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Climate-based Land Optimization to Increase Agricultural Production in Banten Province

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Abstract.
Banten Province has 701,901 ha of agricultural land with a harvest area of 405,668 ha. The largest agricultural land area in Pandeglang Regency, while the smallest is South Tangerang City. The agricultural land is generally used for rice, but its productivity is still low. Therefore, to increase agricultural productivity, climate-based land optimization is carried out. In optimizing the land, an enterprise architecture planning method is used by integrating climate and land functions. The results of climate analysis, obtained a temperature range of 22.1-37.4oC and rainfall between 0-424 mm with the number of rainy days per year 176-177 rd. Temperature and rainfall conditions in all districts in Banten Province are suitable for improving agriculture. Furthermore, if it is viewed from the land area, Pandeglang and Lebak Regency is suitable to increase rice production. Meanwhile, other food crop production, from five types of food crops produced in Banten Province, which has the potential to be increased, namely corn plants. The ratio between harvested area and land area in Banten Province has only reached 60.15%. Therefore, productivity needs to be improved, because Banten Province has the right temperature and rainfall for agriculture.

Keywords. Agricultural Land, Land Optimization, Temperature, Rainfall, Agricultural Productivity.

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INTRODUCTION

Banten Province has an area of 9,662.92 km^2 consisting of four districts and four cities. The area of the regency is between 147.19-3426.56 km^2. For agricultural land, the biggest is Pandeglang Regency while the smallest is South Tangerang City. In general, Banten's agricultural production consists of: rice, secondary crops, and horticulture. The ratio between the area and agricultural production in Banten Province is between 0.171-2,773 ha/ton. Differences in agricultural productivity in each region indicate the need for land optimization (Melkonyan, Banks, and Wendel, 2016). To optimize the function of land in each region, it is necessary to take into account local climate conditions (Chen, et al., 2016). In optimizing land functions, it is necessary to pay attention to planting area, harvest area, and productivity (Tsitsimpelis, Wolfenden, and Taylor, 2016). Therefore, in increasing agricultural productivity it is necessary to take into account cropping patterns, types of crops and management of agricultural land. Processing agricultural land is an action to maintain and enhance land productivity taking into account its sustainability (Circle, 2013). Meanwhile, Hanl, et.al. (2017) states that land management is one component of the management of agricultural technology in sustainable farming systems. Furthermore, Jurgenson (2016) states that land management needs to refer to: contour, terrace, and drainage. Johnson, Bell, and Teisl (2016) state that land management is closely related to soil and water conservation techniques applied to the land. Meanwhile, according to Djaenuddin, et al., (2003) the level of land productivity is strongly influenced by land management systems, land cover selection, soil fertility, rainfall, temperature, and humidity. Differences in temperature and rainfall in each region have implications for agricultural productivity (Enete, 2014). The temperature and rainfall conditions at each place depend on the astronomical conditions of the place (Mendelsohn, 2009).

Banten Province has astronomical limits of 05^{o}07'50' and 07^{o}01'01' S and 105^{o}01'11'and 106^{o}07'12' E. The astronomical boundary range has implications for climate conditions, so the climate in each region is different (Petkovic, et al., 2017). In general, Banten Province has a tropical and wet climate, with a temperature range of 22.5-34.1^{o}C and rainfall between 11-424 mm (BMKG Banten Province, 2016). Under certain conditions of temperature and rainfall, some areas of Banten Province are potential for agricultural development. Therefore, it is assumed that there is an association between the astronomical boundaries of a region, climate conditions and land functions, so there needs to be a climate-based land optimization study.

Related to land optimization, Sakti, et al., (2013) conducted land mapping based on population, production, planting area, harvest area, productivity, planting index and raw material requirements for food agroindustry. Then, Barus, et al., (2012) made rice field mapping and food crop protection with a model of rice field mapping and its protection using remote sensing and GIS. Furthermore, Zulfikar, Barus and Sutandi (2013) conducted a mapping of paddy fields and their potential by paying attention to the characteristics of the land. Based on this, in this study optimization of land with climate was carried out as the main indicator. The research

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was conducted with the aim of optimizing climate-based land. Based on these climatic conditions, the land will be optimized to increase agricultural production.

MATERIAL AND METHODS

To optimize climate-based land, the following data are needed: climate data for 10 years from 2005-2015. Furthermore, to determine the land, an astronomical boundary, temperature, and rainfall analysis of an area were carried out. The study began by examining the area and function of land in each district/city. In optimizing land, it starts with testing the land to find out the characteristics of the local land. According to Spewak (1992) the testing method uses enterprise architecture planning components. The component is then integrated with the climate and function of the land as shown in Figure 1 below.

