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DETECTION TREND OF METEOROLOGICAL DROUGHT USING STANDARDIZED PRECIPITATION INDEX (SPI) IN THE DOLAGO WATERSHED, CENTRAL SULAWESI

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ABSTRACT

Drought events worldwide are increasingly becoming a critical issue due to their negative impacts on water resources. Therefore, it is necessary to understand the characteristics of drought to plan disaster mitigation measures. This study detected meteorological drought in the trend domain using the Standardized Rainfall Index (SPI) in the Dolago River Basin. Monthly rainfall data for 20 years (2003-2022) from two meteorological stations (Dolago Bendung and Dolago Padang) were used in this study. SPI was used to reconstruct drought events and characterize the trend of drought events. Drought frequency was estimated as the ratio of the specified severity to the total number of events. Changes in drought events were detected using the non-parametric Man-Kendall trend test. The main drought conditions detected by SPI are severe drought, moderate drought, near normal, moderate wet, very wet, and very wet conditions. From these results, the SPI value fluctuated greatly from month to month. In the first decade (2003-2012), many normal conditions occurred, and changes from wet to dry months did not occur suddenly. In contrast to the second decade (2013-2022), the normal conditions are reduced from the first decade and the weather conditions change rapidly. The SPI value, which represents seasonal conditions, shows that dry conditions in various categories are more prominent in the second decade, while wet conditions are almost the same between the first and second decades. Trend analysis shows that most SPI values experience a decreasing/negative trend, but not all are significant at the 90% level. The SPI value is significant in April (-1.65) and December (-3.41). It is recommended that these findings be adopted for decision-making related to the drought early warning system in the watershed.

Keywords: SPI, Drought Detection, Man-Kendall, Climate, Dolago Watershed

INTRODUCTION

Drought is a phenomenon related to nature with deficit water availability due to low rainfall Rain compared to an average term (Botai, C.M., Botai, J.O., Wit, J.P., Katlego, P.N., & Adeola, A.M., 2017). Drought more often occurred and was severe in the area dry and semi-dry compared to the area humid. dryness is a disaster in nature that affects large and deep areas term a longer time compared to with disaster natural other like floods. Globally, several countries are experiencing drought with different characteristics. Likewise, each region experiences drought with different characteristics. Very important For detecting characteristics and trends in different droughts like drought meteorology For planning coordinated mitigation with good. Drought meteorology which is the most common drought known associated with long time intervals with rainfall very heavy rain low or No There is The same once and increase temperature air. Deficiency rainfall Rain causes low infiltration, decreasing overflow surface and filling groundwater recharge. On the side other, temperature high air causes changes in the characteristics of wind like improved speed wind, low Humidity Relative (RH), and increased evapotranspiration (ET).

Several index drought have been developed and implemented To evaluate drought, such as the Aggregated Drought Index (ADI) (Keyantash, J.A. & Dracup, J.A., 2004), Standardized Precipitation Index (SPI) (Vicente-Serano, S.M., Begneria, S., & Lopez-Moreno, J.I., 2010), Palmer Drought Severity Index (PDSI) and Z-Index (Palmer, 1965), Effective Drought Index (EDI) (Park, J.H., Kim, K.B. , & Chang, Y., 2014), Keetch -Byram Drought Index (KBDI) (Keetch, J.J. & Byuram, C.M., 1968), Hybrid Drought Index (HDI) (Karamouz, M., Rasouli, K., & Nazi, S., 2009), Vegetation Drought Response Index (VegDRI) (Brown, J.F., Wardlow, B.D., Tadesse, T., Hayes, M., & Reed, B.C., 2008), Reconnaissance Drought Index (RDI) (Tsakiris, G. & Vangelis, H., 2005), Rainfall Anormally Index (RAI) (Van-rooy, M.P., 1965), Drought Severity Index (DSI) (Bryant, S., Arnell, N.W., & Law, F.M. , 13-14 October 1992), National Rainfall Index (NRI) (Gommes, R.A. & Petrassi, F., 1994)and Drought frequency index (DFI) (Gonzalez, J. & Valdes, J., 2006). Between index drought meteorology, SPI in general more Lots used than index drought other Because only rainfall Rain as a variable input single.

