



# Analysis of Climate and Land Potential to Improve Corn Production in Banten Province, Indonesia

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**Abstract.** National corn production continues significantly increased, ranging from 9,347,192 tons to 19,611,704 tons. The highest corn production in East Java Province with an average production of 3,525,913.467 tons with productivity of 4.112 tons/ha. Meanwhile, the average corn production in Banten Province is 20,559.533 tons, with productivity of 3.033 tons/ha. An analysis of climate and land-based potential was carried out, while regression analysis was used to determine the corn production trend. The temperature analysis results showed that of the four districts, only South Tangerang City was not suitable for corn plants. Meanwhile, according to the analysis of production, the average corn production in Banten Province amounted to 20,559.53 tons of harvested area of 12,534 ha. The regression analysis results, with the harvested area obtained by corn production, amounted to 32,773.485 tons. It shows that corn production in Banten Province only reached 62.73%. Therefore, a change in the planting period is required to achieve ideal corn production. Based on the rainfall analysis results, corn's planting period in Banten Province was three times, namely in January, June, and September. Furthermore, the optimal area to increase corn land in Pandeglang and Lebak districts. Through the maximum planting, corn production will increase in Banten Province.

**Keywords:** increased · temperature · rainfall · land · productivity · corn production

## 1 Introduction

Indonesia has 1,916,862.20 km<sup>2</sup> consisting of thirty-four provinces with an area of 664.01 km<sup>2</sup> to 319,036.05 km<sup>2</sup>. The province with the most significant area, Papua Province, is 16,672% while the smallest one is DKI Jakarta Province at 0.035%. Meanwhile, Banten Province has an area of 0.505% (Badan Pusat Statistik Provinsi Banten, 2021; BPS Indonesia, 2018). Each province expands the land to increase corn production based on the large area. (Barbosa et al., 2017; Handayati et al., 2022).

National corn production for a period of fifteen years, from 2001 to 2015, continued to increase from 9,347,192 tons to 19,611,704 tons. This improvement is an accumulation of corn production in each province. The increase of corn production in each province

against national corn production is between (0–1.38) %. The highest corn production is in East Java Province, while the lowest is DKI Jakarta. Meanwhile, Banten Province has an average production of 0.12% of the national corn production (Alfarizy et al., 2021; Hanifa et al., 2021). A province's corn production increase depends on land area and climate (Lee & Durmaz, 2016; Ruhiat, 2021).

The total area of each province in Indonesia varies, from 664.01 Km<sup>2</sup> to 309,036.05 Km<sup>2</sup>. The province with the largest area of Papua Province, while the smallest is DKI Jakarta. Meanwhile, the corn harvest area of each province except DKI Jakarta is between 180 hectares (ha) to 1,204,063 ha. The largest area of corn is East Java Province, while the smallest is Riau Islands. Meanwhile, Banten Province has an area of 9,662.92 Km<sup>2</sup> with a corn harvest area of 12,534 ha. The difference ratio between the corn harvest area and the plant area would be based on the different climate conditions in each province (Iizumi & Ramankutty, 2015).

Indonesia has three elements, namely: monsoon, tropical, and ocean climate. The monsoon climate occurs because it changes direction every half year (Loo et al., 2015). Meanwhile, the monsoon consists of southwest monsoons and northeast monsoons. The southwest monsoon is helpful to increase agricultural productivity, while the northeast monsoon is in a dry season (Anderson et al., 2019; Campbell et al., 2016). High-yield corn crops will achieve regarding climate conditions, if it harvested in the dry season (Castro et al., 2013; Ketterings, 2017). Meanwhile, growing corn plants require a threshold of rainfall and temperature. The point of rainfall for corn plants between 250 mm (mm) to 5000 mm, while the temperature is between 21 °C to 34 °C (Hatfield & Prueger, 2015; Vogel et al., 2019). Climate and land analysis are implemented in Banten Province, referring to the rainfall and temperature threshold. The extent of land with a suitable climate for corn plants has potential influence to increase corn production in Banten Province.

