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Design and Implementation of Geographic Information Systems to Support The Food and Energy Security.

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ABSTRACT

The Geographic information systems (GIS) has function to support in making decision and define the location and area of land as an effort to develop specific bioenergy biofuel from palm oil plants and diversification of agriculture to support food security. The Plantation area of palm oil and paddy fields are inversely decreased in national and local level. The interpretation of design in using land has been change with natural resources that include natural resources forestry and natural resources for land plantations, rice fields and other different use in community. The capacity in one area is a component to supportanalysis of natural resources. The arearesources were calculated due to degradation of land resources into description useof the land. Result of the study reveals an analysis of food-carrying capacity of land in each region has **surplus food** consists of Indragiri Hilir, RokanHulu, **adequatefood** consists Indragiri Hulu, Pelalawan, RokanHilir, **scarcefood** consists KuantanSingingi, Siak, Kampar, Bengkalis, Meranti, Pekanbaru, Dumai based on extensive comparison plantations producing bioenergy and land use in agricultural production of food. The capacity conditions of land for bioenergy developed **surplus energy** consists of Indragiri Hilir, Pelalawan, Siak, Kampar, Rokan Hulu, **adequateenergy** condition consists of Kuantan Singingi, Indragiri Hulu, Bengkalis, Rokan Hilir and **scarceenergy** conditions consisted of Meranti Islands, Pekanbaru and Dumai.

Keywords: GBEP, balance resources and forest lands, plantations, agriculture, GIS, Indonesia

1. INTRODUCTION

Indonesia known as an agricultural country that earns financialfactor from agricultural resources. A very large area of agricultural area, the various types of commodity crops into the community economy, but it is not associated with the amount of time food production with the number of people who occupied in a certain area. The local government as managing natural resources in the region tried to find solution for problems in food. Efforts are being made to search for specific food commodities which

can be increase for the level of economy in community. Local governments faced problems in the areas of energy, specifically fossil fuel made from the scaling distribution of the community in economy experienced value and larger volumes of fuel supplies are decreasing. In the level of regional areas, natural resources have success factors for community life. Distinctive use of natural resources utilization land for public, agriculture, and plantation became the main destination of regional development. If the area does not observe rules of using land, new problems will arise and difficult to find the solution. The issue is the food and energy security's progress of in region, to solve both of these problems, the researcher chooses this research model.

First step that refers to *Bioenergy and Food Security (BEFS, 2010)* in setting the framework and explore the issues of food security and renewable energy to the guidelines in developing energy based biofuels, mainly from palm oil and food production through the utilization of land use for agriculture. The correlation of guidelines associated with the general diagnostics, environment, technology and improving the quality of social and economic. The guideline components are (i) analysis of the conditions agriculture related with supply chain management of agricultural products in the process production, prices, supply and storage, distribution of products to the public. Component (ii) natural resource wealth of the region and can be appropriated with the development of food products and energy, related with natural resources forestry, agriculture, plantation and water. Component (iii) the technological development of biofuel from palm oil and of food products agriculture such as rice, increased production volumes and could meet energy needs, as well as the environmental impact of the use of biofuels affect climate and greenhouse gases (GHG). It come to the analysis of food supply and activities of energy production, distribution and main needs.

Global BioEnergy Partnership (GBEP) is supporting consensus bioenergy development of several countries in creating and producing alternative energy as a plant-based bioenergy in a sustainable method. GBEP explains the role of the component in the process of analyzing indicators in bioenergy ecological, economical and social. The three elements have component which indicate effort to develop bioenergy, another environmental element has a greenhouse gas emission indicators, quality area, transformation of forest land area, pollution, quality of water resources in environment, utilization of water resources, biological environment, and changes in biological environment. Social element containing biological resources for bioenergy, increasing production and economic value of bioenergy at the national level, change in growth socioeconomic communities, employment areas of bioenergy, increasing household income, use of bio-energy change society, birth and death rates, disease caused by bioenergy. Economic element containing bioenergy production, balance the use of bioenergy, increasing bioenergy production changes, changes in energy use, increased employment, energy supply, distribution bioenergy, bioenergy capacity utilization.