Studies about characteristics of drought and trends drought become attention big in the area flow river Because effect the bad every time it happens. Because of that, That needs to be prioritized in planning action proper mitigation time with objective For entered in a system warning early drought.

RESEARCH METHODS

Description of research

The overview location is located at 0°52'14.21" south scope and 120°09'57.44" east longitude, inside the Dolago Watershed. Within the Makassar Strait, the 8.87-kilometer-long Dolago Stream flows from east to west. The Dolago Watershed is 29.04 km^2 in size. The area under consideration can be seen in Figure 1 below.

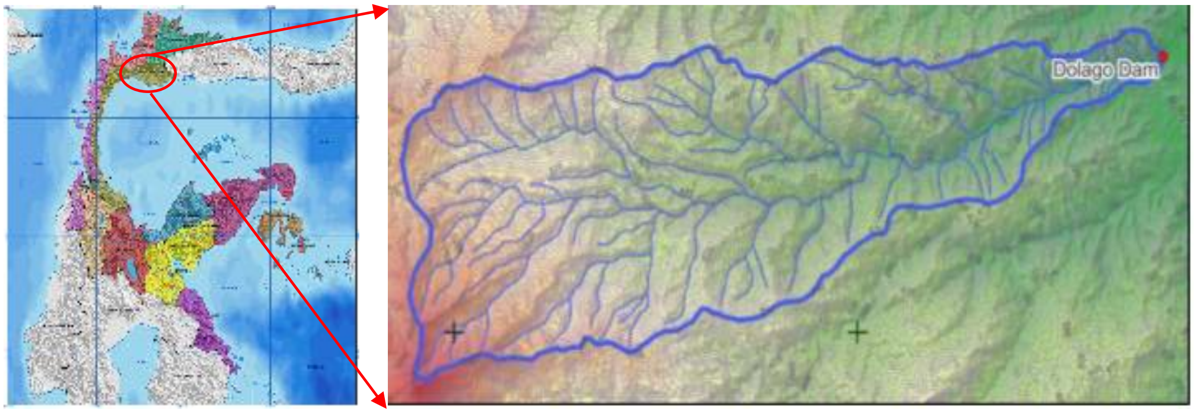

Figure 1. Research location

Data sources

Information for this thought was given by the Office of Human Settlements and Water Assets (Cikasda) of Central Sulawesi Territory. They were gotten from the taking after two hydro-climate stations: Dolago Padang and Dolago Bendung. The information arrangement contains everyday precipitation from 2003 to 2022.

Research methods

The slant and noteworthiness of the dry season list and climate inconstancy were tested in this investigation using the Mann–Kendall test. Precipitation files were analyzed using the Standardized Precipitation File (SPI).

Mann-Kendal test

The Mann-Kendall test is a widely used nonparametric statistical analysis method (Jian, H., Luo, Y., & Xie, D, 2011), (Kang, Zhang, Liu, Yang, & Yang, 2009), (Kendall, 1975), (Burn, D.H. & Elnur, M.A.H, 2002), (Abdul Aziz, O.I. & Burn, D.H, 2006), (Mishra, A.K. & Singh, V.P., 2010), (I W. Sutapa & Galib, Ishak, 2016), (Sutapa I. W., 2015), (Sutapa I. W., 2017), (Sutapa, Arafat, Tunas, & Fitrianti, 2021), (I W. Sutapa, Darman, S., Nurdin, D., & Faturrahman, 2021), (I W. Sutapa, Yassir A., S. Lipu, Nina B.R, & A. Munif, 2022), (I W. Sutapa & Rinawati, 2021), (Rachmawati A., Nina B. R, & I W. Sutapa, 2023), (Y. Arafat, I W. Sutapa, & Y. Hasanah, 2022), (I W. Sutapa, Y. Arafat, Nina B.R, S. Lipu, & Frederichsen F. P., 2022), (Juan Wu, Zhi-yong Wu, He-juan Lin, Hai-ping Ji, & Min Liu, 2020), (I W. Sutapa, Yassir A., & W. Andita, 2021). Its distinctive advantage is that the information test includes a high degree of evaluation and does not need to be taken following a specific dissemination design. Furthermore, this test is frequently used to predict long-term trends in hydrometeorological time arrangement data, including water quality, temperature, precipitation, and runoff (Liu, Z., et al., 2020), (Dong, Z., et al., 2020).

