Pioneering Agriculture Bioenergy: Geospatial Analysis and Soil Quality Evaluation of Abandoned Lands of Tidal Swamp[1]

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ABSTRACT

Abandoned lands basically can be utilized for various useful purposes. This research, a very beginning step of a major research that has been implementing, was conducted to observe the potency of abandoned lands in Barito Kuala (Batola) Regency South Kalimantan Province Indonesia in order to pioneering agriculture bioenergy. Through maps overlaying and data and field observation, abandoned tidal swamplands were identified. To observe the soil quality, soil at the surfaces of 0-15 cm to 0-20 cm was sampled and analyzed in laboratory. The results showed that among 19 districts in the Batola Regency, there were 5 districts have the largest uncultivated tidal swamplands, those were Kuripan (72.5 %), Tamban (5.8 %), Cerbon (5 %), Tabukan (3.5 %), and Bakumpai (2.4 %) with estimated whole area of 6.986 ha. The soil quality indicators (soil quality is not publishing yet) showed that the soil quality of 5 districts is considered low. Soil reaction was very acid (pH < 4), cation exchange capacity (CEC) was medium to high (13.35 – 39.500 g kg^{-1}), total organic carbon (TOC) was 0.33 - 8.12 %, whilst the dissolved iron, Fe^{++} (ppm) was around (45.56 – 937 ppm). The tidal swamp plants were dominated by Nephrolepis bisserata (Sw.) Schott (ferns), Stenochlaena palustris Bedd (fern shrimp), Melaleuca cajuputi (galam wood), which spread across whole districts in the Regency. Other plants were Mimosa invisa Mar. was only found in Kuripan, whilst Imperata cylindrical was found in Cerbon, Bakumpai, and Tabukan. The local energy crops found were oil palm, corn, sugar palm, cassava, sago, seed sorghum (corn millet), hanjeli, sweet potato, canna, arrowroot, and dahlia tubers. It is important to find water plants that has characteristic of potential for bioenergy that suitable in Batola.

Keywords: Abandoned land**,** Soil quality, Tidal swampland, Agriculture bioenergy, Biomass

INTRODUCTION

Human needs for energy continue to increase with increasing of population, the quality and standard of living, as well as technology. This energy is most supplied from gasoline, diesel, and other fossil fuels such as coal and natural gas. In addition, whenever the soil is exploited, the utilization of the energy emit CO_2 -that safely sequestered below the surface of the earth for hundreds millions years- into the atmosphere and cause global warming. One way to get out of the problems of decreasing the availability of fossil fuel energy and anthropic climate change is to utilize renewable energy sources of bioenergy, one of them is biomass.

Biomass is organic materials come from animals and plants. Biomass can include energy crops, plant materials, animal manure, landfill waste, wood pellets, vegetable oil, even paper and household garbage (excluding plastics and non-organic materials) can be use as biomass

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fuel sources. Biomass can be converted directly into heat energy through combustion (is as old as a caveman's fire, and it remains an important source of renewable energy worldwide), like the burning of a log in a fireplace. In other cases, biomass is converted into another fuel source; examples include ethanol gasoline made from corn, or methane gas derived from animal waste. Policy makers are currently biomass for power, heat, fuels, and products to reach energy security, improving rural economy, and environmental goals. Obvious advantage that biomass fuels have over other energy sources is that biomass is renewable: We can grow more plants, but nobody can make more oil (GCEP, 2005; Campbell and Block, 2010; IEA, 2007).

In fact, Indonesia has around 50 potential bioenergy plants (Soerawidjaja, 2004), which 25 of them are annual food producing plants and 10 of them are forest trees. This renewable stock resource depends on lands, water, and ecosystem, as well as on natural generation/degeneration rate and anthropic production/consumption rate. From the land point of view, to establish bioenergy cropping system could compete with food producing cropping system, which should be grown in good soil quality in order to gain high production. On the other hand, to open new areas from the forest could increase the greenhouse gas emissions. Therefore, to establish energy cropping system it is considered a wise movement to use abandoned lands. This research aimed to observe the potency of abandoned tidal swamplands in order to pioneering agriculture bioenergy in Batola.

