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IMPACT OF CLIMATE CHANGE ON METEOROLOGICAL DROUGHT IN INSANA BARAT DISTRICT, TIMOR TENGAH UTARA, EAST NUSA TENGGARA

Maria Serlince Sanit, Turningtyas Ayu Rachmawati, Nailah Firdausiyah
Brawijaya University, Malang, Indonesia.
Email: serlincesanit@gmail.com, t_tyas@ub.ac.id, firdausiyah@ub.ac.id

Abstract

Uncertain climate change has an impact on the limited availability of surface water and low rainfall, causing Insana Barat District to become one of the areas prone to drought. Drought is a cause of poverty because it is usually associated with the cycle and spread of disease and threats to food security. Therefore, it is necessary to identify drought characteristics in this region for early anticipation and adaptation to reduce the impact of drought due to current and future climate variability. The Standardized Precipitation Index (SPI) is an index used to determine the deviation of rainfall from normal over a long period. The SPI method was chosen because of its ability to calculate the index and describe the severity of drought, and it is simpler than other methods. The advantage of SPI is that it is sufficient to use monthly rainfall data to compare drought levels between regions even with different climate types. The data used in this study is rain data from rain stations located in Insana Barat District from 2007 to 2021. The results show that in the drought deficit period the deficit period is 3 months in 2021 with an index value of -5.123. The worst 6-month deficit period for the -4,458 index occurred in 2020. The worst 12-month drought index deficit period of -2,191 occurred in 2021.

Keywords: Android, Google Maps, Tickets, Apps.

Introduction

Climate change is characterized by increasing temperatures, rainfall, and more extreme climatological events (de Oliveira-Júnior, J. F., de Gois, G., de Bodas Terassi, P. M., da Silva Junior, C. A., Blanco, C. J. C., Sobral, B. S., & Gasparini, 2018) Climate change is a phenomenon natural influences on stability atmosphere (Pangestu & Gernowo, 2015). These changes, pose major challenges for agricultural production and water resources (Hidayati, 2017) (Sutrisno, N., & Hamdani, 2019). Droughts are natural disasters that can occur anywhere, cause prolonged periods of water shortage in various parts or throughout the hydrological cycle, and can be modulated or amplified by other natural processes and human activities (Chan, S. S., Seidenfaden, I. K., Jensen, K. H., & Sonnenborg, 2021) (Surmaini, 2016). Droughts are generally divided into three types: 1) meteorological droughts, which usually result from a lack of rainfall; 2) hydrological droughts, mainly caused by a lack of river flow and water storage; and 3) agricultural droughts, a combination of the two previous droughts caused by reduced soil moisture storage (Li, Y., Lu, H., Yang, K., Wang, W., Tang, Q., Khem, S., Yang, F., & Huang, 2021). Information about the current climate and climate projections in the future is a

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form of risk mitigation against the effects of climate change (Bellard, Bertelsmeier, Leadley, Thuiller, & Courchamp, 2012). Therefore, projections related to climate in the future are needed.

Insana Barat district is one of 21 sub-districts in Timor Tengah Utara Regency that experiences drought every year. In 2020, based on the calculation of the drought category according to the climate type of Schmidt and Ferguson, Insana Barat District is included in the dry category with a Q value or total monthly rainfall of 200 percent. The dry month or rainfall <60 mm per month is felt from April to November resulting in a decrease in water availability, water wells dry up so that to meet the community's clean water needs, it is obtained by buying.

Drought monitoring and analysis efforts can be carried out using the drought index (Herdita, 2020) (Febrianti, Murtilaksono, & Barus, 2018). World Meteorological Organization 2012 as the World Meteorological Agency recommends all national meteorological and hydrological agencies to use the Standardized Precipitation Index (SPI) method in monitoring drought levels. SPI is an index that is widely used in detecting meteorological drought and rainfall abnormalities based on rainfall series analysis (Tigkas, D., Vangelis, H., & Tsakiris, 2019). SPI is a drought index that has several characteristics and is an improvement from the previous index, including simplicity and temporal flexibility that allows its application to water resources at all time scales. SPI has several advantages, such as the data used for analysis is enough to use monthly rainfall data, which can be used to compare the level of drought between regions even with different climate types, so that it can be used as input to determine the impact of climate change on meteorological drought disasters in Insana District (Sudibyakto, 2018).

