Research Paper

J. Ecol. Field Biol. 35(4): 323-329, 2012

JEFB Journal of Ecology and Field Biology

GIS overlay analysis for hazard assessment of drought in Iran using Standardized Precipitation Index (SPI)

Elham Asrari[1,*], Masoud Masoudi[2] and Somaye Sadat Hakimi[2]

[1]Payame Noor University (PNU), Tehran 19395-4697, Iran

[2]Department of Desert Regions Management, College of Agriculture, Shiraz University, Shiraz 71141-65186, Iran

Abstract

The Standardized Precipitation Index (SPI) is a widely used drought index to provide good estimations of the intensity, magnitude and spatial extent of droughts. The objective of this study was to analyze the spatial pattern of drought by SPI index. In this paper, the patterns of drought hazard in Iran are evaluated according to the data of 40 weather stations during 1967-2009. The influenced zone of each station was specified by the Thiessen method. It was attempted to make a new model of drought hazard using GIS. Three criteria for drought were studied and considered to define areas of vulnerability. Drought hazard criteria used in the present model included: maximum severity of drought in the period, trend of drought, and the maximum number of sequential arid years. Each of the vulnerability indicators were mapped and these as well as a final hazard map were classified into 5 hazard classes of drought: one, slight, moderate, severe and very severe. The final drought vulnerability map was prepared by overlaying three criteria maps in a GIS, and the final hazard classes were defined on the basis of hazard scores, which were determined according to the means of the main indicators. The final vulnerability map shows that severe hazard areas (43% of the country) which are observed in the west and eastern parts of country are much more widespread than areas under other hazard classes. Overall, approximately half of the country was determined to be under severe and very severe hazard classes for drought.

Key words: drought, GIS, hazard map, Iran, Standardized Precipitation Index

INTRODUCTION

Within Iran, drought is one of the main natural hazards affecting the economy and the environment (Bruce 1994, Obasi 1994, Wilhite 2000). Droughts cause crop losses (Austin et al. 1998, Leilah and Al-Khateeb 2005), urban water supply shortages (DeGaetano 1999), social alarm (Morales et al. 2000), degradation and desertification of land (Nicholson et al. 1998, Pickup 1998, Evans and Geerken 2004), and forest fires (Flannigan and Harrington 1988, Pausas 2004). Drought is a complex phenomenon which involves different human and natural factors which contribute to the risk of,and vulnerability to drought. Although the definition of drought may be very complex (Wilhite and Glantz 1985), it is usually related to a long and sustained period in which water is scarce (Dracup et al. 1980, Redmond 2002). Drought can essentially be considered as a climatic phenomenon (Palmer 1965, Beran and Rodier 1985) related to an abnormal decrease in precipitation (Oladipo 1985, McKee et al. 1993).

Crucially, efforts toward the development of methodologies to quantify different aspects related to droughts have been made. Further efforts have been made to develop drought indices, which allow for the earlier identi-

Open Access http://dx.doi.org/10.5141/JEFB.2012.038

pISSN: 1975-020X eISSN: 2093-4521

Received 15 August 2012, **Accepted** 10 October 2012

***Corresponding Author**
E-mail: e_ asrari@pnu.ac.ir
Tel: +98-711-6303236

fication of droughts, their intensity and potential surface extents of the drought. During the twentieth century, several drought indices were developed, which were based on different variables and parameters (Heim 2002). Drought indices are very important for monitoring droughts continuously in time and space, and early warning systems for droughts are based primarily on the information that drought indices provide (Svoboda et al. 2002).

The majority of drought indices have a fixed time scale. For example, the Palmer Drought Severity Index (PDSI) (Palmer 1965) has a time scale of about 9 months (Guttman 1998), though does not allow for the identification of droughts within shorter time scales. Moreover, this index has many other problems related to its calibration and spatial comparability (Karl 1983, Alley 1984, Guttman et al. 1992). To solve these problems, McKee et al. (1993) developed the Standardized Precipitation Index (SPI), which can be calculated for different time scales in order to forecast droughts based on the monitoring of different usable water resources. Moreover, the SPI is applicable to any time scale and is not specific to any one location (Hayes et al. 1999, Lana et al. 2001, Wu et al. 2005).