## 2 Material and Methods

To find out the appropriate climate for corn plants, an analysis of astronomical conditions was carried out because corn grows in areas located between (0–5)<sup>o</sup> North Latitude (N) and (0–40)<sup>o</sup> South Latitude (S). Then, climate data analysis was carried out for five years, from 2014 to 2018. Analysis of climate data focused on rainfall and temperature in each region or province. Furthermore, to increase corn production, an analysis of the growing period of corn is carried out because the corn harvest in the dry season is better than in the rainy season.

Land area and harvest area in each region to increase corn production analysis. The soil type analysis was carried out related to the intensification of land area for corn plants because the soil suitable for corn plants consisted of andosol, latosol, grumusol, sandy soil, and peat soil. In analyzing corn production, analysis of corn production was carried out for fifteen years, from 2001 to 2015. Regression analysis was used to fit the regression model to analyze the potential increase in corn production in Banten Province (Sellam & Poovammal, 2016). Meanwhile, to find out the trend of corn production, the researchers used time series trend analysis (Morojele & Sekoli, 2016). By using these two equations, the trend of increasing corn production in Banten Province would be achieved.

### 3 Results

Astronomically, Indonesia is located between: 6°04'30" N to 11°00'36" S and 94°58'21" to 141°01'10" East Longitude (E). When referring to the southern latitude astronomical boundary, the entire territory of Indonesia has the potential for the growth of corn plants because the astronomical limits are in the range of 0–40oS. Climate data analysis refers to the temperature and rainfall threshold for corn plants from 2014 to 2018. The results of the analysis of temperature, rainfall, harvest area, and corn production on each island in Indonesia are shown in Table 1.

Based on Table 1 above, temperatures in Indonesia are 14.40 °C to 40.30 °C, while rainfall is between 460.90 mm to 5,041.00 mm. Referring to the Indonesian region's temperature threshold, certain areas are not suitable for corn plants because the temperature is below or above the threshold. Meanwhile, if it refers to rainfall, only Maluku is above the rainfall threshold. The rain and temperature analysis results in all provinces in Indonesia over the five years are shown in Fig. 1.

In Fig. 1.a it appears that all provinces in Indonesia are at the threshold of rainfall, except Maluku Province (no. 31), which has rainfall above the point, but the excess is only 3.82%. Furthermore, Fig. 1.b appears all provinces are below or above the temperature threshold, except for two provinces, namely Bali Province (no. 17) and West Papua (no. 33). Based on the temperature analysis results, eleven provinces have four to seven locations. The eleven provinces are two provinces in Sumatra, two provinces in Java, one province in Nusa Tenggara, two provinces in Kalimantan, and four provinces in Sulawesi. Meanwhile, twenty-one other provinces have one to three locations that are below or above the temperature threshold. The province has eight provinces on Sumatra Island, four provinces on Java Island, one province on Nusa Tenggara Island, three provinces in Kalimantan, and two provinces on Sulawesi. The difference in rainfall and temperature on each island or province has implications for corn production.

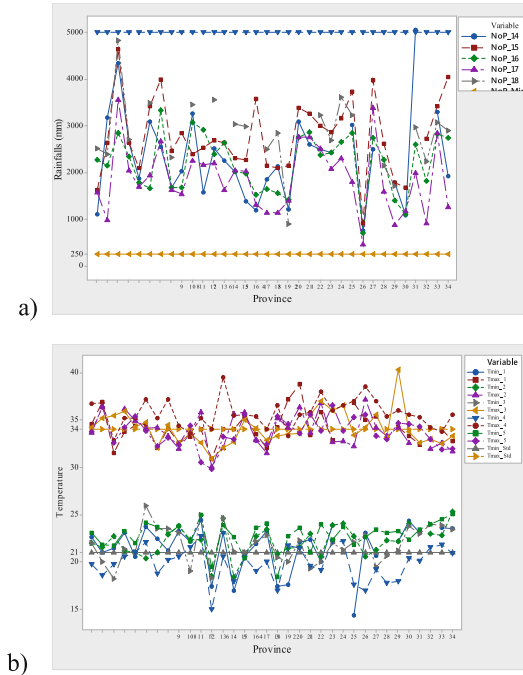
Indonesia's corn production for fifteen years, from 2001 to 2015, increased by 68.93%. Based on Table 1 above, all islands in Indonesia have corn production between zero and 6,295,301 tons. The highest and lowest corn production is in Java, namely East Java and DKI Jakarta. East Java Province has an average corn production of 3,525,913.467 tons with productivity of 4.112 tons/ha. Meanwhile, the average production of corn in Banten Province is 20,559.533 tons, with a productivity of 3.033 tons/ha. The results of the analysis of national corn production East Java and Banten provinces are shown in Fig. 2.

