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Climate and Land Classification to Increase Agricultural Production in Banten Province, Indonesia

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Abstract: Banten province is tropical wet and has production of rice, corn, soybeans, peanuts, green beans, cassava, and sweet potatoes. The productivity of each of these plants and district/city varies depending on the land area and climatic conditions. Climate and land classification were carried out in each district/city to determine productivity. This article aims to analyze climate using downscaling statistics with the delta method and regression analysis. The climate analysis resulted that the temperature range is 19.6-37.4^{o}C, and rainfall is 0-436.3 mm/month. The range of temperature and rainfall in Banten Province is generally suitable for crops. Therefore, the seven crops can grow optimally at temperatures between 11^{o}C and 30^{o}C with rainfall between 85 and 820 mm/month. Based on rainfall, in Banten Province, five types of plants have optimal productivity. The five plants in question, namely: rice, corn, peanuts, green beans, and cassava, can grow with optimal productivity. Rice and maize can be developed in Pandeglang and Lebak Regencies because these two districts have suitable climatic conditions and sufficient land area.

Keywords: agricultural production, climate classification, temperature, rainfall, rice, maize.

氣候和土地分類以增加印度尼西亞萬丹省的農業產量

摘要：萬丹省屬熱帶濕潤地區，盛產大米、玉米、大豆、花生、青豆、木薯和紅薯。這些工廠和地區/城市的生產力因土地面積和氣候條件而異。在每個地區/城市進行氣候和土地分類以確定生產力。本文旨在使用三角洲方法和回歸分析的降尺度統計來分析氣候。氣候分析結果表明，溫度範圍為之間19.6和37.4℃，降雨量為0和436.3毫米/月。萬丹省的氣溫和降雨範圍普遍適合農作物生長。因此，這七種作物在11℃至30℃的溫度下生長最佳，降雨量在85-820毫米/月之間。根據降雨量，在萬丹省，五種植物具有最佳生產力。有問題的五種植物，即：水稻、玉米、花生、青豆和木薯，可以以最佳生產力生長。潘德朗和勒巴克縣可以發展水稻和玉米，因為這兩個地區氣候條件適宜，土地面積充足。

关键词：農業生產、氣候分類、溫度、降雨量、水稻、玉米。

1. Introduction

Banten Province has an area of 9,662.92 km^2 and is divided into four regencies/municipalities. The area of each regency/municipality has changed, especially in the regions of Serang and Tangerang Regencies. The area of the two regencies has changed due to the expansion into several towns. Changes in the area are assumed to have implications for land use, so the harvested area in each regency/municipality changes. Changes in the harvested area are thought to impact agricultural production directly.

Banten Province's agricultural production consists of paddy, maize, soybeans, peanuts, mung beans, cassava, and sweet potatoes. Of the seven plants, paddy

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and maize are the types of plants with the most significant production amount. In 2015 the total paddy production of Banten Province was 2,188,996 tons, and maize was 11,870 tons [1]. On a national scale in the same year, paddy production amounted to 75,397,841 tons, while maize amounted to 19,612,435 tons. Nationally, the production of paddy and maize in Banten Province ranks eleventh.

In contrast, the first rank is East Java Province with total paddy production of 13,154,967 tons and maize of 6,131,163 tons [2]. When referring to the area, East Java Province is almost five times the area of Banten Province. Ideally, paddy and maize production in Banten Province, is one-fifth of East Java's paddy and maize production. Therefore, land in Banten Province needs to be optimized to increase productivity.

Within five years, from 2014-2018, the paddy productivity of Banten Province tended to increase from 5.30 tons/hectare (tons/ha) to 5.54 tons/ha while maize productivity has risen from 3.34 tons/ha to 5.05 tons/ha. On a national scale, during that period, the highest paddy productivity was in Bali Province, while the highest maize productivity was in West Java Province. Meanwhile, paddy productivity in East Java Province fluctuated and decreased from 5.98 tons/ha to 5.76 tons/ha, but maize productivity increased from 4.95 tons/ha to 5.24 tons/ha [3]. Referring to the productivity trend, Banten Province has the opportunity to increase the amount of production so that the order of paddy and maize production on a national scale can increase. The amount of output is increased, linearly related to increased productivity. One of the factors causing land productivity is due to climate differences [4].

The climate in an area is a combination of various weather conditions so that each region has a different climate. These differences affect soil formation, rock weathering, and agricultural land fertility, types of cultivation plants, erosion, and sedimentation [5]. Climate differences in a region are influenced by many factors, including location, the position of the Sun, land area and sea area, topography, and others [6]. The difference in location and position of the Sun is shown by the astronomical boundaries of each region [7].

Astronomically, Banten Province is at 105°1'11"-106°7'12" East Longitude (E) and 5°7'50"-7°1'1" South Latitude (S) with an altitude of 0-1,000 meters above sea level (masl). The planetary boundary of 0°-23°S has a tropical climate, while the area with an altitude of 0-1,500 masl is hot and temperate [8]. The region has astronomical and topographic limits above that can optimize paddy, tobacco, and coffee production [9]. Referring to the planetary and topographic boundaries, Banten Province can increase agricultural production. Expanding the type of agricultural output is inseparable from the region's climatic conditions. Climatic conditions are related to the diversity of annual crop yields, which are reflected in the form of production. The astronomical and topographic boundaries assumed that each region in Banten Province has different weather and land functions. Therefore, climate classification is needed so that agricultural land in each area has high productivity.