The SPI was published 1993 following a careful developmental procedure (Redmond 2002), and due to its robustness it has already been widely used to study droughts in different regions, including the USA (Hayes et al. 1999), Italy (Bonaccorso et al. 2003), Hungary (Domonkos 2003), Korea (Min et al. 2003), Greece (Tsakiris and Vangelis 2004), Spain (Vicente-Serrano and Beguería 2003, Lana et al. 2001), and Iran (Noruzi 2007). SPI has also been included in drought monitoring systems and management plans (Wu et al. 2005). In general, different studies have indicated the usefulness of the SPI to quantify different drought types (Edwards and McKee 1997, Hayes et al. 1999, Komuscu 1999). The long time scales (over 6 months) are considered as hydrological drought indicators (river discharges or reservoir storages) (McKee et al. 1993, Hayes et al. 1999).

The purpose of this study is to establish a spatial pattern for drought using a multi-temporal assessment of SPI in Iran. For this purpose, different aspects of drought hazard, namely, the maximum severity of drought in the period, trend of drought, and the maximum number of sequentially arid years have been prepared in the GIS, deploying the new model. It is the first attempt of its kind in Iran, and preparing such hazard maps may prove to be useful for regional planners, and policy makers for agricultural and environmental strategies, not only in Iran but also in other countries facing similar problems of water shortage.

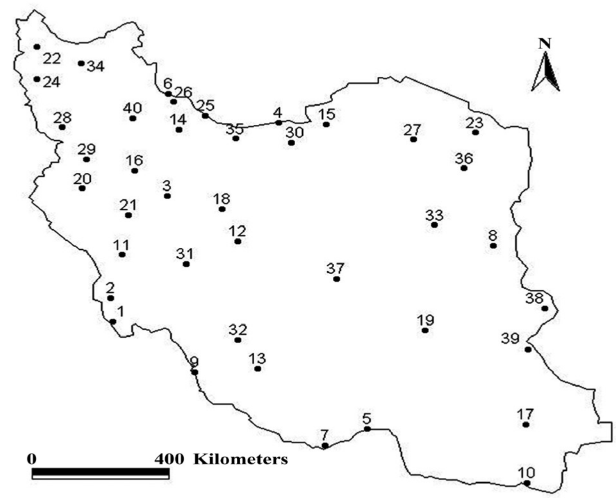

Fig. 1. Locations of weather stations of this study.

MATERIALS AND METHODS

Study area

Iran was selected as a study area for a test assessment of drought vulnerability. It covers an area of 1,648,195 km^2, which lies between the latitudes of 25°14′ and 39°42′ N and the longitudes of 44°10′ and 63°11′ E. The population of the country has increased from 34 million in 1978 before of the revolution to 68 million in 2006, with an effective doubling of the population in less than thirty years. The elevation varies from sea level to around 5,500 m in the Damavand Mountains, and the climate differs widely but most parts of the country are arid or semi arid, with a mean annual rainfall of 50-2,000 mm. The average precipitation in Iran is 245 mm per year, and the main period of precipitation is during the winter (60% of total rainfall).

Data and methodology

The meteorological data used in this study, consisting of monthly precipitation and temperature measurements for 40 synoptic stations distributed fairly evenly throughout the country (Fig. 1), were obtained from the Iran Meteorological Organization (IMO). In the present work, to determine the adequate quantity of stations with suitable scatter formula 1 was used. An exhaustive list of the selected stations is given in Table 1.

$$N = \left(\frac{CV\%}{E\%}\right)^2 \qquad CV\% = \frac{SD}{\overline{P}} \times 100 \qquad (1)$$

N: minimum of adequate station number (in this study: