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LAND SUITABILITY FOR *ELAEIS GUINEENSIS* JACQ PLANTATION IN SOUTH SUMATRA, INDONESIA

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ABSTRACT

The research purpose is to identify and to delineate the land suitability for oil palm and to analyze the relationship biophysical characteristics of land resources with the development of oil palm plantations in South Sumatra. Research sampling was carried out based on topographical conditions in South Sumatra (Mountain Zone, Piedmont Zone, Plateau central, Wetlands and Coastal Plain). The research works were divided into two steps, i.e. field survey activities and laboratory work. The research results can be elaborated as follows: Biophysical characteristics and climate condition support the development of oil palm plantations. Researched land suitability is only a general direction because the discussed maps have small-scale (> 500.000). For field application, it is advisable to conduct intensive research with large-scale maps (1:25.000) especially for the purposed land suitability. An optimal development of oil palm should be started with the biophysical analysis of land suitability and socio-economic conditions of local society. Outside of existing oil palm and rubber, it is around 3,787,297 ha (44.03%) of land classified as highly suitable (S1), 376,322 ha (4.37%) belongs to moderately suitable (S2) and 802 673 ha (9.33%) are marginally suitable (S3). Oil palm is still very likely to be developed, especially in areas belonging to the classification of S1, S2 and S3, including N1 with locations scattered throughout the South Sumatra area. The limiting factors (difficult to overcome) are classified as permanent biophysical constraints of land and climate.

Keywords: Land suitability, development, oil palm plantation, South Sumatra

INTRODUCTION

Oil palm (*Elaeis guineensis* Jacq) plays an important role in the Indonesian economy, namely as a source of farmer income, employment, provision of industrial raw materials, the foreign export, the transmigration program development, regional development, and to improve the people welfare besides its role in maintaining sustainability environment and natural resources. The Indonesian government planned to implement the revitalization program of oil palm plantations since last three years. For this purposes, we need to know which area is still suitable to be developed and which plantations are needed to be replanted. The number of palm oil plantation will be done revitalized around 125,000 ha and oil palm are potential to be replanted whose age of more than 25 years (Badrun, 2010).

South Sumatra is one of the palm oil producing provinces and has third rank in acreage and production after Riau and North Sumatra. The rank is expected to increase if the potential land is suitable for oil palm cultivation. This opportunity is still widespread and attracts investors to develop oil palm plantations in South Sumatra. Although oil palm plantations do not require specific biophysical requirements, but to achieve optimal results, it is known and understood that some biophysical characteristics and land suitability will be very helpful to optimize the palm oil production. Therefore, the main purpose of this paper is to identify and to delineate the land

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suitability for oil palm and to analyze the relationship biophysical characteristics of land resources with the development of oil palm plantations in South Sumatra.

RESEARCH METHODS

This research was conducted in South Sumatra Province, Indonesia. The study was carried out from January to April 2011. Materials used in this study are Maps of South Sumatra Province, Landsat TM image Path/Row 124/62 in June 1992, June 2001 and August 2010 that packaged in a CD-media ROM, and Questioners for big plantations as well as farmers, cropping patterns and tracking network data. Tools used are Global Position System (GPS), Drill the ground, Label, Elastic Band, Plastic sample, program of image interpretation tool of Arc View GIS (Geographical Information System) and its stationery. Data processing and analyses were carried out in stages. The stages can be explained in the flow diagram of Figure 1. Data analyses included as follows (FAO, 1976, FAO, 1981):

