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The Impact of Population Pressure on Agricultural Land towards Food Sufficiency (Case in West Kalimantan Province, Indonesia)

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Abstract. Estimation of food sufficiency is important as food is one of the people's primary needs. West Kalimantan Province has a large area of agricultural land use so that it is relevant to find out whether the need for food is fulfilled. The relationship between the physical and social environment indicates the appropriate environmental management in certain regions. This research aims (1) to identify the population pressure on certain land carrying capacity and (2) to identify the correlation between land pressure and food sufficiency in West Kalimantan. Institutional data in terms of population, land use, land productivity, and agricultural commodities are analyzed quantitatively. The results show that (1) the land pressure of West Kalimantan is mostly categorized as safe, except for Pontianak City which population presses the most among all cities so that the land carrying capacity is classified as low. It is due to factors of population growth and main activities of certain region that affect the land use and consequently the environment condition; (2) land pressure and food sufficiency in West Kalimantan have negative correlation, which could threaten the food security, so that it is important to consistently implement the food diversification program based on technology-oriented sustainable agricultural approaches.

1. Introduction

The rapid population increase theoretically affects the need increase of community on the land [1,2]. Such condition directs to the apprehension in which the agricultural land is probably narrowed because of the massive conversion to the new land use, such as settlement or another more profitable land use. Furthermore, in the particular period, population pressure on the land is also able to affect agricultural productivity condition [3].

As a result, the population pressure on the land can surpass the land carrying capacity in the area [4,5]. The population pressure is the various troubles of the population due to its struggles for lives as a result of



the imbalance between population density and area provided [6-10]. Therefore, population pressure on the land tends to be caused by the population density increase in an area. The total population is increasing from 2012-2015 [11-14].

Such condition is hypothesized will also affect the land area and agricultural productivity. Furthermore, it will affect the food sufficiency in West Kalimantan Province. Based on the background, the aims of this research are (1) identifying the population pressure on certain land carrying capacity and (2) identifying the correlation between the population pressure on the agricultural land and the food sufficiency in West Kalimantan Province.

2. Methods

West Kalimantan Province is one of the province in Indonesia which is traversed by the equator, exactly in Pontianak City. Such condition causes the West Kalimantan Province has a tropical climate with the high temperature and humidity. Astronomically, West Kalimantan Province is located among 2°08' N-3°02' S and among 108°30 E-114°10' W in which the northern part is directly adjacent to Malaysia (Sarawak), the southern part is adjacent to the Java Sea and Central Kalimantan Province, the eastern part is adjacent to East Kalimantan Province, and the western part is adjacent to Natuna Sea and Karimata Strait. The province which has an area about 146,807 km² or 7.53% of Indonesia area consists of 14 regencies/cities (figure 1). There are four regencies which are adjacent directly to Malaysia, they are Sambas Regency, Sanggau Regency, Sintang Regency, and Kapuas Hulu Regency.

