APPLICATION OF GIS ON THE DETERMINATION ANALYSIS OF SUSTAINABLE FOOD AGRICULTURAL LAND IN SERANG REGENCY

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ABSTRACT. The rapid conversion of agricultural land into non-agricultural land directly reduce the land availability for food production activity. Therefore, to control the rate of food agricultural land conversion needs many efforts, such as implementing sustainable food agricultural land program. This study aimed to analyze the determination of sustainable food agricultural land in Serang Regency. By using GIS technology and doing weighted overlay analysis, the result of the research showed that based on optimistic scenario, the determination of sustainable food agricultural land covered 21.489,30 Ha of rice field. While based on pessimistic scenario, the determination of sustainable food agricultural land covered 37.176,25 Ha of rice field. The determination of sustainable food agricultural land needs to be carried out in order to ensure the sustainability of the food supply and to protect the fertile lands which have high productivity in Serang Regency.

Keywords: sustainable food agricultural land, GIS, weighted overlay, land conversion

INTRODUCTION

One of the major problems facing agricultural land is uncontrolled land conversion. The rapid urbanization has resulted many land conversions from agricultural land into urban activities (Hsueh-Sheng *et al*., 2009; Mohammed, *et al*., 2015; Nuhu & Ahmed, 2013). According to data from BPS (2004), in Indonesia, during the period 1979-1999, the land conversion of rice field was reached 1.627.514 Ha or 81.376 Ha/year. In recent years, the speed of rice field land conversion is much higher than the speed of creating new rice field lands. The rapid conversion of agricultural land into non-agricultural land can affect the performance of agricultural sector. The land conversion directly reduces the land availability for food production activity, so it will greatly effect to local and national food supply. Therefore, to control the rate of food agricultural land conversion needs many efforts, such as implementing sustainable food agricultural land program. The challenge to reduce the rate of agricultural land conversion is how to protect the land availability of agricultural land through spatial planning and spatial controlling.

In order to protect agricultural land, the government has issued The Law No. 41/2009 concerning sustainable food agricultural land. It regulates the protection of agricultural land for food crops and the mechanism for converting agricultural land. For its implementation, each regency has to determine sustainable food agricultural land in their respective regions, including Serang Regency.

This study aimed to analyze the determination of sustainable food agricultural land in Serang Regency. The process of analysis was carried out by using GIS. The component of GIS consists of hardware, software, geographical information data, and management. According to Parimala & Lopez (2012), GIS is a technology used to collect, store, query and analyze spatial information, which combines graphics with different types of database. The accurate and real spatial information with charts and texts according to the actual need and also data attributes correlation can be exhibited by GIS method. GIS has been widely used by several authors as a tool for decision-making related to land suitability analysis (Konan-Waidhet *et al*., 2015).

METHODOLOGY

Framework

The Framework of this study is depicted in Figure 1. This framework developed as a guideline of analysis steps.