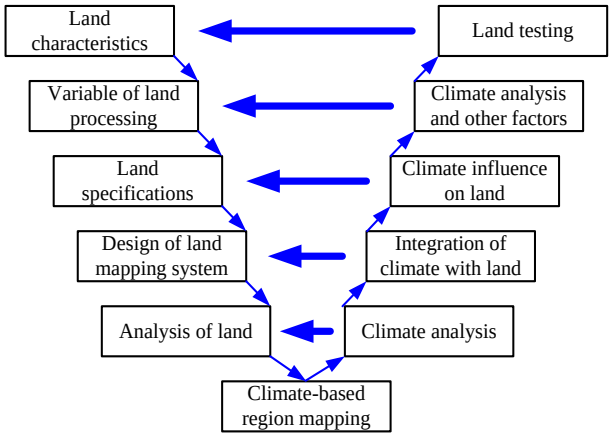

Figure 1. Stages of optimizing land based on climate

Based on Figure 1 above, in mapping the land first a climate analysis is carried out, from the results of the analysis obtained by climate-based land analysis. Then, the integration between climate and land was carried out, from the results of the integration the land mapping system design was obtained. Furthermore, an analysis of the influence and other factors on the land was carried out, from the results of the analysis obtained specifications and variables that affect the function of the land. The final stage is testing the land for agriculture, this is done to find out the characteristics of the land that is suitable for increasing agricultural production. The stages for increasing agricultural production are shown in Figure 2.

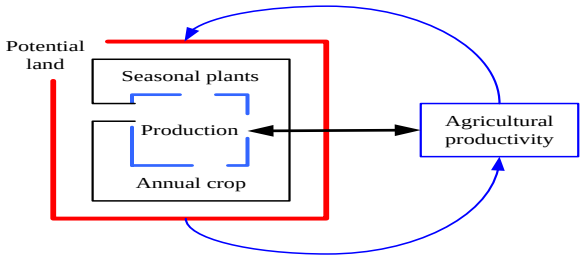

Figure 2. Stages for increasing agricultural production

Based on Figure 2 above, in increasing agricultural production, an analysis of the potential of land is carried out to determine the types of plants that are suitable on the land. Based on the potential of the land, the types of annual or seasonal crops will be known, so that the land functions optimally. Conformity between land and plants, is assumed to increase agricultural productivity.

RESULTS AND DISCUSSIONS

In general, plants are very vulnerable to temperature and rainfall, therefore climate analysis is carried out. Referring to climate data, analysis of temperature and rainfall was carried out in Banten Province. The results of the temperature analysis in each district/city in Banten Province are shown in Figure 3.