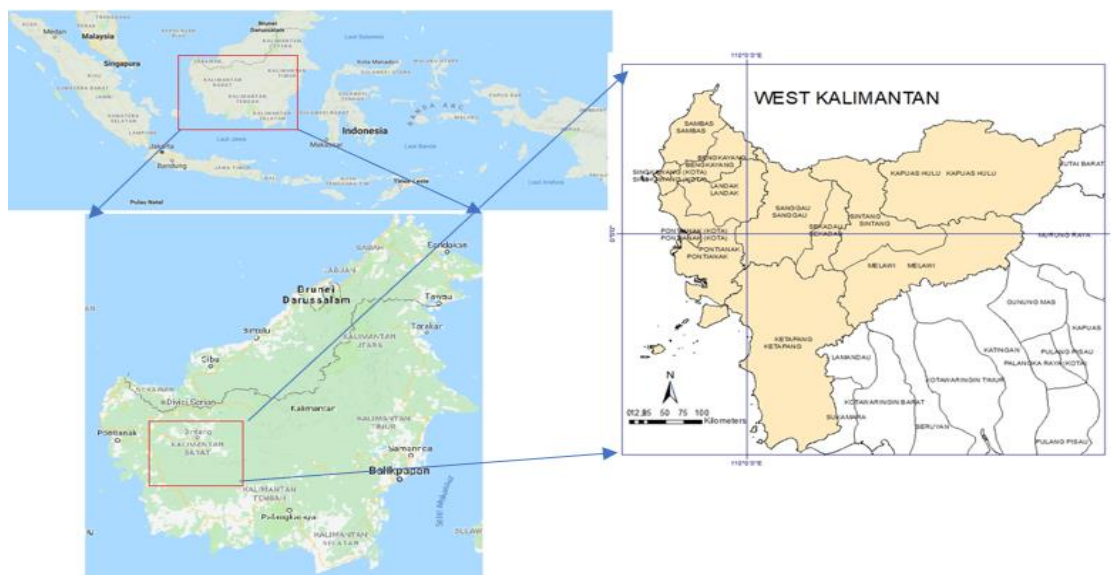


Figure 1. West Kalimantan Province as the Research Area

2.1 Tools and materials

The tools used in this research involve Microsoft excel software to inventory and process the data in the research variable. Processing data spatially uses GIS Software, ArcMap 10.2, which is then in synthesizing and analyzing data uses Microsoft Word. Data used overall are secondary data which is supported by literature study, among them is statistic data in the figure of each city in West Kalimantan Province 2012-2015 which is obtained from Indonesia Central Bureau of Statistics (BPS-Statistics Indonesia) official website.

In detail, secondary data are used as basic calculation of population pressure on agricultural land and as a reference in land carrying capacity calculation which involves total agricultural and non-agricultural land area, total farmers and farm laborers, and the total population in 2012 in each regency/city of West Kalimantan Province. Paddy harvest results data which is converted to rice data according to BPS and the total population in 2012-2015 which is also converted as an amount of rice needed in each regency/city are used to calculate food sufficiency in West Kalimantan Province. Literature studies related to relevant previous research are used as a data amplifier to deepen the analysis.

2.2 Calculating the Population Pressure (PP)

The population pressure on land is a comparison between total population and minimum total area for a feasible living [6]. In the model (1), population is considered only live from cultivated agricultural land. Population pressure formula in this model is:

$$PP = \frac{Z F P_0 (1+r)^t}{L} \quad (1)$$

where:

- PP : population pressure
- Z : a minimum total area for feasible living
- f : fraction (%) farmer to the total population
- P₀ : total population in the early year
- R : population growth rate
- t : period
- L : total agricultural land area

Z value is obtained by using the following formula:

$$Z = (0,25LSI2) + (0,50LSI1) + (0,50LST) + (0,6LLK) \quad (2)$$

where

- Z : minimum land area required for feasible living
- LSI2 : irrigated fields rice area, harvest >2 times/year
- LSI1 : irrigated fields rice area, harvest 1 time/year
- LST : rain-fed rice fields area
- LLK : dry land area

f value is obtained from the following formula:

$$f = \frac{\text{number of farmers and farm laborers}}{\text{total population}} \times 100 \quad (3)$$

The population growth is calculated based on a geometric formula, which mathematically defines as follows:

$$P_t = P_0(1 + r)^t \quad (4)$$

where:

- P_t : total population in t year
- P₀ : total population in the early year
- R : population growth rate
- T : Period which is expressed in year

2.3 Calculating land carrying capacity (LCC)

Land carrying capacity value is a reverse value from population pressure on agricultural land

$$LCC = \frac{1}{PP} \quad (5)$$

The result can be classified as follows:

LCC > 1: high land carrying capacity

LCC = 1: optimum land carrying capacity

LCC < 1: low land carrying capacity

2.4 Calculating Food Sufficiency

Food sufficiency is obtained from the following formula.

$$\text{Food Sufficiency} = \text{Availability} - \text{Needs} \quad (6)$$

Whereas 62,7% of paddy production results which have been the rice and 100 grams rice is equal to 130 kcal, meanwhile the food needs for each person is 1000 kcal/day.