1.1 Food Security

In Indonesia, the Government has a regulation about food. The food security defines as the fulfillment of the conditions of food for the household, as reflected in the availability of adequatefood, both in quantity, quality, safe, equitable and affordable.

In *FIA 2005, Food Security and Vulnerability Atlas (FSVA)* stated the three pillars of food security: Pillar (i) Availability of food in the region, which is obtained either from the domestic production, import or trade and food aid. The availability of food define from food production in one area, agricultural land, and food supplies from distribution of market mechanism through both entry and departure from a particular area, food stocks and government-owned merchants. Pillar (ii) Food access is the ability of households to obtain carbohydrates as a source of raw materials food. Availability of food in a region of the physical volume of inventories sufficient, but not all of the food sources of the community especially small and large household has the ability to have a large volume of food continuous and type of food other food through the mechanism above. Pillar (iii) food utilization, indications the use and needs household food and an individual's ability to absorb and metabolize nutrients the elements in the food product. Food utilization also includes ways food processing, presentation of food products obtained by using water, fuel and food health. Production and availability of food products with quite a number of national and provincial level, the precise number will not be sure to compliance of food products and the individual household level in that food security. The number of food products with a large amount of calculations and empirical covered the needs food at particular area, but access to food by some members households can not encounter appropriately, due to safety conditions, food distribution, food facilities and infrastructure so that food access will affecting the utilization of food products by the public. The concept framework of food security contains the elements of food availability, food access and food utilization and also correlation of these elements will affect food security levels of household food consumption and the environment in the form of excess ownership inaccurately food which affecting the political, social, institutional and economic development. Area of food security is determined by the factor of environmental agriculture (agro-environmental) special land, socio-economic and geographic regions as well as political. Food insecurity is the opposite condition of food security, where conditions scarcefood for household needs and compliance with food on the level to the wider community are not coveredin continuous time. While scarcefood with uncertainty condition is a situation of natural conditions change due to natural disasters, epidemics, drought, political conspiration and transportation damage.

1.2 Energy Security

This is the condition which energy utilization for food security could contribute to the process and utilize source of food and energy as resource management. As described on the pillars of food security, in the third pillar which is food utilization, the contribution food of bio-energy is crucial for the community. Based on economic aspect in a large scale, the volume production of renewable energy as the form of biofuel will be used for biodiesel in economy for transportation. In the level of specific energy production of palm oil, Indonesia got second ranks after Malaysia as an exporter of palm oil and supplying more or less 90% (*ITCP, 2012*) of the needs in the world's palm oil. In fulfillment of the new energy, it is referred as bioenergy, the volume of palm oil is processed into biodiesel energy source has 5% of any production diesel oil in Indonesia. Furthermore, the World Economic Forum (2006) explains that the securityof energy is

the ability of the economy to ensure the availability of stock energy resources as a sustainable supply of energy at a price level does not affect the performance of the regional economy. Factors which affected energy security, such as:

1. Availability of energy reserves in the country and export,
2. Explore the ability of the supply / energy sources,
3. Level of economic diversification of energy resources,
4. Accessibility of energy resources, especially energy and transport infrastructure.
5. Political conditions of the area of energy sources.