Based on Fig. 2.a national corn production has decreased three times, namely in 2006, 2011, and 2013. Then, in Fig. 2.b, East Java Province, which has the highest corn production, has decreased production in 2006, 2013, and 2014. However, both of them still show an increase in production, which is stated by the equation:  $Y_t = 8372573 + 828191t$  for national corn production, while East Java Province  $Y_t = 3346175 + 194019t$ . Furthermore, Fig. 2.c fluctuating production of corn in Banten Province. The most extensive corn production in 2001 and decreased production in 2011 and 2012, then gradually got increased. The corn production in Banten in a given year can be analyzed using the equation:  $Y_t = 30281 - 1215t$ . The results of the regression analysis have the potential to increase corn production each year as follows:

Method Categorical predictor coding (1; 0) Analysis of Variance

**Table 1.** Temperature, rainfall and corn production in Indonesia

No	Island Name	Area (Km <sup>2</sup> )	Province Number	Area (Km <sup>2</sup> )	Planted and Harvested Area of Maize Plant		Temperature (C)		Rainfalls (mm)
					Planted Area (ha)	Production (ton)	Min	Max	
1	Sumatera	480,793.28	10	8,201.72-91,592.43	180-447,509	473-2,126,571	18.20	37.20	975.90-4,627.40
2	Java	129,438.28	6	664.01-47,799.75	0-1,348,462	0-6,295,301	15.00	39.50	1,197.00-3,549.10
3	Bali	5,780.06	1	5,780.06	15,346-51,038	40,603-113,921	20.00	34.00	1,133.80-2,489.00
4	Nusa Tenggara	67,290.42	2	18,572.32-48,718.10	24,969-273,194	50,777-959,973	17.00	37.20	1,147.93-2,824.00
5	Kalimantan	544,150.07	5	38,744.23-153,564.50	445-45,593	973-181,407	19.10	38.80	2,069.40-3,599.00
6	Sulawesi	188,522.36	6	11,257.07-61,841.29	5,201-131,791	17,343-1,528,414	14.40	40.30	460.90-3,973.00
7	Maluku	78,896.53	2	31,982.50-46,914.03	2,464-18,814	3,778-25,069	20.10	35.30	913.40-5,041.00
8	Papua	421,991.20	2	102,955.15-319,036.05	965-6,116	313-9,269	20.90	35.60	1,265.90-4,033.00



**Fig. 1.** Temperature and rainfalls in Indonesia

Source	DF	Adj SS	Adj MS	F-alue	P-Value
Regression		1	258.66	258.663	157.60
Indonesia	1	258.66	258.663	157.60	0,000
Error	13	21.34	1.641		
Total	14	280.00			
<b>Model Summary</b>					
S	1,28113	R-sq	92.38%	R-sq(adj)	91.79%
				R-sq(pred)	89.99%
<b>Coefficients Term</b>					
	Coef	SE Coef	t-Value	P-Value	VIF
Constant	1991.27	1.37	1450.24	0.000	
Indonesia	0.000001	0.000000	12.55	0.000	1.00

**Regression Equation**

$$t_n = 1991.27 + 0.000001 \text{ Indonesia}$$

Banten Province’s corn production for fifteen years has averaged 0.14% of the total national corn production. Referring to the temperature threshold, harvest area, and corn productivity, Banten Province has the opportunity to increase corn production. Based on Table 1 Banten Province’s corn planting area is 1.30% of the Banten area. Meanwhile, East Java Province’s planting area has reached 28.21% of its total area. If the corn planting area in Banten Province is getting increased, then the province has the potential