3. Result and Discussion

3.1 The Population Pressure on Certain Land Carrying Capacity

Identifying population pressure (PP) value in each regency/city can help to know the variability PP value rate spatially. The distribution of PP value in each regency/city of West Kalimantan Province is generally at a value below 1. Nevertheless, Pontianak City is the only region with the PP value more than 1, i.e. 1.9 (table 1).

Table 1. Population Pressure in Each Regency/City of West Kalimantan Province, 2012-2015

Regency/City	Population Pressure (PP)	Classification
Sambas	0.196085	PP < 1
Bengkayang	0.141771	PP < 1
Landak	0.173692	PP < 1
Pontianak	0.768519	PP < 1
Sanggau	0.135084	PP < 1
Ketapang	0.015132	PP < 1
Sintang	0.052151	PP < 1
Kapuas Hulu	0.026215	PP < 1
Sekadau	0.440102	PP < 1
Melawi	0.587734	PP < 1
Kayong Utara	0.074470	PP < 1
Kubu Raya	0.520052	PP < 1
Pontianak City	1.917798	PP > 1
Singkawang City	0.518201	PP < 1

Pontianak City has the highest PP in period 2012-2015, even exceeds province PP value, i.e. 1.05. such condition shows that Pontianak City has the highest population pressure on land in West Kalimantan Province (figure 2). The high population pressure practically causes the effects on land needs so reducing the availability of habitable land. Further, the effects caused by the population pressure is food sufficiency. It is because the existence of interest between agricultural land and settlement/building land to fulfill people needs. The population pressure increase generally affects the following things: (1) decline in the size of farmers household; (2) the sustainability of cultivated land activity which leads to intensification and accumulatively causes the land degradation; and (3) land rental price increase and the change in business related to land allocation.

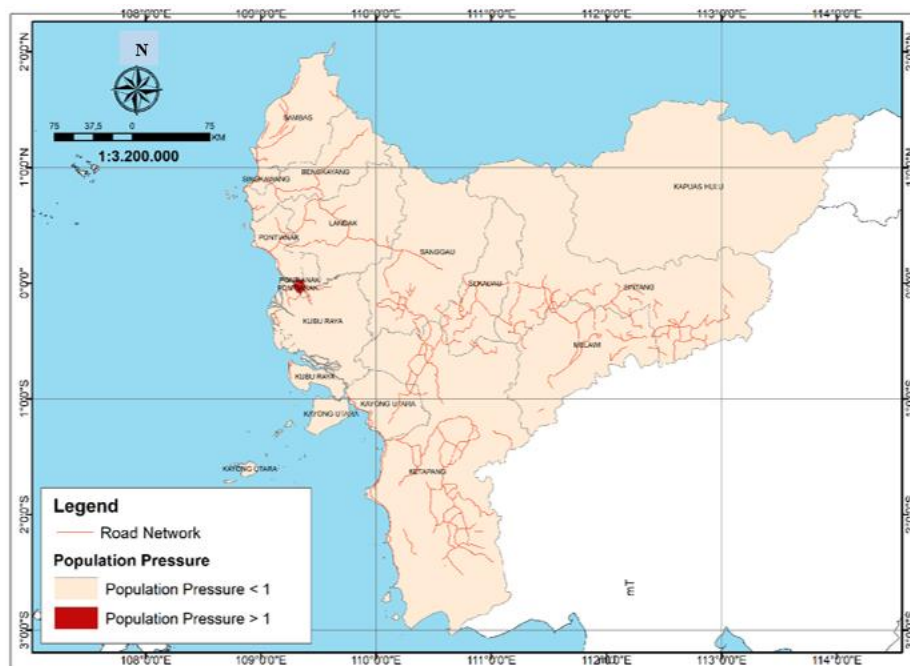


Figure 2. Map of Population Pressure on Land in West Kalimantan Province, 2012-2015

There is a correlation between population pressure with population growth rate. Population growth rate can affect the population pressure and threat the land availability which is shown by the decline in forest land and land erosion increase. The condition in Pontianak City and Singkawang City shows that the high population growth rate is also followed by the high population pressure. Those 2 regions have a population growth rate of 1,07 from 2012 until 2015. That value is not proportional to the land availability which tends to have the same total area during the same period so it increases the pressure on the local land resource.