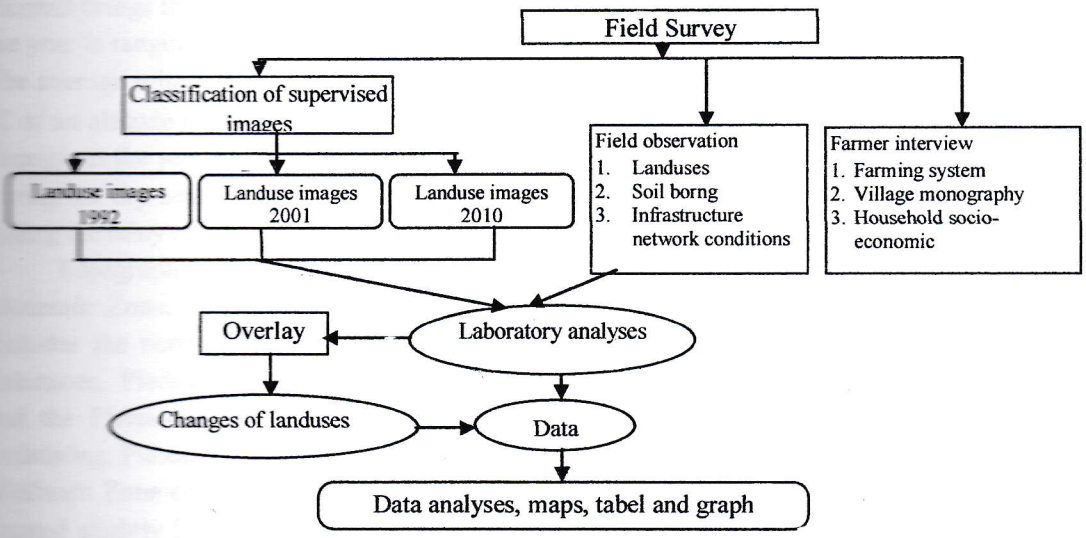

Figure 1. Flowchart of field activities and data analysis

RESULTS AND DISCUSSION

1. Climate and Topographical Conditions

The climate condition is divided into two major types, namely type A and type B. Type A is only a small portion which covers a total area of 1,354,734 ha (15.74%) that lies between the south and east (southeast), the area of Kayu Agung, Indralaya and Palembang city. Type B with a total area of 7,251,137 ha (84.26%) is located in most areas of South Sumatra. Type B means that the area with wet months of 7-9 months continually per year and up to three months of continually dry months. Wet months are defined if rainfall is more than 200 mm/month, while the dry months are understood if rainfall is less than 100 mm/month (Figure 2).

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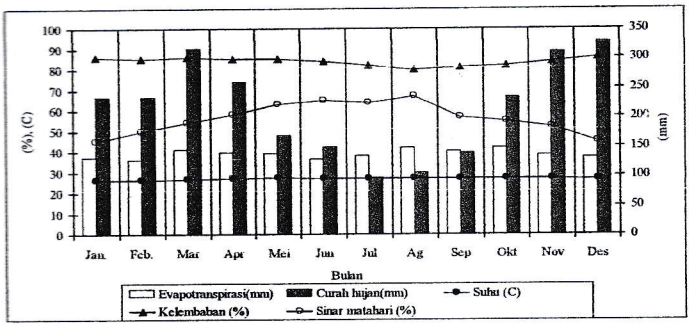

Figure 2. Climate conditions in South Sumatra (JICA Team, 2003)

Average annual rainfall varies less than 2,000 mm in the coastal plain and 3,500 mm in Lahat which is located at the east foot of The Bukit Barisan. This place has higher evaporation and transpiration (evapotranspiration) capability than any region ranging from 1,200 mm to 1,500 mm. Rainfall brings the impact of evapotranspiration throughout the year. Relative humidity throughout the year is ranging between 60-90%. An average temperature showed little variation (about 28 °C). The average minimum temperature is around 20 °C and the maximum temperatures are around 35 °C at an altitude of less than 150 m above sea level (m asl). The day length varies under 12 hours throughout the year in relation to the location below latitude. The wind will blow from the southeast during the dry season, usually occurs in May to October, and the wind blows from the southwest during the rainy season usually occurs from November to April.

Topographical conditions are divided into five zones starting from the western zones, namely Mountain Zone, Piedmont Zone, Plateau Central, Wetlands and Coastal Plain. Mountain Zone includes the northwest and southeast of the study area consisting of valley, plateau plates and volcanoes. Piedmont Zone is almost 40 km in width which is the transition between the Mountains and the Plateau centrals Zone. The Piedmont Zone covers the terrain of hills and plains to undulating. Plateau Central consists of three parts, namely the high land, flood plains and river bank. Wetlands Zone consists of a natural levee of the river and swampy area (lebak). Swampy area is located slightly lower than the river surface and flooding during the rainy season. Coastal Plain consists of low plains and lowlands along the north coast of the delta, which is covered with peat swamp forests. Based on the slopes, South Sumatra is divided into different slope classes, i.e. the flat area (0-8 %), slightly sloping (8-16 %), moderately sloping (16-25 %), steep terrain (25-40 %) and very steep (> 40 %). Flat area covering the largest area (78.28%) is found throughout the east coast of South Sumatra to the Bukit Barisan. The smallest area is the slightly sloping area (3.56%) which spread uneven especially in the west. Moderately sloping (8.19%), steep terrain (5.52%) and very steep (4.46%) were found along the Bukit Barisan also spread unevenly. Only the very steep and very flat area or basin area with always stagnant water is not suitable for oil palm plantations (Table 1).

2. General Characters of Soils

General soils character is important to be discussed relating to the soil suitability for oil palm plantations, among others, soil morphology, physical and chemical soil characteristics. Soil morphology showed that the extent to which the ability of the soil as growing medium for oil palm. From the soil morphology, it clearly illustrated with large carrying capacity on the development and growth of oil palm plantations. Some general characteristics of physical and chemical properties classified as the major constraints to the oil palm development are summarized in Table 2.

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Table 1. South Sumatra area on the basis of slopes

Nr	Slope classes */	Acreages	
		Hectares (ha)	Percentage (%)
1.	Flat area (0-8 %)	6,736,534	78.28
2.	Slightly sloping (8-16 %)	306,027	3.56
3.	Moderately sloping (16-25 %)	704,513	8.19
4.	Steep terrain (25-40 %)	474,687	5.52
5.	Very steep (> 40 %)	384,110	4.46
	Total	8,605,871	100

Description : */class division is based on the slope of AG Bodenkunde (1996)
Source : Earth visual maps of Indonesia with scale of 1:50,000, Landsat images in 2010.

The main key of land management based on soil properties is how to maintain organic material at levels > 3%, especially for soils classified as S1, S2 and S3. By maintaining organic matter > 3%, then the various physical properties, chemical and biological soil constraints for the development of oil palm can be easily managed because the organic materials can improve the physical, chemical and biological soil properties. To land categorized as N2 (not suitable permanent), then the soils faced the permanent constraints which are very difficult to reclaim or require a very high cost to make soils suitable for oil palm. Based on both physical and chemical characters, the soils have not a severe constraint to develop oil palm plantations.

Table 2. General characters of soils in South Sumatra

Nr	Soil properties	General characters of soils
1.	Physical properties	1) Low activity clay content is high (40-65%), porous and low water holding capacity (pseudosilt) 2) Content of organic matter is low (< 2%), soils are sensitive to leaching, erosion and soil compaction 3) Drainage classes are poor to moderate and topsoil is thin (Ah horizon <10 cm).
2.	Chemical properties	1) High soil acidity (soil pH < 4.5) and deficiency of N, P, K, Ca and Mg nutrients 2) Cation exchange capacity (CEC) and base saturation (BS) is low (CEC <5 meq/100 g and BS <10%) 3) Levels of Al, Fe and Mn is high, thus forming crocos (Fe hard layers), low water holding capacity, root penetration and it acts as inhibiting factors of plant growth.

3. Soil Orders, Soil Regionalization and Land Suitability for Oil Palm Plantation

Generally South Sumatra soils can be grouped into two main groups, namely mineral soils and peat soils. Mineral soils are formed from parent material originating through rock weathering process. Mineral soils formed in a region that is relatively high and there is no accumulation of organic material. The process of mineral soil formation is dominantly influenced by climate, particularly rainfall and intense sunlight. The mineral soils are classified according to Soil Taxonomy (Soil Survey Staff, 1998) into the Orders of Andisols, Oxisols, Ultisols, Gelisols, Inceptisols, and Entisols. Peat soils are classified as the order Histosols. Histosols are formed of the peat or dead vegetation deposits that are distinguished by the depth and degree of peat decomposition. Further it is subdivided into sub-classifications based on peat soil deposits such as fibric, hemic and sapric (Table 3).

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Table 3. Acreages of soil orders in South Sumatra

Nr	Soil order */	Area acreages	
		ha	%
1.	Ultisols (Podsolik)	3,410,844	39.63
2.	Entisols (Alluvial and Rendzina)	1,751,477	20.35
3.	Gelisols (Gley)	1,079,781	12.55
4.	Histosols (Hidromorf)	870,029	10.11
5.	Oxisols (Latosol)	815,385	9.47
6.	Andisols (Andosol)	352,898	4.10
7.	Inceptisols (Litosols and Regosol)	325,457	3.78
	Total	8,605,871	100.00

Description : */Soil classification according to Soil Taxonomy (Soil Survey Staff, 1998)
Source : Earth visual maps of Indonesia with scale of 1:50,000, Slope maps, field survey, land cover maps and Landsat images in 2010.