2. MATERIAL AND METHODS

This research based on the concept of *GBEP Project*, the aims of this research is to develop sources of biofuels from vegetable oils. The production of vegetable oil is palm kernel into *CPO (Crude Palm Oil)*. This research is conducted in the area of Indonesia, precisely in Riau Province, the main reason for choosing this region; because Riau province has a number of large oil palm plantations which each year more CPO increased productivity in line with the results palm oil production and plantation area. The function of plantation has limitations use with the procedures and permit to use of land. Information of land resources came from Department of Forestry to manage, organize, superviseand managing changes in land use. Information of spatial data from government derived with image interpretation has the function of region specification forest. Forest areas designated as forest use area that will change into land in accordance with an agreement with the local government. The use of land will reduce to forest resources, and it will stable with the formation of forest resources and have a surplus or deficit with previous period. On the other side, the forest resources is reduced, land resources managed a surplus of land due to land use change. The land for plantations growing oil palm purpose will transform function based on the agreement with local government; there are factors changes of the transmigration of each individual with an area that used for plant and changes due to plantation development. The land use change from forest to plantation areas, residential areas, agricultural are into components preparation of resource per region. Preparation of resource balance model includes components of natural forest resources and land resources. Source of research material from the forest map of 2009 - 2011, coconut plantations palm and paddy fields as well as the interpretation of the supporting data covering production, labor productivity and support the development of bioenergy and food.

2.1 Methodology

Geographic information systems (GIS) has functions to support decision-making in manage and determine the location and area of land in an effort to develop specific bioenergy biofuel from palm oil plants and diversification agriculture to support food security. The forest areas are known as region and land resources for the development of agriculture and plantation. It carries capacity of the forest to benchmarks of sustainable bioenergy development and utilization of food in terms of land. The correlation elements of forest land, plantation and agriculture became the principal calculation of the energy balance and food security. If the forest area has a small

number of stakeholders will concern to the each region for the development of plantation and agricultural areas. The length of plantations will provide information so the use of land could reduces the capacity of forest land. The relationship between the condition of high value of liabilities in the event of a change to the information region in terms of climate, weather, and food conditions, as well as socio-economic society. Stakeholders in each region should have the power of information capacity of land for assets and liabilities of land. Technical operation and development of geographic information systems arranged in 2 phrases data processing:

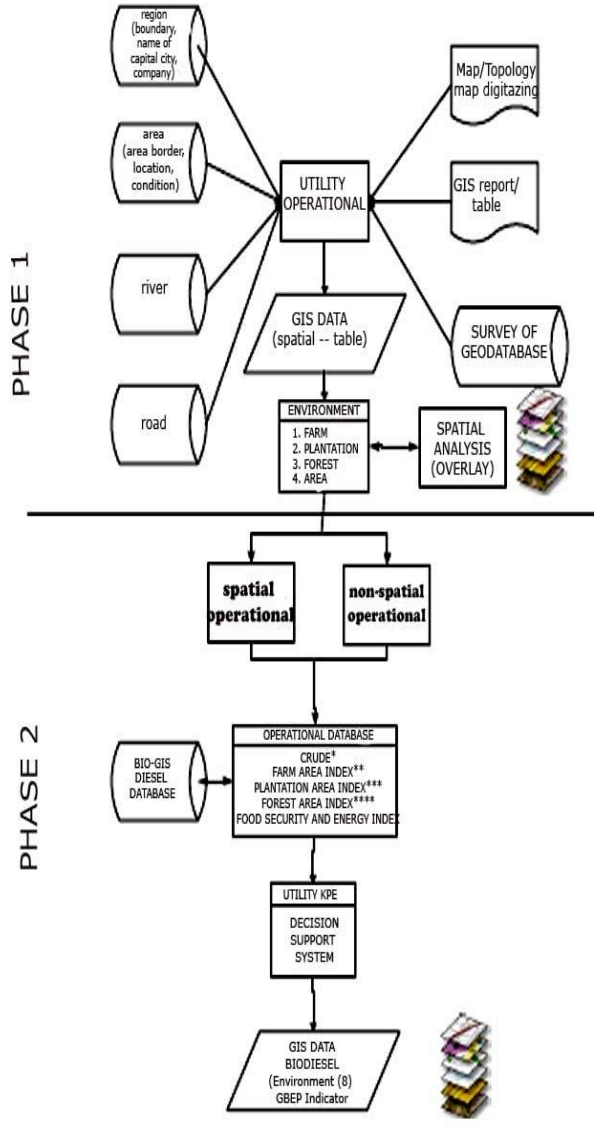

Figure 1. The Methodology of the Land Use Resource Balance's Arrangement

Phrase 1 : The process of operational geographic information systems included data preparation areas, forests, farms, plantations, rivers, and roads. Data obtained from digitizing / topology / internal location data in a geographic map with Quantum GIS software and information from accountability of government agencies, data management of statistical object forestry, plantation, agriculture and directory palm in oil companies, as well as the preparation of the data in the form of a digital map as source of the department forestry which included in operations that will result in output of form in maps and geographic information system data tabulation. Analysis performed on spatial data administration and forest areas components of forest resources, as well as administrative areas and plantation agriculture to be a component of land resources. The concept of system development used *Object Oriented Programming (OOP)*.

Phrase 2: Object data table and map are processed from a database management system function into a geographical information system function. Spatial and non-spatial data in the forms of statistic data information on the development of plantation, agriculture and forestry production and fields are put into a database. The database management uses a *Postgresql* software, a web-based visualization application with a windows-based

mapserver (MS4W) software and *PhpMapscripts* for scripts writing.The process continues in an operational database which has a component ofanassessment index process analysis of agriculture and plantation fields in the calculating process of the field resources. This process will resultmap and balance indexes for each region's natural resources, where the Activa component shows the information on the region's natural resources that can be used for the region and society development (housing, transmigration, industry and governance, plantation), agriculture and plantation based on some chosen parameters.These components interactioncreate an index of land utilization based on its function to support each region's food security and energy security. Production data collection is put into an information system that represents area, land, river, road and palm oil production volume in some areas. As for the companies as developers of palm oil and biofuel plantation, the system will also provide information on the company's location, plantation area and areas map. The scope of this geographical information system includes:

1. Types of plants used to process bioenergy materials are palm seeds which are processed into CPO and grains.
2. Map of areas for food and bioenergy plantations in Indonesia, specifically Riau Province.
3. Areas, forests, palm oil plantations, and agriculture areas in Riau Province.
4. Option to search documents on food and bioenergy statistic reports during the periods of 2009 to 2012 (Palm oil and food statistics, Ministry of Agriculture, 2012)
5. This study is focused on the geographical information system which will show a map of Indonesia thematically and its administrative border areas for food and bioenergy plantations information.

2.2. Areas Mapping

The first phase begins with an areas mapping process as a source of research trials. Data on forestry shows the government's moratorium mapping that is aimed to recalculate a forest area, which in principle, the authorization for its management could be carried out by other party. The authorization to use the forestry land is provided by the Department of Forestry. The forest land will be released particularly for public interests.Information on plantation areas is resulted from the proces of forestry utilization authorization by the large companies, public society or government, in which the implementation is limited to particular period and area of the used areas. The forest utilization should be authorized by the Department of Agriculture and also the Department of Forestry which initiated the forestry and non-forestry lands management. The objective of the forest land use is to give economic values for the local society and increase national economy.

Table. Areas Mapping of Riau Province
Land Functions Resources Balance
Riau Province

No.	District	Status	Total Area (Map)	Forest	Land	Plantation	Agriculture
1	1401.Kuantan Singingi	District	531.960,86	97.366,81	530.528,30	88.734,94	71.080,13
2	1402.Indragiri Hulu	District	805.837,08	266.873,30	804.551,99	111.928,71	125.050,12
3	1403.Indragiri Hilir	District	1.352.547,33	416.198,82	1.341.910,97	334.269,89	312.907,22
4	1404.Pelalawan	District	1.315.542,49	334.696,71	1.297.028,30	256.133,85	95.007,31
5	1405.Siak	District	787.477,79	167.645,15	787.403,44	191.592,86	75.288,57
6	1406.Kampar	District	1.077.260,86	198.146,48	1.076.420,66	256.070,61	187.734,42
7	1407.Rokan Hulu	District	732.547,40	90.938,89	730.257,29	186.127,14	226.708,40
8	1408.Bengkalis	District	856.902,30	311.904,67	855.006,27	98.101,64	77.146,19
9	1409.Rokan Hilir	District	915.059,67	207.682,41	895.313,68	133.997,16	190.481,80
10	1410.Meranti	District	366.628,12	205.457,98	363.433,37	6.433,74	22.675,55
11	1471.Pekanbaru	Municipal	62.984,20	4.940,84	62.990,39	3.720,09	23.578,95
12	1473.Dumai	Municipal	228.660,20	66.327,66	227.360,24	7.747,78	39.078,08
Total			9.033.408,30	2.368.179,72	8.972.204,89	1.674.858,42	1.446.736,74

