Land Use Change Identification Using SPOT 6 for Food Security Analysis of Denpasar City, Bali Province, Indonesia

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Key words: Land Conversion, Agricultural Land, Food Security, SPOT 6 Imagery, Bali Island.

SUMMARY

Land use change or known as partially or totally land conversion of the original function to another function, is common in Indonesia, including Bali, especially land conversion from paddy field to another uses. This phenomena cause serious problems in the future, so government awareness is needed immediately. Based on statistical data of Bali 2015, rice field area continued to decline every year, both irrigated rice field and rainfed. This condition can understood, because Bali Island especially Denpasar is one of the world tourist destination, so many reasons to change agricultural land into other functions such as residential, hotel and other uses. This paper will discuss about land use change and the impact on food security in Denpasar area. The research used topographic map 1: 25,000 based on data 2002 and SPOT 6 imagery acquired 2015. By comparing the different data acquisition, it can be seen the changes of land cover in research area. The results of this analysis showed that the residential and built area in Denpasar increased amounted 1,736 hectares and the rice field area decreased amounted 1,695 hectares during 13 years, or the increasing rate of settlement area was 133.5 ha / year and declining rate of rice field area was 130 ha/year. There were declining of rice field area in Denpasar, but at the same time the population increasing rapidly, it is necessary to analysis its impact on food security in Denpasar area. The result of food availability analysis showed that the Denpasar city still lack food amount 129,496.5 tons in 2015, or only fulfilled about 24% of food needed, if only rely on crop yields in the region itself. Therefore, it is very necessary import policy from the surrounding area and a moratorium policy related conversion of agricultural land. Agricultural land conversion in Denpasar is a threat to the achievement of food security towards food sovereignty, where land conversion have serious implications for food production, in welfare and rural agricultural communities whose livelihood depends on the land. The research can be used as input for planning and formulating the local policy as well as national in Indonesia.

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1. INTRODUCTION

Landuse change or land conversion can be interpreted as a change in the function of part or the entire region of the original function into other functions that have a negative impact on the environment and the potential of land itself (Muslikin, 2015). Conversion of land also means the conversion or transfer of land generally involves a transformation in the allocation of land resources from one use to another use (Soemarno, 2011). Land conversion from agriculture to non-agriculture, especially paddy field to non-paddy field such as plantations, settlements or other awoke region is very common in Indonesia, including in Bali Province. Referring to the 2015-2019 RPJMN that food sovereignty is one priority sector development dimension. Geospatial Information Agency of Indonesia as the only organizer for basic geospatial information in Indonesia can play a role in providing basic geospatial information, remote sensing imagery and supporting spatial analysis of strategic issues that can support the development priorities. Study of the use of satellite imagery for land changes analysis especially in agricultural land is highly relevant mainly carried out in which the results are used to support food security analysis of a region in terms of the spatial aspect. Denpasar Municipality is a selected sample, since this area is one of the tourist destinations, with the highest density in the province of Bali, and farmland tend to change the function. Percentage of land conversion in Bali over the past 15 years, is the highest occurred in Denpasar, on average 1.30% per year to switch the function of agricultural land become non-agricultural land (BPS Prov. Bali, 2015). Therefore, in this study, Denpasar became the object of a sample to be examined regarding food security.

According to the World Health Organization (WHO), the definition of the main components of food security namely food availability, food access and food utilization (Mun'im, 2012). Food availability is the ability of a person, group of people (households) has a number of food sufficient for basic needs. Food access is the ability to have the resources economically and physically to get nutritious food. While the utilization of food is the ability to utilize food properly and well and proportionate. But in this paper is focused on the components of food availability in Denpasar based on spatial analysis and the use of the statistical data of the Regional Statistical Bureau. Research questions on this study is: how extensive the paddy field changes become non paddy field in Denpasar by using SPOT imagery 6 acquisitions 2015, and whether the existing paddy field is still able to meet food needs the population entire Denpasar.

This research is important to do despite the availability of food is not the only factors that determine the food security of an area, but there are other factors that will determine the achievement of food security (Mun'im, 2012). However, due to conversion of agricultural land is a serious threat for

security and food safety, it was necessary to study in this region. Conversion of fertile farmland have been less offset by a concerted effort to develop agricultural land through the use of marginal land. On the other hand, food agriculture land conversion leads to reduced tenure thus decrease the income of farmers. Therefore, the results of this study can be used as a warning for this local government to look back the land conditions, especially land changes from agricultural into non-agricultural which can cause reducing availability of food (rice) in this region. Besides this, with the results of this study can be used as the input of policy what will be done, such as controlling wetland conversion, creating new wetland or other policies that can be strengthening food security.