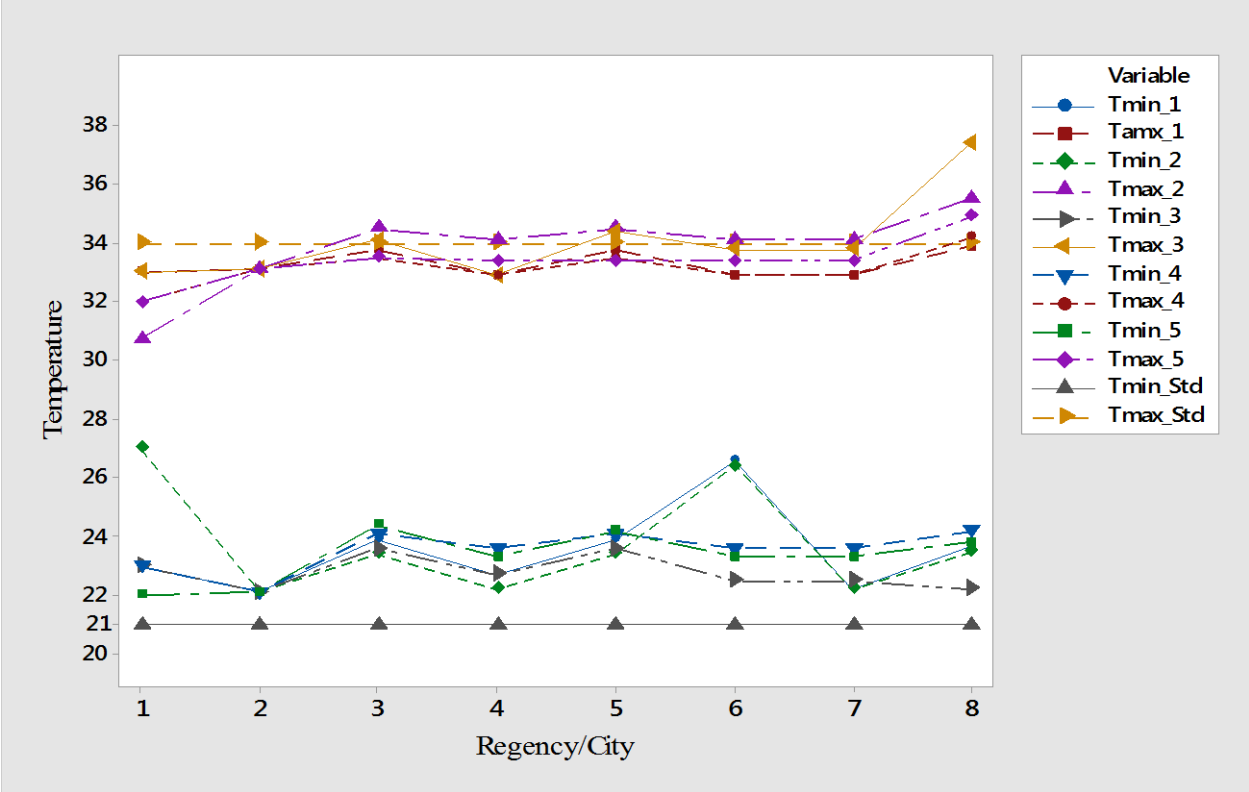

Figure 3. Temperature of each district/city

Based on Figure 3 above, the temperature in Banten Province is in the range of 22.1°C to 37.4°C. The minimum temperature of each district/city is in the range of 22.1-27.0°C while the maximum temperature is in the range of 30.7-37.4°C. Meanwhile, the temperature ranges for plants in general, between 21.0-34.0°C, in high temperatures, plant growth is hampered or even stopped regardless of the water supply, and then miscarriages leave or fruit prematurely.

Referring to the temperature range for plant growth, each regency/city in Banten Province has the potential to increase agricultural production. However, only South Tangerang City has a temperature above 34°C,

making it less suitable for seasonal plants. This is in line with the results of the Hatfield and Prueger (2015) study which states that temperature effects on plant growth and development are dependent on plant species.

Furthermore, other climate variables to increase agricultural production, namely rainfall. The pattern of monthly rainfall in Banten Province is shown in Figure 4.