METHODOLOGY

Primary and secondary data was obtained through interview and survey. Several maps collected were used to conduct field observation and decide soil sample points. The maps include Administration map of Batola (digital format), Map of Spatial 1: 250.000 and 1 : 100.000 (Province and Regency levels), Map of Land Use 1 : 100.000, Map of Land Covers 1 : 100.000, and Rain Zoning Map of South Kalimantan 1 : 250.000. After overlaying the maps, field observation was conducted to see the distribution of abandoned tidal swaplands in the regency and to decide the soil sample points for observing soil quality.

To observe the soil quality, soil surfaces of 0-15 cm to 0-20 cm was sampled and analyzed in laboratory. The soil samples were analyzed in the laboratory according to standard procedures of Chemical Laboratories Staff (1995). Soil moisture content (WC, %) is the soil mass before and after drying, measured using gravimetric method. Soil texture is the fraction of particles of sand, silt and clay, obtained using Bouyoucos hydrometer method. Bulk density (BD, gcm^{-3}) is the ratio between the mass of soil by volume. Chemical soil quality was observed through the indicator soil quality of soil acidity, pH, and some nutrients. Level measurements are interpreted in terms of sufficiency or excess, not for a specific plant. Soil pH, obtained by calculating the pH of soil in suspension (H_2O 1: 5) was measured using a pH meter. N-total (%), calculated using micro-Kjeldahl method. Soil organic carbon (SOC,%), determined based on the amount of oxidized C. Soil organic matter (SOM, %) calculated based on levels of C, assuming carbon C amounted to 48-58% of the total weight of soil organic matter. Biological soil quality indicators were represented from TOC and N. According to Gregorich et al. (1997) total organic C and N is also a rough measurement of soil biological attributes. Overall soil quality index (not published yet) was evaluated using SMAF (Andrews et al., 2004).

Plant investigation was done through field study, interview, and literature review. Information of soil suitability of some plants was obtained from the research done by Bappeda and PTISDA, 2008.

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After processing and analyzing data, the results of study provided the information of amount and distribution of uncultivated tidal swaplands in Batola, soil quality and specific plants growing.

RESULT AND DISCUSSION

Geography

Batola is located between the southern latitude 2° 29 '50" - 3° 30' 18" and the eastern longitude 114° 20 '50" - 114° 50' 18" with a boundary of the North is Hulu Sungai Selatan and Tapin District, the South is the Java Sea, the east is the Banjar District and the city of Banjarmasin, and the western side is Kuala Kapuas regency Central Kalimantan Province (Figure 1) with total area is 2.996.96 km^2 (Tabel 1).

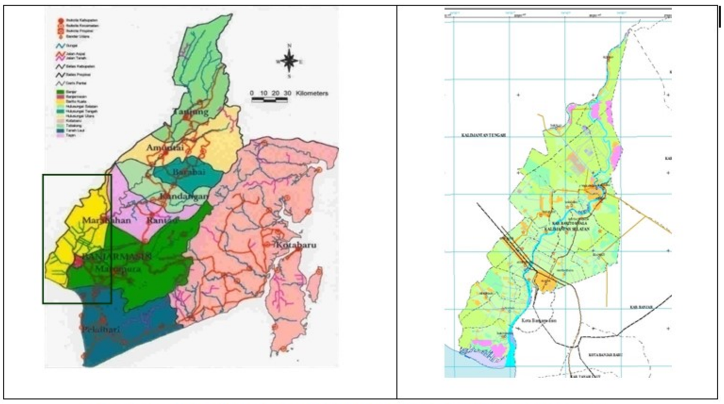

Figure 1. Barito Kuala Regency South Kalimantan Province Indonesia

Tabel 1. Ares under the Districts of Barito Kuala South Kalimantan

No	*District*	*Area (Km^2)*	*Persentage (%)*
01	Tabunganen	240,00	8,01
02	Tamban	164,30	5,48
03	Mekarsari	143,50	4,79
04	Anjir Pasar	126,00	4,20
05	Anjir Muara	117,25	3,91
06	Alalak	106,85	3,57
07	Mandastana	136,00	4,54
08	Belawang	80,25	2,68
09	Wanaraya	37,50	1,25
10	Barambai	261,81	8,74
11	Rantau Badauh	206,00	6,87
12	Cerbon	183,00	6,11
13	Bakumpai	261,00	8,71
14	Marabahan	221,00	7,37
15	Tabukan	166,00	5,54
16	Kuripan	343,50	11,46
17	Jejangkit	203,00	6,77
	Jumlah	*2.996,96*	*100,00*

Source : Statistics Bureau (BPS) of Barito Kuala Regency (2012)

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Survey and data evaluation showed that Batola has 3 kinds of landscapes; seascape, floodplain area/embankment, and swamplands. Batola was a district drained by rivers and streams and the lands have generally tidal wetlands. According to Nationwide Study (1984), lying near the coastal wetlands, Batola is categorized of low-lying area with low land (tidal) widest (100% of area) with a slope of 0 - 2% and a height of 1 - 3 meters above sea level.

Batola has climate type B according to Schmidt and Ferguson, suffered a 1 - 2 month dry and the remaining 10 - 11 months of wet every year. Batola was flanked by two large rivers, the River Barito and Kapuas River. In the rainy season, at the time of high tide, the river could be the flood parts of county down streams. Batola was fed also by several other streams; those were the River State, River Alalak, and Handil-Handil, Tamban Anjir River, Kapuas River, and River Puntik. The small natural drainage capacity could cause the formation of swamplands, either continuously or periodically. The area that was always flooded continuously could reach to 60.38% (Bappeda and PTISDA, 2008).

The population of Batola is 274.147 people with sex ratio of 100.41. The livelihood potential sector was in agriculture. This regency is the largest rice producer in the province of South Kalimantan. The potential plantation in 2010 was Rubber, Coconut, Oil palms, sago, and rush. Other livelihoods were fishermen and industrial workers.

Soil Type, Land Use, and Land Cover

Exploration of Batola Soil Map 1 : 100.000 (Batola , 2012), showed that there are two types of soil, Organosols 101,900 ha (34%) and Alluvials 191,390 ha (64%). The Alluvials had almost largely utilized for cultivation, and the some Organosols Glei humus were continuously inundated areas. The soils in general has high clay content (57.8 % clay). This land is a great area for tidal farm in Batola. The results of overlapping maps of land use and land capability map showed that Alluvials was generally cultivated area for rice farming. Other than agricultural lands, there were also land overgrown with shrub, including *keramunting*, ferns, trees *Galam*, tall grass, acacia, rush (*Eleocharis Dulcis*), and other creeping plants. Those plants were usually found in all tidal swamp area of South Kalimantan, precisely in areas that were not used.

Tabel 2. Land Use Types from year 2007 - 2010

Land use type	*Land (Ha)*			
	2007	*2008*	*2009*	*2010*
1. Tidal for rice	109.560	100.220	101.424	100.183
2. Not cultivated	23.505	20.241	19.219	20.779
3. Yard	15.758	23.517	23.537	24.095
4. Moor/garden	13.308	11.610	12.559	13.359
5. Shifting/*huma*	1.899	1.805	1.825	1.928
6. livestock grazing	10.928	9.278	14.597	13.444
7. Not cultivated	11.769	14.973	13.313	8.590
8. Others	48.672	49.082	45.861	49.689
Total	*235.399*	*224.890*	*232.335*	*231.063*

Source: Data processing of year 2010 secondary data of Office of Agriculture of Barito Kuala Regency

Coastal swamps was generally covered by mangroves forest (Mangrove), and was found a little fir (Cacuarina sp.). The area were still influenced by brackish water, lots of palm trees and overgrown by *nibung*. *jingah*, *rambai* grow along the river; plants Galam (Malaleucaspp) and rush used to live side by side and sometimes interspersed grasses. *Galam* (*Malaleuca Cajuputi*) is a very dominant tree in this area. Other timber types are belangiran (*Shorea Belangiran*), tumih. Other aquatic plants are water hyacinth and water grass (Government of Batola, 2012). The expansion of land use in agriculture and forestry could be seen at Tabel 2 and Tabel 3.

Tabel 3. Summary Data of Potential Plantation in 2010

No.	*District*	*Rubber*	*Coconut*	*Hybride Coconut*	*Oil Palm*	*Cloves*	*Coffee*	*Sago*	*Purun*	*Hazelnut*
1.	Tabunganen	-	1.970	-	-	-	-	-	-	-
2.	Tamban	10	5.092	-	-	-	-	-	-	-
3.	Mekarsari	75	4.811	-	-	-	-	-	-	-
4.	Anjir Pasar	500	30	-	-	-	-	78	390	-
5.	Anjir Muara	25	800	-	-	-	-	-	-	-
6.	Alalak	10	410	-	15	-	-	-	-	-
7.	Mandastana	5	104	-	20	-	-	-	-	-
8.	Belawang	15	202	-	-	-	-	-	-	-
9.	Wanaraya	600	70	-	70	-	-	-	147	-
10.	Barambai	426	405	-	-	-	-	-	-	-
11.	Rantau Badauh	-	-	-	-	-	-	-	-	-
12.	Cerbon	50	300	-	325	-	-	229	-	-
13.	Bakumpai	20	10	-	-	-	-	152	555	-
14.	Marabahan	-	-	-	-	-	-	-	-	-
15.	Tabukan	35	40	-	-	-	-	-	-	-
16.	Kuripan	10	-	-	5	-	-	-	780	-
17.	Jejangkit	-	5	-	10	-	-	-	-	-
	Total	1.701	14.249	-	450	-	-	459	1.872	-
	Year 2009	1.679	14.249	-	368	-	16	159	1.152	-
	Year 2008	1.702,29	13.307,72	47,32	286	16,3	120	158,78	776,01	40,21
	Year 2007	875,94	13.473,58	48,50	167,85	16,3	62,45	127,82	697,26	40,21

Source : Office of Forestry and Plantation of Barito Kuala (2010)

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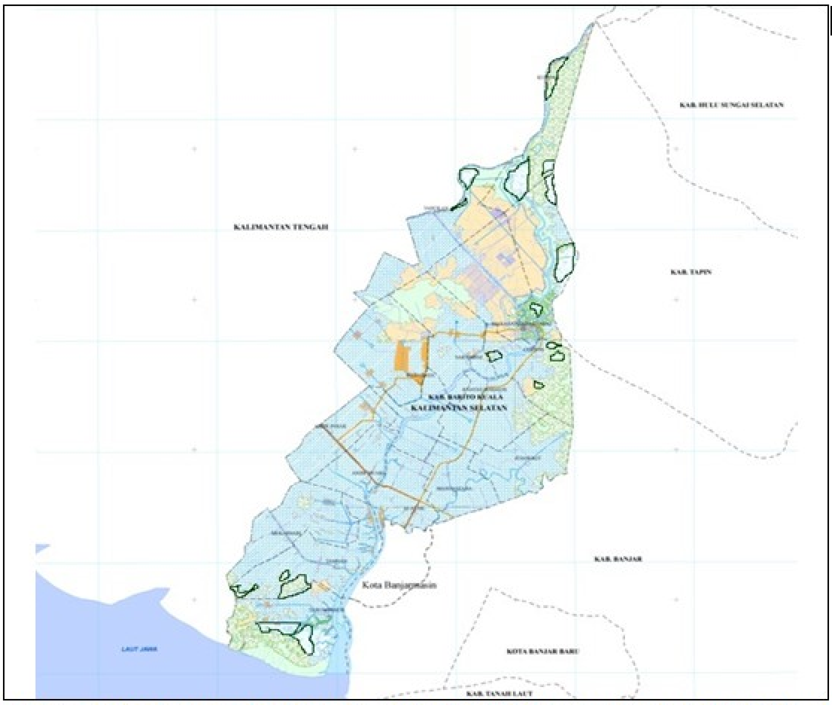

Figure 2. Distribution of Widest Uncultivated Tidal Swamplands in Barito Kuala

Tidal Swampland Distribution and Soil Quality

The results of the study revealed that tidalands area in general was planted and there are 120.94 ha arable lands scattred in all districts. There several plants found in Batola thouse were sugar palm, cassava, sago, seed sorghum (corn millet), hanjeli, sweet potato, canna, arrowroot, and dahlia tubers. However, there were tidal swaplands that uncultivated and considered as abandoned tidal swaplands. Data processing and field observation showed that among 19 districts in Batola, there were 5 districts have the widest abandoned lands (Tabel 4 and Figure 2); Kuripan (72.5%), Tamban (5.8%), Cerbon (5%), Tabukan (3.5%) , and Bakumpai (2.4%) as a whole is 6986 ha (6.6%). Particularly in District Tabukan, abandoned land scattered around the settlement. The soil quality condition and natural vegetation of each district can be seen in following figures (Figure 3 – Figure 7).