2. DATA AND METODE

Land use change dynamics can be observed by multi-temporal land use changes. The data used in this study consisted of spatial and non-spatial data. Spatial data used topographic map scale of 1: 25,000 created 2002 and SPOT 6 acquisition 2015. While non-spatial data used statistical data from BPS such as number of population, population projection, wetland area, the number of crops, etc. Land use information is the result of human activities in land, land use or land function, so it can't always be estimated directly from remote sensing images, but can be recognized from the land cover association. The procedure of processing and analysis of remote sensing imagery is done by beginning stages of pre-processing data. At this stage, the geometric process correction is needed in order to improve the appearance of the object distortion and geographic position within the limits of the study area. The radiometric and atmospheric correction to eliminate or reduce atmospheric interference is done by systematicallyproccess.

The land use classification is carried out by visual image interpretation. Visual interpretation made based on basic element interpretation approach such tone / color, texture, pattern, size, shape, shadow and association asa guidance for land use classes (Purwadhi, S.H et al, 2013). In this study, the land use are grouped into 12 classes: lake, ponds, mangroves, swamp forest/peat, grasslands, plantations/gardens, settlements and activities, swamps, paddy fields, scrub, moor/ fields, and non-cultivated vegetation.in The land use change were observed by overlaying the maps of land use in 2002 obtained from topographical maps and land use maps in 2015 from the results of SPOT 6 image interpretation.

Food self-sufficiency is the ability of a region to produce food that can ensure sufficient food needs until at an individual level. Food self-sufficiency can be calculated based on the carrying capacity of food in a region. Or consumption needs of the population to food, especially rice by 114 kg / capita / year (Mahbubi, A., 2013). If rice production in a district divided by the population exceeds the consumption of rice per capita per year, then the district can meet the needs for itself, even if production is large, then the district may send its food production to other districts. Otherwise, the district can't be self-sufficient, so it must import food or rice from other districts. The ratio of consumption to the net production of rice normative per capita is one of the determinants of food insecurity (Sulistyo, W. 2015). Carrying capacity of the food in each municipality can be formulated as follows:

$$DDP = (Lx\ Pp)/Pe \geq 114 \quad \text{..... (1)}$$

where:
DDP = Carrying Food / Daya Dukung Pangan (kg/capita/year)
L = Area Harvested / Luas panen (ha)
Pp = Rice Productiviy / Produktivitas padi (kw/ha)
Pe = Number of Population / Jumlah penduduk (people)

The DDP index 114 explains that food consumption per capita was 114 kg / capita / year is a critical limit food consumption per person per year. If DDP ≤ 114, itmeansthe carrying food is deficit, that food production can't meet the needs of the population residing in this region. Otherwise, if the DDP> 114, then food production in the region could meet the food needs of the population residing in the territory, it means food surplus.

3. RESULT AND DISCUSSION

3.1 Image Classification

Remote sensing technology continues to evolve so as to produce image data of high resolution remote sensing satellite capable of recording an object with a size of less than one meter. This is certainly easier for users to recognize an object recorded by satellite imagery and provide more detailed information. This study used land use data obtained from topographic map scale of 1: 25,000 and the results of SPOT 6 image interpretation acquired 2015 which has a spatial resolution of 1.5 meters. Based on the topographic map scale of 1: 25,000 were created in 2002, land use / coverage area of Denpasar consists of Lake, ponds, mangroves, swamp forests, grasslands, plantations, swamps, paddy fields, scrub, moor / fields, and non-cultivated vegetation. The largest land use in Denpasar City are the settlements and activities, fields, and plantations / gardens. Based on the results of rectified SPOT 6 image classification 2015, it can be seen that the largest land use is still the same, namely settlements and its activities, paddy fields, and plantations / gardens, but its wide has undergone changing. Figure 1 shows the SPOT imagery 2015, the research sites that used as a data source for / land use classification. Figure 2 shows the topographic map created in 2002 and Figure 3 shows the results of SPOT image classification map, 2015.