Research Methods

Study Area

Insana Barat District is one of the sub-districts in Timor Tengah Utara Regency. Insana Barat District has an area of 102 km2, which geographically is located at coordinates 90º 32' 0" South Latitude – 90º 23' 30” South Latitude and between 1240º 29' 20" East Longitude - 1240º 39' 40" East Longitude and is divided into 12 (twelve) villages including Subun Village, Lapeom, Usapinonot, Unini, Letneo, Banae, Atmen, South Letneo, Nifunenas, Subun Tualele, Subun Bestobe, Oabikase Village. The research locations are shown in Figure 1.

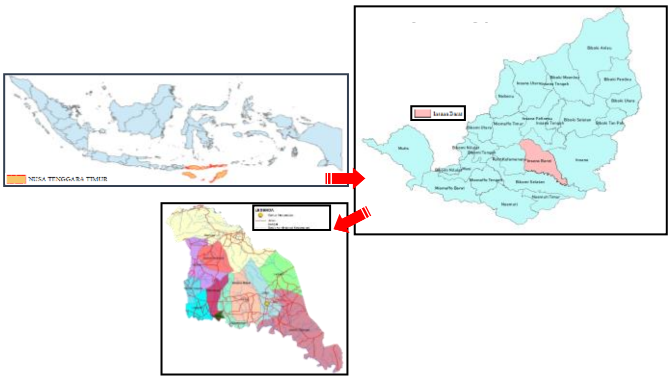

Figure 1. Study Area

Data Set

In this research total 15 years of rainfall data have been used to estimate the Standardized Precipitation Index

(SPI). Month-wise average rainfall data from 2007 to 2020 has been collected from Regional Disaster Management Agency for Timor Tengah Utara Regency. Drought indices (SPI) can be calculated by minimum 15 years of rainfall datasets but in general, researchers used 30 years of data sets. SPI has also been successfully applied for Trends and variability of drought in the extended part of Chhota Nagpurplateau (Singbhum Protocontinent), India applying SPI and SPEI indices 1996–2020 (Bera, Shit, Sengupta, Saha, & Bhattacharjee, 2021).

Table 1
Monthly Rainfall In Insana Barat District 2007-2021

Years	Months												Average (mm)
	Jan	Feb	March	April	May	June	July	August	Sept	Oct	Nov	Dec	
2007	166	33	221	142	0	0	0	0	0	0	0	188	750
2008	183	133	225	64	12	26	0	0	0	20	0	0	663
2009	90	230	38	41	0	0	0	0	0	0	12	134	545
2010	308,5	327	105,7	4	0	0	0	0	0	0	0	81,8	827
2011	153	76	185	115	4	0	0	0	0	27	266	576	1402
2012	503	375	275	285	66	32	68	0	132	46	183	443	2408
2013	606	347	119	74	212	184	10	11	0	27	74	290	1954
2014	312	184	0	0	110	0	0	0	0	0	157	228	991
2015	266	206	191	56	10	59	0	0	0	0	0	82	870
2016	266	206	191	56	10	59	0	0	0	0	0	82	870
2017	57	211	132	14	138	44	64	0	43	0	96	202	1001
2018	140	184	216	193	10	18	0	0	0	0	85	315	1161
2019	142	194	348	257	15	17	10	0	0	20	418	514	1935
2020	122	119	82	4	60	21	0	0	0	0	0	98	506
2021	106	119	93	53	45	0	0	0	0	58	17	113	604

Source : Regional Disaster Management Agency for Timor Tengah Utara Regency data, 2021