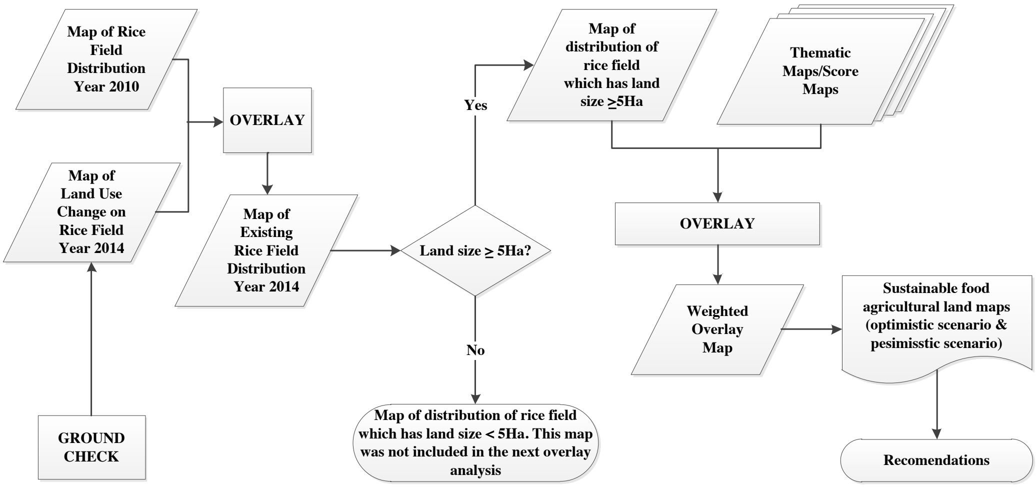

Figure 1. Framework

Data Sources

The data being used to analyze the determination of sustainable food agricultural land were map of rice field distribution (derived from the interpretation of satellite imagery in 2010), slope map, map of network roads, administrative map, demographic data, statistical data of rice production, and data of planting index. The maps and data were obtained from The Department of Agriculture, Forestry, Plantation, and Fishery of Serang Regency and from some government agencies.

Analytical Method

The analytical method used in this work was weighted overlay. It was a technique for applying a common scale of values to diverse and dissimilar input to create an integrated analysis (Parimala & Lopez, 2012). This weight overlay analysis was also supported by multi-criteria analysis. To identify which potential land that can be proposed as sustainable food agricultural land, there were five criteria being used, such as type of rice field, planting index (PI), class of slope, infrastructure, and land size. Furthermore, each criterion has attributes and scores. The score of each attribute was shown in Table 1.

Table 1. Criteria, Attributes, and Score

No	Criteria	Attributes	Score
1	Type of rice field	a. Lowland rice	4
		b. Upland rice	2
2	Planting Index (PI)	a. PI >= 2	4
		b. PI <2	2
3	Class of slope	a. Slope 0-2%	4
		b. Slope 2-15%	3
		c. Slope 15-25%	2
		d. Slope 25-40%	1
		e. Slope >40%	0
4	Infrastructure (Accessibility)	a. <= 50m from arterial/collector road	4
		b. > 50m from arterial/collector road	2
		c. <= 20m from local road	4
		d. > 20m from local road	2
		e. <= 10m from "other" road	4
		f. > 10m from "other" road	2

In the process of overlay analysis, the rice field which has land size less than 5 Ha was not included in the mapping of potential land for sustainable food agricultural land. While, the rice field that has land size greater than or equal to 5 Ha was included in the mapping of potential land for sustainable food agricultural land. It can be identified that the rice field which has land size less than 5 Ha was 3.339,10 Ha and the rice field which has land size greater than or equal to 5 Ha was 38.342,27 Ha.

RESULT AND DISCUSSION

Mapping of Existing Rice Field Distribution

The map of existing rice field distribution was resulted from overlaying map of rice distribution in the year 2010 with map of land use change on rice field (Figure 2). Whereas, the map of land use change on rice field derived from ground check activity in the year 2014. From the map of existing rice field distribution, could be determined that the land availability for rice field in Serang Regency in the year 2014 was 41.681,37 Ha.