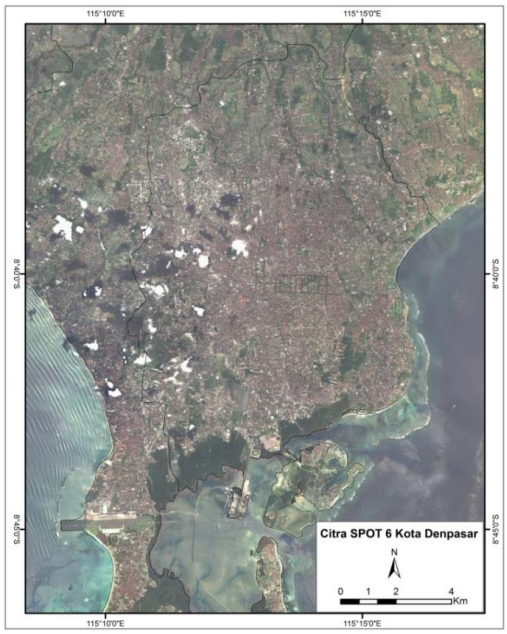

Figure 1.Ortorectified SPOT Image 6 acquired 2015 of Denpasar City

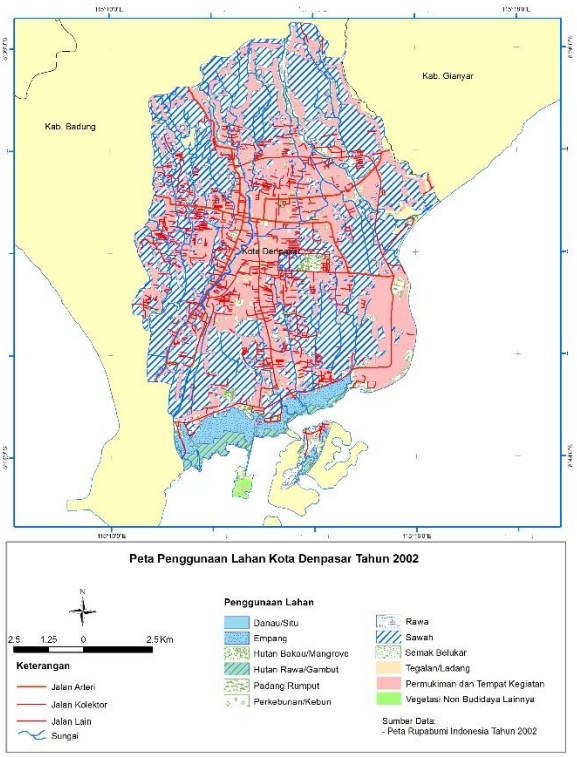

Figure 2. Landuse / land cover 2002
Source: Base map 1:25.000

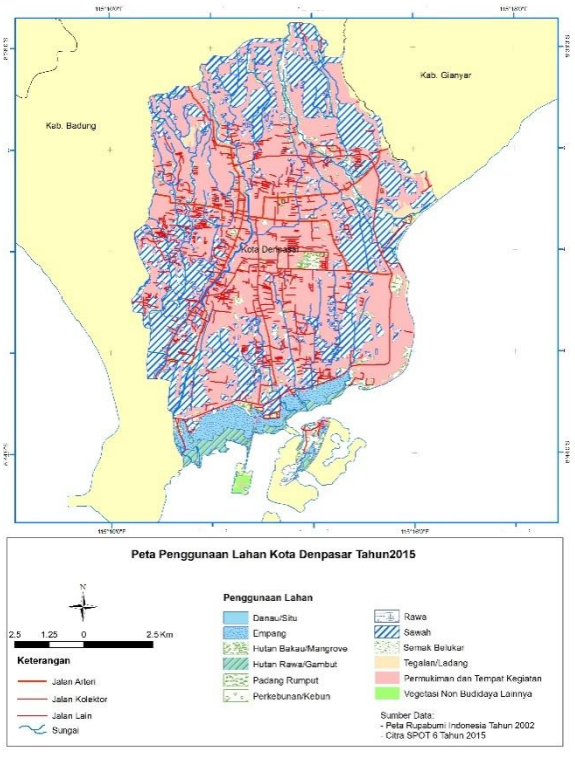

Figure 3. Landuse / land cover 2015
Source: SPOT 6 acquired 2015

3.2 Land Use Change

Based on the land use changes analysis 2002 – 2015 was obtained the coverage of land use change, as shown in Figure 5. The map showed some land use changes, namely some grassland change into settlements, some plantations / gardens change into settlements, some plantations / gardens changes into paddy fields, some scrub changes into settlements and some paddy fields change into settlements. Settlement and its activities is the largest increased amount 1.735.58 ha for 13 years or increasing rate 133.5 ha/year, followed by paddy fields change decreased amount 1.694.81 Ha or decreasing rate 130 ha/year, and plantation change decrease amount 26.90 Ha or 2 ha/year. The increased in built up area was accompanied by a drop in agriculture areas. The land conversion is mainly for housings and settlement purposes (Harini, 2007). For more details can be seen in Table 1 that inform land use change in Denpasar based on data from 2002 and 2015. Figure 4 shown illustrated with a graph.

