and the southern part of the land is almost completely flat. The flat area would be waterlogged in the rainy season. On the other hand, the hilly areas in the north part would contribute to the drainage of surface rainwater.

The topographic characteristics indicate that the drainage capacity of the soil in the southern part might be a problem for agricultural activities. A soil survey was performed in the southern part and water permeability was measured, which was 10^{-9} m/s. Drainage characteristics, evaluated by the pF (potential free energy) test, were very low. The clay soil, containing large amounts of water, was not suitable for root crops such as cassava, sweet potato and yam potato, which are typical candidate fuel crops in this area. In areas with soils of this kind, sugarcane, rice and sago palm would be candidate crops for bio ethanol production.

4. Simulation for Ethanol Production and Its CO_2 balance

In this study, four kinds of crops are listed as candidates for fuel crops: sugarcane, cassava, rice and sago palm. These crops would be cultivated on land suitable for them. However, detailed soil distribution data have not been obtained. It is assumed that each kind of crop is cultivated on one-fourth of the total area: 500 km^2 each. Aramaki *et al.* (2008) calculated the ethanol production potential from statistical data for each crop. **Table 1** shows the calculated ethanol production for each crop.

Aramaki *et al*. (2008) discussed life cycle assessment with regard to CO_2 emission. **Fig. 3** shows project emission, which is the total emission from seeding to processing into ethanol. In the case of sugarcane, the residue after squeezing the sugar juice can be exploited as fuel. Some former studies showed that the energy extracted from the residue is adequate for the process of ethanol fermentation. Thus, project emission is much lower than the baseline emission (shown as 'Emission curtail' in Fig.3). On the other hand, cassava needs energy for saccharification and fermentation. As a result, project

Table 1. Ethanol production capacity of each crop.

	Sugar cane		Cassava		Rice (Hokuriku193)	Sago palm
	min	max	Min	max		
Development area (km^2)	500		500		500	500
Row material yield unit (Mg/ km^2/365d)	5120	6900	1563	3125	1000 (1 harvest a year)	4000
Row material for $1m^3$ Ethanol (Mg/ m^3)	12.7		4.46		2.5	6.67
Ethanol production (10^3 m^3/365d)	202	272	175	350	200	300

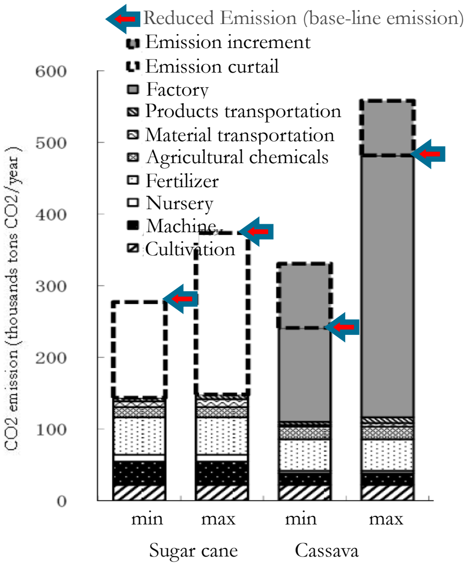

Fig. 3. Comparison between "Base-line emission" and "Project emission" for Sugarcane and Cassava.

emission exceeds baseline emission. Rice and sago palm show the same result. For these crops, alternative energy resources covering the amount necessary for the process from raw material to ethanol are required.

5. Grass as Energy Resource for Ethanol Production

The study site is covered with grass, locally called Kunai grass. Kunai grass is not exploited by the local people under the current situation but it is known to grow rapidly. This grass can be considered as an available resource for energy production. In this study, part of the land would remain as grassland and the harvested grass would be used for biomass power generation.

Power generation from Kunai grass is estimated by formula (1):

$$W=P * LHV * C \quad (1)$$

W: Power production

P: Yield amount(kg), LHV: Lower heat value (J/kg)

C: Power generation efficiency coefficient (0.278 kWh/MJ)

P and LHV is estimated by the field survey shown as below

5.1. Grass yield

The weight of grass per unit area (2 m × 2 m) was determined. Sampling points are shown in Fig. 2. At the first harvest on 4 June 2008, 2500Mg/ km^2 was harvested on average. After the first harvest, the local people helped to measure the height of the grass every week because our laboratory is a long distance from the site. **Fig.4** shows the average height of five grass plants. Two months after harvesting, the plants had already approached their maximum height. Plant density was not observed in this study, but leaf density would increase after the plants have reached their maximum height. As a rough estimate, harvesting could be done every 4 months, i.e. three times a year.

The second harvest was carried out on 26 October 2008. The amount harvested was 1130 Mg/ km^2 on average. This was less than the first harvest. The first harvest included dead grass that had accumulated over a long period. Therefore, yield at the second harvest, 1130Mg/ km^2, represents the true yield of grass.

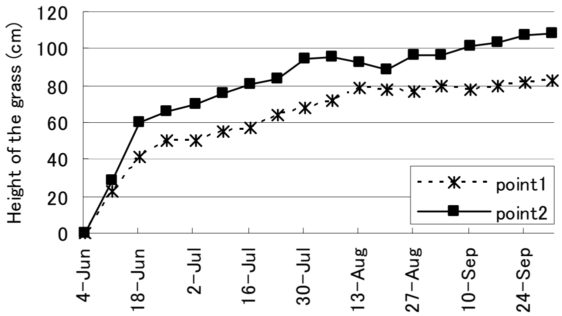

Fig. 4. Growth of Kunai Grass.

5.2. Lower heat value

At the first harvest, the grass was sampled to measure the heat value. The higher heating value of complete dried grass was 16.8 MJ/kg. Considering the water content at the second harvest (53.3%), the lower heat value was 6.47 MJ/kg. From these numbers, the power production potential of the grassland is 1210 MWh/km^2.

5.3. Power generation potential of the grass land and master planning of crops and grass land

The energy demand for the production of 1 m^3 bio ethanol is 9660 MJ heat and 300 kWh electricity. This energy can be produced from 700 m^2 of the grassland.

On the other hand, 1800-2500 m^2 of sugarcane field, 1400-2800m^2 of cassava field, 2500 m^2 of rice field and 1700m^2 of Sago palm field can produce 1 m^3 ethanol. Therefore, 22–28%, 20–33%, 22% and 29% of the original grassland should be reserved for sugarcane, cassava, rice and Sago, respectively, and used to supply energy for fermentation. This means that the ethanol production from 500 km^2 of the four crops would be 157–195, 140–235, 157 and 213 (m^3/365d) respectively. In total, 667,000–800,000 m^3 ethanol could be produced from the land per year. In order to replace the entire amount of gasoline consumed in Japan with E3 (3% ethanol blended gasoline), 1,800,000 m^3 of ethanol is required. Therefore, this project site could produce around 40% of this requirement.

6. Conclusions

The available grass land area for the bio ethanol production was evaluated by the satellite image analysis. It was about 2,000 m^2. Based on the result of soil characteristics and topography, the four candidate crops were defined. The life cycle assessment for the crops shows the project emission is above the base-line emission except the case of sugar cane. For alternating the fossil fuel consumption in the fermentation process, the biomass power generation is suggested. Part of the land should remain as grass land for power generation.

Annotation

A) http://www.nature.com/climate/2008/0801/full/climate.2007.71.html

References

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