Drought index

Because the Standardized Precipitation Record (SPI) is one of the most widely used lists in the world and because of its ability to quantify precipitation abundances or shortages on various time scales, it is used in dry spell lists Blain (2014) (Blain, G.C., 2014) describes SPI as a numerical computation used to find and describe precipitation irregularities associated with expected weather conditions. In this instance, a negative SPI value indicates below-normal precipitation, while a positive value indicates above-normal precipitation.

SPI is primarily used to screen for temperature precipitation and dry spell conditions. Without reservation, the World Meteorological Organization (WMO) recommends its use. because it enables the comparison of different climate zones and districts. Finding the probability thickness work that best fits the precipitation frequency distribution on the given time scale is also the first step in calculating this metric. The gamma conveyance, one of the various disseminations suggested in the text, is widely used in climatology and is therefore used in this consideration to discuss the hypothetical dispersion of these factors.

RESULTS AND DISCUSSION

Drought index results monthly SPI and characteristics drought in the Dolago watershed with using rain data monthly station Dolago Padang and Dolago Bendung presented in Figure 2.

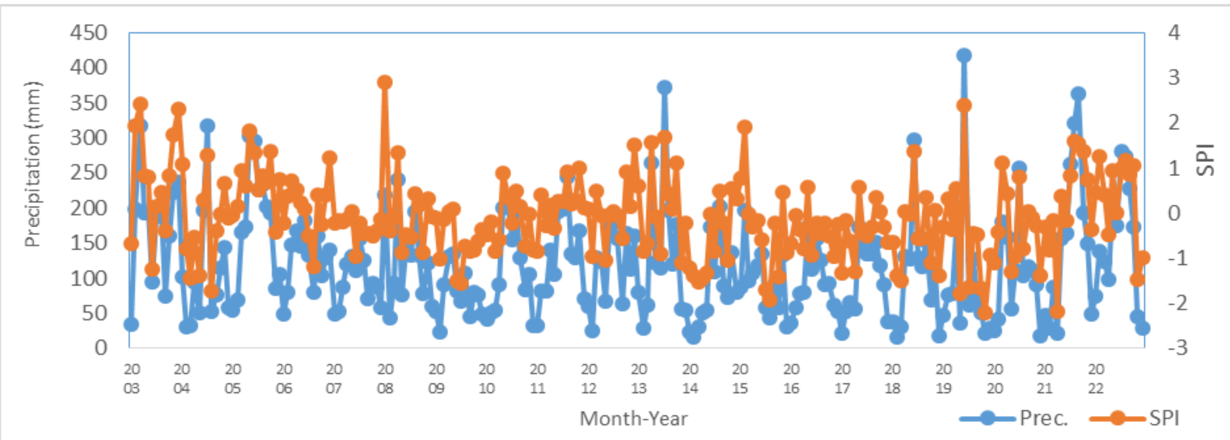

Figure 2. SPI and precipitation for Dolago Bendung and Dolago Padang meteorological station

SPI index and rainfall Rain monthly average Station Dolago Padang and Dolago Bendung plotted for making it easier comparison as given in Figure 2. SPI is used to detect the occurrence of drought (negative SPI value or level wetness (positive SPI value) in the area flow river. Figure 2 illustrates the more rainfall Rain so SPI value is increasing big, so on the contrary. Rainfall monthly maximum occurred in June 2019 (417.27 mm) with an SPI index of 2.38, classified as Extremely wet and the smallest occurred in February 2014 (15.50 mm) with an SPI index of -1.39, classified as Moderate Drought. The largest SPI index occurred in January 2008 with SPI 2.90, classified as Extremely wet with Rain monthly 218.09 mm. The smallest SPI index occurred in November 2029 with SPI -2.2, classified as Extreme Drought with Rain monthly 21.00 mm.

The frequency of the occurrence month dry dry normal and wet based on SPI is presented in Figure 3. Total months wet 56 (23.34%), month dry 71 (29.58%), and normal 113 (47.08%). The proportion of wet months was 6.24% lower than dry months.