Histosols are less suitable for oil palm because their heavy constraints are unable to sustain the growth of oil palm root system. Likewise Andisols are less suitable for oil palm since these soils are formed and located in areas with an altitude > 750 m above sea level. If Andisols are still forced to be planted with oil palm, the oil palm can produce less Fresh Fruit Bunches (FFB). However, Andisols are very suitable for coffee because these soils are generally found in mountainous areas. Some important factors of high suitability for oil palm because oil palm is more dominant due to the high ability of oil palm to adapt to soil environmental conditions. Oil palm has a wide range of adaptation to agro-climatic conditions. Soil regionalization are prepared on the basis of elevation level or on the basis of zoning, namely Mountain Zone, Piedmont Zone, Plateau Central, Wetlands and Coastal Plain (Table 4, Table 5, Table 6 and Table 7).

Table 4. Relationship between soil regionalization with land suitability in Mountain Zone (Elevation > 500 m above sea level)

Nr	Order	Suborder	Great Groups	Land suitability */	
				Oil palm	Coffee
1.	Andisols	Aquands	Palcaquands, Duraquands &	S3 and N	S1 and S2
			Endoaquands	S3 and N	S1 and S2
2.	Ultisols	Udults	Kanhapludults &	S3 and N	S2
			Kandiudults		S2
3.	Oxisols	Orthox	Haploperox	S3 and N	S2

Description: */N (not suitable), N1 (not suitable at this time), S (suitable), S1 (very suitable), S2 (moderately suitable) and S3 (marginally suitable)

Table 5. Relationship between soil regionalization with land suitability in Piedmont Zone (Elevation 50-500 m above sea level)

No	Order	Suborder	Great Groups	Land suitability	
				Oil palm	Coffee
1.	Inceptisols	Aquepts	Tropaquepts	S1 and S2	S3
		Tropepts	Dystropepts, Humitropepts &	S1 and S2	S3
			Eutropepts	S1 and S2	S3
		Andepts	Eutrandepts & Dystransdepts	S1 and S2	S3
2.	Ultisols	Udults	Kanhapludults & Kandiudults	S1, S2 and	S3
				S3	S3
3.	Oxisols	Orthox	Haploperox	S2 and S3	S3

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Table 6. Relationship between soil regionalization with land suitability in Plateau Centrals Zone (Elevation <50 m above sea level)

Nr	Order	Suborder	Great Groups	Land suitability	
				Oil palm	Coffee
1.	Entisols	Aquents	Hydraquents	S1 and S2	S3
		Fluvent	Fluvaquents, Endoaquents &	S1 and S2	S3
			Sulfaquents	S1 and S2	S3
2.	Inceptisols	Aquepts	Epiaquepts, Endoaquepts &	S1 and S2	N1
			Sulfaquepts	S1 and S2	N1
3.	Ultisols	Udults	Kanhapludults &	S1 and S2	N1
			Kandiudults	S1 and S2	N1

4. Area Acreages of Some Plantation Commodities

Common plantations found in South Sumatra are oil palm, rubber, coconut, coffee and various plants. Rubber and, coconut and coffee are largely cultivated by the local people, while the oil palm is mostly cultivated and managed by the big private sector and regional government generally in the form of large estates. Only oil palm, rubber and coffee have extensive real > 296 000 ha, while the vast reserves for oil palm and rubber is currently at 314,254 ha (14.93%). Coffee area expansion is not provided because the coffee development is more emphasis on intensification (Table 8).

5. Land Suitability for Oil Palm, Rubber and Coffee

Land suitability is discussed here only for biophysical properties for oil palm, rubber and coffee in general, it does not consider socioeconomic factors and culture in society. The discussion of three commodities as whole is to compare the land use for plantations, as it is well-known that oil palm and rubber compete most seriously in the field in terms of land use. If coffee is planted in the lowlands, then the coffee will also compete with oil palm and rubber, while coffee in Mountain Zone does not get meaningful competition from oil palm and rubber.

