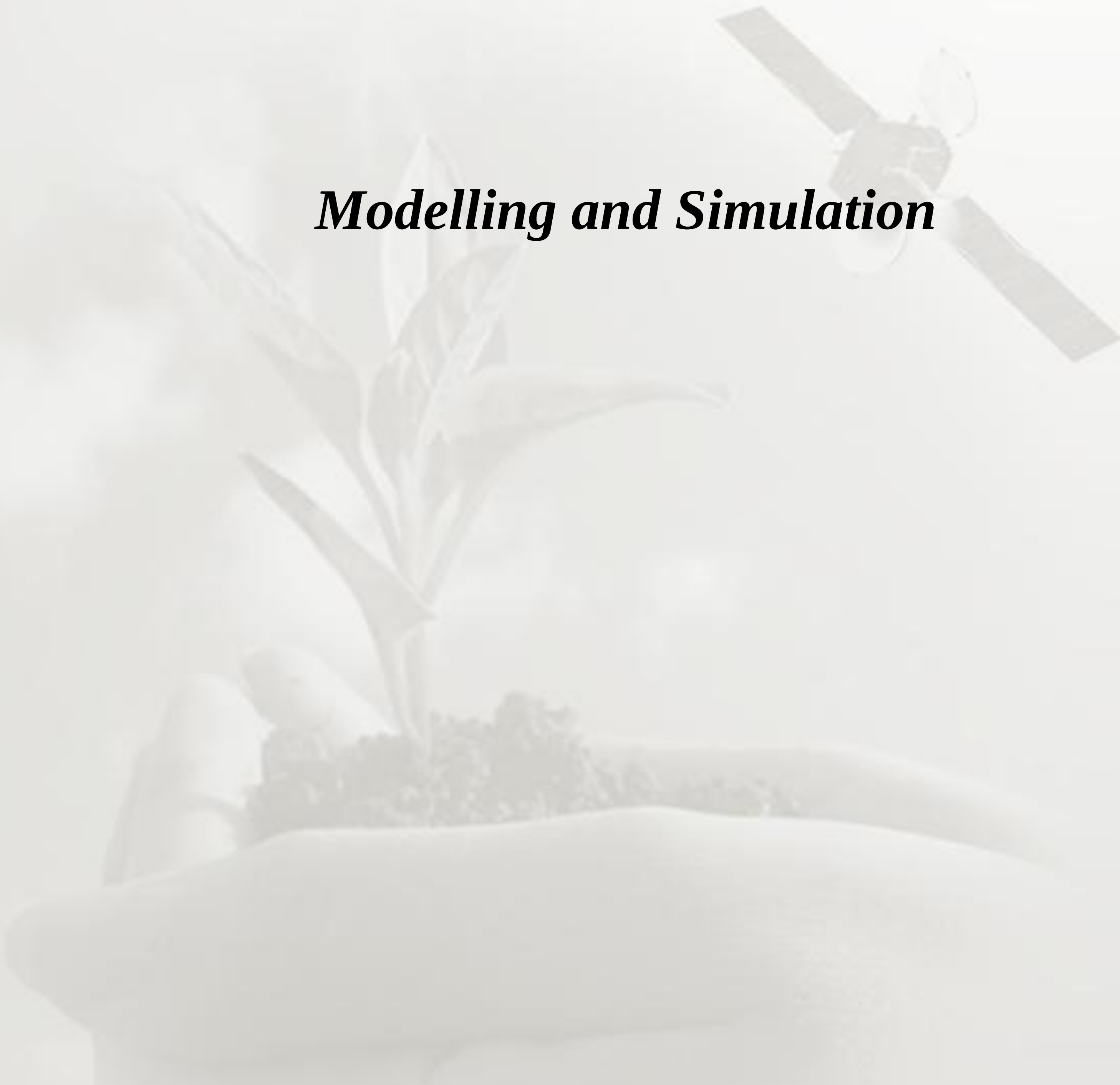
Modelling and Simulation



Simulating Bioethanol Production from Sago Palm Grown on Peatland of West Kalimantan, Indonesia