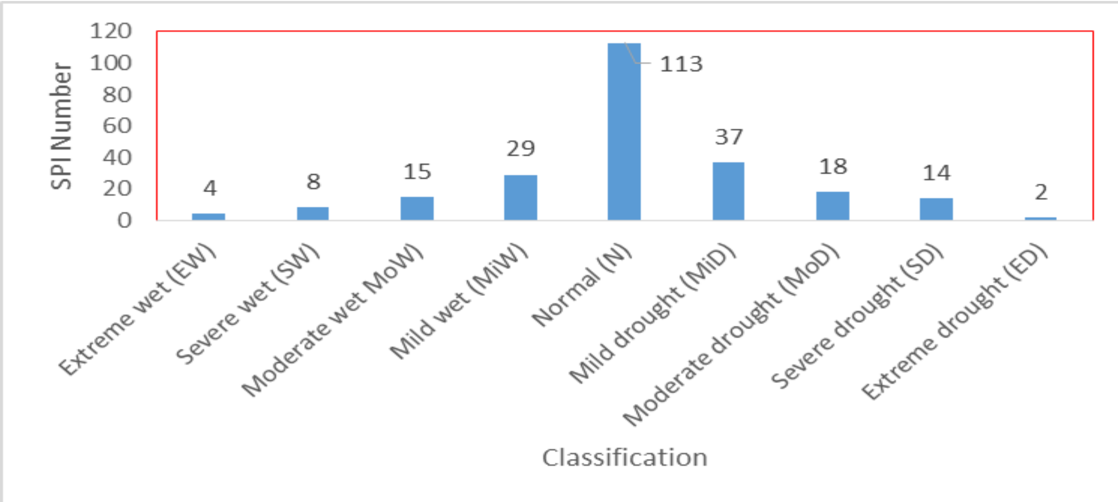

Figure 3. Number of months at different SPI classifications

The value of the SPI varies significantly from month to month. The transition from wet to dry months did not happen abruptly during the first ten years (2003–2012), which saw a lot of typical conditions. For example, normal conditions in July, August, and September of 2003 gave way to wet conditions in October, November, and December of the same year. Compared to the second decade (2013–2022), weather conditions changed quickly and normal conditions declined from the first decade. For example, dry conditions occurred in April 2021, but they soon gave way to normal conditions the following month. Table 1 presents the specifics.

Seasonal conditions are represented by the SPI value, which indicates that while wet conditions are almost equal in the first and second decades, dry conditions in several categories are more prevalent in the second decade (Figure 4). Wet and dry conditions had no effect in the years 2007, 2010, and 2016. The alternating floods and droughts are another interesting finding. For example, flooding was brought on by heavy rainfall in 2003 (2115 mm), and drought was brought on by a dry year in 2004 (1275 mm).

Table 1. Temporal variations of climatic characteristics that are classified based on SPI values

Year	Jan	Feb	Mar	Apr	May	June	Jul	Aug	September	Oct	Nov	Dec
2003	MiD	SW	EW	MiW	MiW	MoD	N	N	N	MiW	SW	EW
2004	MoW	MiD	MoD	Mid	MoD	N	MoW	SD	N	N	Miw	N
2005	N	N	MiW	MiW	SW	MoW	MiW	MiW	MiW	MoW	N	MiW
2006	N	N	MiW	MiW	N	N	Mid	MoD	N	N	N	MoW
2007	N	N	N	N	N	MiD	N	N	N	N	N	N
2008	EW	N	N	MoW	MiD	N	MiD	N	N	MiD	N	N
2009	N	SD	N	N	N	SD	SD	Mid	N	MiD	Mid	N
2010	N	N	Mid	Mid	MiW	N	N	N	N	MiD	N	MiD
2011	MiD	N	N	N	N	N	N	MiW	N	N	MoW	N
2012	N	MiD	N	N	SD	N	N	N	MiD	MiW	N	MoW
2013	MiW	MiD	MiD	SW	N	MiD	SW	N	N	MoW	SD	N
2014	MoD	MoD	SD	MoD	MoD	N	Mid	N	N	MoD	MiW	N
2015	MiW	SW	N	N	N	MiD	SD	SD	N	MoD	Miw	MiD
2016	MiD	N	N	MiD	MiW	MiD	N	N	N	N	MiD	N
2017	MoD	N	Mid	MoD	MiW	N	N	N	N	N	N	MiD
2018	MiD	MoD	SD	N	N	MoW	MiD	MiD	N	SD	N	MoD
2019	N	N	N	MiW	SD	EW	SD	N	N	SD	ED	MiD
2020	MoD	N	MoW	N	MoD	MiD	MiW	MiD	N	N	N	MoD
2021	N	MiD	N	ED	N	N	MiW	SW	SW	MoW	MiW	N
2022	N	MoW	N	N	MiW	N	MiW	MoW	MiW	MoW	MoD	MiD