Tabel 1. Land use change of Denpasar City 2002 – 2015

Landuse/land cover	Topographic Map 2002 (Ha)	SPOT Imagery 2015 (Ha)	Land Use change(Ha)
Lake	10.33	10.33	0
Ponds	384.14	384.14	0
Mangroves Forest	2.27	2.27	0
Swamp forests/Peat	245.47	245.47	0
Grasslands	195.53	182.62	-12.91
Plantations/garden	687.68	660.78	-26.90
Settlement and its activities	8621.76	10357.34	1.735.58
Swamps	33.79	33.79	0
Paddy fields	5238.15	3543.34	-1.694.81
Scrub	20.5	19.98	-0.52
Moor / fields	111.23	110.79	-0.44
Non-cultivated vegetation area	32.53	32.53	0

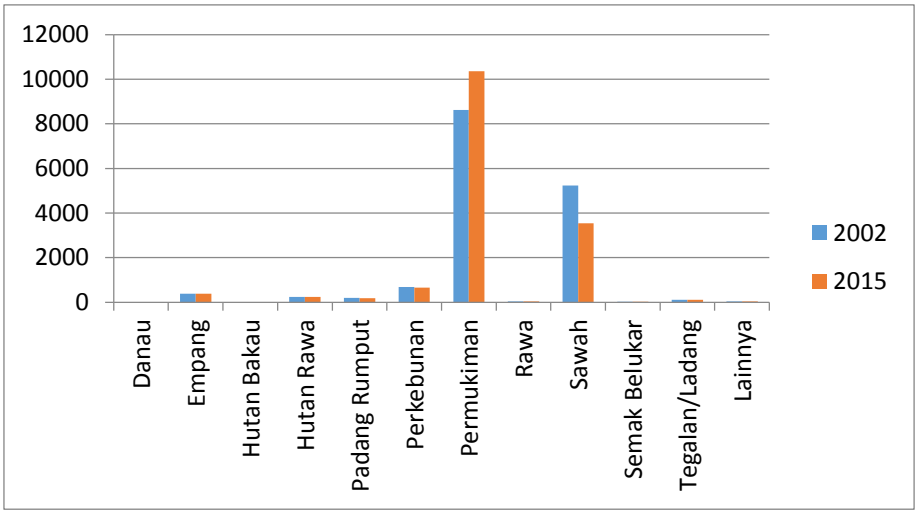

Figure 4. Land use change graph of Denpasar City 2002 – 2015

3.3 Food Security Analysis

For Indonesia, food is often associated with rice because this type of food is the main staple food. The impact of land conversion, especially paddy fields would eliminate the function fields as land intended for the production of rice (Iqbal and Sumaryanto, 2007). With the conversion to other functions will reduce rice production. This could threaten food production in a region that led to the inability to meet the food needs of population in the region. For example, due to conversion of paddy fields in Java for a period of 18 years (1981-1998) accounted for accumulation has been loss of 50.9 million tons of grain, or approximately 2.82 million tons of grain per year. When calculated rice equivalent, then the loss of food production is approximately 1.7 million tons per year (Irawan, B., Friyatno, S, 2012). The result of the carrying capacity calculation of land in Denpasar shows that the city of Denpasar in 2014 has harvested area of 4,232 ha. With an average yield of 6.19 tons / ha, rice production reached 26,200 tons. Of the value of production will produce 16,558 tons of rice. The result of the calculation of food requirements in Denpasar with a population of 659,623 and an average consumption of 114 kg per capita per year reached 75,197 tons. The calculations show that the food security of Denpasar currently not able to feed themselves independently. There is a deficit amount 58,638.6 tons of rice that can't be met by the Denpasar from existing rice crops.

