Development of a New Comprehensive Multivariate Aggregate Drought Index (ADI) based on Principal Component Analysis (PCA) for Hydro- Meteorological Droughts Assessment in the Southeast of Iran

(Case Study: Pishin Dam Basin)

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1. Introduction

A drought is a prolonged period of water deficit and usually occurs when an area does not receive significant precipitation for a sustained period of time, say several months (Chen, Kuo, & Yu, 2009; Linsely, Kohlerm, & Paulhus, 1959). The effects of drought often accumulate slowly over a considerable period of time that may linger for several years even after the termination of drought. Therefore, some authors have called it a creeping phenomenon (Wilhite, 2000). It is difficult to precisely determine the onset and end of a drought event. A drought can be short, lasting for a just a few months, or it may persist for years before climatic conditions return to normal. Drought considered as the most complex, but the least understandable phenomenon of all the natural hazards affecting more people than any other hazards (Mishra & Desai, 2005). Droughts can be classified into four categories as meteorological, hydrological, agricultural and socio-economic (American Meteorological Society, 1997; Palmer, 1965; White & Walcott, 2009). The preparedness and planning for a drought depend on the information about its areal extent, severity and duration (Mishra & Singh, 2011). This information can be obtained through drought monitoring that is usually done with the use of drought indices (DIs) which provide information to decision makers about drought characteristics. Thus, these indices can be used to initiate drought action plans. Prediction of droughts is useful for early warning that may reduce the response time and consequently the impact of a drought. For many regions, especially semi-arid regions, limited knowledge is available about the diurnal and seasonal cycles of land surface interactions. Semi-arid areas pose a challenge due to large contrasts between dry and wet conditions within a temporal cycle (Schuttemeyer, 2005). Meteorological drought is generally an indicator of other drought types with below normal precipitation, and usually occurs first before other drought types do. The seasonality and climatological

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conditions vary by location. Drought severity may differ from site to site under different climatic conditions, hence, as many as applications of DIs and their comparisons are beneficial for specific regions in the world.

The objective of this study is to develop an aggregate drought index (ADI) based on principal component analysis (PCA) to assess the severity of Hydro-Meteorological drought in the southeast of Iran. Therefore, Stream flow drought index (SDI) and effective drought index (EDI) is determined for several different monthly time steps. The ADI is calculated after a principal component analysis to determine aggregated index value.

2. Study Area

Southeast area of Iran is confined to Sistan and Baluchestan province and located southeast of the intersection of between 29ºN and 57ºE. In this area, precipitation mostly falls in winter and summer seasons. Summer rainfall related to the monsoon mass effect, which comes from Indian Ocean. Climate is arid and semi-arid. Bahouklat is the most important river in area. The origin of this river is the Pir Abad Mountains in the southeastern of Iranshahr city and the passing of Sarbaz, Bahoukalat, Pishin and Dashtyari regions eventually lead to Govare Bay. This river has various names in different regions and called Sarbaz River from Sarbaz to Rask and passes of Pishin dam. Discharge of this river (Sarbaz) is very important in this area.

3. Material and Methods

Hydrological and meteorological drought values are necessary for ADI computation over a long period. Therefore, streamflow drought (SDI) and effective drought (EDI) Indicators were used to estimate the hydrological and meteorological droughts. The input variables include the daily values of stream flow of Sarbaz River in the Pirdan hydrometric station and rainfall during the 21 March 1985 to 20 March 2011 common period. Variables were arranged according to water year (also water year, flow year or discharge year), which begins in October in Iran. Daily timestep of SDI and EDI were estimated respectively according to Nalbantis (2008) and Byun and Wilhite (1999) and then ADI were calculated based on principal component analysis according to Keyantash and Dracup (2004).

4. Results and Discussion

Drought is a very common phenomenon in Iran and particularly in the south east and it has become a recurrent phenomenon in this area in the last few decades .The hydro-meteorological drought index was applied for the identification of drought severity in south east of Iran and drought occurrences were monitored during the experimental years of 1985/86 to 2010/11. Results based on the aggregate drought index (ADI) revealed that a long period of hydro-meteorological drought occurred from 1994/95 to 1998/99. Also, a prolonged wet period has started immediately after the end of drought and has continued to June 2005. In addition, according to drought severity, 1997/98 and 2003/04 water years respectively are extreme drought and extreme wet years. Finally, we have compared the performance of EDI (Meteorological drought index) and SDI

(Hydrological drought index) with aggregate drought index. Based on this comparison, aggregate drought index (ADI) could be better highlighting the drought conditions and its characteristics.

5. Conclusion

Aggregate drought index (ADI) is methodology presented for replacing the uni-dimensional analysis of drought phenomena which can assist authorities and stakeholders to take rational decisions for combating droughts. Using this approach, a more effective way for assessing the severity of drought is obtained. On the other hand, ADI shows capability to detect dry and wet years. Moreover, it has capability to detect historical drought. Overall, by considering the results, the ADI is more reliable than EDI and SDI for drought monitoring in the study area. In this study, ADI time series were compared against the EDI and SDI to describe an important and long drought event in south east of Iran, the 2003-2004 event from a hydro-meteorological perspective. The ADI methodology provides a clear, objective approach for describing the intensity of drought and can be readily adapted to characterize drought on each area.

Keywords: Hydro-meteorological drought, Aggregate Drought Index, Principal component analysis, Pishin Dam Basin, Southeast of Iran.

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