Spatial pattern of drought disaster area and types of agriculture plant in Lebak Regency, Banten Province

M H D Susilowati*, A Wibowo and D Susiloningtyas
Department of Geography, Faculty of Mathematics and Natural Sciences, Universitas Indonesia
E-mail: maria.hedwig@ui.ac.id

Abstract. Drought is a natural phenomenon that is one of the most frequent natural disasters in Indonesia. Significantly reduced water availability characterizes drought over a period occurring over a large area. Thus, drought occurs due to the deviation of weather conditions, that is lower rainfall than normal conditions that occur in a region. Lebak Regency is a dry area that has average monthly or annual rainfall below normal and most agricultural activities on dry land. The research objective is to analyze the drought and plant species in Lebak Regency, Banten Province. The method of analysis used in this study is spatial analysis (spatial analysis) and statistical analysis (Chi-Square). The results found, e.g. (1) The high drought areas concentrated in the northeast and southwest regions that are far from the center of Lebak Regency. (2) The types of crops are dominated by plantations, especially outside the Capital Region of the Regency. (3) The relationship between drought and crop type is insignificant at the real level of 0.05, which means that in high drought areas it is not always planted with certain types of crops. This research concluded that drought in Lebak Regency concentrated in the northern and southern part outside the capital city and the agriculture type dominated with the plantation.

1. Introduction
Drought is a natural phenomenon characterized by significantly reduced water availability over a period occurring over a large area [1]. Drought occurs due to the deviation of weather conditions, that is lower rainfall than normal conditions that occur in a region [2]. As a natural disaster, drought has the potential to harm human life, including property and property setup measurements. Drought is one of the most frequent natural disasters in Indonesia. According to [3], drought is one of the significant humanitarian catastrophes that impact damage to the economy, malnutrition, human pride, and death. Shorter rainy season and low rain intensity cause decreasing of yield ([4], [5]). Drought is a condition of water shortage in an area for a long time (months to years) and one of the most inaccessible and recurring disasters. In general, the definition of drought is the availability of water [6] far below the water requirement for the necessities of life, agriculture, economic and environmental activities. The occurrence of drought in a region can be an obstacle to increasing food production in the area ([7], [8]).

Lebak Regency had a drought area, especially in the northern part, which has an average annual rainfall of less than 2,000 mm/year, increasing to the south of the higher rainfall [9]. This condition can affect the types of crops grown by the community.

* To whom any correspondence should be addressed.
Lebak Regency as pockets of poverty located in Banten Province consisted of 28 districts and divided into 345 villages, the number of low-income families continues to increase. Based on BPS data in 2011, approximately 50% of all villages classified as low-income family, and more than 50% of families are poor. The livelihoods are dominated by farmers that are > 70% of the total working population [10]. The main problem in a low-income family environment in Lebak Regency is food. Food can obtain from the crops cultivated by the local community. The existence of drought and crop regions is not sufficiently demonstrated in statistical data, but about regional development, the distribution aspect in the spatial dimension becomes important. The space dimension of distribution of crops in a location indicated in the geographic position on the surface of the earth often called spatial information, presented in the map. Spatial data and attribute data processed with Geographic Information System (GIS), then the analysis that can use is spatial analysis and attribute analysis. Spatial data is data related to spatial locations in the form of maps ([11], [12], [13]). Therefore, mapping of drought areas and suitable types of crops can use as input into regional development strategies. The objective of the study is to analyze the drought and the type of agricultural land use in Lebak Regency, Banten Province.

2. Methodology

2.1 Data Collection and Processing

This data collection included data include; Rainfall data from BMKG (Meteorology Climatology and Geophysics Agency) [14] and land use from image data obtained from google earth data. Daily rainfall data from 1980 to 2015 on 13 stations with different year data, processed to determine the start of the rainy and dry seasons. To determine the duration of the dry season using the amount of rainfall in the dry season and the sum of them with ten-days intervals uses de Boer method. Daily rainfall data each year is processed into data of ten-days intervals, in one month there are three ten-days intervals (36 ten-days interval/year). The ten-days intervals I is 1-10 days, interval II is 11-20, and interval III is 21-28/29 for February and 21-30/31 for the other month. Measures to make wafer drought and types of crops: (1) Determining the start of the dry season is determined based on the amount of rainfall in one ten-days less than 50 millimeters and followed by the next several ten-days interval. The beginning of the rainy season determined based on the amount of rainfall in the ten-days intervals with more than 50 millimeters and followed by some of the next ten-days intervals; (2) The duration of the dry season calculated from the early ten-days interval of the dry season to the beginning of the rainy season. (3) Prepared data dry season and duration of the dry season every station; (4) Calculate the dryness level per station by summing the rainfall during the dry season divided by the duration of the dry season (number of ten-days intervals); (5) Make a map of drought-level areas; (6) Types of crops seen from land use maps, so that the existing types of agricultural obtained.