Table 7. Relationship between soil regionalization with land suitability in Wetlands and Coastal Plain Zones (Elevation < 10 m above sea level)

Nr	Order	Suborder	Great Groups	Land suitability	
				Oil palm	Coffee
1.	Histosols	Hemists	Haplohemists & Sulfihemists	N and S3	S3
		Saprists	Haplosaprists & Sulfisaprist	N1	S3
		Folist	Haplofolist	N1	S3
2.	Entisols	Aquents	Hydraquents, Fluvaquents,	S2 and S3	S3
			Endoaquents & Sulfaquents	S2 and S3	S3
3.	Gelisols	Histels	Folistels, Fibristels, Hemistels	S2 and S3	S3
			& Sapristels	S2 and S3	S3
		Orthels	Historthels, Aquorthels &	S2 and S3	S3
			Haplorthels	S2 and S3	S3

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Table 8. The acreages of plantations in South Sumatra in 2010

Nr	Type of plantation commodity	Area acreages	
		ha	%
1.	Rubber	852,006	40.48
2.	Oil palm */	425,020	20.19
3.	Coffee	296,450	14.08
4.	Coconut	29,478	1.40
5.	Tea	15,027	0.71
6.	Paddy	172,560	8.20
7.	Potential for oil palm and rubber**/	314,254	14.93
	Total	2,104,795	100

Description: */ Palm oil has been produced, **/Location provisioning for oil palm and rubber

This land suitability is only a general direction because the used map scale is very small scale (> 1:500.000). With this scale, some constraints of oil pal development are not possible to be explained in detail. If the scale level of maps will be applied in the field, it is advisable to conduct intensive research to large-scale maps (1:25.000) for the location of purposed land suitability and the targeted location. Levels for land suitability for oil palm, rubber and coffee can be summarized in Table 9. Oil palm and rubber have almost the same limiting factor in the field. Outside of oil palm and rubber in the field, it was approximately 3,787,297 ha of land (44.03%), including land highly suitable (S1), 376 322 ha or 4.37% including moderately suitable (S2) and 802 673 ha (9.33%) are marginally suitable (S3). It could be argued that not all regions of South Sumatra are suitable for oil palm, rubber and coffee. The permanent limiting factors are difficult to be solved, namely biophysical constraints of soils and climate conditions. Oil palm and rubber are still very likely to be developed, especially in areas belonging to the classification of S1, S2 and S3 and N1 with locations scattered throughout the area. However for coffee, it is stressed to do intensification activity.

Table 9. Land suitability for oil palm, rubber, coffee and various commodities */

Nr	Komoditi	Code	Acreages		Descriptions
			ha	%	
1.	Oil palm/Rubber	S1	3,787,297	44.03	Very suitable
2.	Oil palm/Rubber	S2	376,322	4.37	Moderately suitable
3.	Oil palm/Rubber	S3	802,673	9.33	Marginally suitable
4.	Oil palm/Rubber	-	1,591,280	18.50	Oil palm & rubber available
5.	Coffee	S1&S2	296,450	3.45	Suitable & moderately suitable
6.	Various commodities	-	217,065	2.52	Variety of plants available
7.	Oil palm/Rubber	N	1,530,784	17.80	Not suitable
	Total		8,601,871	100.00	

Description: */suitability analysis based on data landsat 2009, soil maps, geological maps, slope maps, climate data, the results of field survey 2010 and laboratory data generalization

CONCLUTIONS

Biophysical characteristics and climate conditions support the development of oil palm plantations. Researched land suitability is only a general direction because the discussed maps have small-scale (> 500.000). For field application, it is advisable to conduct intensive research with large-scale maps (1:25.000) especially for the purposed land suitability. An optimal development of

oil palm should be started with the biophysical analysis of land suitability and socio-economic conditions of local society. Outside of existing oil palm and rubber, it is around 3,787,297 ha (44.03%) of land classified as highly suitable (S1), 376,322 ha (4.37%) belongs to moderately suitable (S2) and 802 673 ha (9.33%) are marginally suitable (S3). Oil palm is still very likely to be developed, especially in areas belonging to the classification of S1, S2 and S3, including N1 with locations scattered throughout the South Sumatra area. The limiting factors (difficult to overcome) are classified as permanent biophysical constraints of land and climate.