Drought monitoring and analysis efforts can be carried out using the drought index. WMO (WMO, 2012) recommends all national meteorological and hydrological agencies use the SPI (Standardized Precipitation Index) method in monitoring drought levels. The SPI analysis uses rainfall data for the recording period of 15 years, namely between 2007 – 2021, using equations 1 to 10 with a monthly deficit period of 3 months, 6 months, and 12 months. Calculation of the dryness index Spi using the SPI value calculation is based on the number of gamma distributions which are defined as a function of frequency or probability of occurrence with the following equation:

$$g(x) = \int_0^x g(x)\,dx = \frac{1}{\beta^{\alpha}\tau(\alpha)}\int_0^x t^{\alpha-1} e^{\frac{-x}{\beta}}\,dx$$

Equation 1

The values of and are estimated for each rain station using the following formula:

$$\alpha = \frac{\bar{x}^2}{sd^2}$$

Equation 2

$$\beta = \frac{x}{\alpha}$$

Equation 3

Dimana:
g(x) : function of the gamma distribution
x : the amount of rainfall (mm/month)
τ(α) : gamma function
e : exponential
α : shape parameter
β : scale parameters

Since the gamma function is undefined for x = 0, the value of g(x) becomes
H(x)=q+(1-q)G(x), Equation 4

q = m/n where m is the number of 0 mm rain events in the rain data series. If m is the number of months without rain during the study period, then q can be estimated by m/n. The cumulative probability H(x) is then transformed to a standard normal random variable Z with a mean of zero with a variance of one, which is defined as the SPI value.The gamma function is undefined if x = 0 and the rainfall distribution can contain zeros, then the cumulative probability can be calculated using the equation

$$t = \sqrt{ln\left[\frac{1}{H(x)^2}\right]}$$ untuk $0 < H(x) \leq 0.5$ Equation 4

$$t = \sqrt{ln\left[\frac{1}{(1-H(x))^2}\right]}$$ untuk $0.5 < H(x) < 1.0$ Equation 5

Where q is the probability of an event without rain. If m is the number of months without rain during the study period, then q can be estimated by m/n. The cumulative probability H(x) is then transformed to a standard normal random variable Z with a mean of zero with a variance of one, which is defined as the SPI value.

SPI value calculation for 0 < H(x) 0.5

$$Z = SPI = -\left(t - \frac{c_0+c_1+c_2t^2}{1+d_1+d_2t^2+d_3t^3}\right)$$ Equation 6

and distribution gamma transformation : $t = \sqrt{ln\left[\frac{1}{H(x)^2}\right]}$ Equation 7

While the calculation of the SPI value for 0 < H(x) 0.5

$$z = SPI = +\left(t - \frac{c_0+c_1+c_2t^2}{1+d_1+d_2t^2+d_3t^3}\right) \quad \text{Equation 8}$$

and distribution gamma transformation: $$t = \sqrt{ln\left[\frac{1}{(1-H(x))^2}\right]} \quad \text{Equation 9}$$

where :

c0= 2.515517	d1= 1.432788
c1= 0.802853	d2= 0.189269
c2= 0.010328	d3= 0.001308

Drought occurs when the SPI is continuously negative and reaches a drought intensity with an SPI of -1 or less. A positive SPI value indicates that the rainfall obtained is greater than the average rainfall, while a negative value indicates that the rainfall obtained is smaller than the average rainfall. The SPI method can be presented in normal, wet, and dry climates in the same way. According to McKee, 1993, the values for the SPI classification can be categorized as follows:

Table 2
Spi Index

Nilai	Kategori
> 2,00	Extremely wet
1.50 sd 1.99	Severely wet
1.00 sd 1.49	Moderately wet
-0.99 sd 0.99	Normal
−1.00 sd −1.49	Moderate drought
-1.50 sd -1.99	Severe drought
≤ −2.0	Extreme drought

Source: (Zhou et al., 2020)

Results and Discussion

The analysis involves 1 rain station located in Insana Barat District with a long recording period of 15 years. The results obtained show that every year for a period of 15 years with a deficit period of 3, 6 and 12 years, drought has entered a Very Very Dry condition with varying frequency of occurrence, which is indicated by an index value smaller than -2. Table 2 provides drought index values with a deficit duration of 3, 6, and 12 monthsn.

