Analysis droughts index by Standardized Precipitation Index (SPI) and productivity of rain-fed rice fields in Indramayu West Java

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Abstract. This study attempts to map drought and analyze rice productivity of Rain Fed Rice Fields in Kabupaten Indramayu West Java. The methodology which used in this research is descriptive. Arc GIS 10.2 is used for mapping the SPI, and it will be used to analyze rice productivity of Rain-Fed Rice Fields in Kecamatan Indramayu West Java. The result showed that District Indramayu experienced, the drought began in May to October. The area that is prone to drought in the same period of the last ten years is Anjatan regions with 33 times scene drought. August experienced scene drought most. District of Indramayu has planting patterns in the two times rice planting season and various kind of crops. The growing season of rice starts on November-December-January and the second growing season starts on May-June-July. The Pattern of productivity from the first planting period to the second planting second on average for ten years showed a decline. The pattern is followed with dryness index. The increased productivity only happen in growing season in 2007, 2008, 2011, and 2013 in 10 years.

1. Introduction
Global Warming results in climate change and increases the frequency and intensity of extreme weather events. Global warming can lead to significant changes in physical and biological systems such as increased intensity of tropical storms, changes in precipitation patterns, salinity of seawater, changes in wind patterns, animal reproduction, and plants, species distribution and population size, pests and disease outbreaks, as well as affecting various ecosystems located in high latitudes and coastal ecosystems.

One of the significant impacts of climate change, namely extreme weather changes. One of the elements of weather that looks once changed is rainfall, with patterns and inertia that change. This phenomenon will affect the seasonal shifts that are difficult to predict.

Kabupaten Indramayu is a national rice supplier that is very strategic to build people's economy. This district is one of the rice granaries in the area of pantura. Based on statistical data of West Java Province in 2013, the largest rice field area of Indramayu Regency in West Java is 224,688 Ha. By seeing this condition, it can be ascertained that the people in the area are the majority of farmers who are very dependent on the weather, especially rainfall in doing agricultural activities. The shift of the rainy season, which is the beginning of the rice planting season in pantura area has occurred since 2001. The rainy season that usually begins in early October simultaneously was shifted starting in November and even in some places until December.
As one of the rice granaries, Indramayu Regency is also a drought-prone area in Indonesia. With the occurrence of drought in Indramayu affecting the agricultural sector causes the farmers to lose because of reduced crops and even the most severe experience of crop failure or puso. Rain-fed rice fields that use rainfall as a source of irrigation water will affect the level of productivity. Drought index analysis used with Standardized Precipitation Index (SPI) method. After the index value is obtained, it is interpolated to know the spread of the districts in Indramayu Regency that suffered drought for ten years so that it can be done the awareness step to face future drought disaster.

By looking at the background above, it is necessary a study of the condition of the nature and patterns of rainfall so it will be predicted trends of the entry of rainy season for the benefit of agricultural activities. Other weather phenomena, such as El Nino and La Nina are also factors that have little effect on rainfall patterns.

Information about the beginning of the rainy season, to start planting, or before the dry season would be very useful for decision-making related to the time of rice planting in the area.

The research will be conducted using a different method that is modeling by combining overlay map of rain fed rice field distribution with rainfall pattern and drought index. By developing this model is expected to produce more accurate information in a fast time and covers a wider area so that the user can more perceive its use.

Research urgency is linked to the farmer's need to plan future crop patterns to make it easier for farmers to plan to develop agriculture, to determine the provision of fertilizer, to coordinate the marketing of agricultural products and to reduce the risk of loss in the process of agricultural management.

The finding of targeted innovation is the completion of planting pattern in Indramayu regency. The benefits and targets of this research are in line with those mandated in the RPJPN 2005-2025, namely food and agriculture. This research is expected to be useful for the sustainability and utilization of natural resources.

The availability of water strongly influences rice growth. However, many places lack water during the dry season, so the rice plants depend on the rain. This type is called rain-fed rice field. Indramayu Regency has three districts with rain-fed rice field with a total area of 22,088 Ha.