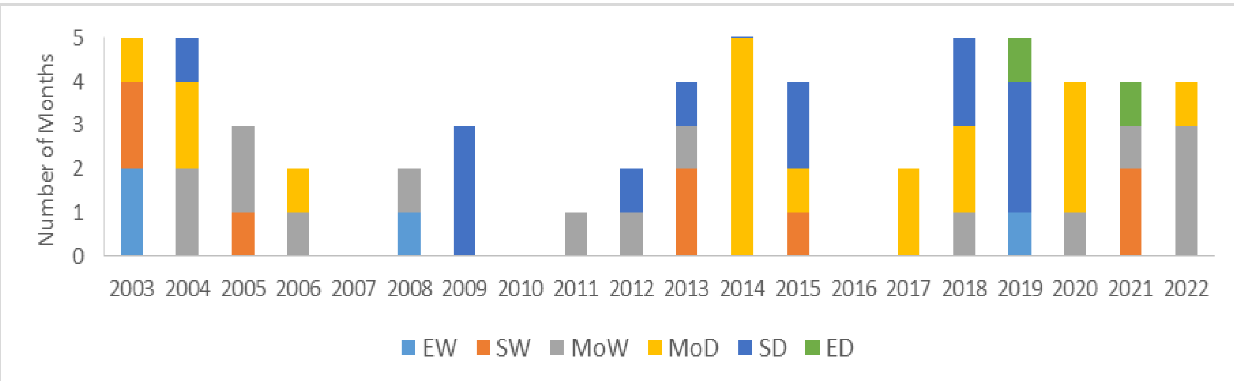

Figure 4. The number of months affected by dry/wet conditions (SPI ≤ -1 and SPI ≥ 1) from 2003-2022

Table 2. SPI Trends (2003-2022)

Variables	Mann-Kendall Test Trend												
	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Ave
SPI	-1.14	-0.58	-0.81	-1.65	-0.42	0.29	-0.19	0.52	1.17	-0.45	-1.52	-3.41	-1.46
	NNS	NNS	NNS	NYS	NNS	PNS	NNS	PNS	PNS	NNS	NNS	NYS	NNS

Where:
PNS = Positive No Significant
NYS = Negative Yes Significant
NNS = Negative No Significant

SPI trend uses the Mann-Kendall and Sens (Makesens) models, with level significance (α) = 10%. Analysis trend shows that part large SPI experienced a decline/trend negative (Table 2), but Not everything significant. The SPI value is significant in April (-1.65) and December (-3.41).

CONCLUSION

Based on the results analysis, can concluded that SPI values vary between -2.2 (Extreme Drought) to 2.90 (Extreme Wet). Incident month wet 56 (23.34%), month dry 71 (29.58%), and normal 113 (47.08%). The proportion of wet months was 6.24% lower than dry months. Transition from month wet to month dry No happen in a way suddenly in the first decade (2003–2012). In decade second (2013–2022), conditions of weather changed fast, and normal conditions decreased from decade first. Condition seasonal, indicating that conditions wet almost the same in decade first and second, conditions dry in several categories more general happened in the decade second. Condition wet and dry No influence in 2007, 2010, and 2016. Analysis trends show that part large SPI experienced a decline/trend negative, but Not everything significant. The SPI value was significant in April (-1.65) and December (-3.41) for level significant (α) = 10%.

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