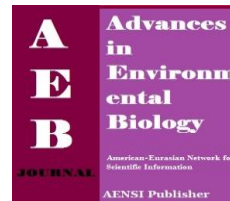




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## Drought Indices Prediction Model Using Markov Random Process in Shoushtar City

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### ABSTRACT

The lack of rainfall and increased temperature, drought conditions in climatic conditions may occur Characteristics of drought or wet in a basin of water resources, watershed management planning is the most important element. In this paper, drought status of the city for ten years based on the Branch and PNPI SPI indices were examined. During the recent period of drought SPI control 10 of them have been the worst it's been in the water 1991. The results were nearly PNPI index. Then by the Markov chain to be drawn to the prospect of a drought year. Markov chain with more than 80 percent PNPI index predicts the likelihood of a normal water year.

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## INTRODUCTION

Periodic droughts and natural features that occur in all climatic conditions. Phenomenon of catastrophic events that will cause a lot of damage. The results of a survey by the National Land Agency of Japan has indicated that between 1992 to 1996 years since drought is the most serious accident happened in the world [3].

According to reports in 2001, about 6/2 million acres of irrigated and rainfed agriculture 4 million acres and 1/1 million acres of orchards have been affected by drought. Damage caused by drought on the fields in the year amounted to \$ 520 million.

According to research conducted in the country, the direct effect of reducing the damage caused by each 1 mm of rainfall is equal to 98 billion riyals. [4].

In many parts of the country, people with low rainfall and long dry and semi-arid climates are faced with declining rainfall in some years has exacerbated the phenomenon.

Iran to take the belt dry and geographic strip of desert at 25 to 40 degrees north latitude is located, the climate is among the areas of low rainfall world comes and average rainfall in only about a third of the world average [4].

One of the key strategies for drought studies determined based on indicators that can assess the level of severity, and duration of the drought could countering and mitigating the damage caused by this observational event is being developed. Indicators are based on much climatic data predict the [2].

## MATERIALS AND METHODS

### Standard Precipitation Index (SPI):

Standard Precipitation Index by McKee *et al* [5] were introduced. The SPI index based on the idea took shape that is different impacts on various natural components. Since the drought of the sense of place is a geographical perspective, drought severity index as a function of the variability of precipitation at any location in the same place. From the perspective of Climatology degree of drought (wet) can be determined according to the following equation

$$SPI = \frac{P_{ik} - P_i}{SD}$$

SPI is degree of drought (wet) and  $P_i$  indicate Precipitation Mean Monthly rainfall and SD is Standard Deviation of Monthly Rainfall.

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Other features include a SPI index variation range of positive and negative values. The grade is calculated cumulative rainfall during the drought, which is the drought cumulative grade levels showed a positive cumulative  $\rightarrow$  more year, and if it is negative, the drought has stated [1].

*Percentage of normal precipitation PNPI:*

The index rainfall amounts than the long run, which is calculated as a percentage. The following simple equation calculates Percentage of normal rainfall.

In this respect, the rainfall in a given year, the average long-term rainfall PNPI Percentage of normal rainfall.

$$PNPI = \frac{P_t}{\bar{P}} * 100$$

**Table 1:** Classification of scale meteorological drought severity using PNPI.

Intensity	Drought				Normal	Wet
Tendency	Very intense E	Extreme S	Medium M	Weak L	Normal threshold N	Lower threshold Sally W
PNPI	Lower 40	40 to 55	55 to 70	70 to 80	80 to 120	Higher than 120

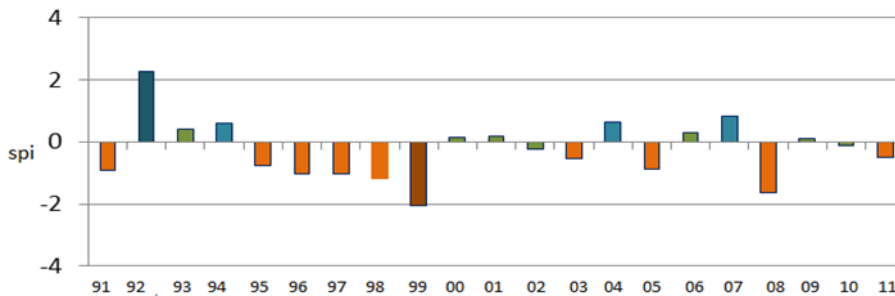
*Markov chain:*

One method of drought analysis method called Markov chain is called. Markov chain is a mathematical approach to probabilistic model of the process, the likelihood of a climate state at time t with respect to time (t-1) showed offers. This method relies on the observation model for the possible structure.