2.2 Data Analysis

The analysis used is spatial analysis with map overlay method and statistical analysis with the Chi-Square method. For crops, the seeds obtained from land use maps. The correlation between drought and crop use is used in spatial analysis using overlay map between drought and plant area and reinforced by Chi-Square correlation test. The number of contingency coefficients will express the magnitude of the correlation. Correlation of variables tested with Chi-Square Test, the formula used saw in Formula 1 [14].

\[
x^2 = \sum \frac{(O - E)^2}{E}
\]

\[
CC = \sqrt{\frac{x^2}{x^2 + N}}
\]

With \(x^2\) is Chi-Square, \(O\) is Observation Frequency, \(E\) is Frequency of Hope and \(CC\) is Contingency Coefficient. The SPSS (Statistical Product and Service Solutions) program will be used to process
statistical data, thus obtaining Chi-Square (X2) and Contingency Coefficient (CC) values and can be interpreted from the output obtained.

![Research Framework](image)

**Figure 1.** Research Framework.

3. Result and Discussion

3.1 Rainfall

Based on rainfall data at 13 stations in Lebak Regency, the average maximum rainfall occurred in January and minimal rainfall in August. The highest average rainfall in January was 344 mm, and the lowest was August 89 mm [9]. Figure 2, shows the decrease in rainfall from May to June. Those indicate that in June, Lebak Regency began to enter the dry season. The decrease in precipitation continued until September. The peak of the dry season fell in August; then rainfall starts from September to October. This rainfall indicates that Lebak Regency started entering the rainy season in October and peaked in January. The rainfall is in line with De Boer's assertion that October is the time to enter the rainy season and increase to the peak rainfall in January, especially on the island of Java.

![Monthly Rainfall on Lebak Regency](image)

**Figure 2.** The Monthly Rainfall on Lebak Regency.

In spatial distribution, the amount of rainfall is low in the north, the higher the south (Figure 3.a). Based on data from the last 35 years (1980 - 2015), the average rainfall in Lebak Regency shows that places with relatively low altitude (0 - 200 msl) in the north have low rainfall less than 2,000 mm/year. The northern regions include Warunggunung, Cikulur, Cibadak, Rangkasbitung, Kalanganyar, Maja, Lebakgedong, Cipanas, and Curugbitung District. While the rainfall between 2,000 - 3,000 mm in the
northern and central regions Lebak Regency, including Cileles, Bojongmanik, Leuwidamar, Cibeber, Muncang, Cirinten, Gunungkencana, and Banjarsari District with the dominance of the height of 200 - 500 mm. In the southern part, there are Cilograng, Bayah, Wasalam and Malingping District. Rainfall >3,000 mm/year located in the south and south include Cijaku, Cigemblong, Panggarangan and Cihara District.

3.2 Duration of Dry Season
One of the indicators used to see the dangers of meteorological drought [15] is the duration of the dry season. Drought events begin early in the dry season in a region. The calculation of the duration of the dry season is done by determining the beginning of the dry season, then calculate the number of the ten-days intervals that follow it, before entering the rainy season. The results of preliminary data processing of the dry season and the beginning of the rainy season can see in Table 1.

For 35 years start of the dry season in thirteen stations occurred on the 14th or 14th day between mid-May and mid-June. After the initial average calculation of the dry season in Lebak Regency for the last 35 years is on the 16th ten days interval or early June. The beginning of the rainy season in thirteen rainfall stations for 35 years in Lebak Regency occurred on the 28th-30th ten-days interval or in early October until the end of October. After the calculation of the average, the beginning of the rainy season in Lebak Regency for 35 years is on the 29th ten days or mid-October. Based on the early calculation of the dry season and the beginning of the rainy season then obtained the duration of the dry season as can be seen in Table 1. The average duration of the dry season in Lebak Regency is for 14 ten-days intervals.

In the Spatial Distribution, the shortest duration of drought in Lebak Regency has a time span of less than 12 ten days (less than four months) of 120,409 ha stretched from center to south covering Muncang, Leuwidamar, Cirinten, Cigemblong, Panggarangan, Cihara, Cijaku and partly Malingping District (Figure 3.b). The duration of the dry season spans 12 - 14 ten-days intervals or 4 to 5 months spread not as wide as the duration of less than 12 ten-days intervals. The area of this duration is only 69,615 ha covering Maja District, part of Warung Mountain District, Kalanganyar, Rangkasbitung, Curugbitung, Lebakgedong, Cibeber, and Bayah District.