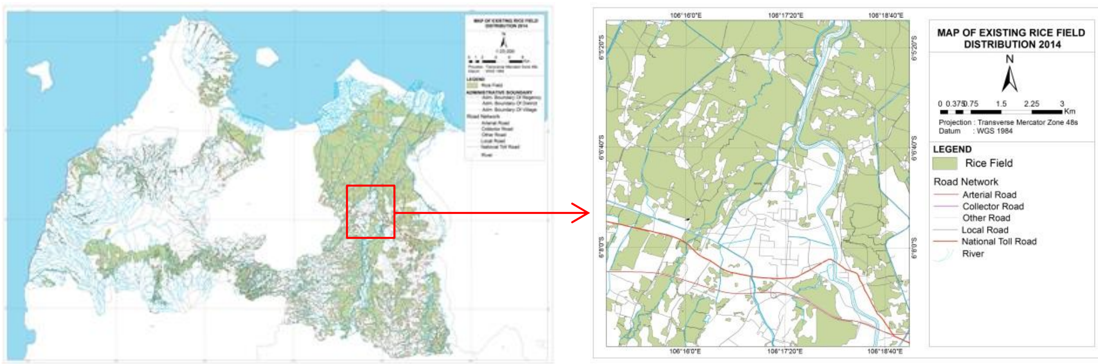

Figure 2. Map of Existing Rice Field Distribution, 2014

Score Mapping of Each Criterion

Score mapping of each criterion was built by filling the score into the attributes of each criterion on each thematic map/data layer. So that, there were 4 thematic maps/data layers (Figure 3-6), such as score map of rice field type, score map of planting index (PI), score map of slope, and score map of infrastructure. From this analysis step, could be identified that:

a. The score mapping of rice field type criterion consists of 21.997,40 Ha for score 4 (lowland rice) and 16.334,87 Ha for score 2 (upland rice).

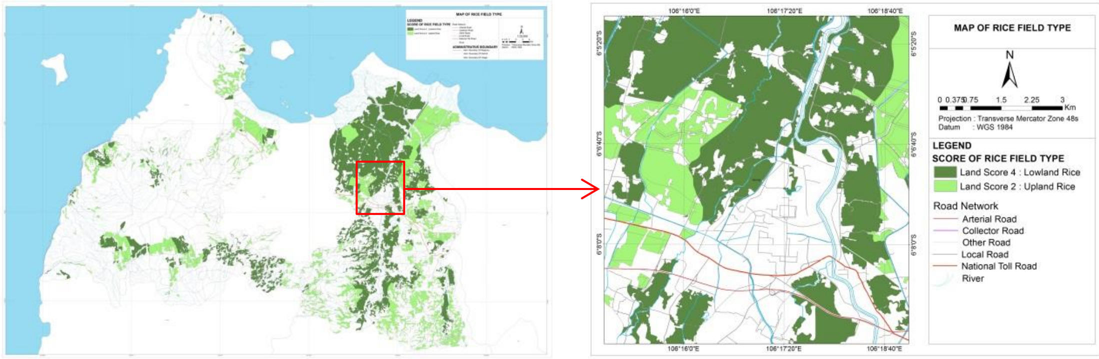

Figure 3. Map of Rice Field Type

b. The score mapping of planting index (PI) criterion consists of 15.909,77 Ha for score 4 (PI>=2) and 22.432,50 Ha for score 2 (PI<2).

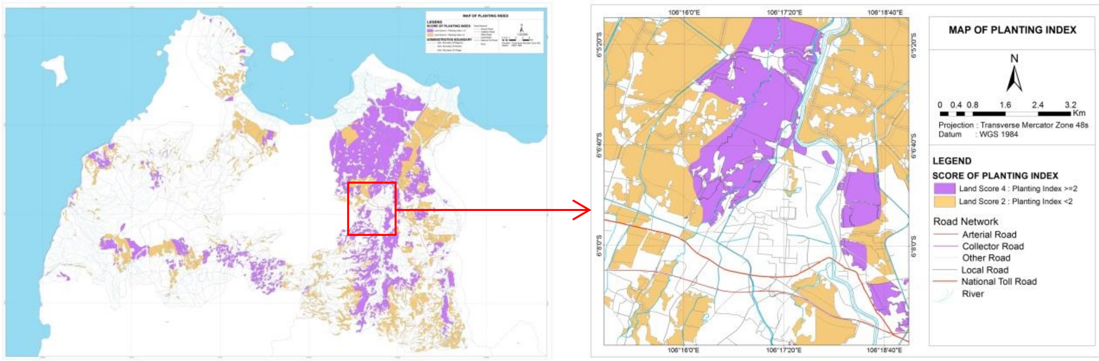

Figure 4. Map of Planting Index (PI)

c. The score mapping of slope criterion consists of:
Score 4 (slope 0-2%): 33.769,95 Ha

- ✓ Score 3 (slope 2-15%): 4.502,92 Ha
- ✓ Score 2 (slope 15-25%): 50,38 Ha
- ✓ Score 1 (slope 25-40%): 1,65 Ha
- ✓ Score 0 (slope >40%): 17,36 Ha.