Tabel 4. Uncultivated Tidal Swamp in BaritoKuala Regency Soth Kalimantan Province

No.	*District*	*Area (Ha)*	*Persentage (%)*
1	Kuripan	5.000	72,51
2	Tabunganen	452	6,55
3	Tamban	406	5,89
4	Cerbon	350	5,07
5	Tabukan	250	3,62
6	Bakumpai	170	2,46
7	Jejangkit	127	1,84
8	Alalak	91	1,32
9	Barambai	40	0,59
10	Anjir Muara	10	0,15
	Total	6,896	100

Source: Data processing of year 2012 secondary data of BPS of Barito Kuala Regency

Kuripan District

Table 4 shows that the area of Kuripan is 343.50 km^2 and Table 3 shows that in Kuripan, there is 5000 ha of tidal swamplands that was not cultivated. However, from the observation of overlapping Map of Spatial and Map of Land Cover, it was found that most of the area covered by marsh grass had already remarked for plantation crop. There was also a flood prone area in some particular lands. Maps and field surveys revealed that the settlement was only scattered around along the river ways.

Soil quality indicators showed that the soil was very acid (pH was 3.7). The cation exchange capacity was considered high (23.55 me $100g^{-1}$). This could happen probably because the texture of soil has high clay content (57.8 %) and the organic material was high (3.65 %).

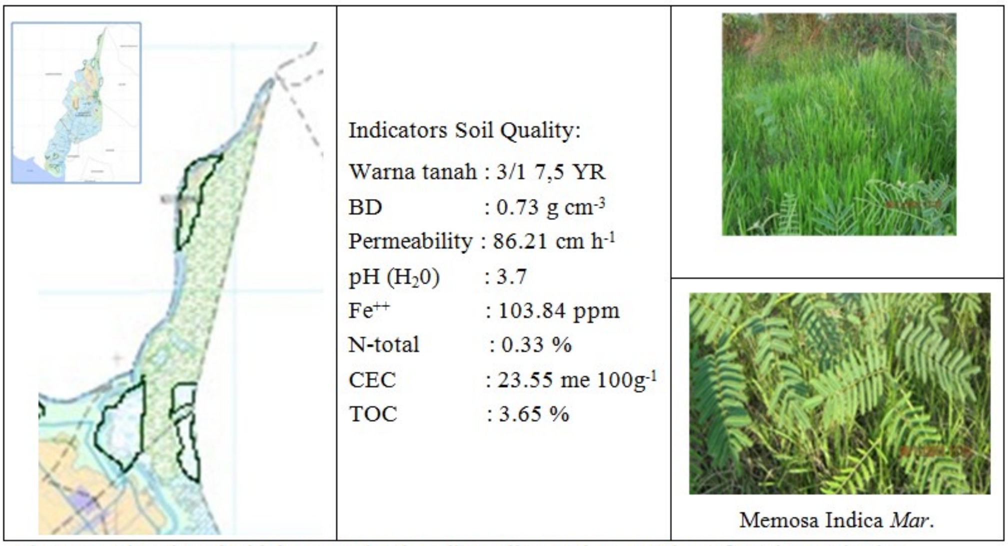

Figure 3. Abandoned Tidal Swampland, Soil Quality, and Vegetation of Kuripan District

Tamban District

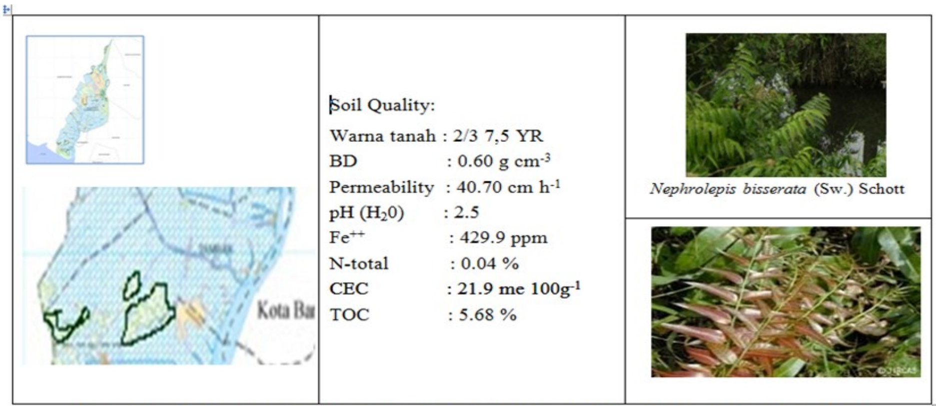

Figure 4. Abandoned Tidal Swampland, Soil Quality, and Vegetation of Tamban District

Area of District Tamban is 164.30 km2 with uncultivated tidal swampland was 406 ha. The dominant vegetation in this area was bush of ferns.