2. Materials and Methods

Climate and agricultural production data are used to classify climate and land in increasing agricultural production in Banten Province. Both climate data and agricultural production data were analyzed for 18 years, from 2002 to 2019. Climate data is sourced from the Meteorology, Climatology and Geophysics Agency (BMKG) Serang and Ciputat stations, while agricultural production data is sourced from the Central Statistics Agency of Banten Province. Statistical downscaling is used with the "delta" method to determine climate projections. The principle of this method is the multiplication or addition of the average change to the baseline period [10] as follows.

$$X_{cor,i} = X_{o,i} + \mu_p - \mu_b \quad (1)$$

$$X_{cor,i} = X_{o,i} \times \frac{\mu_p}{\mu_b} \quad (2)$$

where $X_{cor,i}$ is the corrected value, $X_{o,i}$ is the observation value for the baseline period, p is the average in the projection period, and b is the average for the baseline period.Simple regression analysis was used to determine the trend of climate change. Based on the trend of temperature and rainfall and the relationship between the two, an analysis of crop production was then carried out to determine the amount of production and productivity of agricultural land in Banten Province. The combination of climate data and crop production is needed to determine the types of plants with high productivity.

3. Results

3.1. Banten Province Agricultural Production

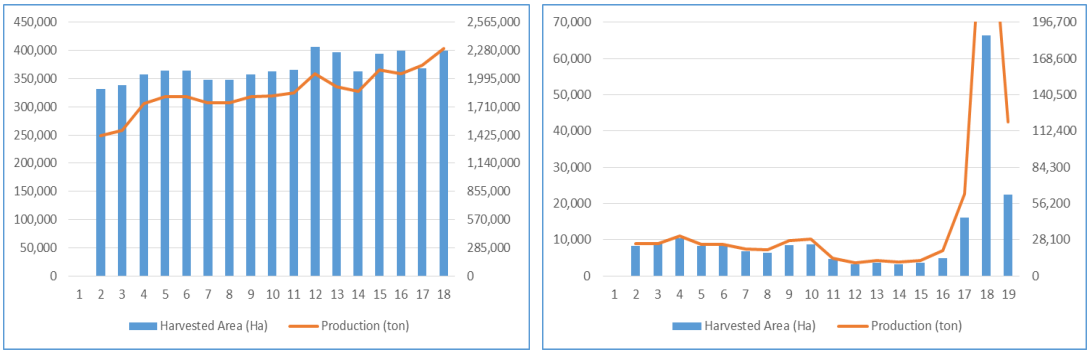
Agricultural production of Banten Province in eighteen years, starting from 2002-2019, consisted of paddy, maize, soybeans, peanuts, mung beans, cassava, and sweet potatoes[12]. Seventh crop production, the amount of production varies depending on each harvested area. The amount of harvested area and production has implications for the productivity of these plant types. The results of the crop production and productivity analysis in the Province of Banten are shown in Table 1.

Table 1 Results of analysis of agricultural production in Banten Province

Type of Agriculture	Harvested Area (ha)	Production (tons)	Productivity (tons/ha)
Paddy	332,029 - 406,411	1,419,643.07 - 2,300,546.43	4.28 - 5.78
Maize	3,074 - 66,376	9,821.18 - 331,961.19	2.85 - 5.33
Cassava	3,166 - 11,950	70,914.87 - 163,967.61	13.72 - 25.93
Peanuts	3,400 - 14,211	3,941.28 - 20,379.44	1.06 - 1.53
Soybeans	1,472 - 23,595	1,206.45 - 18,098.15	0.67 - 1.41
Sweet potato	915 - 3,638	12,788.20 - 41,275.98	11.35 - 16.95
Mung beans	295.8 - 2,840	221.98 - 2,767.18	0.75 - 0.98

Based on Table 1 above, paddy is the most abundant harvest area, while the smallest is mung beans. Compared with the provincial harvested field, the paddy harvested area was 76.82%, while the second was maize at 12.55%.

Within eighteen years, paddy production in Banten Province was in the range of 1,419,643.07-2,300,546.43 tons, while maize production was between 9,821.18-331,961.19 tons, as shown in Fig. 1 below.