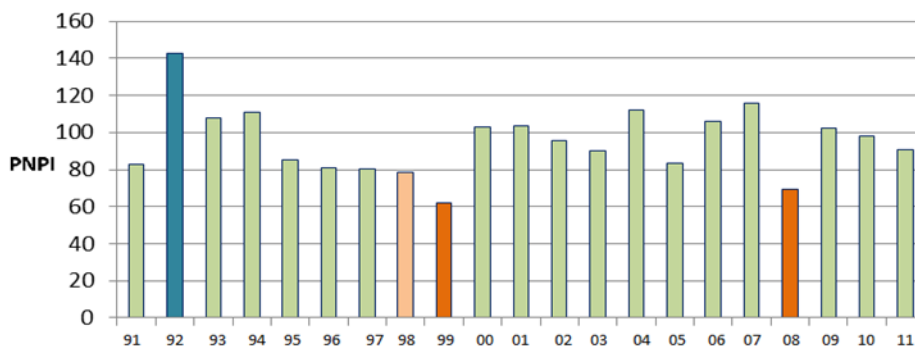
The high correlation between the probability of transition from state i to state j, n the number of times the state transition i to state j and N is the number of possible states [1].

$$P_{(i,j)} = \frac{n_{(i,j)}}{(\sum_{K=1}^N n_{(i,K)})}$$

In this study, rainfall data for 21 years (1991-2011) Shoushtar city synoptic stations by SPI and PNPI indicators were examined. Based on the results of SPI, as shown in Figure 1, the period of 21 years we've been kind of seeing 10 cases of drought severity in blue it is 1999. Based on the results of the index threshold PNPI can also be found in more than 1992 years we have seen and experienced drought in years 1997, 1998 and 2008 are normal situation (Figure 2)



**Fig. 1:** Diagram of SPI in synoptic station shoushtar city.



**Fig. 2:** Diagram of PNPI in synoptic station shoushtar city.

PNPI index is calculated based on Table 2, based on the state of water in the past, by the Markov chain can be studied probability at the current water year.

Markov chain predicate about situation of next water year and other year by probability of rain or Drought in through time of this research about shoushtar city

**Table 2:** Comparison of meteorological drought severity using PNPI and SPI and Markov chain for predicate model.

Water year	SPI	*D.o.d vs SPI	PNPI	*D.o.d vs PNPI	Markov chain
1991	-0.93584	Mild and dry	82.58571	Normal threshold	N
1992	2.278881	Extremely wet	142.4057	Wet threshold	W
1993	0.424418	Approximately normal	107.8976	Normal threshold	N
1994	0.578956	Mild, wet	110.7733	Normal threshold	N
1995	-0.78292	Mild and dry	85.43143	Normal threshold	N
1996	-1.02921	The average dry	80.84832	Normal threshold	N
1997	-1.0437	The average dry	80.57873	Normal threshold	N
1998	-1.17087	The average dry	78.21229	Weak	L
1999	-2.04015	Severely Dry	62.03663	Average	M
2000	0.145926	Approximately normal	102.7154	Normal threshold	N
2001	0.199049	Approximately normal	103.7039	Normal threshold	N
2002	-0.22754	Approximately normal	95.76587	Normal threshold	N
2003	-0.53823	Mild and dry	89.98457	Normal threshold	N
2004	0.643347	Mild, wet	111.9715	Normal threshold	N
2005	-0.89399	Mild and dry	83.36454	Normal threshold	N
2006	0.310124	Approximately normal	105.7708	Normal threshold	N
2007	0.83974	Mild, wet	115.626	Normal threshold	N
2008	-1.63771	Mild and dry	69.52536	Average	M
2009	0.12178	Approximately normal	102.2661	Normal threshold	N
2010	-0.10842	Approximately normal	97.98254	Normal threshold	N
2011	-0.50764	Mild and dry	90.55372	Normal threshold	N

According to Markov chain derived from the index PNPI, 13 times the transition from normal to normal and one-time transition from normal to wet, one-time transition from normal to dry mode weak and one-time transition from normal to dry medium occurred is generally 16 times the transfer case from the blue end of the year, that is normal in other cases occurred. relations the possibility of transfer to other modes is shown in the blue. Probability of four situation of transform drought shown in below

$$P_{N,N} = \frac{13}{16} = 0.81 \quad P_{N,W} = \frac{1}{16} = 0.062 \quad P_{N,L} = \frac{1}{16} = 0.062 \quad P_{N,M} = \frac{1}{16} = 0.062$$

#### Results:

Droughts occurred in the city of synoptic stations shoushtar by PNPI and SPI indices was performed and the results are listed in Table 3 Comparison Between them , the proximity of the two parameters was observed

As was observed in the Markov chain using PNPI index more than 81% probability gives a normal water year .regional authorities to manage water resources .

The following guidelines are provided in the field of water resources management:

- Demand Management modern irrigation.
- Aquifer Storage and considering the plan to curb floods.
- domestic and municipal wastewater for agricultural purposes, according to city shoushtar high potential for agriculture Change the paradigm from traditional to scientific thinkers and scholars and thinkers water.

Note: This article is based on a research project with this title “Drought indices prediction model using Markov random process in shoushtar city” in Islamic Azad University shoushtar branch .

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