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Climate-Based Land Engineering Model for Management Sustainable Agriculture in Banten Province

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ABSTRACT: *Development in Banten Province leads to industrial and agricultural development. The increase in the number of industries has implications for the reduction of agricultural land, so that in certain areas there is contact between industry and agricultural land. To maintain the rate of increase in the two developments, a climate-based regional mapping is carried out, while to maintain the productivity of the land around the industrial area, land engineering is carried out. The method for land mapping uses astronomical limits and climatic conditions for each region, while land engineering is carried out by creating intermediate land which functions to sterilize pollutants from industry. Furthermore, to increase agricultural productivity, a climate change-based cropping pattern is implemented. The results of climate-based regional mapping show that Pandeglang and Lebak districts have the potential for agriculture, while Cilegon City and Tangerang Regency have the potential for industry.*

KEYWORDS: climate, astronomical boundaries, regional mapping, land engineering, agricultural productivity

INTRODUCTION

Banten Province has an area of 9,018.64 km2 with astronomical limits 105o1'11"-106o7'12"E and 507'50"-701'1"S. Based on the total area, Banten Province has the potential for agricultural and industrial development (Mubarokah et al., 2020;

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Muchendar et al., 2020; Suciantini et al., 2020). The number of industries in Banten Province, from 2017 to 2019 increased from 2,515-2,927 (BPS Banten, 2019). Based on these data, every year the industry in Banten Province increases by around 137 industries. The number of these industries is spread across all districts/cities with different areas.

Referring to the number of industries above, the largest number of industries is in Tangerang Regency at 46.22% and the smallest is in Pandeglang Regency at 0.34% spread in Pandeglang Regency (BPS Banten, 2019). Of the four regencies and four cities in the province of Banten, the industry is developing in Serang Regency, Tangerang Regency, Cilegon City and South Tangerang City. The industrial area in Serang Regency is 3,051.24 hectares (ha), Tangerang Regency is 1,424.71 ha, Cilegon City is 1,150 ha and South Tangerang City is 200 ha (BPS Banten, 2019). The increase in the industry has implications for a decrease in agricultural land in the region.

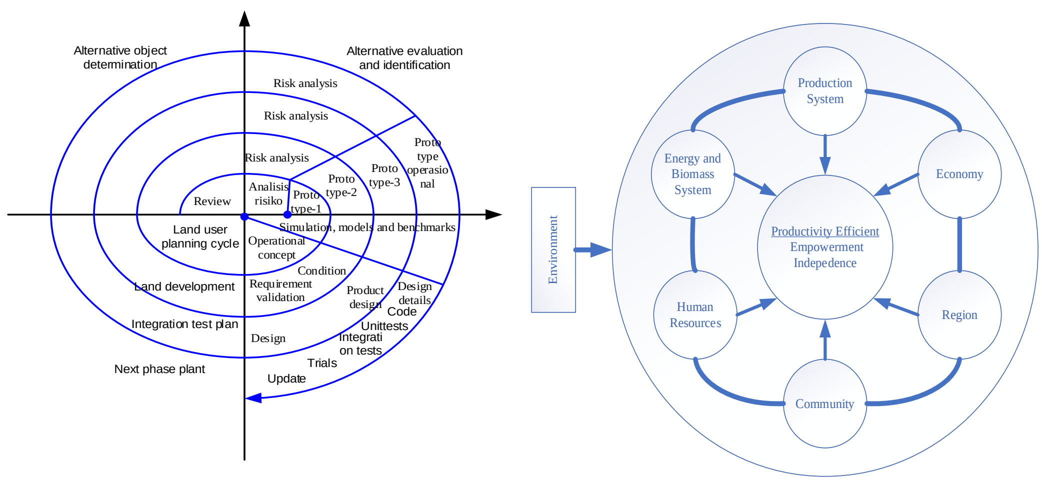
Based on the results of observations in each district/city, in general, industrial areas adjoin agricultural areas. The adjoining industrial areas and agricultural areas have implications for the decline in land use in these areas (Melkonyan et al., 2017; Prihatin, 2016). To maintain land functions in the area, land engineering is carried out (Functions & Region, 2020; van Broekhoven & Vernay, 2018). In carrying out land engineering, it is carried out in two ways, namely: neutralizing pollutants from industry, and creating special land between industry and agriculture (Kaini, 2020; Long & Qu, 2018). Land engineering in these two ways is a solution for processing agricultural land.