Table 3
Drought Index Value In Insana Barat District

c	SPI 3	Klasifikasi	SPI 6	Klasifikasi	SPI 12	Klasifikasi
2007	-3,377	ED	-2,070	EW	2,413	ED
2008	-1,842	ED	-1,994	ED	-1,648	ED
2009	-4,379	ED	-3,324	ED	-1,633	ED
2010	3,348	EW	2,331	EW	2,645	EW
2011	-3,467	ED	-2,624	EW	3,946	ED
2012	7,365	EW	7,373	EW	7,332	EW
2013	6,597	EW	7,411	EW	5,612	EW
2014	3,376	EW	1,647	EW	3,178	SW
2015	2,556	EW	2,624	EW	2,181	EW

20162,556	EW	2,237	EW	2,181	EW
2017-3,681	ED	-2,395	EW	2,749	ED
2018-1,853	ED	2,040	EW	3,011	EW
20192,769	EW	3,567	EW	6,347	EW
2020-5,033	ED	-4,458	ED	-2,111	ED
2021-5,132	ED	-3,716	ED	-2,191	ED

Description : ED = Extreme Drought
EW = Extremely Wet
SW = Severely Wet

The classification of drought in Insana Barat district in the deficit period of 3, 6, and 12 months within 15 years is classified into 3 classifications, namely, Extremely Wet (EW), Severely Wet (SW), and Extremely Dry ED). The highest frequency of drought occurred in the 3-month deficit period, namely the ED classification in 2007, 2008, 2009, 2011, 2017, 2018, 2020, and 2021 and the least drought occurred in the 6-month deficit period with the classification dominated by EW. This is because the calculation of the drought index only uses rain data and compares it to normal rain events in that location. So that when the rain decreases from its normal condition, even though it is still raining, it could result in a smaller index number or read as a drought event.

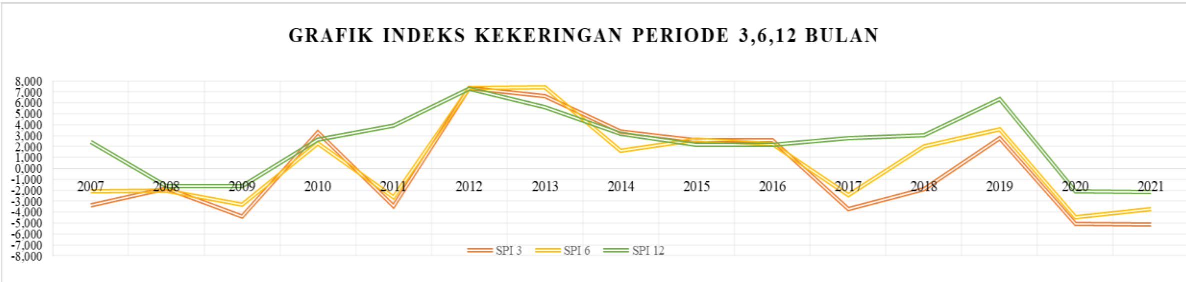

Figure 2
Result Of 3, 6, 12 Month Period Drought Index

Conclusion

A drought index with a deficit period of 3, 6, and 12 months can be used to describe the level of drought according to real conditions in the field. Evaluation of drought characteristics in Insana Barat District using the SPI method shows that Insana Barat District almost always experiences drought events every year with every deficit period and almost every year has experienced Extreme Drought events which are marked by a Drought Index smaller than -2. For further research, it is recommended to calculate the drought index using the Standardized Precipitation Index (SPI) with longer rainfall data and with a more complete number of rain stations according to the total number of rain stations in the research location district. This is done to obtain validation results that are more in line with real conditions in the field.

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