

Assessing the decadal variations of drought's indicators in Indonesia from 1981 - 2020

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According to the Intergovernmental Panel on Climate Change (IPCC), the global temperatures is expected to increase by approximately 1.5° Celsius by 2030. This temperature increase is expected to result in variations in precipitation patterns and amounts, which will not be evenly distributed worldwide. As a result, certain regions may experience more severe droughts. Droughts can reduce water availability from both surface and groundwater sources, which in turn can have a significant impact on various sectors that rely heavily on water, such as domestic, industrial, and agricultural sectors. To assess drought conditions, various drought indexes have been developed, including the Standardized Precipitation Index (SPI), which was introduced by McKee et al. in 1993 and only requires long-term precipitation data as input. By utilizing probability distributions and normalization, the SPI is able to evaluate wet and dry conditions. This study used the SPI-3 to assess drought indicators such as frequency, duration, severity, and intensity in Indonesia from 1981 to 2020. The precipitation data was obtained from the Multi-Source Weighted-Ensemble Precipitation (MSWEP) dataset, which provides monthly precipitation data at a resolution of 0.1° from 1979 to the present day. The results of the assessment indicate that the frequency, duration, severity, and intensity of droughts have tended to increase in recent decades, particularly in South Sumatera and Java Island. However, the worst drought event occurred between 1991 and 2000, during which precipitation levels were recorded as the lowest compared to other decades. This research will be useful in identifying regions that are particularly susceptible to droughts, and in developing appropriate mitigation and preparedness strategies.

Key Words: *Drought indicators; SPI; Decadal Variation; Indonesia.*

1 Introduction

Climate-related hazards can have a significant impact on human life, one of which is drought. The World Meteorological Organization (WMO) defines drought as a slow onset phenomenon resulting from a lack of precipitation. Unlike other climatological hazards, such as floods or landslides, droughts take longer to develop, and their impacts accumulate over time. According to Wilhite (2000), there are four types of droughts: meteorological, agricultural, hydrological, and socioeconomic. Meteorological droughts occur due to a deficiency of precipitation and can lead to less water reaching the soil and higher evapotranspiration rates. Agricultural droughts occur because of depleted soil moisture (Legesse, 2010) and can negatively impact crop production. Hydrological droughts occur when there is a low water supply on surface and groundwater. Socioeconomic droughts occur when demand for water exceeds supply and can affect social, economic, and environmental aspects. To assess drought conditions, various precipitation-based indexes have been developed, such as the Standardized Precipitation Index (SPI).

SPI was introduced by McKee et al. in 1993 and can be used to evaluate drought conditions with the use of long-term precipitation data (minimum 20-30 years). By utilizing probability density function and normalization, the SPI can assess wet and dry conditions in any region (drought is indicated where $SPI \leq -1$). Additionally, the SPI has temporal versatility, allowing it to be calculated for various time scales as per the user's requirement. In this research, SPI-3 was chosen as the drought index to examine the impact of drought on vegetation (Ali., 2001; Ji&Peters., 2003; Patel et al., 2007), and to assess decadal variations of drought events in Indonesia from 1981 to 2020. Further research on this topic will be beneficial in identifying regions that are particularly susceptible to droughts and developing appropriate mitigation

and preparedness strategies.

2 Materials and methods

The SPI analysis was carried out using monthly precipitation data from the Multi-Source Weighted-Ensemble Precipitation (MSWEP) dataset, which has a resolution of 0.1°, for the period of January 1981 to December 2020 in Indonesia. Various drought indicators were then evaluated as follows:

1. Frequency: Frequency is the total number of drought event. According to McKee et al., (1993) drought event is defined as a period when the SPI value is -1 until it becomes positive.
2. Duration: The duration of a drought event can be calculated as the number of months between its start (included) and end month (not included) (Spinoni et al., 2014).
3. Severity: Drought severity is the absolute value of the cumulative SPI values during the drought event (Tan et al., 2015)
4. Intensity: Drought intensity can be defined as the ratio between drought severity and drought duration for each drought event (Tan et al., 2015). The larger the drought intensity value means more severe drought event.

3 Results and discussion

(1) Drought frequency

As seen in Fig. 1, the occurrence of drought events has been increasing in recent decades, particularly in West Kalimantan, South Sumatera, and Java Island. However, the period from 1991 to 2000 had the highest frequency of drought events. As shown in Fig. 2, this is due to the lowest levels of precipitation during that period, particularly during the dry season from May to October.