Processing of agricultural land is an action to maintain and increase land productivity by considering its sustainability (Chazdon et al., 2020; Yin et al., 2018). Meanwhile, Pellegrini & Fernández (2018) state that land management is a component of agricultural technology management in a sustainable agricultural system. Several forms of land management are as follows: land preparation according to contour/slope cutting, making mounds, terraces, and water channels/disposal, regular bunds, bund terraces and credit terraces, and bench terraces (Islam et al., 2018; Talukdar et al., 2020). Problems with cropping systems, land management are closely related to soil and water conservation techniques applied to the land (Kidane et al., 2019; Yan et al., 2018). Meanwhile, according to Wang et al., (2018) the level of land productivity is strongly influenced by land management systems, land cover selection, soil fertility, rainfall, temperature, and humidity.

Referring to astronomical conditions, each region in Banten Province has different climatic conditions. In general, Banten Province has a tropical and wet climate, with a temperature range of 27.3-38.4^{o}C and annual rainfall between 298-377 mm (BMKG Banten Province, 2019). Based on this range, it shows that each region has different temperatures and rainfall. The climate differences that exist in each region will have implications for agricultural productivity (Kukal & Irmak, 2018; Ruhiat & Purnomo, 2022). According to BPS Banten Province (2019) agricultural production produced by Banten Province is rice, secondary crops, horticulture. Paddy production is in the range of 845-588,539 tons with a ratio between 0,171-2,773 ha/ton. Referring to the rice production, Banten Province has the potential to increase agricultural production. Then, referring to the extent of land used by the industry, to increase production around the industrial area, a climate-based land engineering model was created.

METHOD

For sustainable agricultural land management in Banten Province, two scenarios are made. In the first scenario, creating "intermediate land" which functions to neutralize pollutants from industry, while in the second scenario, climate analysis is carried out in each district/city. With these two scenarios, soil vulnerability analysis is then carried out by considering several parameters.In making the land engineering model, an analysis of the area of "intermediate land" is carried out to absorb pollutants. According to (Collier et al., 2018) the engineering model uses an enterprise architecture planning component. In engineering the land, various soil performance analyzes were analyzed based on: soil depth, soil loss, nutrient loss, surface soil loss, and land suitability. The stages of land engineering are shown in Figure 1.



(a) (b)

Figure 1. Engineering models and integrated farming systems

Figure 1.a is a land engineering model, which begins with a cycle analysis of land use plans, land development, and integration tests. In planning land use, a review and risk analysis is carried out to determine alternative evaluation and identification. Then, in land development, the requirements and product design are validated. Furthermore, in land development and integration testing, simulations, trials and updates are carried out. Then, Figure 1.b represents an integrated farming system based on environmental optimization. In optimizing the environment, it leads to productivity and empowerment. This can be achieved through production systems, economy, regional planning, optimizing communities, human resources, and utilization of energy and biomass systems. The six components are interconnected with each other in a circular manner, for integrated land use. Furthermore, the use of land to increase agricultural production is adjusted to the climatic conditions in the region.

In mapping climate-based regions, research begins by analyzing the astronomical conditions of each district/city. To analyze climate conditions, climate data is used from 2010-2019. Based on the climate data, then the average daily maximum rain is calculated with the equation:

$$\bar{X} = \frac{1}{n}\sum_{i=1}^{n} X_i \qquad \text{....... (1)}$$

with $\bar{X}$ is the average daily maximum rainfall, the amount of data, and $\sum_{i=1}^{n} X_i$ is the total daily maximum rainfall per station. From the rainfall data in an area, land functions in each area can be mapped.