2. Theoretical framework
Drought is one of the disasters that are difficult to prevent and come repeatedly and affect the availability of water in the soil, both needed for agricultural purposes and human needs in Puturuhu [1]. The occurrence of drought in an area can be an obstacle to increasing food production in the area. Drought in Indonesia is a problem that has a significant impact mainly in agriculture, such as the decline in crop production and the detriment of farmers. Natural drought according to Shelia B. Red [2] in Ferad Puturuhu [1] can be grouped by type, namely:

2.1. Meteorological drought
Meteorological drought is related to below normal rainfall levels in a season. This comparison must be specific to a particular area and can be measured in the daily and monthly seasons, or the amount of annual time scale rainfall. Rainfall alone does not always create drought hazards. Meteorological drought measurement is the first indication of drought. Drought intensity is based on meteorological definitions as follows:

- dry: if rainfall is between 70% -80%, from normal conditions (rainfall below normal)
- very dry: if rainfall is between 50% -70% of normal conditions (rainfall is far below normal)
- very very dry: if rainfall is below 50% of normal conditions (rainfall is far below normal)

More specifically the meteorologist's drought is defined by Palmer [3] in Ferad Puturuhu [1] as a time interval in which the supply of actual rainwater at a location falls/ falls shorter than the actual climatological water supply according to normal estimates.
2.2. Hydrological drought
Hydrological drought covers the reduction of water sources such as rivers, groundwater, lakes, and water reserves. The definition covers data about the availability and level of use associated with the normal activities of the supplied system (domestic, industrial, agricultural systems that use irrigation). One of the impacts is competition between water users in these storage systems. This drought is measured based on the elevation of river water levels, reservoirs, lakes and groundwater levels. There is a period from reduced rainfall to decreasing elevation of river water levels, reservoirs, lakes and groundwater levels. Drought intensity based on the hydrological definition is as follows:

Dry: if the river discharge reaches a return period below a 5-year period, it is very dry: if the river discharge reaches a return period far below the 25-year period, it is very dry: if the river discharge reaches a return period, the flow is very far below the 50-year period.

2.3. Agricultural drought
Agricultural drought is the impact of meteorological and hydrological drought on the production of food crops and livestock. This drought occurs when soil moisture is insufficient to maintain yield an average growth of plants or in other words associated with shortages of soil (water content in the soil) so as not to be able to meet the needs of certain crops in a certain period in a wide area. Water needs for plants, however, depend on the type of plant, growth rate, and soil facilities. The impact of the agricultural drought is difficult to measure due to the complexity of plant growth and the possibility of other factors that can reduce yields such as pests, reeds, low soil fertility, and low crop prices. Hunger drought can be considered as a form of extreme drought, where food shortages are so severe that a large number of people become unhealthy or die. Hunger disasters usually have complex causes which often include war and conflict. Although food scarcity is a major factor in famine, death can occur as a result of other complex influences such as illness or lack of access and other services. This agricultural drought occurs after symptoms of meteorological drought.

The Standardized Precipitation Index (SPI) method is a method developed by Mc Kee [4]. The aim is to find out and monitor drought. According to Earthquake and Geophysics Meteorology Agency (BMKG) the value of SPI [5], determined the level of drought and wetness categories as follows:

2.3.1. Drought
- Very Dry: If the SPI value is 2 -2.00
- Dry: If the SPI value is -1.50 to -1.99
- Somewhat Dry: If the SPI value is -1.00 to -1.49
- Normal: If the SPI value is -0.99 to 0.99

2.3.2. Level of wetness
- Very Wet: If the SPI value is 00 2.00
- Wet: If the SPI value is 1.50 to 1.99
- Rather Wet: If the SPI value is 1.00 to 1.49

Productivity is the relationship between the quality produced by the amount of work done to achieve results according to Syarif [6]. With increased productivity has the dual benefit of optimizing resources and also enhancing usqaha capacity in supporting results. According to the Dictionary of General Agriculture that productivity itself is the amount of production per certain unit area for a particular maintenance period stated in Kg / Ha / Year [7].