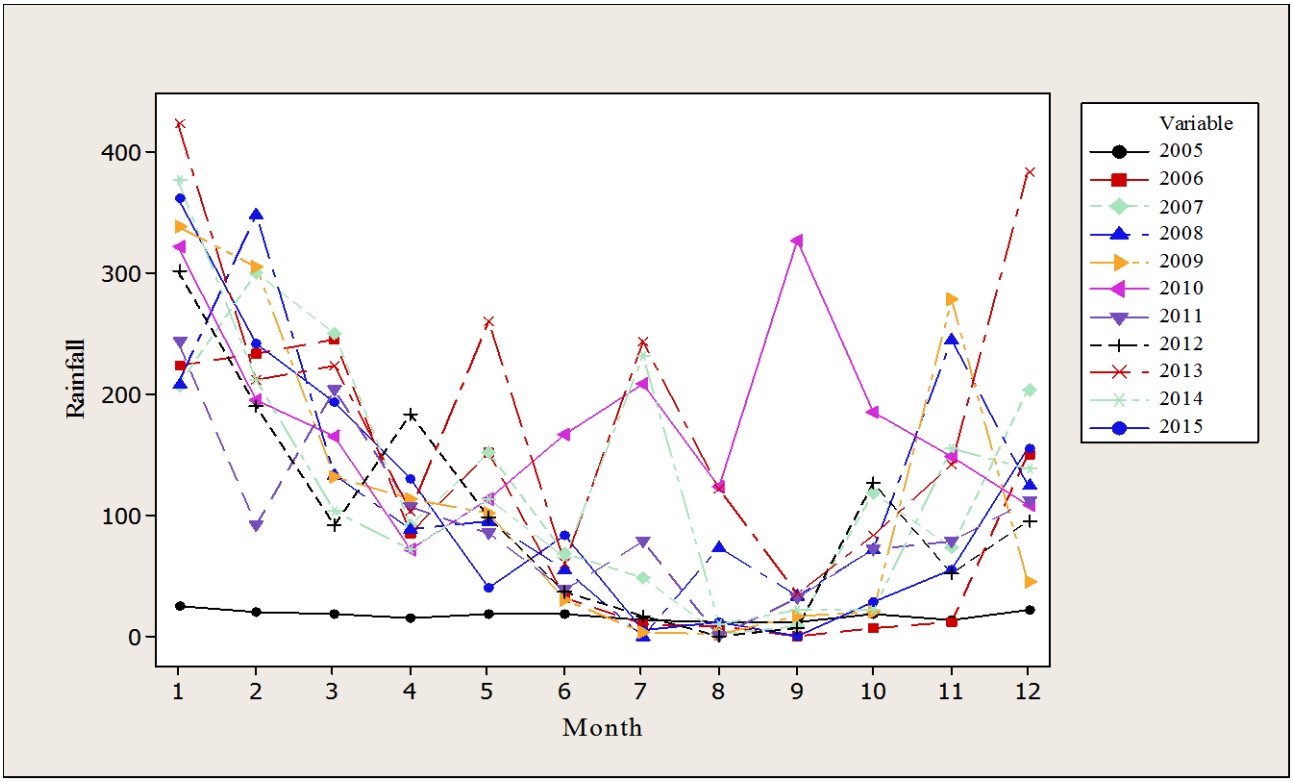

Figure 4. Banten Province rainfall patterns for the period 2005-2015

Based on Figure 4 above, the rainfall in Banten Province is in the range 0-424 mm the average high rainfall occurs in January with a rainfall range between 207 mm to 424 mm. Within 10 years, in the year 2005 in Banten Province there was a dry season with a range of rainfall between 11-25 mm. In that year, most areas in Banten Province experienced drought.

Meanwhile, in 2013 there was high rainfall, so that in some areas in Banten there were floods in that year. The rain pattern is almost parabolic, in this case rain occurs at the beginning and end of the year.

In 2015 in Pandeglang and Lebak Regencies the rainfall ranged from 64-303 mm with temperatures between 21.9-33.1^{o}C.

The results of temperature and rainfall analysis are then compiled with the astronomical boundaries of each regency/city and land functions. The results of compilation between temperature, rainfall and land function, are fully shown in Table 1 below.

Tabel 1. Climatic conditions in Banten Province

Regency/City	Total Area (km^2)	Astronomical Limit (S and E)	Climate Condition (Temperature and Rainfall)	Land Function
Pandeglang Regrency	2,746.89	06°21'00"-07°10'00"S 105°48'00"-106°11'00"E	Temp: 21.0-33.0°C Rf: 424 mm (177rd)	Agriculture (Major) Industry (13)
Lebak Regency	3,426.56	05°00'00"-10°00'00"S 106°00'00"-106°21'00"E	Temp: 22.1-33.1°C Rf: 361.4 mm (176rd)	Agriculture (Major) Industry (20)
Tangerang Regency	1,011.86	06°00'00"-06°20'00"S 106°20'00"-106°43'00"E	Temp: 23.4-34.1°C Rf: 208 mm (177rd)	Agricultural Industries (782)
Serang Regency	1,734.28	05°50'00"-06°20'00"S 105°00'00"-106°22'00"E	Temp: 22.2-34.1°C Rf: 328 mm (167rd)	Agricultural Industries (148)
Tangerang (City)	153.93	06°06'00"-06°13'00"S 106°36'00"-'103°42'00"E	Temp: 23.9-34.5°C Rf: 177.3 mm (165rd)	Agricultural Industries (559)
Cilegon	175.50	05°52'24"-06°04'07"S 106°36'00"-106°05'11"E	Temp: 22.5-34.1°C Rf: 245 mm (167rd)	Agricultural Industries (81)
Serang (City)	266.71	06°01'00"-06°12'00"S 106°03'00"-106°16'00"E	Temp: 22.2-34.1°C Rf: 381.4 mm (177rd)	Agricultural Industries (22)
South Tangerang City	147.19	06°39'00"-06°47'00"S 106°14'00"-106°22'00"E	Temp: 22.2-37.4°C Rf: 204 mm (165rd)	Agricultural Industries (57)

Based on Table 1 above, the astronomical boundaries, climate conditions and functions of regency/city land in Banten Province show different conditions. The results of the climate analysis indicate an association between astronomical boundaries, climatic conditions and land functions. At the astronomical boundary between 105°00'00"-106°21'00" E the rainfall is in the range of 361-424 mm with temperatures between 21.9-33.1^{o}C. The number of rainy days per year in the area with the astronomical boundary is in the range 176-177 rd. Meanwhile, at other astronomical boundaries, both the rainfall weight and the number of rainfall days (rd) are smaller than

those in the astronomical boundary. Areas with astronomical boundaries and temperatures and precipitation are suitable for agriculture. These include Pandeglang Regency and Lebak Regency, which can be optimized to increase agricultural production in Banten Province.