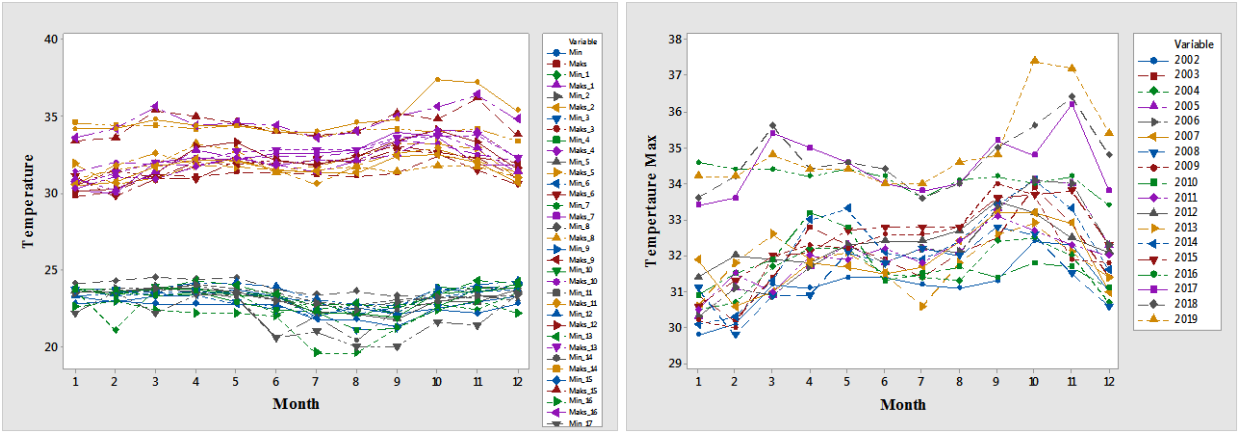
a) Harvested area and paddy production b) Harvested area and maize production

Fig. 1 Extent of harvest and production of paddy and maize

In Fig. 1, it appears that the harvested area of paddy and maize in Banten Province has fluctuated. In Fig. 1a, the paddy harvest area tends to decrease, but productivity tends to increase. The largest harvested area occurred in 2012 of 406,411 hectares (ha), with productivity reaching 5.05 tons/ha. In 2017 the paddy harvested area decreased to 368,152 ha, but its production increased to 5.76 tons/ha. Then, in 2018 paddy harvested area will rise to 406,411 ha; at the same time, productivity will increase to 5.78 tons/ha. Since 2017 paddy production in Banten Province has continued to grow so that its productivity is more significant than national productivity. Furthermore, in Figure 1b, it appears that the highest maize production in 2018. The harvested area increased to 66,376 ha in that year, with total production reaching 331,961.19 tons and productivity reaching 5.00 tons/ha. However, in 2019 the maize harvest area will decrease to 22,346 ha, but maize productivity increased to 5.34 tons/ha in that year.

3.2. Banten Province Climate

Based on climate data for eighteen years, from 2002-to 2019 shows that the temperature in Banten Province is in the range between 19.6-37.4^{o}C. The lowest temperatures occur in July and August, while the highest temperatures occur in October. The lowest temperature occurred in 2018, while the highest temperature occurred in 2019 is shown in Fig. 2 below.



a) Total monthly temperature b) Maximum monthly temperature

Fig. 2 Banten Province monthly temperatures

In Fig. 2a above, it appears that there was a significant increase in temperature in the period of four years, 2016-2019. During this period, the maximum temperature was in the range 33.4-37.4^{o}C, whereas in the period of fourteen years 2002-2015, the maximum temperature was in the range between 29.8-34.1^{o}C. In Fig. 2b, it appears that in Banten Province, the maximum temperature continues to increase; the highest average maximum temperature occurs in September and October, then in November, the temperature drops again. Under normal conditions, the temperature of 2002-2015, the pattern of the increase is almost formed a half-circle. A significant increase in temperature starts from June and peaks in October. However, within four years, 2016-2019, temperatures in Banten Province showed an increasing trend. Regression analysis based on temperature data for the previous ten years was conducted to examine the trend of temperature changes more deeply. The results of the regression analysis are shown in Table 2.

Table 2 Results of monthly maximum temperature regression analysis in Banten Province

Coefficients[a]

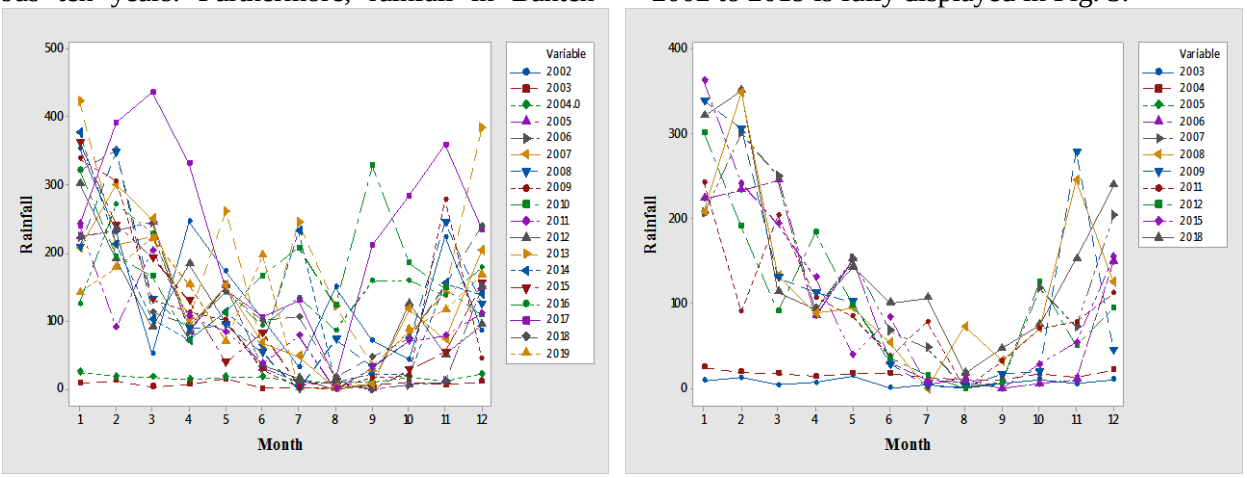
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	326.580	353.907		.923	.526
	Temperature_n-10	-2.207	2.133	-2.231	-1.035	.489
	Temperature_n-9	-4.664	5.172	-2.649	-.902	.533
	Temperature_n-8	-1.751	1.844	-1.062	-.949	.517
	Temperature_n-7	-4.252	7.165	-2.139	-.593	.659
	Temperature_n-6	5.083	6.737	3.165	.754	.589
	Temperature_n-5	3.137	2.440	3.384	1.285	.421
	Temperature_n-4	1.980	3.880	1.629	.510	.700
	Temperature_n-3	-3.457	3.424	-1.014	-1.010	.497
	Temperature_n-2	1.989	2.977	1.457	.668	.625
	Temperature_n-1	-4.526	7.332	-3.300	-.617	.648