To increase agricultural production, a soil vulnerability analysis is carried out based on several parameters. The parameters referred to include: depth of groundwater table, rainfall, type of aquifer, soil texture, slope, type of unsaturated zone, and aquifer hydraulic conductivity. To get the DRASTIC index of the seven parameters, the equation is used:

$$Vu = D_R D_W + R_R R_W + A_R + A_W + S_R S_W + T_R T_W + I_R I_W + C_R C_W \qquad \text{.......(2)}$$

With: Vu is vulnerability, D is depth to water table, R is recahge/rainfall, A is aquifer media, S is soil media, T is topography, I is impact of vadose zone media, C is hydraulic conductivity. The weighting of the DRASTIC vulnerability parameters is shown in Table 1.

Table 1. DRASTIC vulnerability parameter value

No.		Parameter	Value
1.	D	Depth to water table	5
2.	R	Recharge	4
3.	A	Aquifer media	3
4.	S	Soil media	2
5.	T	Topography	1
6.	I	Impact of vadose zone media	5
7.	C	Conductivity hydraulic	3

Source: Aller, et al. 1987

RESULTS AND DISCUSSION

In carrying out land engineering around the industrial area, a model of "intermediate land" was created as an effort to neutralize pollutants from industry. The model built with "intermediate land" consists of: buffer land, damping land, and neutralizing land. Referring to Figure 1 above, an "intermediate land" model was created with the three types above and the land engineering model results were obtained, as shown in Figure 2.

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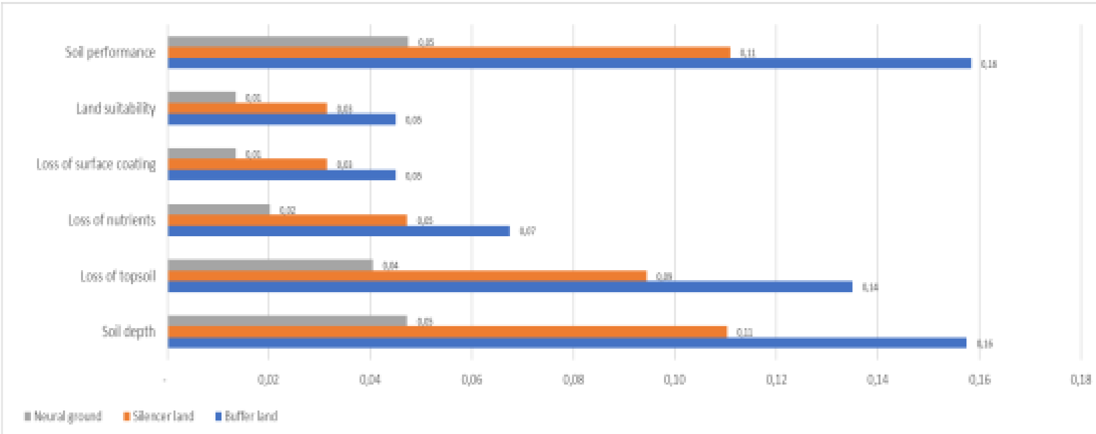

Figure 2. Land engineering model results

Based on Figure 2 above, with a 100 m^2 "intermediate land" model, a simulation was carried out for the performance of the land in reducing and neutralizing pollutants. With this area, the intermediate land is able to support industrial pollutant by 16%, reduce pollutant by 11% and neutralize pollutant by 5%. Based on this, it appears that "intermediate land" can function to buffer, dampen and neutralize pollutants from industry. By creating "intermediate land" between industrial and agricultural areas, it is hoped that agricultural production in the region can increase. However, in increasing this production, there are other things related to agricultural production, namely climatic conditions.

In order to explore the climatic conditions in an area, especially the Bantten Province, a climate analysis was carried out starting in 2010-2019. The climate variables related to agricultural production are rainfall and temperature. The results of the analysis of rainfall and temperature in Banten Province in the range above are shown in Figure 3. Within this range in Banten Province, rainfall ranges from 0-500 mm while temperatures are between 28-38°C. In the figure, it appears that rainfall in Banten Province occurs in a hyperbolic pattern, meaning that in Banten Province there will be a rainy season and a dry season. Every year in Banten Province, the rainy season occurs at the beginning and end of the year, while the dry season generally occurs in the middle of the year. In Banten Province the rainy season occurs from October to February, while the peak of the rainy season generally occurs in January or February. Meanwhile, the dry season starts from April to September, while the peak generally occurs in June to August.