Figure 2. Recapitulation of Digital-Map based Total Areas Calculation

2.3. Areas SupportingResources Optimization

Calculating every area supporting resources has various supporting and challenging variable characteristics. In an area where the society has agriculture sectors as its economic source, its supporting resources is calculated based on its food materials production. Physical need per person required daily is 2,600 - 3,600 kalories or 265 kgs of rice (*Vicky R.B. Moniaga,2011*). Calories are used to calculate an individual daily need on the basis that the calories are contained in the primary food sources, such as grains, corns, soybeans, potatoes and beans. Total area for food plantations is a component in calculating the agriculture area's supporting resources, resulted from dividing the minimum physical need values by the annual food plantation production which is converted into calories and kilograms of rice. The converted result value will therefore be compared to food production volume of each area into kilograms of rice/person/year. The total area of the land will affect the area's condition. The less the total area is, the larger the area's supporting resources, and vice versa. Food plantation crops area is gained by calculating the total area of the agriculture corp per capita divided by the number of the population living in each area. The total food corp area will be larger when the crops area is bigger. The land supporting resources will be equal when the total area and the total crops are equal, making it the best indicator in planning

the sustainable bioenergy development. The area's condition and corps total areas will provide the area with adequate food security.The larger result value of the area's supporting resources will ensure the area's food surplus, and otherwise.

Agriculture and Plantation Supporting Resources
Riau Province

No.	District	Status	Total Area (Map)	Total Population (2010)	Land supporting resources Index (Agriculture)	Land supporting resources Index (Plantation)	Total Values
1	1401.Kuantan Singingi	District	531.960,86	292.100,00	0,6739	2,5705	**3.2**
2	1402.Indragiri Hulu	District	805.837,08	363.400,00	1,3476	2,6424	**2.2**
3	1403.Indragiri Hilir	District	1.352.547,33	661.800,00	2,5441	7,1060	**1.1**
4	1404.Pelalawan	District	1.315.542,49	301.800,00	1,1278	20,0623	**2.1**
5	1405.Siak	District	787.477,79	376.700,00	0,4546	7,2053	**3.1**
6	1406.Kampar	District	1.077.260,86	688.200,00	0,8469	3,8563	**3.1**
7	1407.Rokan Hulu	District	732.547,40	474.800,00	2,5946	4,2804	**1.1**
8	1408.Bengkalis	District	856.902,30	498.300,00	0,2728	1,0796	**3.2**
9	1409.Rokan Hilir	District	915.059,67	553.200,00	1,3493	1,6342	**2.2**
10	1410.Meranti	District	366.628,12	776.300,00	0,0097	0,0019	**3.3**
11	1471.Pekanbaru	Municipal	62.984,20	877.800,00	0,0082	0,0005	**3.3**
12	1473.Dumai	Municipal	228.660,20	253.800,00	0,2698	0,0260	**3.3**
		Total	9.033.408,30	6.118.200,00			

Figure 3. Recapitulation of Agriculture and Plantation Supporting Resources

The area supporting resources calculation will be implemented in calculating the palm oil plantation area. Total plantation required to produce palm oil (ton) is gained by dividing the vegetable oil need consumtion ine each area. If the need value is made in percentage, total need required will be used to calculate the supporting resources value of each area to produce pal oil. The oil surplus will be excluded to be the export need of CPO and materials for biosolar mixing which around 5%, and if the analysis could be up to 7.5% per liter, the consumptionof fuel will be diesel.The converted vegetable oil need, biofuel and export need will affect the need and use of palm oil consumption. The land supporting resources which is gained from each calculaton component will result optimal number of total population, shwoing the number of populaton which have the resources to fulfil their daily needs, in each area.Meanwhile, the land function resources balance will calculate the activa components, consisting of the total area, the forest area;

and result the total land areas with adequate resources to be environmental resource reserve areas. The utilization of these areas will be under direct control of local stakeholders. Meanwhile, the passiva value is the component that uses the land function which was previously a released land. This therefore will reduce the land function capacity value. The larger the activa value, the more conducive and safer the area is to use the land function. The larger the passiva value, the less conducive the area is and will challenge the utilization of the land function. The extensive capital could be source of data in developing land for food, bioenergy and other uses such as industrial society, government regional center, of transmigration.

The land mapping optimization has resulted a new map: (i) Forest Area, (ii) Land utilization area, (iii) Plantation Area and (iv) Agriculture Area. The forest area map in each district shows the information on the natural resources condition, particularly the forests, that can be utilized as economic area. The land utilization that uses the analysis data source in considering the area development is categorized as ACTIVA, while the plantation and agriculture area is categorized as PASSIVA in the natural resources balance. An overlapping technique is used to find out the crosscutting area between the area borders and the identification border of utilized land, plantation and agricultre, mapped in the first phrase. The overlapping and forests moratorium layers will result a layer of forest map; the area and land utilization layers will result land utilization map; the plantation layer and area will result plantation map; and agriculture map and area will result agriculture map layer that covers all mapped provinces. The forest area for Kuantan Singingi (4,1%), Indragiri Hulu (11,26%), Indragiri Hilir (17,58%), Pelalawan (14,13 %), Siak (7,08%), Kampar (8,37%), Rokan Hulu (3,84%), Bengkalis (13,17%), Rokan Hilir (8,77%), Meranti (8,68%), Pekanbaru (0,21%), Dumai (2,80%) of all total Riau Province areas. The identified land utilization is 99,32% (source: Ministry of Forestry, *2011*). Plantation area in the districts of Kuantan Singingi (0,9823%), Indragiri Hulu (1,2391%), Indragiri Hilir (3,7004%), Pelalawan (2,8354%), Siak (2,1209%), Kampar (2,8347%), RokanHulu (2,0604%), Bengkalis (1,0860%), Rokan Hilir (1,4834%), Meranti (0,0712%), Pekanbaru (0,0412%), Dumai (0,0858%) of total Province area. Meanwgile, the agriculture area in each area ofKuantan Singingi (0,7869%), Indragiri Hulu (1,3843%), Indragiri Hilir (3,4639%), Pelalawan (1,0517%), Siak (0,8334%), Kampar (2,0782%), RokanHulu (2,5097%), Bengkalis (0,8540%), Rokan Hilir (2,1086%), Meranti (0,2510%), Pekanbaru (0,2610%), Dumai (0,4326%)

2.4. View Results

Spatial data management which has been integrated into a file database can be classified based on forests and lands supporting resources balance. The overlapping process of forests and administrative areas data will result the number of forest area in each district. The percentage of total forest areas in each district is resulted from the total forest area divided by the total administrative area of the district. The total forest area of each district added with the forest function area will result the vaue of the forest resources (ha). Forestry resources balance could be gained by categorizing the components of each area with the national standardized forest resources. The map illustrating the forest area at the government level is made smaller, therefore the areas

border will be more accurate. Below is one of the calculate recapitulation of Lands Function Resources Balance in the are of Kuantan Singingi (1401).

Recapitulation Lands Function Resources
Land Function : **1401.Kuantan Singingi**

Activa			Value of Activa	Passiva		Value of Passiva
Area	1.	Total area	531.960,86	1.	**Land Function**	
Forest	2.	Total Forest Area	97.366,8121	1.1	Plantation	88.734,94
				1.2	Agriculture	71.080,13
		A (Land Function Resources Activa)	434.594,0458		P (Land Function ResourcesPassiva)	159.815,07
					Capital (Land Function Resources)	**274.778,9749**
Total Value of Land Function Resources Balance			**434.594,0458**			**434.594,0458**

Figure 4. Recapitulation of Land Function Resources Balance

Capital is the total land functions which can be implemented and developed in each area into plantation, agriculture and other areas. By understanding the capital required to develop the lands area, such as agriculture, plantation, administrative disaster relocation area, industrial area food distribution terminal and bioenergy areas.Total capital areas of each area should not exceed the activa value. The higher needed capital shows that the area does not fit to be an area for development. Otherwise, when the capital value is less than the activa and passiva values, along with a reserved forest area, the area has an adequate supporting resources to be a food and bioenergy development area

Agriculture Land Support Resources
Riau Province

No.	Regions	District/Municipal	Agriculture Condition	Plantation Condition
1	**1401.Kuantan Singingi**	District	Scarce Food	Adequate Energy
2	**1402.Indragiri Hulu**	District	Adequate Food	AdequateEnergy
3	**1403.Indragiri Hilir**	District	Food surplus	Surplus Energy
4	**1404.Pelalawan**	District	Adequate Food	Surplus Energy
5	**1405.Siak**	District	Adequate Food	Surplus Energy
6	**1406.Kampar**	District	Scarce Food	Surplus Energy
7	**1407.Rokan Hulu**	District	Food surpluss	Surplus Energy
8	**1408.Bengkalis**	District	Adequate Food	AdequateEnergy
9	**1409.Rokan Hilir**	District	Scarce Food	AdequateEnergy
10	**1410.Meranti**	District	Scarce Food	AdequateEnergy
11	**1471.Pekanbaru**	Municipal	Scarce Food	AdequateEnergy
12	**1473.Dumai**	Municipal	Scarce Food	AdeuateEnergy

Figure 5. Food and Energy Security Index per region in Riau Province

The food security index will be categorized into“surplus”, “adequate”, or “shortage of food”. This food security categorization is set based on the total area of agriculture land function in each region. Adequate food security is one of the considerations to estabish a food security framework for each region. The agriculture land function index is compared to the plantation land function index in order to find food security categorization index based on the three combined lands. Forestry and field resources balance shows a composition of land function area for each component of activa and passiva in the balance. Each balance component calculation result shows actions required to develop bioenergy and food potentials. When the plantation land functionarea is larger than the agricultural land function, a diversification or intensification process will be an option to maintain the region’s food security. When thearea of theland for agriculture function is larger than the plantation land function, there will be food surplus in the agriculture production which will help each region to maintain their food security.

3. RESULTS

The calculation of forest resources are classified in several categorizations, based on the Indonesian national standard it divides into 2 major categories, forested and non-forested areas. Food security each region havecategorization of **surplus food** consists of Indragiri Hilir, RokanHulu, **adequatefood** consists of Indragiri Hulu, Pelalawan, RokanHilir, **scarce food**consists of KuantanSingingi, Siak, Kampar, Bengkalis, Meranti, Pekanbaru andDumaibased on the ratio of the function of producing bioenergy plantations and functionfarms producing agricultural food production. The condition capacity of land for bioenergy **surplus energy** consists of IndragiriDownstream, Pelalawan, Siak, Kampar, RokanHulu, **adequateenergy** consists of SingingiKuantan, Indragiri Hulu, Bengkalis, RokanHulu and **scarceenergy** conditionsconsists of regions Meranti, Pekanbaru and Dumai. The condition that should beconcern is Siak and Kampar region,whichboth of these conditions are better in capacitythan agriculture. The stability of resource make a decision which use by the value of social welfare composed with pattern of bioenergy development. The functions of large plantations indicated agricultural production due to utilization of coconut plantation function of excessive oil. Extensive agricultural area should be preserved for productionfoodstuffs and expanded agricultural function of food security in each region. A reference index of food availabilitydetermines the development of bioenergy and food, so that the direction of food security can be use in each region.

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