[a] Dependent Variable: Temperature_*n*

From this table, the regression equation is obtained as follows:

$$T_n = 326.580 - 2.207T_{n-10} - 4.664T_{n-9} - 1.751T_{n-8} - 4.252T_{n-7} + 5.083T_{n-6} + 3.137T_{n-5} + 1.980T_{n-4} - 3.457T_{n-3} + 1.988T_{n-2} - 4.526T_{n-1} \quad (3)$$

Using equation (3), you can predict the temperature of a particular month (n^{th} month temperature) by inputting the same month temperature data in the previous ten years. Furthermore, rainfall in Banten Province is in the range of 0-436.3 mm/month. The lowest rainfall occurs in August and September, while the highest rainfall occurs in March. Rainfall from 2002 to 2019 is fully displayed in Fig. 3.



(a) Total monthly rainfall (b) Normal rainfall

Fig. 3 Banten Province monthly rainfall

Based on Fig. 3a above, rain in Banten Province appears almost every month for eighteen years. However, there was no rainfall in August 2003, 2011, 2012, and September 2005, 2006. The highest rainfall occurs in January and February, except for 2017, the highest rainfall occurs in March. In general, rainfall decreased from April to August and rose again until February. From 2003 to 2009, rain in Banten Province commonly occurred within seven years, so the curves formed a satellite dish, as shown in Fig. 3b. However, from 2010 to 2019, rainfall tends to increase. In 2010, high rainfall occurred from May to July. Almost in three years, namely in 2013, 2016, and 2019 in that month, there was high rainfall. Examine the trend of changes in precipitation in Banten Province more deeply, and regression analysis is conducted. The results of the regression analysis are shown in Table 3 below.

Table 3 Results of monthly rainfall regression analysis in Banten Province

Coefficients[a]						
Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**
		B	**Std. Error**	**Beta**		
1	(Constant)	195.425	19.235		10.160	.062
	Rainfall_n-10	-.278	.073	-.457	-3.789	.164
	Rainfall_n-9	-.417	.074	-.436	-5.650	.112
	Rainfall_n-8	2.382	.326	2.158	7.307	.087
	Rainfall_n-7	-.820	.105	-.976	-7.827	.081
	Rainfall_n-6	-.977	.127	-1.599	-7.702	.082
	Rainfall_n-5	-.586	.121	-.826	-4.835	.130
	Rainfall_n-4	-.003	.145	-.005	-.023	.985
	Rainfall_n-3	-.596	.160	-.439	-3.719	.167
	Rainfall_n-2	-.167	.101	-.279	-1.652	.347
	Rainfall_n-1	1.849	.222	2.555	8.337	.076

[a] Dependent variable: Rainfall_*n*

From this table, the regression equation is obtained as follows:

$$R_n = 195.425 - 0.278R_{n-10} - 0.417R_{n-9} + 2.382R_{n-8} - 0.820R_{n-7} - 0.977R_{n-6} + -0.586R_{n-5} - 0.003R_{n-4} - 0.596R_{n-3} - 0.167R_{n-2} + 1.849R_{n-1} \quad (4)$$

Rainfall can be predicted in a particular month (n-month rain) with the same month rainfall data input in the previous ten years using equation (4).

Referring to equations (4) and (5), the temperature and monthly rainfalls in Banten province change. Changes in monthly temperature form a semicircular distribution pattern, as shown in Fig. 1. Meanwhile, changes in monthly rainfall form a parabola, as shown in Fig. 2. Both models form a different peak point. From May to July, rainfall has decreased, whereas the temperature has increased. Analysis was carried out using equations (1) and (2) to find out the relationship between temperature and precipitation. The study results using these equations obtained the relationship of changes in rainfall and monthly temperature, as shown in Fig. 4.