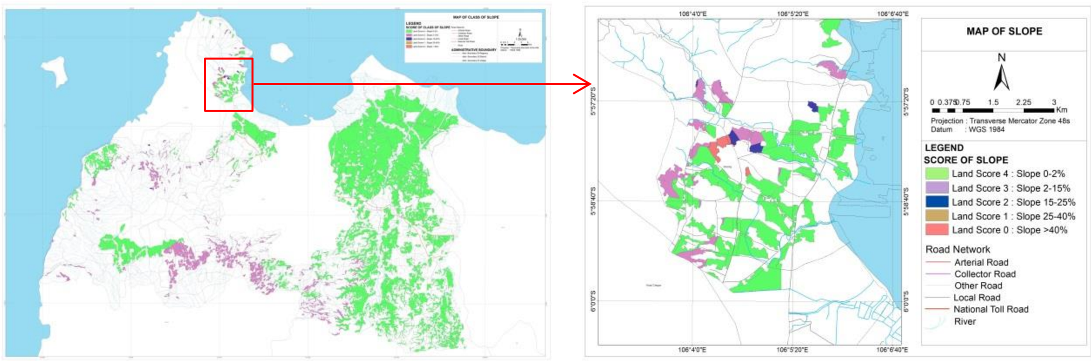

Figure 5. Map of Slope

d. The score mapping of infrastructure criterion consists of:

- ✓ Score 4 (<=50m from arterial/collector road, <=20m from local road, and <=10m from "other" road): 5.126,36 Ha
- ✓ Score 2 (>50m from arterial/collector road, >20m from local road, and >10m from "other" road): 33.215,91 Ha.

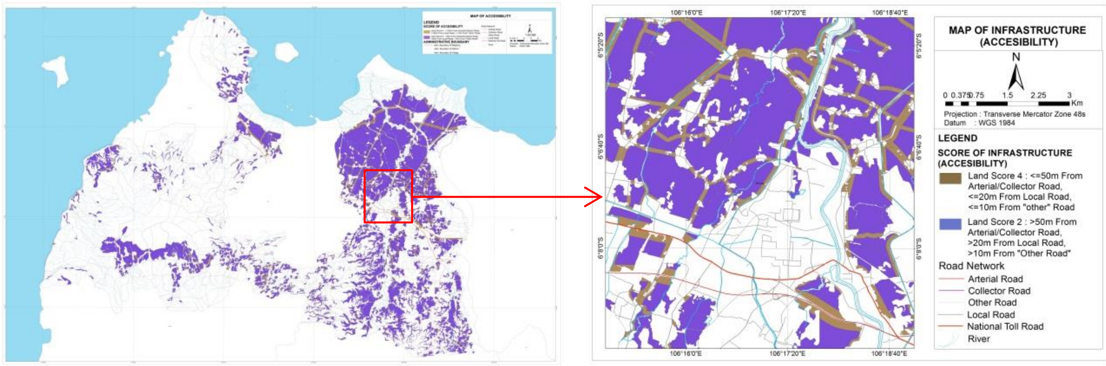

Figure 6. Map of Infrastructure (Accesibility)

Weighted Overlay Analysis

After being created thematic maps, the next step was to overlay all of thematic maps with the map of existing rice field distribution (Figure 7). The result of this step was weighted overlay map which showed the total score of each land unit formed. From this map can be identified that the greatest total score was 16, and the lowest total score was 6 (Figure 8 and Table 2). The total score of each land unit was considered to determine which potential lands that could be proposed as sustainable food agricultural land.