The results of the analysis of climate and astronomical boundaries in each district/city in Banten Province show different land functions. Pandeglang Regency with astronomical limits 06^{o}21'00"-07o10'00"S and 105^{o}48'00"-106^{o}11'00"E and Lebak Regency with astronomical limits 05^{o}00'00"-10^{o}00'00"S and 106^{o}00 '00"-106^{o}21'00"E. The results of the climate analysis show that in this area the temperature in Pandeglang Regency is 22.50-27.90^{o}C with rainfall of 3.814 mm (177hh) while the temperature in Lebak Regency is 22.10-33.1^{o}C with rainfall of 3.614 mm (176hh). Land in both districts is potential for agriculture. Meanwhile, two regencies and four other cities in certain areas have potential for industry and other areas for agriculture. Tangerang Regency and Cilegon City are potential areas for industrial development.

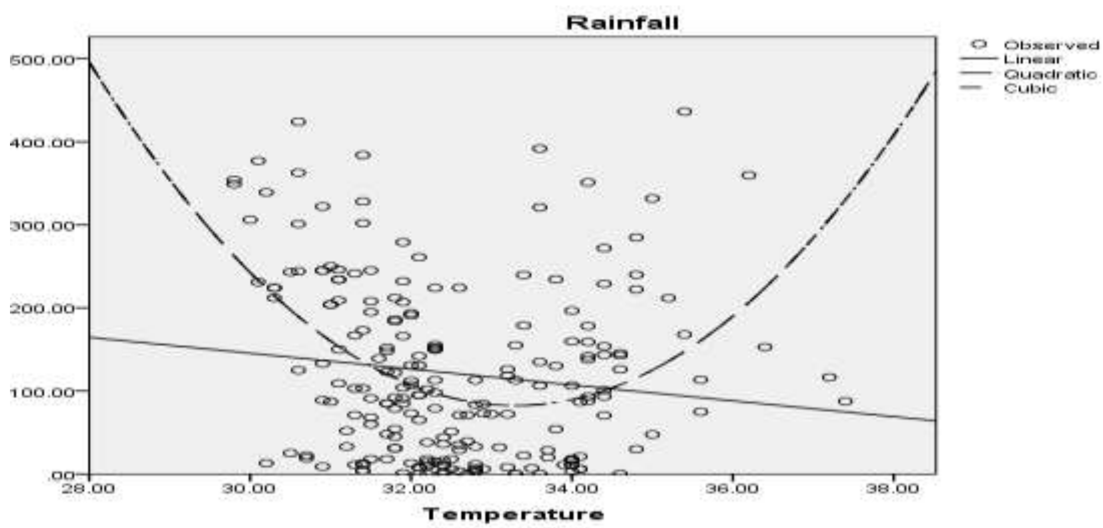

Figure 3. Distribution of rainfall and temperature in Banten Province

There are two climatic components that most influence land capability in Indonesia, including temperature and rainfall. Low temperatures will affect the type and growth of plants. The most important factor affecting air temperature in the tropics is the altitude of a place above sea level. Rainfall and temperature affect each type of plant, while the growth rate of each type of plant has a minimum, optimum and maximum temperature limit. The upper temperature limit that kills the activity of plant cells ranges from 48.89^{o}C to 60^{o}C. In high temperatures, plant growth is stunted or even stopped regardless of water supply, and premature loss of leaves or fruit occurs. Referring to the maximum temperature in Banten Province, the existing plants will grow well.

CONCLUSION

In mapping the land, it begins with climate analysis, climate integration with land. Climate analysis begins with an analysis of rainfall and temperature conditions. Based on climatic conditions and astronomical limits, Pandeglang and Lebak districts have the potential for agricultural development. Meanwhile, Tangerng Regency and Cilegon City have the potential for industrial development. To increase agricultural productivity, land engineering and cropping patterns are carried out based on climate change.

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