Based on Fig. 4, it appears that monthly rainfall and temperature are linearly related. Based on these images, the equation is obtained:

$$R = 434.10 - 9.12T \quad (5)$$

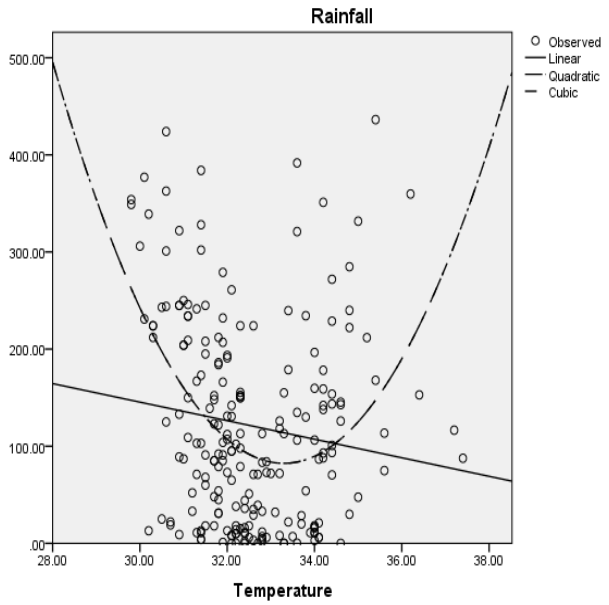


Fig. 4 Relationship of rainfall and monthly temperature

With R is the rainfall, and T is the temperature. Equation (5) is used to estimate the amount of rain under certain temperature conditions. Fig. 4 shows that

the first cut point of raindrops is around 31.6°C, and the second cutoff is around 34.2°C. Using this equation, the rainfall at the two temperatures is 145.97 mm and 122.26 mm. Based on this analysis, it is estimated that in Banten Province, rainfall with relatively high temperatures occurs.

3.3. Climate and Agricultural Land Classification of Banten Province

Banten Province was initially comprised of four districts and one city: Pandeglang, Lebak, Tangerang, Serang Regency, and Cilegon Municipality. In 2009 Serang and Tangerang Regencies experienced a division into several cities. Serang Regency was divided into Serang Regency and Serang Municipality, while Tangerang Regency became: Tangerang Regency, Tangerang Municipality, and South Tangerang Municipality. The expansion has consequences for the area, so there have been changes in Serang and Tangerang counties in the area. These changes affect the harvested area of each type of agriculture. The analysis result for ten years, 2009-2019, in each regency or municipality is shown in Table 4.

Table 4 Harvested area for the agricultural type of regency/municipality

No	Regency/ Municipality	Area (Km^2)	Harvested Area (ha)							
			Wetland Paddy	Dryland Paddy	Maize	Soybeans	Peanuts	Mung beans	Cassava	Sweet Potatoes
Regency										
1	Pandeglang	2,746.89	106,668-145,632	17-21,860	1,962-45,339	2,061-24,049	244-3,368	440-1,591	901-3,018	391-1,206
2	Lebak	3,426.56	9,124-116,790	1,300-12,070	171-17,953	200-4,043	233-1,011	9-284	1,029-2,186	332-1,406
3	Tangerang	1,011.86	53,727-82,392	4-1,209	62-306	0	32-263	0	121-422	28-515
4	Serang	1,734.28	73,663-88,069	542-3,475	287-6,511	145-1,509	2,436-6,075	145-760	891-3,414	209-1,297
Municipality										
5	Tangerang	153.93	450-1,495	0	0-3	0	0	0	2-30	2-4
6	Cilegon	175.50	2,028-2,928	21-82	18-71	41-193	66-3,694	21-64	17-153	19-55
7	Serang	266.71	8,073-16,856	112-74,180	185-1,179	53-150	930-2,265	15-2,001	62-391	46-187
8	South Tangerang	147.19	70-427	0-70	40-344	0-6	72-386	0-2	51-318	26-182

Based on Table 4, the most significant area is Lebak Regency, while the smallest is South Tangerang Municipality. Lebak Regency has an area of 35.46%, then Pandeglang Regency 28.43%, while South Tangerang Municipality is 1.52% of the total area of Banten Province. Within ten years, the largest harvested area of each plant in each regency/municipality is different. The harvested area for paddy, maize, and soybean occurred in 2018 and dryland paddy in 2010 in Pandeglang Regency. The most abundant harvest area of peanuts and mung beans occurred in Cilegon and Serang Municipality in 2010.

Meanwhile, the largest harvested area of cassava occurred in 2012 in Serang Regency and 2016 sweet potatoes in Lebak Regency. The most significant percentage of the seven plants' harvested area is paddy and maize. The most significant paddy and maize harvested area is Pandeglang Regency, at 53% and 17% of the regency's area.

The harvested area has direct implications for the amount of production obtained by each regency/municipality. The amount of output in each regency/municipality varies, depending on the productivity of each land. The results of the regency/municipality crop productivity analysis are fully displayed in Table 5.