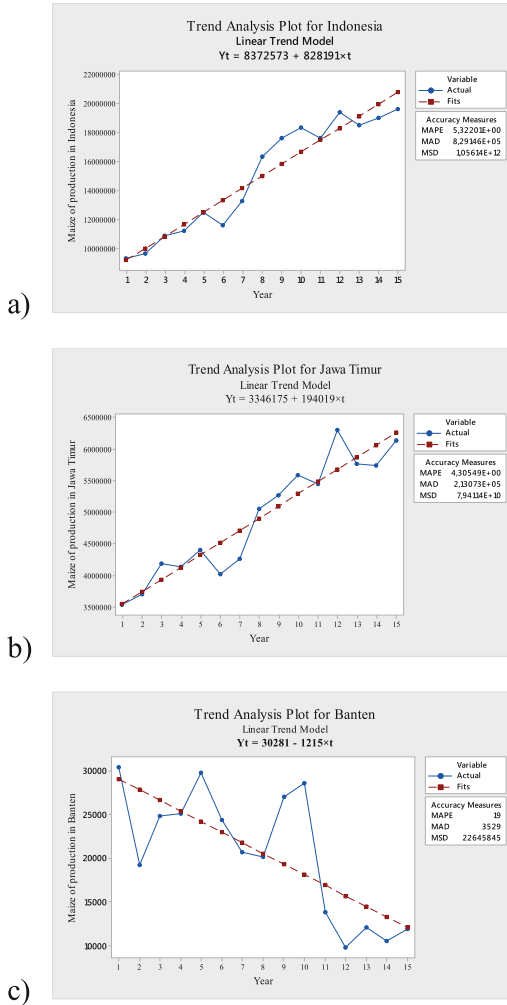
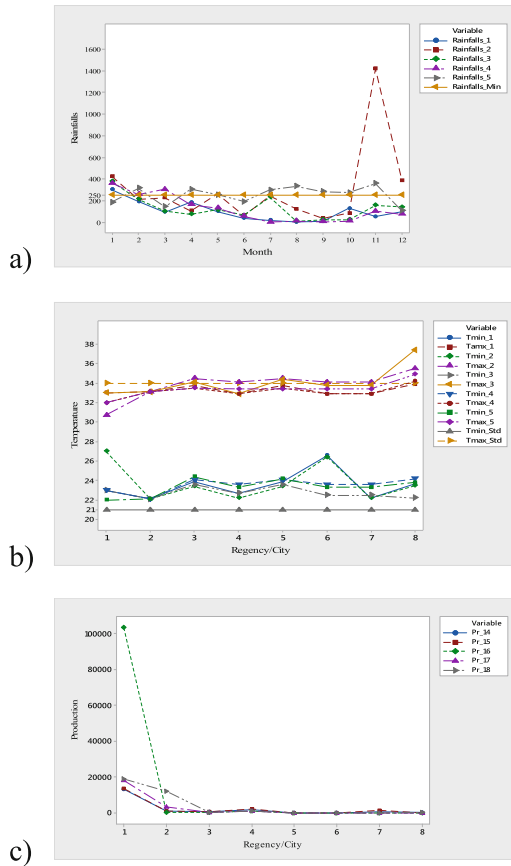


Fig. 2. Trend analysis corn of production

to increase corn production. Increasing corn planting area will be closely related to land area.

The total area of each province ranges from: 0.035% to 16.672% of the total area of Indonesia. The province with the most significant area, is Papua Province, while the smallest is DKI Jakarta. Meanwhile, Banten Province has an area of 0.505% of the total area of Indonesia. Corn planted area in each province, except DKI Jakarta, has an amount of land between 180 ha to 1,348,462 ha. The most significant area of corn planting is East Java Province, while the smallest is Bangka Belitung Islands Province. Meanwhile, Banten Province’s corn planting area has only reached 12,534 ha. Therefore, to increase corn production in Banten Province, it is necessary to extend the land, considering rainfall and the temperature in Banten Province is potential for corn plants.



**Fig. 3.** Monthly rainfall, temperature and corn production

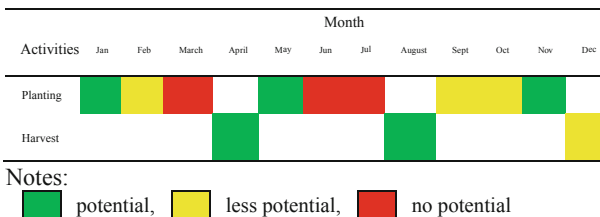
Banten Province has an area of 9,662.92 Km<sup>2</sup> with astronomical boundaries up to 05° 07' 50" S and 07° 01' 01" up to 106° 07' 12" E consisting of four districts and four cities. Referring to the astronomical border, the entire area of Banten Province is potential for corn plants. The results of the analysis of rainfall, temperature, and corn production in four districts/cities in Banten Province in the five years from 2014 to 2018 are shown in Fig. 3.