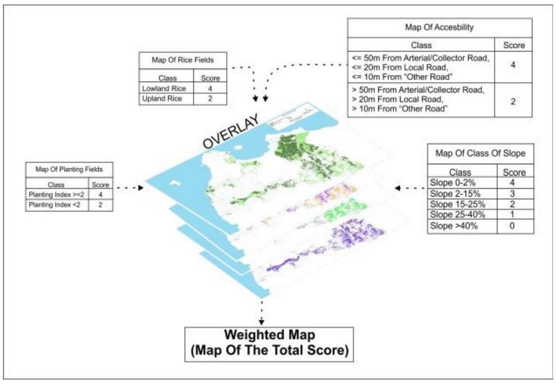

Figure 7. Overlay Analysis

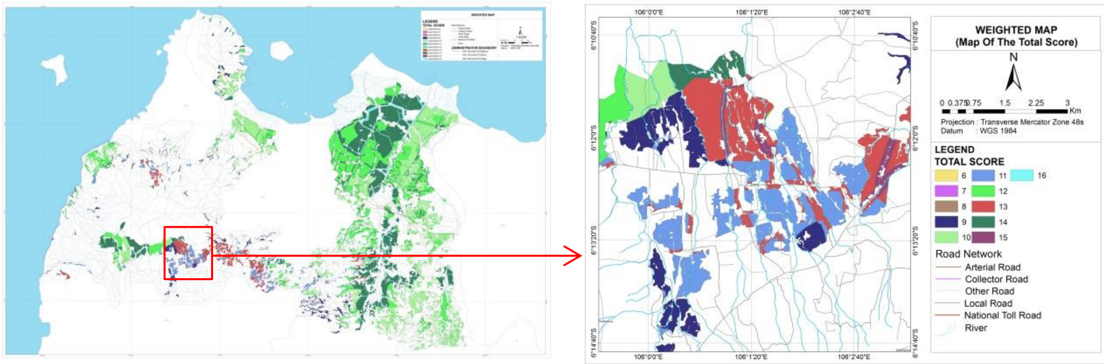

Figure 8. Weighted Map

Determination of Sustainable Food Agricultural land

Determination of sustainable food agricultural land was carried out by considering the needs of rice field (Christina, 2011; Safariah and Kurniadie, 2014). In this study, it was carried out by considering needs of rice field in the year 2034. The projection of rice field needs in the year 2034 in Serang Regency was analyzed with two scenarios, the optimistic scenario and the pessimistic scenario. Both scenarios considered the population growth rate, the rice consumption need, rice productivity, harvest failure, and planting index (PI). The optimistic scenario used following assumptions: rate of productivity risen 1% per year, PI risen 1% per year, risk of harvest failure 1% from total harvest land per year, and the projection of rice field needs decreased because PI risen. Meanwhile, The pessimistic scenario used following assumptions: rate of rice productivity and PI are constant each year, risk of harvest failure 1% from total harvest land per year, and the projection of rice field needs increased.

Table 2. Area of The Rice Field Based on *Score*

Score	Area of The Rice Field (Ha)		Cumulative Area of The Rice Field (Ha)		
	Lowland Rice	Upland Rice	Lowland Rice	Upland Rice	Lowland Rice & Upland Rice
Score 16	1180,09	0,00	1180,09	0,00	1180,09
Score 15	249,92	0,00	1430,03	0,00	1430,03
Score 14	10806,14	217,53	12236,17	217,53	12453,70
Score 13	1443,71	143,76	13679,88	361,29	14041,17
Score 12	7809,42	4142,59	21489,30	4503,88	25993,18
Score 11	508,09	1031,85	21997,39	5535,73	27533,12
Score 10	0,02	9643,11	21997,41	15178,84	37176,25
Score 9	0,01	1125,81	21997,42	16304,65	38302,07
Score 8	0,00	21,43	21997,42	16326,08	38323,50
Score 7	0,00	1,42	21997,42	16327,50	38324,92
Score 6	0,00	17,35	21997,42	16344,85	**38342,27**
Total	**21997,4**	**16344,85**			
	38342,27				

Under the optimistic scenario, the total needs of rice field in Serang Regency was 20.518 Ha in the year 2034 (Safariah and Kurniadie, 2014). Thus, on this scenario, all lowland rice that has a score ≥ 12 could be determined as sustainable food agricultural land. The land availability for lowland rice that have a score ≥ 12 was 21.489,30 Ha. Meanwhile, based on pessimistic scenario, the total needs of rice field in Serang Regency was 31.163 Ha in the year 2034 (Safariah and Kurniadie, 2014). Therefore, to determine sustainable food agricultural land could be set up on all rice field that have a score ≥ 10. The land avaibility of these field was 37.176,25 Ha. These fields consists of both lowland rice (21.997,41 Ha) and upland rice (15.178,84 Ha). The maps of sustainable food agricultural land were presented in Figure 9 (for optimistic scenario) and Figure 10 (for pessimistic scenario).