Table 5 Crop productivity, temperature, and district/city rainfall

No	Regency / Municipality	Climate		Productivity (ton/ha)							
		T (°C)	Rainfall, mm	Wetland Paddy	Dryland Paddy	Maize	Soybeans	Peanuts	Mung beans	Cassava	Sweet Potatoes
National Productivity				5.70	3.28	2.81	2.50	1.40	1.17	19.00	17.50
Regency											
1	Pandeglang	18.9-33.4	0.0-872.0	5.45-5.94	3.35-3.93	3.08-5.20	1.25-1.68	1.06-1.46	0.00-1.31	13.55-23.30	11.50-16.96
2	Lebak	19.2-33.3	0.0-835.5	5.66-6.30	2.49-4.00	2.32-3.68	0.82-1.45	1.32-1.68	0.79-1.00	10.93-23.90	2.80-13.80
3	Tangerang	20.6-38.4	0.0-289.6	5.39-6.85	4.59-5.00	2.95-3.31	0.00-0.00	1.63-1.82	0.00-0.00	12.58-13.05	9.51-9.94
4	Serang	21.9-34.1	0.0-489.6	5.25-5.78	2.70-3.41	2.99-3.85	1.30-1.65	1.22-1.42	0.00-0.95	14.00-17.85	8.54-13.58
Municipality											
5	Tangerang	22.9-34.5	0.0-688.8	5.81-6.60	0.00-0.00	0.00-3.20	0.00-0.00	0.00-0.00	0.00-0.00	0.00-9.00	0.00-6.67

Continuation of Table 5

6	Cilegon	20.0-34.1	0.0-424.0	5.19-6.12	1.32-5.75	0.00-4.39	0.00-1.36	1.00-1.94	080-1.18	9.02-16.26	10.35-15.78
7	Serang	20.0-37.4	0.0-362.7	4.97-6.90	3.03-7.76	1.39-3.90	0.00-1.40	0.00-1.51	0.00-0.20	0.00-16.30	0.00-8.11
8	SouthTangerang	21.0-37.4	0.0-663.3	3.24-6.10	0.00-0.00	0.00-5.32	0.00-1.38	1.14-1.69	0.00-0.00	0.00-17.98	5.66-17.29

Based on Table 5 above, it appears that only two types of plants, namely soybeans and sweet potatoes, have not yet reached national productivity. In ten years, only five years, the productivity of cassava and mung beans is higher than national productivity. Cassava productivity occurred in Pandeglang Regency in 2014 and 2015, while from 2016-2018 in Pandeglang and Lebak Regencies, for mung beans occurred in Pandeglang Regency and Cilegon Municipality in 2009 and 2014 while from 2015-2018 only in Pandeglang Regency. Peanut productivity for ten years is higher than national productivity. From 2019-to 2014, it took place in all regencies and municipalities of Cilegon, Serang, and South Tangerang. However, from 2015-2018 only occurred in the Regencies of Lebak, Tangerang, and Serang.

Furthermore, corn for ten years, in general, has had higher productivity than national productivity that in 2009 and 2010 occurred in all regencies and municipalities of Serang and South Tangerang. In 2011 and 2012, it occurred in Pandeglang, Tangerang and Serang Regency, Serang and South Tangerang Municipalities, in 2013 and 2014 – in all regencies and municipalities of South Tangerang. Since 2016 maize harvested area has been developed in Pandeglang and Lebak Regencies so that in 2018 only the two districts will have higher productivity than national productivity. Then, for ten years, the dryland paddy productivity was higher than the national productivity, but it only occurred in all regencies and the municipalities of Cilegon and Serang. Only Pandeglang and Lebak Regencies had higher productivity than national productivity during that period.

Furthermore, dryland paddy productivity is generally higher than national productivity but only occurs in a few regencies and municipalities in 2009 – Lebak, Tangerang Regency, Tangerang, and South Tangerang Municipalities. Inm 2010 it occurred in Tangerang and South Tangerang Municipalities, while in 2011, it only happened in Pandeglang Regency, in 2012 – in Pandeglang, Lebak, Tangerang Regencies, and Tangerang Municipality, then in 2013 following the municipality of Serang. In 2014 it occurred in all regencies, while from 2015 to 2017, it was all regencies and municipalities of Tangerang and Cilegon. In 2018 high productivity only occurred in Pandeglang and Lebak Regencies and Tangerang Municipality.

4. Discussion

Banten Province has five types of plants whose productivity is higher than the national productivity. Climate classification is needed in each region to increase the production of the five types of plants because each plant requires different climatic conditions. In general, the five types of plants can grow optimally under an altitude of 1,000 masl with a temperature range of 11-30^{o}C and rainfall between 85-820 mm/month. Cassava requires a temperature of 18-35^{o}C with 150-300 mm/month rain. Furthermore, peanut requires a temperature of 27-30^{o}C with a rainfall of 359-820 mm/month, while mung beans and peanut need a temperature of 25-27^{o}C with a 50-200 mm/month [11]. Then, corn plants need temperatures between 21-28^{o}C with rainfall 85-200 mm/month [12]. Furthermore, rice plants require temperatures of 11-25^{o}C with an average rainfall of 200 mm/month [13]. Stages of rice plant growth for germination require temperatures 11-25^{o}C for flowering 22-23^{o}C and seed formation 20-25^{o}C [14].