3.3 Dry Season and Drought Leve in Lebak Regency
The duration of the dry season during the last 35 years of each station varies between 11 to 16 ten-days intervals and an average of 14 durations. From the duration of the dry season, the amount of rainfall during the dry season obtained will create rainfall variation [16]. Variation of rainfall between stations in the dry season ranged from 382 mm to 607 mm (Table 1). If associated with Aldrian's opinion [17], the Monson pattern has six months of dry season and six months of rainy season, with the duration of

Figure 3. (a) The Average Rainfall in Lebak Regency; (b) The Durations in Dry Season in Lebak Regency.
the shortest drought less than of equal to three months and the longest less than 5 months, then climatologically Lebak Regency region has a longer duration in the dry season.

Table 1. Duration of Dry Season and Annual Average of Drought Level in Lebak Regency

| No  | Station                  | Early Rainy Season | Early Dry Season | Duration of Drought Season | Rainfall in Dry Season | Level of Drought | Classification |
|-----|--------------------------|--------------------|------------------|---------------------------|------------------------|------------------|----------------|
| 1   | Malimping Utara          | 30                 | 17               | 13                        | 382                    | 29               | Very High      |
| 2   | BPP Leuwidamar           | 28                 | 17               | 11                        | 425                    | 38               | Moderate       |
| 3   | Warung Gunung            | 28                 | 16               | 12                        | 417                    | 35               | High           |
| 4   | Pasir Ona/Rangkas        | 29                 | 15               | 14                        | 559                    | 40               | Moderate       |
| 5   | Bojong Leles             | 30                 | 15               | 15                        | 555                    | 37               | Moderate       |
| 6   | Cimarga District         | 28                 | 15               | 13                        | 461                    | 35               | High           |
| 7   | Cisalak Baru             | 28                 | 15               | 13                        | 401                    | 31               | High           |
| 8   | Sampang Pundeuy          | 29                 | 15               | 14                        | 492                    | 35               | High           |
| 9   | Sajira District          | 30                 | 15               | 15                        | 515                    | 34               | High           |
| 10  | Cilaki/Ciminyak          | 29                 | 15               | 14                        | 607                    | 43               | Low            |
| 11  | Banjar Irrigation/Cipanas| 30                 | 14               | 16                        | 588                    | 37               | Moderate       |
| 12  | Bayah                    | 29                 | 15               | 14                        | 604                    | 43               | Low            |
| 13  | Panyaungan/Panggarangan  | 30                 | 17               | 13                        | 400                    | 30               | High           |

Source: Data Processing 2018 form BMKG

Drought obtained from the amount of rainfall during the dry season divided by the number of ten days interval dry season, so it is known the amount of rainfall per ten days interval during the dry season, called the dryness level. The amount of dryness is determined based on the amount of rainfall in one ten days interval less than 50 mm. The results of data processing of rainfall of dry season, the duration of the dry season, and drought rate for 35 years see in Table 1 and Figure 4.a. Table 1 shows that the average dryness rate in the 35-year period ranged from 29 to 43 mm/ten-days interval. The lowest dryness rate (29 mm/ten days interval) found in North Malingping precipitation station, while the highest (43 mm/ten-days interval) rainfall located at Cilaki/Ciminyak station. Spatially (Figure 4.a), a very high drought (< 30 mm/ten-days interval) of 53,149.7 ha was located in the northeastern and southwestern regions of Lebak Regency. The highest drought (30-35 mm/ten days interval) of 46,708.4 ha covers Warunggunung, Cikulur, Cijaku, and Banjarsari District. While the lowest drought (> 40 mm/ten-days intervals), an area of 182,165.5 ha located in the central and southern regions of Lebak Regency.

3.4 Agriculture Land Utilization

The use of agricultural land in Lebak Regency consists of food crops such as lowland rice, rainfed rice and paddy crops, while non-food crops are the use of forest land and plantations (see Figure 4.b). The paddy field in Lebak Regency is 59,824.65 ha, consisting of irrigated and rainfed fields. The area of irrigated rice field in Lebak Regency is approximately 99% compared to the rainfed rice field. Irrigated rice fields spread in Wanasalalam, Malimping and Cibeber District. Besides, there are rice fields without irrigation, spread in some districts such as Bayah and Cibeber District. While rainfed lowland only found in Curugbitung District. The farm corp is 32,122.17 ha planted with crops such as corn, cassava, and soybean. The farm crop spread almost all districts in Lebak Regency.