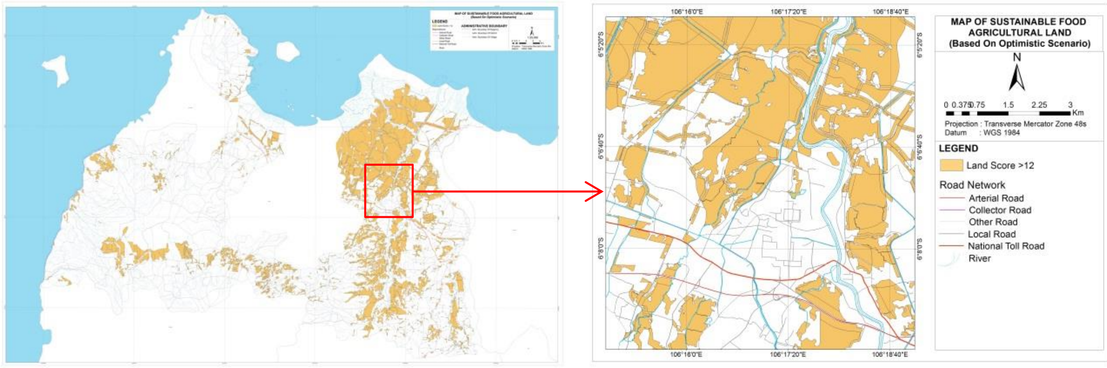

Figure 9. Map of Sustainable Food Agricultural Land (Optimistic Scenario)

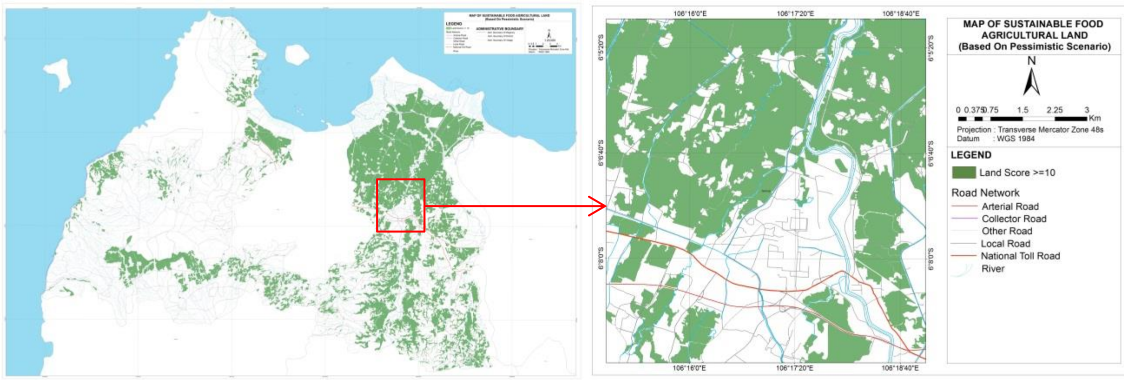

Figure 10. Map of Sustainable Food Agricultural Land (Pesimisstic Scenario)

CONCLUSION

Weighted overlay analysis resulted the map of total score of each land unit. The greatest score was 16 and the lowest was 6. The score was used as a basis for sustainable food agricultural land determination. Based on optimistic scenario, the determination of sustainable food agricultural land covered 21.489,30 Ha of rice field. While based on pessimistic scenario, the determination of sustainable food agricultural land covered 37.176,25 Ha of rice field. The determination of sustainable food agricultural land needs to be carried out in order to ensure the sustainability of the food supply and in order to protect the fertile lands which has high productivity in Serang Regency.

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