Based on the climate data analysis, the temperature in Banten Province is in the range of 19.6-37.4^{o}C, and rainfall is in the field of 0-436.3 mm. Based on the temperature range, the five types of plants can grow optimally, but for germination of rice, plants are less optimal because the minimum temperature does not reach 11^{o}C. Ghadirnezhad & Fallah (2014) state that low temperature significantly affects 1 percent of all treatments. The interaction of temperature with varieties shows that the most tolerant variety about temperature stress along with the least percentage yield (19%) is the Shirdi variety, and the most sensitive one with the most percentage of yield decrease (29%) is the local taro variety [15]. Furthermore, based on the range of rainfall, plants: wetland paddy, dryland paddy, maize, peanuts, mung beans, and cassava can grow with optimal productivity. In contrast, soybeans and sweet potatoes can still grow, but their productivity is less than optimal. Another variable closely related to production and productivity is the harvest area. Develop the harvested area of a type of plant. It is necessary to consider the type of soil of each region.

Referring to the comparison between paddy and maize productivity of Banten Province with national productivity, the production of these plants has the potential to be increased. Based on the trend of growing paddy and maize productivity in Banten Province can increase production. Referring to the pattern, Banten Province could meet the national paddy and maize needs if the paddy and maize harvest area increased. However, in increasing the harvested area, it is necessary to consider the area of each regency or municipality.

The area of regency/municipality in Banten Province is a very significant difference. The largest area is Lebak Regency, while the smallest is South Tangerang Municipality. The area of Lebak Regency is 35.5%, then Pandeglang Regency is 28.4%, while the area of South Tangerang Municipality is only 1.5% of the total area of Banten Province. Based on the results of the productivity analysis, Pandeglang and Lebak Regencies have the potential for plants: cassava, maize, wetland paddy, and dryland paddy. Meanwhile, mung beans will grow optimally in Pandeglang Regency while peanuts in Lebak Regency. Lebak and Pandeglang Regencies are suitable in agriculture because it is still in a low range in terms of the spread of pollution from industry [16].

5. Conclusion

Astronomically, Banten Province is located between 05o07'50"-07o01'01" S and 105o01'11"-106o07'12" E. Based on these astronomical boundaries, Banten Province generally has a tropical and wet climate. Furthermore, Banten Province is located at an altitude of 0-1000 masl, referring to the topography. Banten Province is a hot and moderate area with this altitude and is suitable for crops. These crops can grow optimally at temperatures between 11-30^{o}C with rainfall between 85-820 mm/month.

The range of temperature and rainfall in Banten Province is 19.6-37.4^{o}C and 0-436.3 mm/month. Referring to the temperature and rainfall standards for plant growth, in Banten Province, there are five types of plants that have the potential for optimal productivity. The five plants in question are rice, corn, peanuts, green beans, and cassava. Rice and maize can be developed in Pandeglang and Lebak Regencies, especially lowland rice and upland rice. The range of temperature and rainfall in Pandeglang and Lebak Regencies is quite potential for developing these two crops. With the temperature and rainfall conditions, the trend of lowland rice production in the two districts, the productivity is greater than the national one. If the temperature and rainfall conditions are coupled with land extensification, the production of rice and corn in Pandeglang and Lebak Regencies will continue to increase, both at the provincial and national levels. With high productivity, Banten Province can become one of the top five provinces that have national rice and corn production.

References

[1] STATISTICS OF BANTEN PROVINCE. *BPS Banten, Banten in Figures.* Banten: Badan Pusat Statistik, 2016.

[2] MINISTRY OF AGRICULTURE. *Kementerian Pertanian, Produksi, Luas Panen Tahun 2014-2018.* Jakarta: Kementaerian Pertanian, 2016. https://www.pertanian.go.id/home/?show=pageandact=viewandid=61

[3] MINISTRY OF AGRICULTURE. *Kementerian Pertanian, Produksi, Luas Panen Tahun 2014-2018.* Jakarta: Kementerian Pertanian, 2018. https://www.pertanian.go.id/home/?show=pageandact=viewandid=61

[4] KUSWANTO H., SALAMAH M., RETNANINGSIH S.M., and PRASTYO D.D. On The Impact of Climate Change to Agricultural Productivity in East Java. *Journal of Physics: Conference Series*, 2018,1-9.

[5] GUPTA S., KESSLER A., BROWN M., and ZVOMUYA F. Climate and agricultural land-use change impacts on streamflow in the upper midwestern United States. *Water Resources Research*, 2015, 51(7), 1-17.

[6] LOO Y.Y., BILLA L., and SINGTH A. Effect of Climate Change on Seasonal Monsoon in Asia and its Impact on the Variability of Monsoon Rainfall in Southeast Asia. *Geoscience Frontiers*, 2015, 6(6), 817-823.

[7] XIAO Z.-N., LIN LI D., ZHOU L., ZHAO L., and HUO W.-J. Interdisciplinary Studies of Solar Activity and Climate Change. *Atmospheric and Oceanic Science Letters*, 2017, 10(4), 325-328.

[8] ZHENG L., GAIRE N. P., and SHI P. High-altitude tree growth responses to climate change across the Hindu Kush Himalaya. *Journal of Plant Ecology*, 2021, 14(1), 829-842. DOI: 10.1093/jpe/rtab035

[9] SUCIANTINI. Interaksi iklim (curah hujan) terhadap produksi tanaman pangan di Kabupaten Pacitan. *Prosiding Seminar Nasional Masyarakat Biodiversitas Indonesia*, 2015, 1(2), 358-365.

[10] FAQIH A. *Proyeksi Iklim menggunakan Luaran GCM CMIP5: Statistical Bias Correction for Climate Scenarios Indonesia 3rd National Communication*. Jakarta, 2016.

