



Investigation of Drought Trend Using Satellite Imagery (Case study: West Azerbaijan Province)

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Abstract

Drought is a complex meteorological phenomenon that depends on several environmental factors. This phenomenon is a common natural disaster that is recognized as one of the ecological, hydrological, agricultural, and economic concerns of humanity. In this study, satellite data and Google Earth Engine were used to investigate the drought phenomenon in West Azerbaijan province. In order to achieve this research goal, four indices, namely SPI, NDVI, VCI, and TCI, were selected and utilized for a ۲۳-year period from satellite images of the years ۲۰۰۰ to ۲۰۲۲. In this study, ۵۲۶ images were used for the NDVI, VCI, and TCI indices, and ۸۰۸۱ images were used to calculate the SPI index. The research results showed that severe and moderate droughts were experienced in most parts of the province in the years ۲۰۰۰, ۲۰۰۸, ۲۰۱۵, ۲۰۱۷, ۲۰۲۱, and ۲۰۲۲. Additionally, various levels of drought existed in the central, northern, and southern parts of the province in the years ۲۰۰۲, ۲۰۰۶, and ۲۰۱۹. Moreover, normal conditions were observed in all areas of the province in the years ۲۰۰۱, ۲۰۰۴, ۲۰۰۵, ۲۰۰۷, and from ۲۰۱۲ to ۲۰۱۴ and 2016. Comparing the results of the indices, it can be stated that the VCI and SPI indices were the most sensitive indices for drought identification in the West Azerbaijan province, as they were able to effectively identify different types of droughts. Furthermore, the NDVI index, due to its relatively good sensitivity for drought identification, can indicate a decrease in vegetation cover during drought years. Overall, the results of this study demonstrated that West Azerbaijan province is at risk of drought.

Key words: West Azerbaijan Provinc, Satellite Images, Drought, Drought Indices, MODIS

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Extended Abstract

Introduction

Traditionally, drought monitoring has relied on observations from meteorological stations. Recently, drought identification has been achieved through the use of drought indices. These indices allow for the determination of the extent and intensity of drought in both temporal and spatial dimensions. Researchers provide numerical indices to assess the impacts of drought in a region. The indices describe the qualitative status of drought in a specific area over a given time period and provide a quantitative assessment of its intensity and duration. Each of these indices holds particular significance and plays an equally important role in drought assessment. Drought indices are quantitative metrics that define drought levels by assimilating data from one or more variables, such as precipitation, evapotranspiration, into a specific numerical value. Information regarding drought intensity can be made available to decision-makers and utilized for initiating emergency drought response plans when necessary. Since the concept of drought indices gained traction among researchers, numerous indices have been developed. Some of these indices include the Palmer Drought Severity Index (PDSI), Rainfall Anomaly Index (RAI), Crop Moisture Index (CMI), Balme and Moli Drought Index (BMDI), Surface Water Supply Index (SWSI), National Rainfall Index (NRI), Standardized Precipitation Index (SPI), Reconnaissance Drought Index (RDI), Soil Moisture Drought Index (SMDI), Crop-Specific Drought Index (CSDI), and Vegetation Drought Index (NDVI), among others.

Data and Methodology

Google has developed a cloud-based system called Google Earth Engine to effectively address the challenges of big data analysis. Launched in 2010, this platform has demonstrated its high potential for various applications. Google Earth Engine serves as a system for storing, processing, analyzing, and making decisions based on vast amounts of data. This system provides free access to a large volume of remote sensing imagery for public use. Access to the platform requires a user account and is free for educational and research purposes. The system performs high-speed parallel processing with machine learning algorithms and features a library of application programming interfaces compatible with development environments that support popular programming languages such as JavaScript and Python. The development of Google Earth Engine has fostered significant enthusiasm and participation in the fields of remote sensing and spatial data science.

Results and Discussion

Drought is a natural phenomenon characterized by a shortage of water resources in a large geographical area, extending over a significant period. This natural phenomenon manifests in various forms, including agricultural drought (crop dryness), meteorological drought (below-normal precipitation), hydrological drought (low water levels in streams, reservoirs, and groundwater), and socio-economic drought. This study pursued two objectives: the utilization of MODIS satellite data and the effectiveness of remote sensing indices in monitoring drought in West Azerbaijan Province. The research aimed to monitor drought and evaluate the capability of satellite data in West Azerbaijan Province. The use of meteorological and



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agricultural data in calculating indices, the combination of indices for comprehensive drought monitoring, and the assessment of results are considered advantages of this study. In this research, the NDVI index was employed as an effective remote sensing method for evaluating changes in vegetation cover. This index is derived from the combination of red and near-infrared bands in satellite imagery. NDVI values are provided in MODIS product MOD13A1. In this study, a vegetation cover thresholding method was used to distinguish areas with vegetation cover from those without. Threshold values were determined and applied based on regional conditions and ancillary information, drawing from scientific knowledge and experience. In this research, areas with NDVI values greater than 0.4 were identified as having vegetation cover. Vegetation cover maps were extracted from 8-day data and subsequently converted to 16-day intervals for temporal alignment with other indices, with an average calculated for the entire year.

Conclusion

Overall, the results of this study indicate that West Azerbaijan Province is at risk of drought. The intensity of drought in this province has varied over the relevant period, with severe droughts occurring in certain years in specific areas. Vegetation cover in this province also decreases during drought years. Therefore, water and soil resource management in West Azerbaijan Province should be conducted with consideration of the drought risk. In comparing the results of the four indices studied, it can be concluded that the VCI and SPI indices are the most sensitive for identifying drought in the region, effectively detecting various types of drought. The NDVI index also shows relatively good sensitivity for identifying drought and can assess and indicate reductions in vegetation cover during drought years. Additionally, the TCI index exhibits lower sensitivity for drought identification, primarily detecting mild droughts. Ultimately, it can be stated that MODIS data and the VCI index can serve as suitable alternatives to meteorological indices for drought monitoring. Given that the number of sampling points in satellite imagery far exceeds the number of ground stations, use of remote sensing data is recommended. The use of maps derived from drought assessment indices can significantly enhance drought management programs and play a crucial role in mitigating the impacts of drought.

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