The population increase has caused the shifting cultivation paradigm changes into continuous cultivation in Kalimantan area generally. That perception then developed to the application of land conversion massively to be able to fulfill the people needs. The case in Pontianak City, West Kalimantan, as happens in downtown generally, shows that the material orientation of land resources causes the decline in the agricultural land area rapidly. That thing is based on the agricultural land area data in Pontianak City which is smallest if compared to the other regions.

Pontianak City has a high population pressure which is related to the effects as a region of the capital city in West Kalimantan Province. That Pontianak City position causes some central activities, such as education, economy, and governance. The existence of activity centralization becomes the interest factor for the community to migrate to Pontianak City. There are various aims which appear as a response from the interest factor, i.e. to increase the feasible educational accessibility, to get the more suitable job and the other reasons which encourage someone to migrate to Pontianak City.

Such condition is in line with pull and push factors of people migration. The region which has the development of industry, trade, education, residence, and transportation progress. Inversely proportional with the origin place which has been the push factors. The following factors are the limitation of number and type of employment, unsupported facilities and infrastructures, inadequate education, and poor environmental condition.

The effects of high population pressure cause the low land carrying capacity (LCC). Pontianak City

has the lowest LCC (figure 3). Therefore, the impacts of population pressure on land is strongly influenced by the region condition which has that pressure. The inversely proportional relation between PP and LCC is showed in table 2.

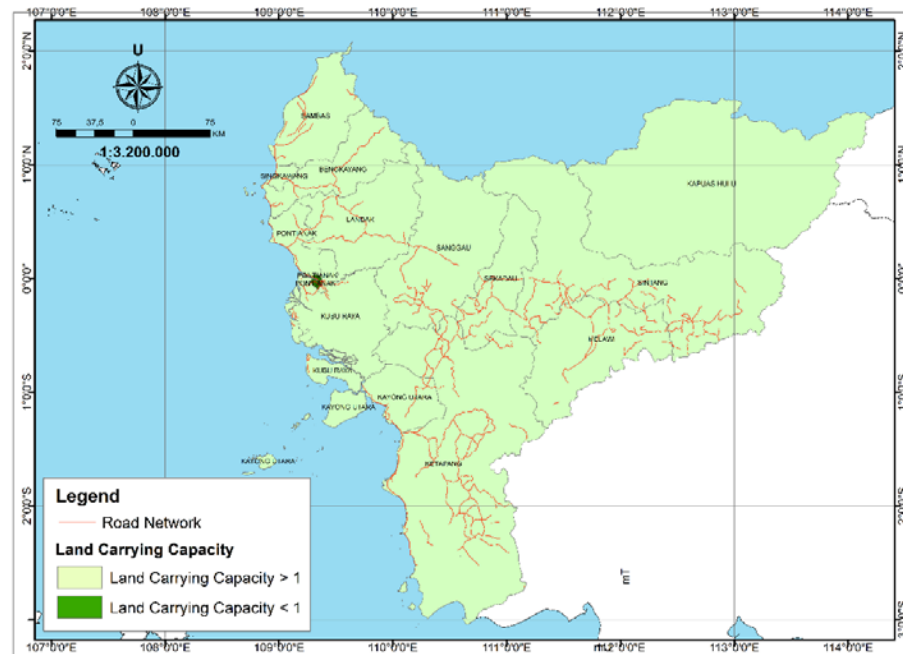


Figure 3. Map of Land Carrying Capacity Distribution in West Kalimantan Province, 2012-2015

Table 2. Land Carrying Capacity in Each Regency/City of West Kalimantan Province, 2012-2015