[11] FAYE B., WEBBER H., DIOP M., MBAYE M., SEKYERE J. O., NAAB J., and GAISER T. Potential impact of climate change on peanut yield in Senegal, West Africa. *Field Crops Research*, 2018, 129(1), 148-159.

[12] HERLINA N., and PRASETYORINI A. Pengaruh Perubahan Iklim pada Musim Tanam dan Produktivitas Jagung (Zea mays L.) di Kabupaten Malang. *Jurnal Ilmu Pertanian Indonesia*, 2020, 25(1), 118-128. DOI: 10.18343/jipi.25.1.118

[13] YULIAWAN T., and HANDOKO I. The effect of temperature rise to rice crop yield in Indonesia uses Shierary Rice model with geographical information system (GIS) feature. *Procedia Environmental Sciences*, 2016, 33(1), 214-220.

[14] HORI K., SAISHO D., NAGATA K., NONOUE Y., YAMAGUCH Y. U., KANATANI A., and MOCHIDA K. Genetic Elucidation for Response of Flowering Time to Ambient Temperatures in Asian Rice Cultivars. *International Journal of Molecular Sciences*, 2021, 22(1), 1-13.

[15] GHADIRNEZHAD R., and FALLAH A. Temperature Effect on Yield and Yield Components of Different Rice Cultivars in Flowering Stage. *International Journal of Agronomy*, 2014, 2(1), 1-5.

[16] RUHIAT Y., and GUNTARA Y. Regional Detection Polluted with Diffusion and Convection Models in Banten

Province. *Journal of Physics: Conference Series*, 2020,1428, 1-5.

参考文:

[1]萬丹省統計數據。萬丹，數字中的萬丹。萬丹：中央統計局，2016 年。
[2] 農業部。農業生產部，2014-2018年收穫區。雅加達：農業部，2016 年。https://www.pertanian.go.id/home/?show=pageandact=viewandid=61
[3]農業部。農業生產部，2014-2018年收穫區。雅加達：農業部，2018 年。https://www.pertanian.go.id/home/?show=pageandact=viewandid=61
[4] KUSWANTO H.、SALAMAH M.、RETNANINGSIH S.M. 和 PRASTYO D.D.關於氣候變化對東爪哇農業生產力的影響。物理學雜誌：系列會議，2018，1-9。
[5] GUPTA S.、KESSLER A.、BROWN M. 和 ZVOMUYA F. 氣候和農業土地利用變化對美國中西部上游徑流的影響。水資源研究, 2015, 51(7), 1-17.
[6] LOO Y.Y.、BILLA L. 和 SINGTH A. 氣候變化對亞洲季節性季風的影響及其對東南亞季風降雨變異性的影響。地球科學前沿, 2015, 6(6), 817-823。
[7] XIAO Z.-N., LIN LI D., ZHOU L., ZHAO L., 和 HUO W.-J. 太陽活動和氣候變化的跨學科研究。大氣和海洋科學快報，2017，10(4)，325-328。
[8] ZHENG L.、GAIRE N. P. 和 SHI P. 興都庫什喜馬拉雅山高海拔樹木生長對氣候變化的響應。植物生態學雜誌， 2021， 14(1)， 829-842。 DOI: 10.1093/jpe/rtab035
[9]SUCIANTINI。帕西坦攝政氣候（降雨）對糧食作物生產的相互作用。印度尼西亞生物多樣性協會全國研討會論文集，2015 年，1(2)，358-365。
[10] FAQIH A. 使用全球移動通信系統輸出公共管理信息協議5 的氣候預測：印度尼西亞第三次國家通信氣候情景的統計偏差校正。雅加達，2016 年。
[11] FAYE B.、WEBBER H.、DIOP M.、MBAYE M.、SEKYERE J. O.、NAAB J. 和 GAISER T. 氣候變化對西非塞內加爾花生產量的潛在影響。田間作物研究, 2018, 129(1), 148-159。
[12] HERLINA N. 和 PRASETYORINI A. 氣候變化對瑪瑯攝政區玉米 (玉米) 種植季節和生產力的影響。印度尼西亞農業科學雜誌, 2020, 25(1), 118-128. DOI: 10.18343/jipi.25.1.118
[13] YULIAWAN T., 和 HANDOKO I. 印度尼西亞氣溫升高對水稻產量的影響使用具有地理信息系統(**地理信息系**統)特徵的**星**报**米**模型。**普**罗西迪亚環境科學, 2016, 33(1), 214-220。
[14] HORI K.、SAISHO D.、NAGATA K.、NONOUE Y.、YAMAGUCH Y.U.、KANATANI A. 和 MOCHIDA K. 亞洲水稻品種開花時間對環境溫度響應的遺傳闡明。國際分子科學雜誌, 2021, 22(1), 1-13.
[15] GHADIRNEZHAD R., 和 FALLAH A. 溫度對開花期不同水稻品種產量和產量成分的影響。國際農學雜誌, 2014, 2(1), 1-5.
[16] RUHIAT Y. 和 GUNTARA Y. 萬丹省擴散和對流模型污染的區域檢測。物理學雜誌：系列會議，2020，1428，1-5。