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Drought Forecasting Using Neuro-Fuzzy Model, Climate Indices and Time Series of Precipitation and Drought Case Study: Zahedan-Iran

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Introduction

Drought is a complicated phenomenon that arises from lack of rain and increasing of temperature. It may happen in all climates. Unlike flood, finding the beginning, duration and ending of drought is so difficult. It may last for weeks and months to recognize that really the drought has happened or not? Although drought happens fewer than other phenomenon in comparing with other natural disasters, but has dedicated the first rank from the view point of people's life and financial damages. Zahedan as the capital city of Sistan and Baluchestan province has been located in the southeast of Iran. This province is located in a hot and dry region and has a bad situation from the view point of natural resources. Lack of rain together with time and spatial dispersion from one hand and heavy evaporation on the other hand are the main reasons of shortage of water resources in this area. Researches show that Zahedan has the third rank of drought in Iran with 43% of frequency.

Research Methodology

This research uses three variables including precipitation, climate indices and SPI in order to forecast drought. The entire 1951-2007 precipitation data have been gathered from synoptic station of Zahedan dependent on weather organization. These data did not have many gaps. Different statistical analysis such as spearman and runs tests applied on data for checking independency, trend and randomness. Climate indices gathered from NOAA website as second group of input variables. These indices were SOI, PNA, MEI, Nino1+2, Nino3, Nino3.4, QBO, SW Monsoon, TNA, TNI, TSA, WHWP, EPO, BEST, AMO, AMM, NAO and WP. Finally, SPI index, constituted the third input variable as well as the output one. Drought forecasting performed on the base of autumn average of SPI index. For this aim, models have been constructed using Adaptive Neuro-Fuzzy Inference System (ANFIS) method. So, subtractive clustering method has been used for finding neuro-fuzzy rules and optimizing parameters of membership functions. The Sugeno system with Gaussian membership function applied as fuzzy inference system. Hybrid learning algorithm with epoch of 100 also applied for training of model.

Discussion and Results

In order to forecast autumn drought, the average of monthly SPI in October, November and December in one month scale (SPI-1) in all years of statistical periods was calculated and considered as the predictable parameter or the same similar outcomes . The length of statistical period is totally 56 years (1952-2007), in which 70% of this period (equal to 39 years) was used for training and the remaining 30% of the remaining period was used for evaluation of the constructed models. Input parameters as mentioned before were climate indices, precipitation and previous time series of standardized precipitation index (SPI).

The models were constructed in 4 groups, that each group uses a three months time interval of time series of input variables, including a. Oct-Nov-Dec, b. Sep-Oct-Nov, c. Aug-Sep-Oct and d. Jul-Aug-Sep as input variables time series(with time delays of 0,1,2 and 3 months respectively).

For evaluation of constructed models, different standards such as correlation coefficient (CORR), root mean square error (RMSE) and mean absolute error (MAE) were used. The obtained results showed that each of input variables in one of the said three months intervals has a proper capability for predicting autumn drought. Among the studied 3 months time intervals, the variables which constructed models had minimum error and their correlation coefficients were meaningful at 0.99%, have been selected and presented in the following table.

Lag Time (month)	0		1		2		3	
Input Variable	CORR	Error	CORR	Error	CORR	Error	CORR	Error
AMO			0.65	0.39			0.59	0.4
Nino3	0.75	0.33						
SOI					0.78	0.31		
precipitation	0.97	0.13	0.67	0.39				
SPI index			0.72	0.35				

Conclusion

In the current study, the function of climatic indices, precipitation and pervious amount of SPI drought index were evaluated for predicting autumn drought in Zahedan. For this purpose, the amount of three months i.e. October, November and December of SPI index was selected as the output variable. Then each of mentioned input variables entered into models with lag times of 0, 1, 2 and 3 month (Oct-Nov-

Dec, Sep-Oct-Nov, Aug-Sep-Oct, and Jul-Aug-Sep alternatively). The models have been developed using Adaptive Neuro-Fuzzy Inference System (ANFIS) method and finally the obtained results were evaluated.

Among the input climatic indices, Nino3 in lag time of 0, SOI in lag time of 2 and AMO in lag time of 1 and 3months had the best results. Precipitation, as the other input variable, had the best results in lag time of 0 and 1. Finally, previous time series of SPI had suitable results just in lag time of 1, for predicting autumn drought.

Keywords: Drought Forecasting, SPI index, Climatic Indices, ANFIS, Zahedan.

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