3.5 Relation of Drought Areas and Types of Agricultural Land Use

Drought is one of the important factors that can affect the type of agricultural use since the selection of crops is determined by the availability of water, as more rice plants require water availability than crops (corn, cassava, yam, soybeans). Long drought problems occur due to climate change, causing changes in cropping patterns. Based on spatial analysis with map overlay, it shows that paddy does not always plant low drought areas, but more palawija is cultivated, covering 14 districts, between Banjarsari, Bayah, Bojongmanik, Cibeber, and Cigemblong District. Chi-Square statistical analysis supports this research shows that there is no significant correlation on the real level (α) 0.05. The amount of
Contingency Coefficient between these variables is relatively small that is 0.365. The people of Lebak Regency tend to prefer the types of crops, compared to rice crops.

**Figure 4. (a) The Drought Level in Lebak Regency and (b) Land Use Type in Lebak Regency.**

### Table 2. Relation of Drought Areas and Types of Agricultural Land Use

| Chi-Square Tests                  | Symmetric Measures       |
|----------------------------------|--------------------------|
| Value                            | Asymptotic Significance  |
|                                  | (2-sided)                |
| Pearson Chi-Square               | 4.306*                   |
| Df                                | 3                        |
| Nominal by Nominal Contingency Coefficient | 28 |
| N of Valid Cases                 | 28                       |
| Likelihood Ratio                 | 4.082                    |
| Df                                | 3                        |
| Linear-by-Linear Association     | 0.010                    |
| Df                                | 1                        |
| N of Valid Cases                 | 28                       |

*6 cells (75.0%) have expected count less than 5. The minimum expected count is .32

### 4. Conclusion

The conclusion of this research, firstly the drought and high-density areas concentrated in the northeastern and southwest regions which are relatively far from the center of Lebak Regency. Secondly, the types of crops are dominated by plantations and fields, especially outside the territory of the Lebak Regency Capital. Third, the relationship between drought rate and type of agricultural land use is not significant at the real level of 0.05, which means that in areas of very high and high dryness levels always not planted with certain types of crops.

### Acknowledgement

The authors are deeply grateful to Research and Public Service Directorate, the University of Indonesia for support of the research grant: Penelitian Terapan Unggulan Perguruan Tinggi year 2018 with contract number 478/UN2.R3.1/HKP.05.00/2018.

### References

[1] Nalbantis I and Tsakiris G 2009 *Water Resource Management* **23** 881
[2] Mujtahiddin MI 2014 *Jurnal Meteorologi dan Geofisika* **15** 99
[3] Kioko M J B 2013 *European Scientific Journal* **9** 29
[4] Moreki J C and Tsopito C M 2013 *Journal of Animal and Feed Research* **3** 6 216
[5] House J 2011 *A guide to dairy herd management* (Meat and Livestock Australia Limited North Sydney Australia) p 68
[6] Muharsyah R and Ratri D N 2015 *Jurnal Meteorologi dan Geofisika* **16** 2 93
[7] Blum A 2011 *Plant Breeding for Water-Limited Environments.* (Springer, New York, NY) p 11
[8] Jaleel C A Manivannan P A Wahid A Farooq M Al-Juburi H J, Somasundaram R A, and Panneerselvam R 2009 *J. Agric. Biol.* **11** 1 100
[9] Badan Meteorologi Klimatologi dan Geofisika 2016 Data Curah Hujan di Kabupaten Lebak. BMKG Tangerang

[10] Badan Pusat Statistik 2011 Perhitungan Angka Kemiskinan BPS VS World Bank. (Download Center, Sensus Peduduk 2010, Tanggal 26 April 2011, jam 14.58. Jakarta)

[11] Borden D Dent 1999 Cartography, Thematic Map Design (WCB Publisher, London)

[12] O’Sullivan D and Unwin D 2009 Geographic Information Analysis (John Wiley & Sons, Inc).

[13] Kraak M J and Ferjan O 2007 Kartografi: Visualisasi Data Geospatial (UGM Press Yogyakarta)

[14] Erickson R and John H 1994 Geographic Measurement and Quantitative Analysis (Macmillan College Publishing Company, New York)

[15] Nurrahman F I and Pamungkas A 2013 Jurnal Teknik ITS 2 2 83

[16] Mulyana E 2002 Jurnal Sains & Teknologi Modifikasi Cuaca 3 1 1

[17] Aldrian E and Susanto RD 2003 International Journal of Climatology 23 12 1435