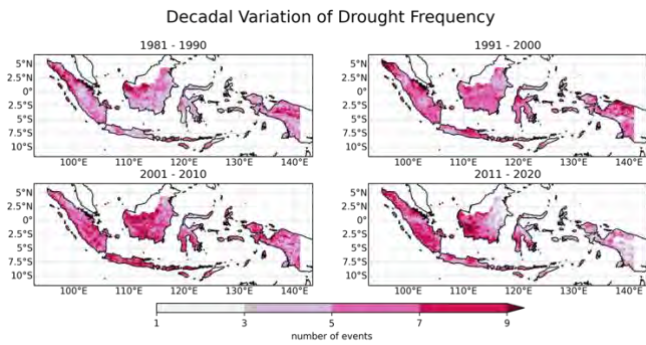


Fig. 1. The decadal variation of drought frequency in Indonesia from 1981 – 2020.

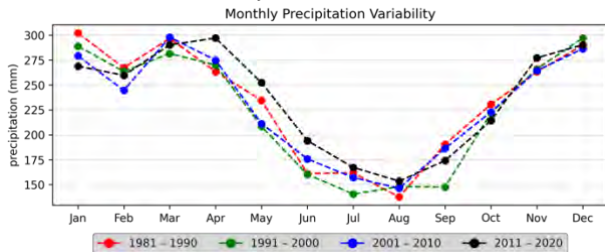


Fig. 2. Monthly precipitation variability.

(2) Drought duration

Fig. 3. also shows that drought event tends to be longer in recent decades, especially in Java Island, Sulawesi Island, and South Sumatera. The findings indicated that regions affected by drought conditions experienced a total of 45-65 months, or approximately 37.5-55% of the months within a decade, characterized as drought months. Additionally, as these regions are major producers of agricultural products, particularly the Java Island, it is essential to focus on reducing the impact of drought on the agricultural sector in the future.

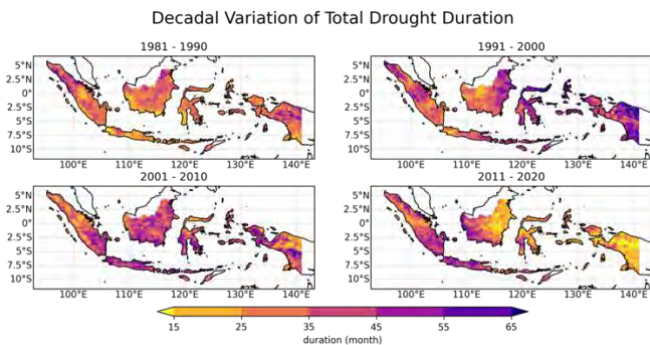


Fig. 3. The decadal variation of drought duration in Indonesia from 1981 – 2020.

(3) Drought intensity

Lastly, **Fig. 4.** shows the drought intensity for each decade. This result also provided an average intensity of drought events in a specific region. The darker blue colour indicated a more severe drought. By comparing this with the result of drought frequency, the regions can be categorized into two groups: 1) those that experience more frequent but relatively less severe drought events, and 2) those that experience less frequent but relatively more severe drought events. The Java Island, as a major producer of agricultural products, falls into the first category, experiencing more frequent drought events with less severity. Therefore, it is important to focus on adapting and mitigating the impact of drought in these regions. This can be done by developing appropriate drought preparedness and mitigation systems to

reduce the impact of drought in the future, particularly in terms of ensuring food security.

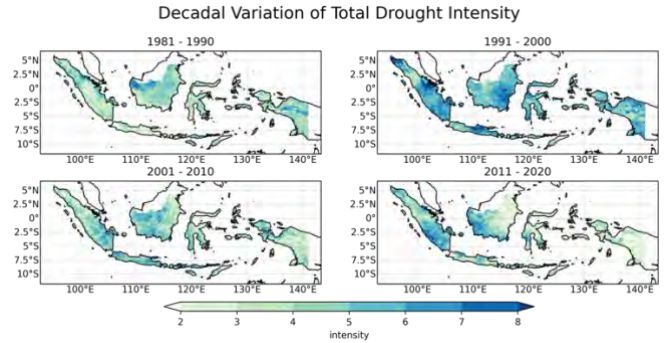


Fig. 4. The decadal variation of drought intensity in Indonesia from 1981 – 2020.

4 Conclusion

This drought assessment aimed to investigate the decade-to-decade variations in drought indicators in Indonesia from 1981 to 2020. The results revealed that the frequency, duration, and intensity of drought events have been increasing in recent years. However, the period from 1991 to 2000 experienced the most extreme drought events, as indicated by the highest frequency, longest duration, and greatest severity and intensity of drought events. This extreme drought decade was caused by the lowest levels of precipitation compared to other decades, particularly during the dry season.

Based on the findings, the Java Island, which is a major producer of agricultural products in Indonesia, should be given particular attention as it experiences more frequent drought events, although with less severity compared to other regions. Developing appropriate drought mitigation and preparedness strategies is essential to reduce the impacts of drought, particularly in ensuring food security in the coming decades when food demand is expected to increase along with population growth.

5 References

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