3. Research methodology
This research uses a descriptive method. Rainfall data using 10-year data series and drought index calculations using the Standard Precipitation Index. SPI method is one method to determine the severity of drought which has advantages that can be calculated for various time scales. The time scale reflects the impact of drought on the availability of water in various sources.
The calculation method using the SPI method is as follows:

\[ Z_{ij} = \frac{X_{ij} - \bar{X}_i}{\sigma_j} \]  

Where is:
\( Z_{ij} = \) rainfall standard index (SPI)
\( X_{ij} = \) average month to month rainfall in years \( i \)
\( \bar{X}_i = \) average rainfall in the range of years \( i \) (t1 s.d tn)
\( \sigma_j = \) rain standard deviation in the range of years \( i \) (t1 s.d tn)

With standard deviation:

\[ \sigma_j = \sqrt{\frac{\sum (X_i - \bar{X})^2}{n - 1}} \]  

X: rainfall data
\( i = \) average amount of rainfall
N: amount of data

Then the drought data is overlaid to produce a drought distribution map using Arc. GIS 10.2. Based on the map and productivity data, agricultural productivity conditions can be analyzed in irrigated rice fields and rain fed rice fields.

4. Results and discussion
The results showed that drought indices in Indramayu Regency varied from normal to very dry conditions. Indramayu district is prone to the drought that starts from May to October. The drought-prone areas in the last ten years are Anjatan area with 33 drought incidents, covering Anjatan, Gantar, Sukra, Haurgeulis, Bongas, Kroya, Kandanghaur, Gabuswetan and Patrol sub-districts. The drought that occurred in Indramayu Regency should be considered in connection with the productive agricultural land. This will have an impact on agricultural production in the future, especially in rain-fed areas with high drought. Here is a map of the distribution of drought indices for ten years.

Gantar, Anjatan, Kandanghaur sub-districts are rain fed rice fields, while Indramayu, Gabuswetan, Kroya, Haurgeulis, and Bongas sub-districts are irrigated rice fields. The condition of rain-fed rice fields during drought is very dry and does not allow agriculture to be carried out. Irrigated rice fields still allow for agricultural business, even when the dry season, even though the Citarum river discharge is reduced. Figure 1 shows the distribution of drought index for ten years.
Figure 1. Map of distribution drought indices during ten years in Indramayu district from January to June (the driest month).

On May, June, and July the class of drought index is rather dry and normal. This condition covers half the part of Indramayu Regency. In August, September, and October, the dryness index is very dry and somewhat dry. The reduced rainfall value is the initial process of meteorological drought. The month of August experienced the most events in each area of the station's polygon because this month was not raining at all, only in 2010 there was rain with an average of 44.3 mm. November-April has begun to show wet-very wet index values. Decreasing rainfall is not beneficial for agricultural production because drastic decreases in rainfall can cause crop failure due to drought and have a negative impact on crop productivity. Variability in production due to climate influences is one of the special characteristics of the agricultural sector.

Agricultural productivity of Indramayu Regency and three districts that have rain-fed rice field that is Haureulis, Gantar, and Indramayu. Planting pattern in three similar sub-districts, i.e. one time rice planting and 1 pulawija with varied species. The rice planting season is the month of November - December - January, and May-June-July. In the N-D-J growing season, all showed high productivity. Meanwhile, during the planting period of M-Jn-Jl, productivity decreased. Gantar sub-district is the
lowest productivity, both in rainy and dry season. 2010 is the lowest productivity year in Indramayu District of 53.88 kW / Ha and the planting period of N-D-J is the highest productivity of 75.33 kW / Ha for ten years from 2007-2017.

5. Conclusion
The rice cropping pattern based on the availability of water for agricultural businesses in Indramayu Regency, for the irrigated area, is, two times. Rice and one-time Palawija and for rain fed rice fields, only one rice is used, and one crop is done.

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