Regency/City	Land Carrying Capacity (LCC)	Classification
Sambas	5,099,837	LCC > 1
Bengkayang	7,053,619	LCC > 1
Landak	5,757,326	LCC > 1
Pontianak	1,301,204	LCC > 1
Sanggau	7,402,793	LCC > 1
Ketapang	6,608,495	LCC > 1
Sintang	1,917,491	LCC > 1
Kapuas Hulu	3,814,615	LCC > 1
Sekadau	2,272,201	LCC > 1
Melawi	1,701,451	LCC > 1
Kayong Utara	1,342,831	LCC > 1
Kubu Raya	1,922,886	LCC > 1
Pontianak City	0,521,431	LCC < 1
Singkawang City	1,929,753	LCC > 1

Land carrying capacity shows the amount of land which is able to support human life, not only as an agricultural land but also for settlement and another socio-economic activity. Based on that definition, it can be stated that the factors of decline in land carrying capacity are influenced by factors of population pressure rate on agricultural land. The triggered factors, such as population growth rate, incoming

migration, and urban area condition are considered as the dominant factors which are possible to increase the population rate and decrease the land carrying capacity.

3.2 Population Pressure and Food Sufficiency in West Kalimantan Province

Graphic in figure 4 shows that the food sufficiency will be fulfilled if the population pressure is getting smaller on agricultural land. The condition in Pontianak City most represents the inversely proportional relation between both variables. Pontianak City has the highest population pressure compared to the other regions of West Kalimantan Province with index values of 1.9 and becomes the regions which have the highest deficit in rice that reaches 221,402,122,320 kcal/year (figure 5).

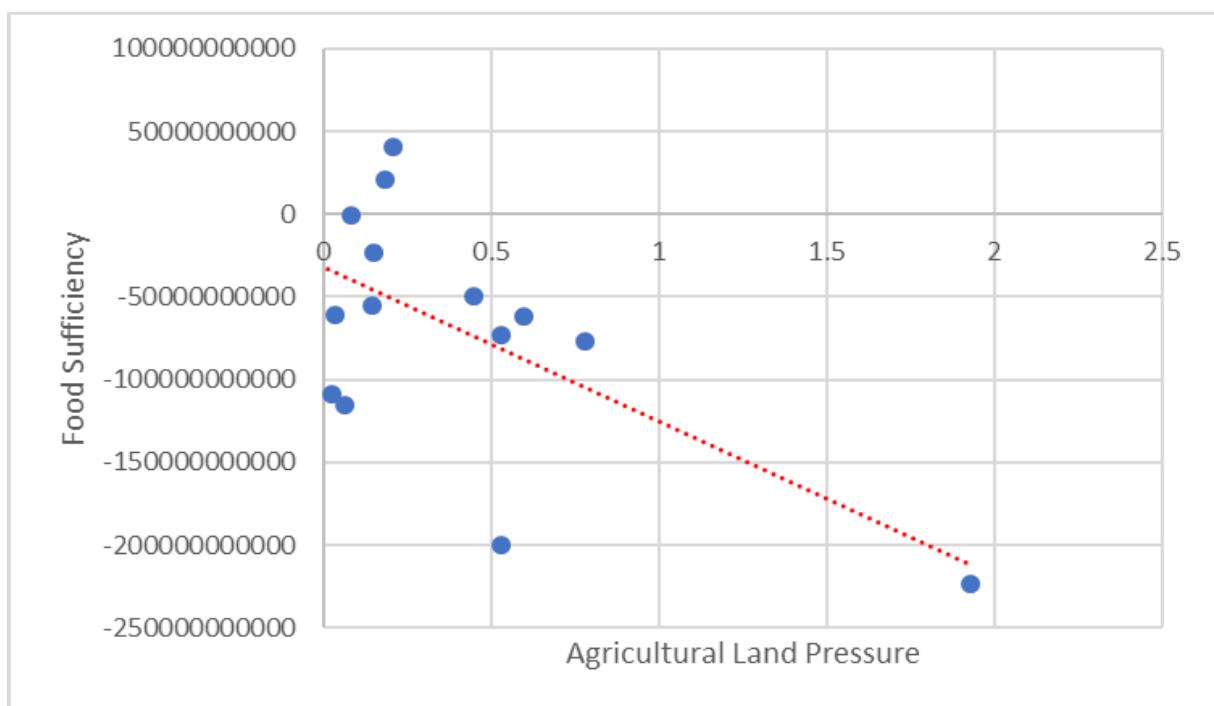


Figure 4. Negative Correlation between Population Pressure on Land and Food Sufficiency in West Kalimantan Province, 2012-2015

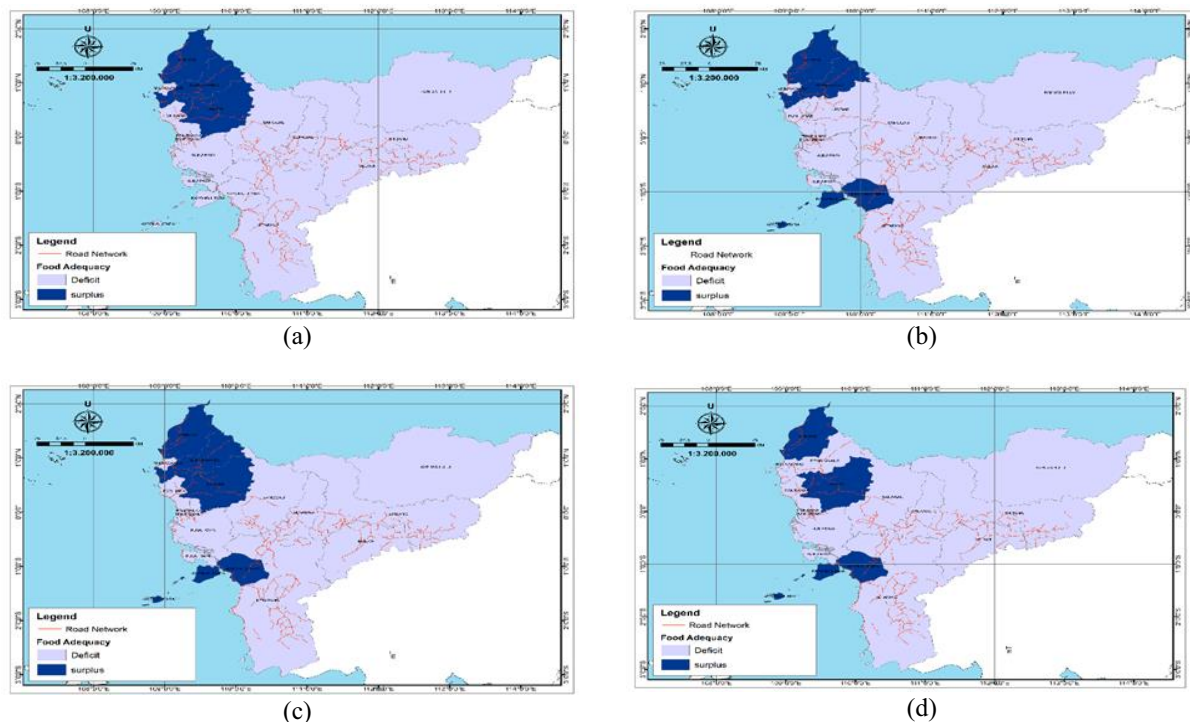


Figure 5. Map of Food Sufficiency Distribution in West Kalimantan Province 2012 (a), 2013 (b), 2014 (c), and 2015 (d)

A large number of population in an area indirectly gives a pressure on land through the activities which are done, mainly in a big city which becomes the central governance, such as Pontianak. Especially for agricultural land, the large number of the population associated with the massive conversion into building land so the carrying capacity decreases. The agricultural land which is getting narrowed in this case increase the imbalance between food needs and resources availability. The population increase causes the bigger encouragement on fulfillment the food needs which is a valuable as 100,000 hectares paddy production land and several tens of thousands of hectares of land for another food commodity production. The area is equivalent to about 0.7% from the total land area in West Kalimantan Province.