Banten Province consists of four districts and four cities, Lebak and Pandeglang Regencies has a very large area, compared to other regency/cities. Referring to Table 1 above, the total area of each regency/city is between: 147.19-3,426.56 km2. The area with the largest area of Lebak Regency with an area of 35.46% while the smallest area of South Tangerang City with an area of 1.52% of the area of Banten Province. The function of each regency/city in general, industry and agriculture. The number of industries in each regency/city between: 13-782 industries, the most is Tangerang Regency while the smallest is Pandeglang Regency. Meanwhile, the results of the analysis of the function of land for agriculture in each city are shown in Table 2.

Tabel 2. Extent of agricultural land and yields in each regency/city

Regency/City	Land area of agriculture (ha)	Harvested area (ha)			Productivity (kw/ha)		Production (ton)			
		Wet field rice	Dry field rice	Other food crops	Wet field rice	Dry field rice	Wet field rice	Dry field rice	Other food crops	Characteristict
Pandeglang Regency	260,203	120,786	20,543	15,174	58.10	39.30	663,620	80,741	13,505	Maize
Lebak Regency	233,130	102,498	1,300	6,120	58.00	29.80	529,210	38,751	4,253	Sweet potato
Tangerang Regency	65,014	38,697	96	1,737	60.23	48.75	433,953	468	4,537	Cassava
Serang Regency	119,307	83,830	3,092	3,307	54.35	33.23	455,583	10,273	7,008	Sweet potato
Tangerang City	2,934	1,124	0	0	57.50	0.00	6,461	0	0	-
Cilegon City	9,485	2,264	25	108	55.84	0.00	13,862	93	6,687	Peanut
Serang City	9,485	1,818	408	2,396	54.05	0.00	78,441	1,347	3,024	Cassava
South Tangerang City	2,343	155	0	190	54.49	0.00	845	0	0	-

Based on the data in Table 2, each city has agricultural land with an area between: 2,343-260,203 ha with a harvest area between 345-156, 503 ha. All cities in Banten Province function their agricultural land for rice plants, with harvested area between: 155-120,786 ha with a total production of 845-663,620 tons. Meanwhile, other types of food crops in each city vary according to the characteristics of the land. There are several types of plants, namely: peanuts, cassava, sweet potato, and corn. From the eight cities, only Tangerang City and South Tangerang only produce rice.

Referring to the area of agricultural land, each city has the opportunity to increase agricultural production. Comparison between land area and harvest in each city between: 0.15-0.60. In other words, there is still land that has not been used optimally for agriculture. Pandeglang and Lebak regencies are potential for rice development,

because in the two districts, except for having extensive agricultural land, the production is also large. If productivity is increased, Banten Province has the opportunity to increase national rice production. Meanwhile, other food crop production, from five types of food crops produced in Banten Province, which has the largest production of corn plants. If the area for maize crops is increased, Banten Province has the potential to increase national maize production.

CONCLUSION

Referring to climate data, especially temperature and rainfall, Banten Province has the potential to increase agricultural production. Rice plants generally require temperatures between 11-25oC with an average rainfall of 200 mm/month. Based on the results of analysis of temperature and rainfall, all cities in Banten Province are suitable for rice plants. Then, for other food crops that are in accordance with the climatic conditions in Banten Province, namely corn plants. Corn plants need temperatures between 21-34oC with rainfall between 85-200 mm/month. Based on the results of climate analysis, all cities are suitable for developing corn plants, except South Tangerang City.

Rice plants and other food crops can be developed in Banten Province, because it has the right temperature and rainfall for agriculture. However, productivity needs to be improved, because if viewed from the harvest area and land area, agricultural production in Banten Province has only reached 60.15%. When referring to temperature and rainfall, this condition is appropriate, but other factors, such as seed quality, distance between plants, and even the planting period need to be increased so that agricultural production in Banten Province increases.

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