Sustainable Urban & Regional Development Studies Quarterly

Volume 6, Issue 4 - Serial Number 22, Winter 2025 **Online ISSN: 2783-0764**
Journal Hompage https://www.srds.ir/
https://www.srds.ir/article_229529.html?lang=en

Monitoring Meteorological Drought Vulnerability Using Satellite Images of Mazandaran Province

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Received Date:01 July 2025 **Accepted Date:** 15 September 2025

Abstract

Background and Objective: Today decision-makers in dealing with drought consider the integrated management approach of crisis management and risk management simultaneously. So far, Mazandaran province has suffered a lot of damage from drought risk. Therefore, determining the level of vulnerability and type of meteorological drought risk situation in the study area, especially in the last two decades, is the main issue of this study.

Methodology: Methodology in order to determine the meteorological drought situation, the Standard Precipitation Index was used in this study. First, the monthlt rainfall statistics for 17 selected meteorological stations in the region were collected and tested for accuracy, precision and feasibility during the common period of 2000-2020. For each of the station in question the percentage of meteorological drought occurrence was determined on an annual time scale. Then the drought Hazard Index (DHI) was extracted by assigning weights and degrees for each of the different intensities. Also the vulnerability of meteorlogical drought was calculated using physical and socio-economic indicators and then the drought- vulnerable zones were determined. Finally based on the two factors of drought hazard index and vulnerability index, the risk of drought damage was calculated and then the zones at risk of meteorological drought were determined.

Results and Findings: Findings and conclusion the results of the research on drought conditions showed that the most severe droughts occurred in the region in 2000, 2008, 2012, 2014, 2016 and 2017. Based on the drought risk index, the results showed that northern part of the region and its central part with an area equivalent to 24% in the SPI index, 22% in the VCI index (vegetation condition index) and 28% in the VHI index (vegetation health index) and 20% in TCI index (surface temperature index) the area of Mazadran province are very susceptible to the risk of meteorological drought. 35 percent of the province's area, located in the north of the province, has very high drought vulnerability. The results of this study indicate that the risk and vulnerabilities caused by meteorological drought seriously threaten Mazandaran province. Meteorological drought risk maps can be used as a suitable warning tool in the risk reduction action plan for all policmakers, managers and stakeholders of the studied region. This issue is of particular importance in planning agricultural activities and the optimal use of water resources, especially in this province where the livelihoods of agricultural operators depend on both rainfed and irrigated agriculture.

Keywords: MODIS remote sensing, drought, damage index, vulnerability, SPI index, Mazandaran Province.

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Cite this article: Arekhi, S. , Emaddin, S. and Sorizaei, N. (2026). Monitoring Meteorological Drought Vulnerability Using Satellite Images of Mazandaran Province. Journal of Sustainable Urban & Regional Development Studies (JSURDS), 6(4), 387-418.

Extended Abstract

Introduction:

Drought is a natural disaster that occurs slowly and can last for a long time and affect large areas of land. Drought and aridity are two different concepts. Drought is a permanent climatic feature in a region that is a characterized by insufficient rainfall to continue the normal vital activities of living organisms in that region, while drought is a drought that is less than the normal level of the region. One of the main differences between drought and other natural disasters is that this disaster occurs over a longer period of time and gradually, compared to others that occur suddenly. This is why this disaster has been considered a creeping disaster. The dangers of are drought much greater than drought. Due to the geographical location and climatic conditions in many parts of Iran, drought is an inevitable threat. The lack of precipitation in a region for long periods of time is known as drought. This water shortage is distributed in the hydrological cycle and creates different types of drought. The occurrence of drought and reduced rainfall affect water resources and agriculture region. The variability of groundwater resources is caused by climate change due to hydrological processes such as precipitation, evaporation and transpiration and interaction with surface water. Droughts often start as meteorological droughts and gradually turn into hydrological, agricultural and finally these systems that one can be aware of the severity and spatial development of drought, which is usually done with drought indicators.

Methodology:

After determining the common statistical period, meteorological data were analyzed using SPSS software and statistical deficiencies were reconstructed using the ratio method. Then the index (SPI) was used to determine the drought status of the province using DIP software and a map of the areas affected by drought was prepared using the interpolation method (IDW) in ArcGIS. The IDW method is one of the common interpolation methods. It is the process of using known values to determine values up to known. This method can be used to predict values up to certain for any geographical point such as rainfall height, etc. using known values. In addition, satellite indices such as the Thermal Difference Vegetation Index (NDVI), Vegetation Condition Index (VCI), Temperature Condition Index (TCI), and Vegetation Health Index (VHI) of the Terra satellite MODIS sensor were used for meteorological drought monitoring during the years 2000 to 2020.