In Fig. 3.a, monthly rainfall in Banten Province is in the range of (0–1419) mm. Several months are not suitable for corn plants Referring to the rainfall threshold. However, in certain months when there is no rain, it will be ideal for the corn harvest. Then, based on Fig. 3.b all cities in Banten Province are by the threshold of corn growth, except South Tangerang City (Fig. 3.b no. 8). Furthermore, in Fig. 3.c the highest corn production in Pandeglang Regency (Fig. 3.c no 1) then Lebak Regency (Fig. 3.c no 2). Meanwhile, corn production in the other two districts and four cities in the Banten Province area ranged from (0–2,279) tons. The results of the analysis of the land area, harvest area, and corn production of Banten Province are shown in Table 2.

**Table 2.** Temperature, rainfall and corn production in Banten Province

No	Regency/City		Maize	
	Name	Area (Km <sup>2</sup> )	Harvested Area (ha)	Production (ton)
1	Pandeglang Regency	2,746.89	3,072–3,885	13,240–19,015
2	Lebak Regency	3,426.56	171–4,541	396–12,198
3	Tangerang Regency	1,011.86	62–200	188–605
4	Serang Regency	1,734.28	287–724	965–2,279
5	Tangerang City	153.93	0–1	0–3.2
6	Cilegon City	175.50	18–41	0–80
7	Serang City	266.71	185–567	0–1,515
8	South of Tangerang City	147.19	40–114	0–395

**Table 3.** Corn planting period according to rainfall in Banten Province



Based on Table 2 above, the total area of each city in Banten Province is 147.19 Km<sup>2</sup> to 3,426.56 Km<sup>2</sup>. The largest area of the Lebak Regency is 35.46% of the total area of Banten Province, while the smallest area of South Tangerang is 1.52% of the total area of Banten Province. It was related to the corn planting area, the most extensive corn planting area of Lebak Regency and Tangerang City’s smallest. However, if compared to the planting area with the area of each city, Lebak Regency is only 1.33%, while Pandeglang District is 1.41%. Therefore, Pandeglang Regency has more excellent corn production than Lebak Regency. To increase corn production in Banten Province, Pandeglang Regency and Lebak Regency are potential for the development of corn planting. Referring to the condition of rainfall and temperature, as shown in Figs. 3.a and 3.b, it is necessary to make a planting period for corn so it can be harvested optimally. This needs to be done so that corn production in Banten Province can increase. The schedule for planting and corn harvesting scenarios in Banten Province is shown in Table 3.

Based on Table 3, in Banten Province, corn can be harvested three times in one year. The first planting period should be planted in January, while the second planting period should be planted in May. For the first and second planting periods, the potential to produce corn optimally. Meanwhile, for the third planting period, it needs irrigation efforts because rainfall in September has not been evenly distributed throughout the



Banten region. This needs to be done so that corn production at that time produces optimal harvests. This is in accordance with the research. Bhalage et al., (2015) it is concluded that pipe water distribution network improves the crop yield significantly.

## 4 Discussion

Indonesia's corn production for fifteen years, from 2001 to 2015, averaged 14,998,050.467 tons. The highest province for average corn production in East Java is 3,525,913.467 tons, while the smallest DKI Jakarta is 27.467 tons. However, in DKI Jakarta since 2006, corn production has continued to decline. Even since 2013, it did not produce corn anymore. Of the thirty-four provinces in Indonesia, Banten Province ranks 24th with an average corn production of 20,559.533 tons. East Java Province has average corn productivity of 4.112 tons/ha, while Banten Province is 3.033 tons/ha. Meanwhile, national corn productivity in that period amounted to 4.02 tons/ha. Therefore, Banten Province has the opportunity to increase its productivity so that corn production increases.