The soil was considered has low fertility. Although TOC was very high (5.68 %), N total was very low (0.04 %) and soil was considered very acid (pH was 2.5).

Cerbon District

Area of District Cerbon was 183.00 km2, and the swamplands not planted was about 350 ha. Dominant crops in the region were *Melastroma Malabathricum*. Soil quality indicators show that the land around the site was very acid, having pH 3.1, low organic matter (TOC 1.87 %), and low nitrogen (N-total 0.04%).

Soil Quality Indicators:
Warna tanah : 2/3 7.5 YR
BD : 0.60 g cm^{-3}
Permeability : 27.36 cm h^{-1}
pH (H_20) : 3.1
Fe^{++} : 288.36 ppm
N-total : 0.18 %
CEC : 27.45 me 100g^{-1}
TOC : 1.87 %

Melastroma malabathricum

Figure 5. Abandoned Tidal Swampland, Soil Quality, and Vegetation of Cerbon District

Tabukan District

Soil Quality Indicators:
Warna tanah : 3/2 7,5 YR
BD : 0.83 g cm^{-3}
Permeability : 45.80 cm h^{-1}
pH (H_20) : 2.9
Fe^{++} : 89.52 ppm
N-total : 0.17 %
CEC : 30.75 me 100g^{-1}
TOC : 2.71 %

Figure 6. Abandoned Tidal Swampland, Soil Quality, and Vegetation of Tabukan District

Area of District Tabukan is 166 km2, and the not cultivated swamplands area were 250 ha. Dominan plants are grasses (*Imperta cilindrica* L.). Soil quality indicators showed that lands in this region was generally having low quality. N total was low (0.17 %), TOC was medium level (2.71 %), and soil was very acid (pH was 2.9). The survey results indicated that location of wetlands that were not planted were located in the yard / around the settlement, thus potentially to be used for bioenergy farming systems.

Bakumpai District

Soil Quality Indicators:
Warna tanah : 3/2 7,5 YR
BD : 0.60 g cm^{-3}
Permeability : 66.62 cm h^{-1}
pH (H_20) : 3.1
Fe^{++} : 46.22 ppm
N-total : 0.04 %
CEC : 24.15 me 100g^{-1}
TOC : 0.56 %

Figure 7. Abandoned Tidal Swampland, Soil Quality, and Vegetation of Bakumpai District

Area of District Bakumpai was 261 km2, and the not cultivated land areas of tidal swamp land were 170 ha. The dominant plants were Eleocharis dulcis and cajuputi Malaleuca. The soil was considered having very low fertility. N total was very low (0.04 %). Soil was very acid (pH was 3.1), and TOC was very low (0.56 %).

Potency of Bioenergy

Agricultural biomass sources can be a primary raw material, in the form of major crops, grains, biomass of annual grasses and woody plants; secondary raw materials, in the form of biomass and animal residues the food and feed, as well as tertiary sources of biomass, and in the form of residue from the production of bioenergy (GLBRC, 2012). Batola Regency, in addition to plant palm oil, can produce bioenergy crops such as bioenergy through the cassava, sago, sorghum grain (corn Cantel), hanjeli, sweet potato, canna, arrowroot, dahlia bulbs, wooden straw, bagasse (residue cane), banana stems. Especially for the five largest districts that have large abandoned swamplands, the district can apply bioergy family-based production, because the lands in general was very close to the settlement. A deeper study is needed to see the possibility of utilization of existing local plants for bioenergy agriculture system and improving soil quality.

CONCLUSIONS

Abandoned Wetlands area that potential to be developed for bioenergy cropping system in Batola district were 6.896 h spread in five districts of Kuripan, Tamban, Cerbon, Tabukan, and Bakumpai. The potential of bioenergy production practice possibly conducted were in the District of Tabukan. Utilization of rice crop residues can be run in all districts.

Deeper investigation of the grass and bushes that grow on the abandoned lands needs to be studied more deeply. Bioenergy production trials should be carried out to establish the energy self-sufficient village to reach energy security.

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