Evi Gusmayanti, Maherawati, Ari Krisnohadi, Sholahuddin
Faculty of Agriculture
University of Tanjungpura
Pontianak, Indonesia
vie_tep02@yahoo.com

Abstract— **Bioethanol is one of renewable energy which is becoming a hot issue as energy crisis crushed almost all countries world wide. It is produced from starchy cellulose-rich plants such as rice, corn, cassava, sugarcane, sorghum, and sago palm. In Indonesia, sago palm is a potential candidate to be used as a raw material for bioethanol production. Beside its benefits such as high starch productivity, relatively sustainable, environmental friendly and multitude of usages, sago starch is not widely consumed as staple food. Therefore using this starch may not adversly affect food security. In West Kalimantan, peatland is a potential area for growing sago palm. It can thrive and nourish on these swampy areas without high external input as do for many other crops. Given the data of sago starch production, we simulate the production of bioethanol by using conversion factor from starch into bioethanol. Applying scenario of growing sago palm along river bank (up to 200 m, 400m, 600m, 800m, and 1000m from the river bank), bioethanol production were mapped.**

Keywords- bioethanol, peatland, sago palm, west kalimantan

I. Introduction

The high price of fossil fuel due to oil depletion leads a lot effort to find alternative energy sources. Bioethanol is one of the alternative energy sources that is believed to be sustainable and environmentally friendly. It is produced from starchy cellulose rich plant, such as rice, corn, cassava, sugarcane, sorghum, and sago palm.

In Indonesia, sago palm seems to be a potential feedstock for bioethanol. Its productivity can reach up to 25 tonnes of dried starch per hectar per year [1]. It is much higher compared to other starchy crops such as rice and corn which is about 6 tonnes/ha and 5.5 tonnes/ha respectively [2]. Sago palm is relatively sustainable, once cultivated it is not necessary for re-planting since it is propagated majorly by suckers. It is also environmental friendly, it can grow well with no or minimal external input and management practices lead to low negative impact to its environment. Moreover, sago starch currently is not widely consumed as staple food [3]. Therefore the moral issue againts food security can be minimalized.

Given the fact that sago palm can thrive and nourish on swampy and acidic peat soils which are unsuitable for other crops, it can be a promising commodity in West Kalimantan where 1.9 million hectares of peat soils are found. Currently peat land in this province is reclaimed for agricultural practices with low until high external input to be optimally productive. Reclamation of this peat land seems permissible due to economic pressure for food and energy supply. However the environmental issue comes into concern in recent years. Exploitation of peat land is believed to be a significant source of carbon lead to the increasing of greenhouse gas emission. In line with the issue sago palm is a promising crop, since it can grow naturally without draining the peat and no application of fertilizer [4]. Indeed, to ensure optimal production, improvement of soil quality is necessary.

The paper is addressed to describe the opportunity of sago palm as bioethanol feedstock. By applying scenarios of growing sago palm along river bank at different distances from the river, potential sago starch and the potential bioethanol produced from it were mapped.

II. Methods

A. Study Area

The study area was West Kalimantan Province, located in the western part of Borneo Island (Fig. 1). The province covers about 14.7 million hectares, which is 13.41% of these area (around 1.9 million hectares) are peatland (Table 1). Of 44% of this peatland is categorized as deep peat (peat depth more than 2 meter), and the remaining is shallow peat (44%) and moderate peat (12%).

B. Maps and Data

The maps used during the study consist of administrative map (scale 1: 100.000), land system and land suitability map (scale 1:250.000), forest and water conservation area map (scale 1:250.000), and landcover and landuse map (scale 1:250.000). While the ancilary data were obtained from literature and published statistical data.

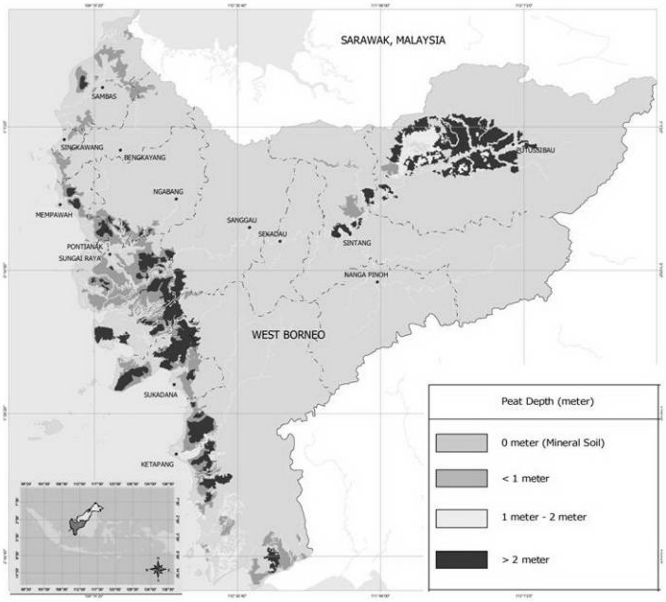


Figure 1. Map of West Kalimantan and distribution of peatland over the area

TABLE I. COVERAGE OF PEATLAND IN WEST KALIMANTAN

Peat Depth	Area (hectare)	Percentage (%)
Shallow (<1m)	877,538	5.96
Moderate (1 – 2 m)	233,472	1.59
Deep (>2 m)	863,396	5.86
Peat Area	1,974,406	13.41
Province Area	14,722,531	100.00

C. Methods

The workflow of this study is shown in Fig.2 The peatland coverage was cropped by conservation areas (such as conservation forest and mangrove areas) based on Regulation from Ministry of Forestry and Plantation to get the cultivable peatland areas. The large scaled plantation as well as rice cultivation areas were excluded from the cultivable areas, and hence available areas for sago palm were obtained for further simulation. Since sago palm naturally grows along river banks, we made five scenarios based on distance from river, at every 200 meter of distance. The consideration was also based on facts that sago palm cultivation practice requires river or water canal to ease transportation process to reach sago starch extraction factory which is always located near the river. Indeed, large commercially managed sago plantation usually build canal networks over the plantation, and therefore distance from river is not a major limitation. The potential sago starch production then was mapped, as well as its potential bioethanol production.

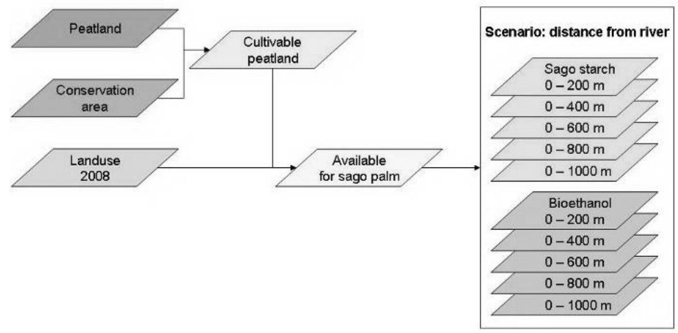


Figure 2. Flowchart of simulation sago starch and bioethanol production on peatsoil of West Kalimantan, Indonesia.

III. RESULTS AND DISCUSSION

A. Potential Production of Sago Starch Grown on Peatland of West Kalimantan

The available areas of cultivable peatland in West Kalimantan is estimated to be 485508 hectares, of 215728 hectares are located up to 1000 meter from river, and the remaining, 269779 hectares are located more than 1000 meter from river (Table 2).

Regarding to classification of peat depth into three categories, the potential production of peat was also classified into three classes. Sago palm grown on shallow and moderate peat are assumed to be productive (≥10 tonnes of dried starch/hectare), while those on deep peat are assumed to be unproductive (less than 10 tonnes of dried starch per hectare). The estimation is based on common practice of sago palm cultivation observed in West Kalimantan. Even all the sago stand found is categorized as cultivated stands, almost no maintenance practice. Therefore the potential production of sago starch is estimated to be lower than that with well management practice such as sago palm plantation.

As shown in Table 1, suitable areas with potential production of sago starch ≥ 10 tonnes of dried starch per hectare are found around 36% of available area in the distance up to 1000 meter from river, and 27 % of available areas are located more than 1000 meter from river. Example of potential sago starch production at four distances from river is shown in Fig 3.

TABLE II. AVAILABLE AREA FOR SAGO PALM CULTIVATION ON PEATLAND AT VARIOUS DISTANCES FROM RIVER

distance (m)	Area (hectares)			
	shallow peat	moderate peat	deep peat	total
0-200	30,690	4,721	8,146	43,557
200-400	29,046	4,774	8,089	41,909
400-600	28,876	5,011	8,442	42,329
600-800	29,617	5,050	8,805	43,472
800-1000	30,099	5,251	9,113	44,463
>1000	115,881	13,399	140,500	269,779
total	**264,208**	**38,206**	**183,094**	**485,508**

The deep peat (peat depth >2m) is assumed to be unsuitable for sago palm. According to direct observation, almost no sago stands found in deep peat. It may due to poor quality of soil nutrient in peatland. However, application of soil treatment to improve soil nutrient quality and sufficient management of water table, growing sago palm on deep peat may be economically feasible.

B. Potential Production of Bioethanol from Sago Palm

Sago starch is a promising feedstock for producing bioethanol. It is estimated that 10 tons of dried starch can produce 6 kilolitre of bioethanol [1]. Example of potential production of bioethanol from sago starch is mapped in Fig. 4.

If 75% of suitable areas (without limitation of distance from river) are cultivated with sago palm, it will produce 2268100 tonnes of dried starch per year. With conversion factor 0.6 kilolitre bioethanol produced every one ton of starch; it implies that there will be 136 thousand kilolitres of bioethanol potentially produced every year. In year 2007, gasoline consumption in West Kalimantan was about 275 thousand kilolitres [5]. As government policy to use 10% of bioethanol in fuel mixture (gasohol) by year 2015 [6], the requirement for bioethanol will be at least 27.5 thousand kilolitres. It means that West Kalimantan potentially has energy surplus (in form of bioethanol) available to support other areas in Indonesia.

The other prospective feedstock for bioethanol is sago palm biomass. It is estimated un-utilized biomass is about 200 kg per palm, consist of 75 kg bark and 125 kg leaves, or about 20 tonnes biomass per hectare. If 75% of this biomass can be converted into bioethanol, there will be additional 15 tonnes biomass which can increase bioethanol production significantly. However the conversion of biomass into bioethanol is still in perspective, but it is not impossible to be applicable in the near future.

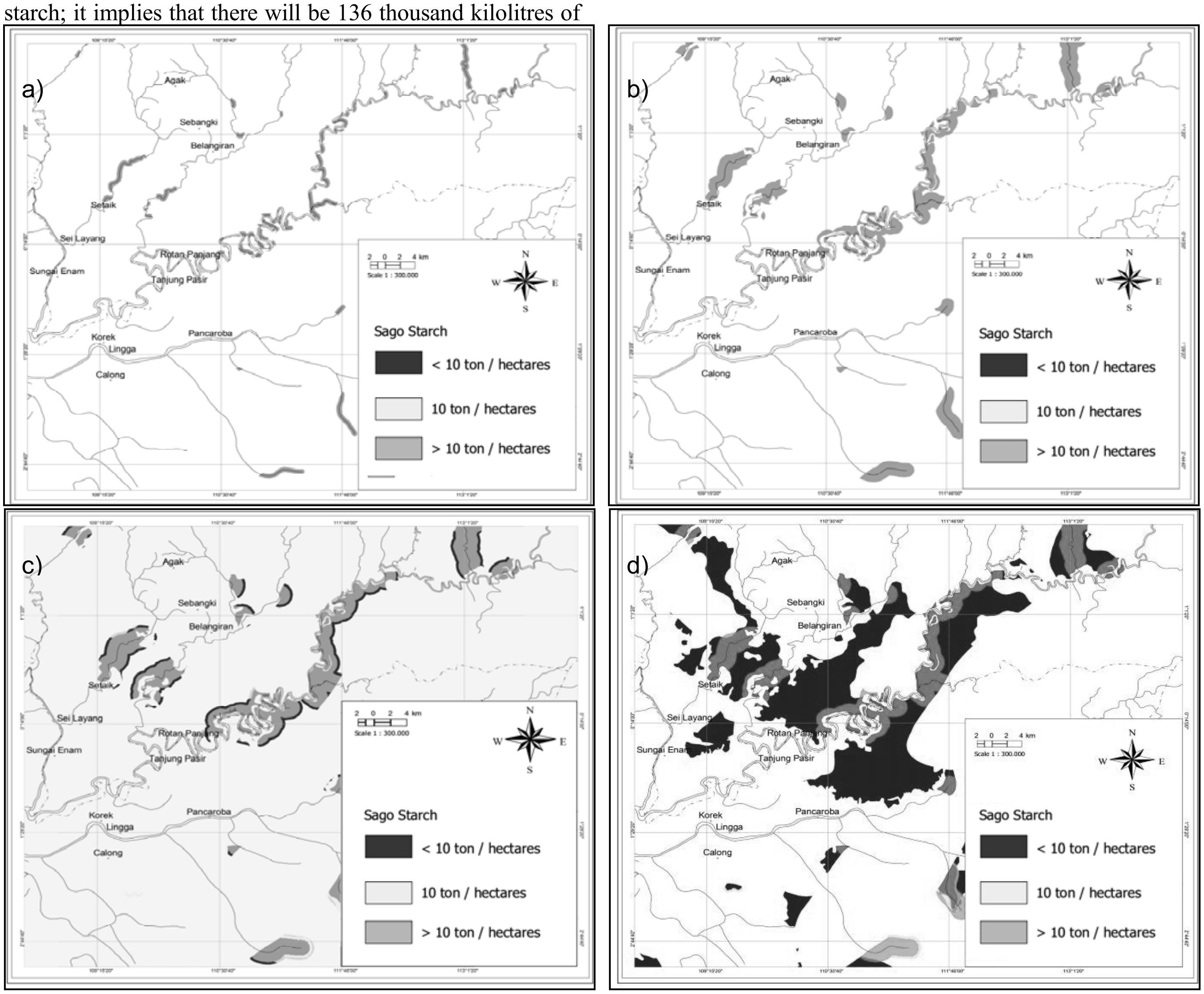


Figure 3. Potential sago starch production along river bank in West Kalimantan at various distances, i.e. a) 0-200 m, b) 0-600 m, c) 0-1000 m, and d) all distances from river

