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Drought assessment and monitoring using meteorological indices in a semi-arid region

N. Haied[a*], A. Foufou[a], S. Chaab[b], M. Azlaoui[c], S. Khadri[a], K. Benzahia[a], I. Benzahia[a]

[a]*Earth and Universe Sciences Department, Ziane Achour-Djelfa University, Djelfa 17000, Algeria*
[b]*Geology laboratory, Badji Mokhtar-Annaba University, Annaba BP 12, Algeria*
[c]*Faculty of Applied Sciences, University Kasdi Merbah, 30000 Ouargla, Algeria*

Abstract

In the last decades a big interest was given to climate changes and especially drought monitoring. Defined as a natural hazard, and characterized by a prolonged absence, a marked deficit or a low precipitation distribution compared to the normal climate, drought may have several impacts on agriculture and hydrology. The drought characterization becomes possible with the initiation of the meteorological, agricultural and hydrological drought indices. Algeria is concerned by this phenomenon, because drought periods have begun since 1975. Deciles, Standardized Precipitation and Reconnaissance Drought Indices have been used to assess the meteorological drought in the world and they show their performance, why they have been chosen to study Wadi Djelfa-Hadjia sub-basin. The two first indices are based on precipitation only. However the RDI uses precipitation and the potential evapotranspiration (PET). Several methods can be used to estimate PET, but Hargreaves method is more accurate for semi-arid regions. The correlation between the SPI and RDI indices is good in the different time scales confirming their performance. The RDI gives the greater number of drought months, but both methods show the same drought durations and severity as the results of the Deciles index.

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Keywords: Drought monitoring; Deciles; Standardized Precipitation Index; Reconnaissance Drought Index; Semi-arid region; Algeria.

* Corresponding author. Tel.:
E-mail address: nhaied@yahoo.fr

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1. Introduction

In contrast to aridity, which is a permanent feature of climate and is restricted to low rainfall areas [1], a drought is a temporary aberration and it is known to cause extensive damage and affects a significant number of people [2]. It is named by some authors as a creeping phenomenon [3]. Drought is a recurring natural phenomenon associated with a deficit availability of water resources over a large geographical area and extending along a significant period of time [4]. Approximately 85% of the natural disasters are related to extreme meteorological events [5] with drought being the one that causes most damages [6]. Drought is considered as a major natural hazard, affecting several sectors of the economy and the environment worldwide. It affects almost all the determinants of the hydrological cycle starting from precipitation and ending with stream flow in the surface water systems or the recharge and storage in the groundwater aquifers. Therefore, our analysis depends upon which part of the hydrological cycle we are interested to focus [7].

Droughts produce a complex web of impacts that span many sectors of the society, including economy and may reach well beyond the area experiencing a drought [8]. Wilhite & Glantz [9] and the American Meteorological Society [10] classify the droughts into four categories: meteorological, hydrological, agricultural and socio-economic. According to statistics 35 countries will face severe water shortage by the year 2020 [11].

The identification of drought was realized by using drought indices. Spatial and temporal extents and severity of drought could be determined using these indices [12,13]. Drought indices are quantitative measures that characterize drought levels by assimilating data from one or several variables (indicators) such as precipitation and evapotranspiration into a single numerical value [14]. It can provide decision makers with information on drought severity and can be used to trigger drought contingency plans, if they are available [15]. Since the initiation of the drought indices notion, multiple drought indices have been developed (more than 150, [16]). They include the Palmer drought severity index (PDSI) [17], rainfall anomaly index (RAI) [18], Deciles [19], crop moisture index (CMI) [20], Bhalme and Mooly drought index (BMDI) [21], surface water supply index (SWSI) [22], national rainfall index (NRI) [23], standardized precipitation index (SPI) [24,25], reclamation drought index (RDI) [26] and reconnaissance drought index (RDI) [27,28,29]. The soil moisture drought index (SMDI) [30] and crop-specific drought index (CSDI) [31].

Generally the Deciles are the one of the simplest meteorological drought indices [19]. The Standardized Precipitation Index is being used for defining and monitoring the drought due to its low data requirement and its ability to analyze the various aspects of drought, which is based on varying time-scales [32]. The Reconnaissance Drought Index is developed to be used in semi-arid and arid regions over the world. This drought index is based on both cumulative precipitation (P) and potential evapotranspiration (PET). It is quite useful drought indicator with low data requirements, flexibility and high sensitivity [27].

This paper aims to monitor and to assess the severity and duration of the meteorological drought in Wadi Djelfa-Hadjia sub-basin by evaluating the performance of the three indices.

2. Study area and Data

The Wadi Djelfa-Hadjia watershed is localized in the central part of Djelfa between 34 ° 24' to 34 ° 59' N and 2° 44' to 3 ° 25' E, it is one of the sub-basins forming the Zahrez watershed, belongs to the Djelfa syncline, which is located in the southern part of the Saharian Atlas (Ouled Nail Mountains). This region is considered as the transition between the North of the country and the Sahara desert. It is located in the South-Western part of the Wadi Mellah watershed. Its area is about 2297 km^2 and have a perimeter of 264.1 km. Its general orientation is NW-SE.

According to the HRNA (Hydraulic Resources National Agency) cutting of the watersheds (Fig.1), Wadi Djelfa-Hadjia watershed has a code 1702 and bounded:

- In the North and North-East by the Wadi Zahrez Gharbi sub-basin (code 1703), including the mountains of Zahrez Gharbi;
- In the East by the sub-basins: Zahrez Chergui (code 1706), Wadi Medjadel (code 1705), and Daiet Mefiteg (code 1704);
- In the South-East by the Wadi Demmed sub-basin (code 606);
- In the South and South-West by the Wadi Taadmit sub-basin (code 605);