The population pressure on the agricultural land condition in West Kalimantan has the low variability spatially. Most of the regions have a population pressure value in low classification (0.015-0.649). As a result, agricultural carrying capacity in West Kalimantan Province is tended to be high with a total area of 14,680,700 hectares in 2013. However, especially for paddy production land only has an area of 1.33% of total agricultural land and has a conversion continuously until 2016 becomes 0.9%. Such condition becomes a threat for rice food sufficiency, shown by the tendency which decreases during 2012-2015 as existed in figure 6. Therefore, there is a positive correlation between land conversion and agricultural productivity as ever stated by Norman Borlaug who is known as the father of the world green revolution.

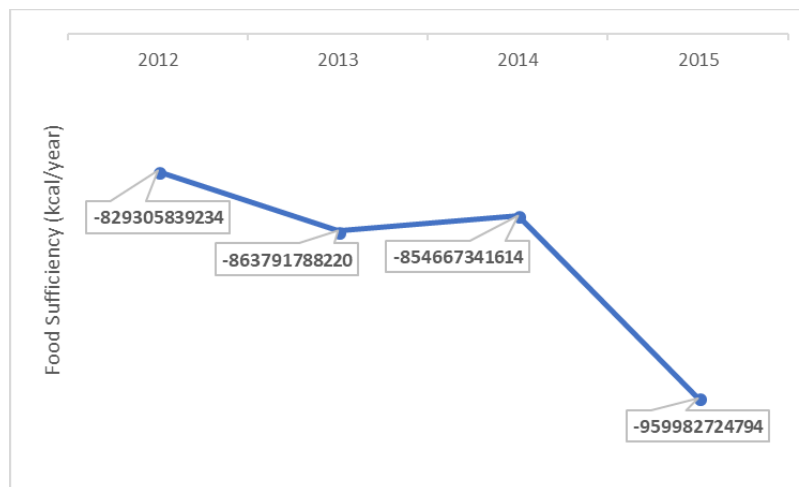


Figure 6. Food sufficiency of West Kalimantan Province, 2012-2015

Food deficit, especially in rice commodity can cause a long period of food vulnerability. It is because food availability becomes one of the indicators used to determine food vulnerability condition in an area. Food diversification is extremely needed to decrease the population dependence on rice commodity. West Kalimantan has a potential in the development of tubers commodity as a carbohydrate source, besides rice. It is based on the factor of the large tubers genetic resources area and the higher tendency of tubers production land productivity during 2005-2010.

Further, the technology development which is able to increase the agricultural patterns efficiency and agricultural production results is also needed. The fulfillment target on rice needs has been in time to get the solution in the form of technology innovation, besides by remain doing the appropriate land management efforts. The existence of massive land conversion which is also compounded by fluctuated climate condition certainly needs a technology modeling to fulfill the food needs in each region.

4. Conclusions

The findings of this research can be concluded as follows: (1) the population pressure on agricultural land of West Kalimantan Province is mostly categorized as safe, except for its central region, i.e. Pontianak City which population has the highest pressure on land among all regencies/cities. Thus, the land carrying capacity which is inversely proportional with population pressure is classified as low or below the safe boundaries in Pontianak City, while in other areas are safe. The condition of one significant spatial gap in West Kalimantan in terms of population pressure and land carrying capacity is causally influenced by factors of population growth and main activities of certain region (e.g. educational, economics, and governance in Pontianak City), which then affect the needs to use land resources and furthermore, the broader environment condition; (2) population pressure on agricultural land and food sufficiency in West Kalimantan have a negative correlation, meaning the food needs will be fulfilled if the land pressure is getting smaller. The continuation of that condition could threaten the food security so that it is important to consistently implement the Indonesian food diversification program on carbohydrate sources. West Kalimantan, as well as the Kalimantan region, has well tubers production rate than rice rate, that needs to be optimized based on technology-oriented sustainable agricultural approaches.

5. Acknowledgment

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