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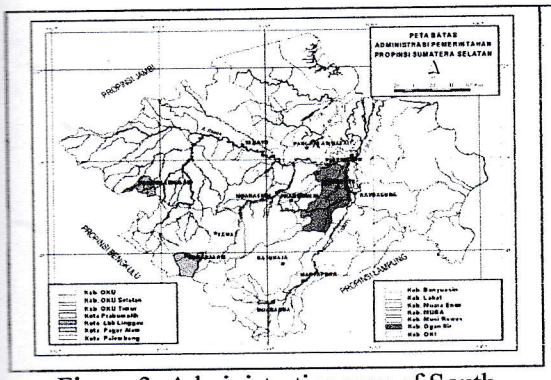

Figure 3. Administrative map of South Sumatra

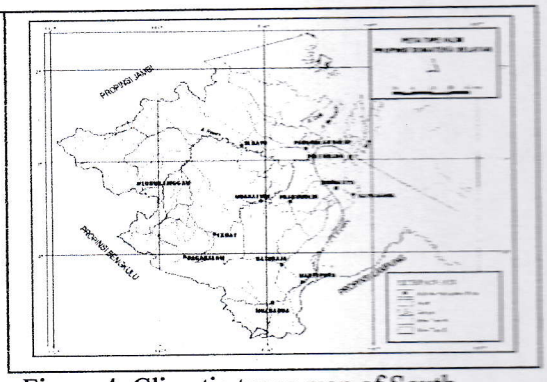

Figure 4. Climatic types map of South Sumatra

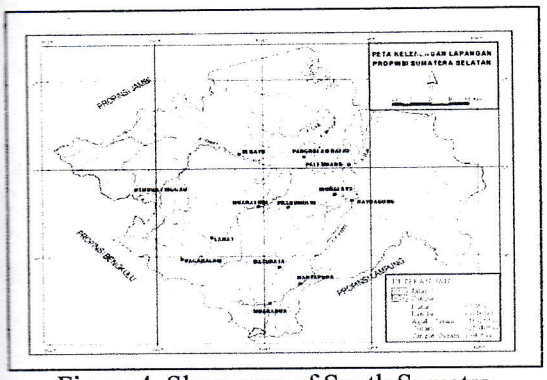

Figure 4. Slope map of South Sumatra

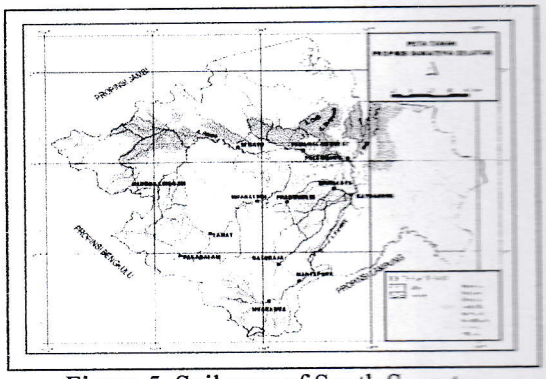

Figure 5. Soil map of South Sumatra

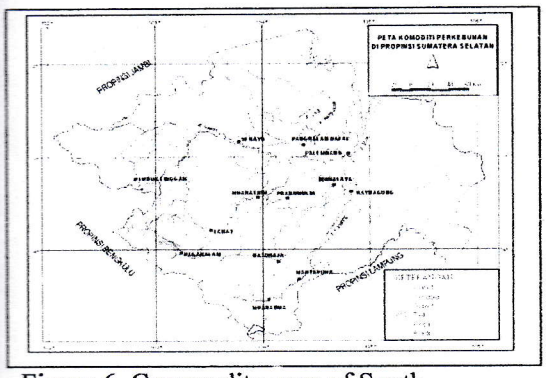

Figure 6. Commodity map of South Sumatra

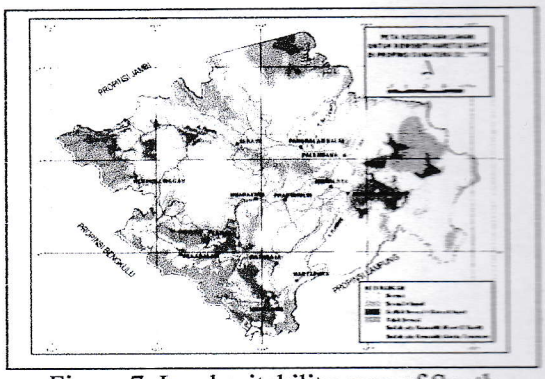

Figure 7. Land suitability map of South Sumatra