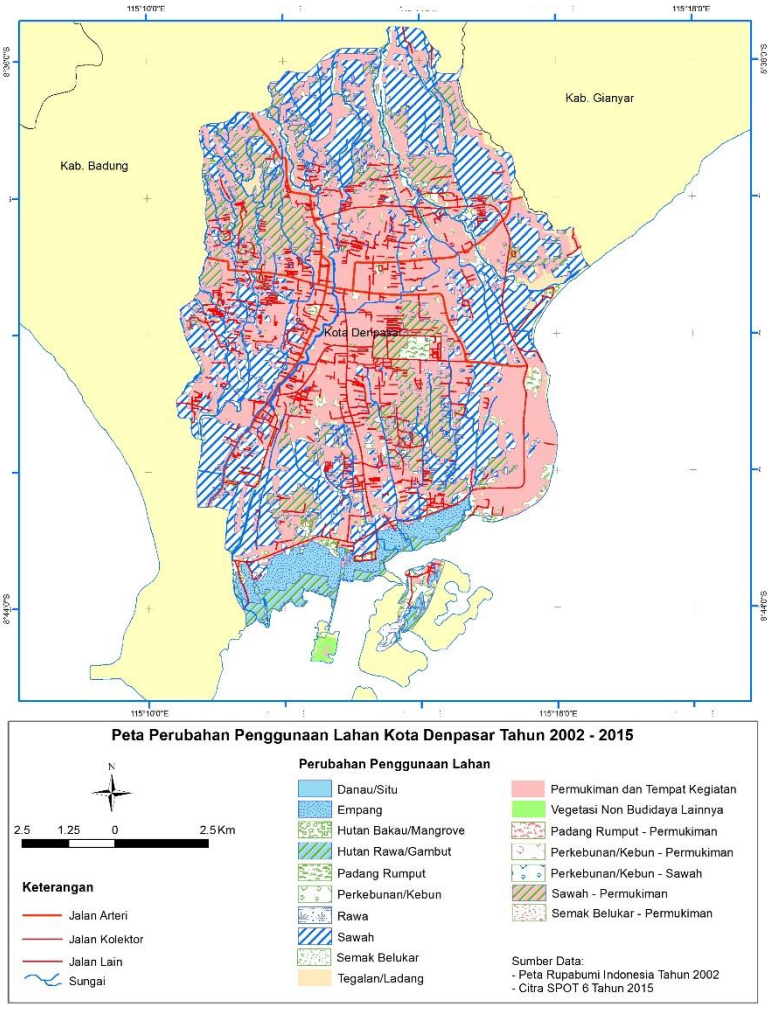

Figure 5. Land use change map of Denpasar City 2002 – 2015

Using the same formula for data 2015, based on data submitted by the Head of Department of Agriculture, Food and Horticulture of Denpasar as mentioned on Denpostnews.com stated that Denpasar on average produce 10-13 tons of rice per hectare during 2015, so the total rice produces 31,213 tons. The projected population of the Denpasar city in 2015 is around 880,600. The total rice in 2015 needs 160,709.5 tons, so there were deficit amount 129,496.5 tons. It means the rice available from Denpasar only about 24% of the need, it can't met the food need of entire population throughout the year, unless there were import policy of the local government.

Based on the wetland dynamics analysis, wetland in Denpasar continues to decline, while the population growth rate reached 1.96% per year. Population growth continues increasing so demand food availability is increased as well. With the wetland conversion rate is high enough, the paddy fields in the Denpasar city no longer be sufficient for current residents and future, can be seen from the above calculation. Denpasar dependence on other areas related to rice supply as a staple food even higher. Therefore we need appropriate government policies related with land conversion of

agricultural land into non-agricultural (Nasoetion, 2003). The local government should be stipulate of a raw rice field's area which should not be their conversion unless the reason for the public interest, with feasibility studies (Parwata, 2014). Need to apply rewards and punishments related to farmers who are able to maintain his farm and working creatively to increase the productivity of land, for example by applying appropriate agricultural and does not switch professions.

4. CONCLUSION

Conversion of agricultural land into non-agricultural in Denpasar is quite high based on classification of SPOT imagery, with the rate of change about 130 ha / year, while the rate of increasing of settlements and other activities amounted 133 ha / year. Wetland/paddy filed changed completely into a settlement amount 1.695.61 Ha, and the rest comes from plantations amount 26.1 hectares, pasture 12.91 hectares, shrubs and moor less than 1 ha during the last 13 years.

Result of food availability analysis of Denpasar using spatial and non-spatial data (statistics) showed that the Denpasar city still lack food amount 129,496.5 tons in 2015, or only fulfilled about 24% of food needed, if only rely on crop yields in the region itself. Therefore, it is very necessary import policy from the surrounding area and a moratorium policy related conversion of agricultural land.

Agricultural land conversion in Denpasar is a threat to the achievement of food security towards food sovereignty, where land conversion have serious implications for food production, and in welfare and rural agricultural communities whose livelihood depends on the land.

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BIOGRAPHICAL NOTES

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