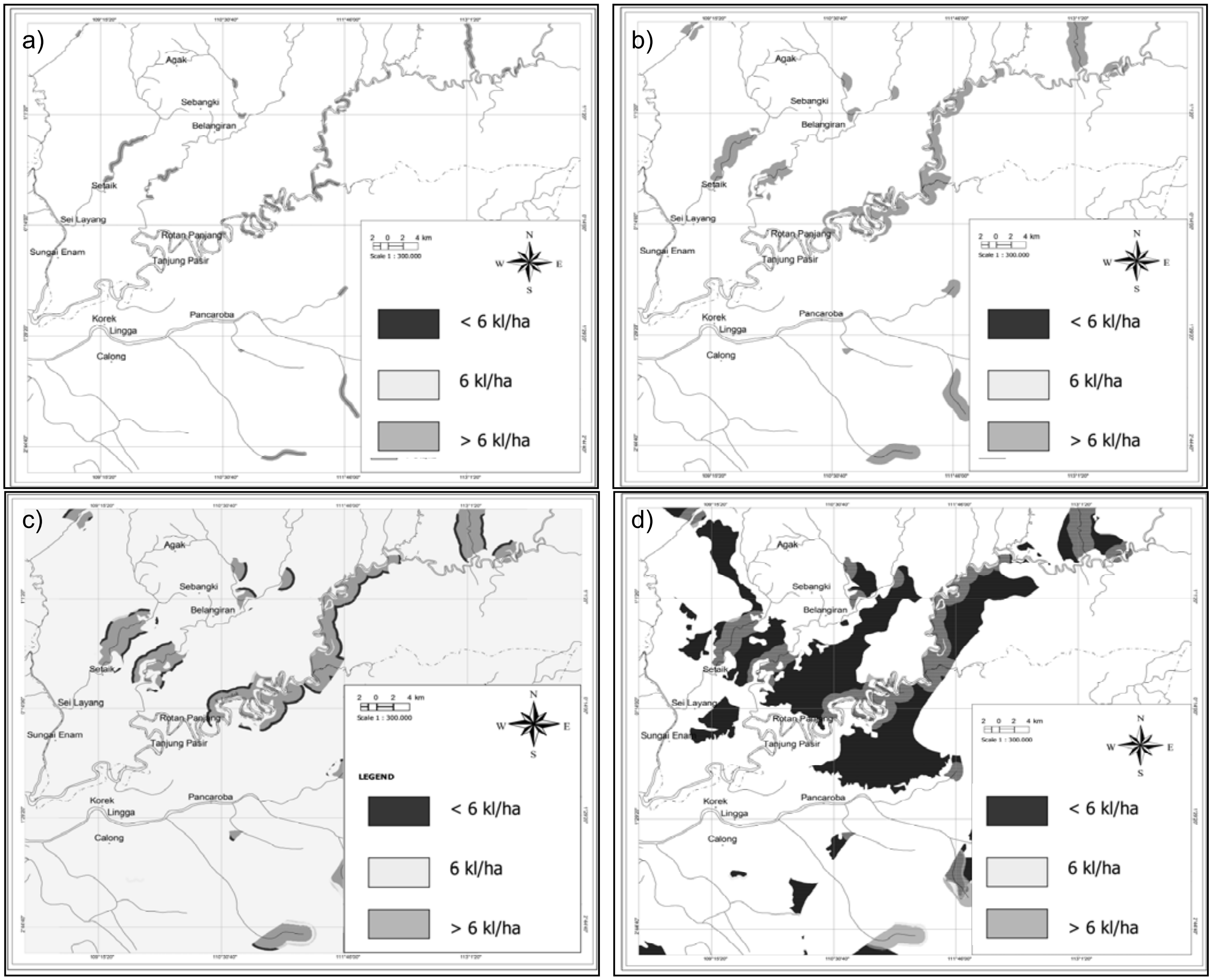


Figure 4. Potential production of bioethanol along river bank in West Kalimantan at various distances, i.e. a) 0-200 m, b) 0-600 m, c) 0-1000 m, and d) all distances from river

IV. Conclusion

Sago palm is a prospective feedstock of bioethanol that can be grown on peatland of West Kalimantan, Indonesia. Based on common practice in the region, sago palm can produce starch at least 10 tonnes of dried starch per hectare on shallow and moderate peat. It is potentially equal to 6 kilolitres of bioethanol. With assumption of sago palm cultivation on 75% of suitable peatland area, West Kalimantan will have bioethanol surplus according to government policy to use gasohol 10% by year 2015.

References

[1] Sumaryono. “Tanaman Sagu sebagai Sumber Energi Alternatif”. Warta Penelitian dan Pengembangan Pertanian. Vo 29 No. 4, 2007.

[2] Badan Pengkajian dan Penerapan Teknologi. Sagu, Potensial Perkaya Keragaman Pangan. 2006. http://www.bppt.go.id/index.php?option=com_content&task=view&id=6033&Itemid=30 browsed 19 July 2007

[3] D. A. Mampioper, “Sagu sumber karbohidrat yang terlupakan”, Berita Bumi, 30 Nov 2006. http://www.beritabumi.or.id/artikel3.php?idartikel=269 Browsed July 19, 2007.

[4] T.A. Chew, I. Abu Hassan, M.G. Mohayidin. “Estimating the environmental benefits of sago cultivation”. *In* Repositioning of the Agriculture Industry in the Next Millenium. Eds A Radam and FM Arshad, 2000. pp. 235–252. Universiti Putra Malaysia, Sedang Selagor.

[5] BPS. Kalimantan Barat in Figures 2008. Badan Pusat Statistik Provinsi Kalimantan Barat. 350.

[6] Departemen energi dan sumber daya. Blueprint Pengelolaan Energi Nasional 2006 – 2025. Jakarta: Departemen energi dan sumber daya, 2007