Results and Discussion:

Drought zoning based on SPI index on a monthly basis

The results presented by the SPI index indicate the occurrence of severe drought in the region in May and June. So that the average SPI index in these months is 1.73 and 2.34. Accordingly large parts of Mazandaran province have experienced higher intensities of drought during this period. Also. Based on this index the month of April is considered the wettest month in the region. In this month the average SPI index is 12.05. According to the SPI table of monthly rainfall in all stations of Mazandaran province, it shows that there was a wet season in the three months of April, May and June of 2000 and a moderate drought occurred in 2001. However from 2002 to 2006 the three months of April, May and June witnessed different classes of wet season. However in the years 2007, 2008, 2011, 2012, 2014, 2015, 2016 and 2017 mild and moderate drought in Mazandaran province continued in the three months of April, May and June which were equivalent to the solar months of May and June. April and May 2018 experienced mild drought and June 2018 experienced mild wetness and April and May 2019 experienced mild wetness and June 2019 experienced mild drought and the three months of April, May and June 2020 experienced mild wetness.

Drought zoning based on remote sensing indices VCI, TCI and VHI

The VCI index indicates the occurrence of severe drought in the region in June so that the average of the index in this month was 26.13. In this month the average VCI index is 69.25. Parts of the northwestern, eastern and central areas of the province have higher wetness intensities. The results presented by the TCI index for the month of June indicate the occurrence of severe drought in the province under study. So that the average of the index in this month is 38.23. The TCI also based on this index the month of April is considered the wettest month in the region. In this month, the average index is 54.15. Large parts of Mazandaran province have higher humidity intensities. The VHI index indicates the occurrence of severe drought in the region in June, so that the average of this index in this month is 37.21. Also based on the aforementioned index the month of April is considered the wettest month in the province under study. In this month, the average index 67.56.

Drought zoning based on SPI index on an annual basis

The result presented the SPI index indicate the occurrence of severe drought in the region in 2016. So that the average SPI index in this year is -2.16. Large parts of Mazandaran province have had higher drought intensities in this period. Also, based on this index, the years 2003 and 2004 are considered as the wettest years in the region. In this year, the average SPI index 2.3 and 2.58.

Results from remotely sensed drought indices VCI, TCI and VHI (annual)

The VCI index indicates that there was a severe drought in the 2015 with 28.23. Also, based on this index, 2003 was considered the wettest year in the region at 87.09. parts of the northwestern, central and eastern areas had higher wet intensities. The TCI index indicates that there was a severe drought in the 2007, Also, based on this index, 2003 is considered the wettest year in the region. In this year, the average index is 80.43. The VHI index indicates that there was a severe drought in the 2013. So that the average of the index in this year is 22.53. Also, based on this index, 2010
is considered the wettest year in the region. In this year, the average index is 81.04.The results of the assessment of the damage map on an annual scale in the 4 drought indices this type of damage fluctuates from low to very high at the regional level. The highest situation in the SPI, VCI, VHI and TCI indices is related to low damage in the southern parts of the province, 22, 23, 17 and 23 percent, respectively, including the cities of Amol, Sari, Babol, Chalus and Noor.

Conclusion:

The highest correlation between SPI and VCI, VHI indices 0.82 and 0.88, which indicates that the northern and central parts of Mazandaran province have experienced moderate and severe droughts. The results of the vulnerability map in the studied indicators showed VCI and VHI models, parts of the south are associated with low and medium vulnerability because in these areas the land has a lower population density and the type of land use is natural and forest and the geology does not allow water to pass through easily. In all 4 indicators, the northern and central parts are associated with high and very high vulnerability due to the presence of agricultural lands, the presence of irrigated land, the slope and the direction of the slope and the presence of drought in these areas.

Declarations

Funding
There is no funding support for this study.

Authors' Contribution
Authors contributed equally to the conceptualization and writing of the article. All of the authors approved the content of the manuscript and agreed on all aspects of the work declaration of competing interest none.

Conflict of Interest
The authors declare no conflict of interest.

Acknowledgments
We are grateful to all the scientific consultants of this paper.

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