In meeting national corn needs, Banten Province needs to increase its productivity so that corn production in the province increases. Based on the area, East Java Province has an area of 2.498%, while Banten Province is 0.505% of the total area of Indonesia. However, East Java Province has a harvest area of 1,348,462 ha or 28.21% of the total area of East Java Province. Meanwhile, Banten Province has a harvest area of 12,534 ha, or 1.30% of the total area of Banten Province. The results of the analysis of ideal production for corn plants in Banten Province are shown in Table 4.

Based on Table 4, East Java Province's corn production data is used as the production standard to increase corn production in Banten Province. By comparing the planting area and corn production in East Java Province, the coefficient is 0.38. The coefficient becomes a multiplier to determine corn production in Banten Province. Ideally, corn production in Banten Province with the planting area, the production of corn is not maximal. With this planting area, corn production in Banten Province has only reached 62.73%. Therefore, to increase corn production in Banten Province, land optimization is needed, both in terms of soil type, temperature, and rainfall.

Banten Province has soil types: alluvial, andosol, glei, latosol, mediterranean, pod-solic, regosol, and rensine soil. The types of soil that can be planted through corn include andosol, latosol, grumous, and sandy soil. Based on the type of land, Banten Province has the potential for corn plants. Then, in optimizing the growth of corn, it is necessary to consider the soil's acidity. The soil's acidity is good for corn plants' growth between 5.6 to 7.5. Therefore, the increase in corn production is possible because the land and climate conditions in Banten Province are primarily suitable for corn plants.

**Table 4.** Results of analysis of corn production in Banten Province

Province	Planted Area (ha)	Real production (ton)	Coefficient	Ideal production (ton)
East Java	1,348,462	3,525,913.467	0.382	
Banten	12,534	20,559.533		32,773.485

Banten Province can potentially increase corn production because almost all regions of the climate conditions are suitable for corn plants. Based on rainfall, Banten Province has monthly rainfall between zero to 1419 mm. The rainfall range is ideal for corn plants that require monthly rain between 250 mm to 5000 mm rainfall. The difference in monthly precipitation can be used for planning the planting period and harvest period so that within one year, Banten Province can produce corn three times. Furthermore, based on temperature, of the four cities in the Banten Province region, only South Tangerang City has temperatures above the threshold. The ideal temperature for corn plants is between 21 °C to 34 °C, while the temperature in the City of South Tangerang is between 22.20 °C to 37.40 °C. Despite the temperature, in specific locations above 34 °C, the city still produces corn up to 395 tons. However, production is difficult to improve because the area is only 1.52% of the total area of Banten Province. Meanwhile, the potential for extensification of corn planting area to increase corn production in Banten Province will be very potential if it developed in Pandeglang and Lebak Districts. Therefore, Pandeglang Regency has an area of 28.43%, while Lebak is 35.46% of the area of Banten Province. This is evidenced by the data on corn production for five years. From 2014 to 2018, corn production in Pandeglang Regency reached 19,015 tons. Referring to corn production in Banten Province, 92% is produced in Pandeglang Regency. Therefore, to increase corn production in Banten Province, the development of corn land is carried out in Pandeglang and Lebak District.

## 5 Conclusions

The national highest corn production in East Java Province with the production of 3,525,913.47 tons from the harvested area of 1,348,462 ha. Meanwhile, Banten Province is number 24, with an average production of 20,559.53 tons from the harvested area of 12,534 ha. With this planting area, corn production in Banten Province has only reached 62.73%. Therefore, to increase corn production in Banten Province, land optimization is needed by reviewing temperature and rainfall.

Temperature data is used to determine the suitable region for corn plants. Referring to the temperature threshold for corn plants, four regencies and three cities were found to be ideal for corn plants. Based on temperature, South Tangerang City, with temperatures between: 22.20 °C to 37.40 °C, is not ideal for corn plant development. Then based on rainfall data, Banten Province, in one year, has the potential to harvest corn three times, namely in April, August, and December. Furthermore, Pandeglang and Lebak regencies are the potential to develop corn-harvested areas based on the area. With the addition of harvested area and frequency of planting period for maize, maize production in Banten Province can increase. The increase in the frequency of corn planting has implications for increasing corn production.

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