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*Full Length Research Paper*

# Zoning droughts and wetness trends in north of Iran: A case study of Guilan province

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**Study on drought has been considerably regarded on recent years, due to drought increase in Iran. On the other hand, survey on wetness makes it possible to prevent from it flood risk to some extent and attempts to manage water supplies. In this study, Standardized Precipitation Index (SPI) was used in annual period of time to survey on drought. Also, in order to zonation frequency of drought, geographic information system (GIS) software and inverse distance weighted of interpolation method, and Boolean Logic used for extracting dry and wet areas and then layers used to obtain frequency of drought and wetness. Results showed that the most droughts and wetness were of medium. The most years in the considered region were in normal status and lots of costal stations had severe droughts between 2008 to 2009. Generally, occurred droughts and wetness in the stations did not follow a definite order.**

**Key words:** Guilan Province, drought, wetness, standardized precipitation index, zoning, geographic information system.

## INTRODUCTION

Many of natural phenomena are not simply controllable or predictable; however, prediction is possible when there is information of their past. Rainfall increase and decrease in comparison with normal condition cause flood risk and drought respectively lead to different social-economic consequences. Drought is one of the natural disasters which could happen everywhere and there is no possibility to prevent it and its influences appear gradually in a relatively long period of time. Unlike dryness which is a permanent climatic phenomenon, drought happens in dry and wet regions and it is a normal status of climate.

Monitoring systems of drought and wetness are depended on Indices which in fact represent severity of drought and wetness and they are provided to evaluate them in different scales of time and place. One of the most important Indices which have recently draw lots of attentions is SPI. Highs (1999) stated that SPI is a flexible and strong index to analyse drought in each time scale. This method was offered by Meci et al. (1993). SPI is computed for each region based on recorded long-term rainfall. At first, proper statistical distribution is fitted on statistic of long-term rainfall and then cumulative distribution function will change to normal distribution using equal probabilities so that it is standardize and its average become zero for each considered region and period. Edwards (1997) stated SPI values between +2 to -2. Positive values show severity of wetness and negative values show severity of drought. Meci et al. (1993) applied SPI in Colorado states, America and found that Gamma distribution is the most efficient distribution to fit rainfall data. Sabra et al. (1986) surveyed about production influenced by rainfall changes in Andhra coasts, India using Markov Chain Model. Dopingi et al. (2001) dealt with effect of drought in Vermont states, America and found that SPI shows onset of drought condition better than PDSI in one-month scale. Bordi and Sutera (2004) used SPI for zoning monthly drought in short, medium and long period of time. Thompson (1990)

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dealt with probability of occurrence and stability of drought, wetness and normal periods in central regions of USA using Palmer index. Paulo et al. (2003, 2004, 2005) analyzed and surveyed changes of drought severity in south of Portugal using SPI and Markov Chain Model (Banejad et al., 2006). To drought changes, geo-statistical methods of Kriging and Cokriging and weighted moving average were used.

The results showed that in compound with SPI for monthly scale, exponential model of Kriking model was proper and for seasonal scale, spherical model was qualified. Also, inverse distance weighted method (IDW) showed better results for six-month, annual and biennial. Raziei et al. (2007) surveyed climatic drought in Sistan and Baloochestan province using SPI and Markov Chain Model. Data showed that probability of drought using SPR, DR and Nitzche Indices, Rahimi (2005) proceeded to modeling wet and dry periods in East Iran. Ghatreh (2000) also, study the drought process in Chaharmahal Iran and drew drought distribution diagram using Deciles method. Yousefi et al. (2007) dealt with drought and wetness in Ghazvin Iran using Markov chain and normal distribution methods and compared two methods. They concluded that Markov chain shows better results than normal distribution. Shahin et al. (2009) conducted a study using SPI method to survey crisis threshold of drought in Fars Iran. Data showed that southern and eastern regions and some parts of central parts had the most droughts in comparison with other regions. Ansari et al. (2010) dealt with drought monitoring using standard indexes of rainfall, evaporation and transpiration in Mashhad Iran. Conclusions showed that SEPI have all advantages of SPI such as computing in different time scales. Eivazi and Mosaedi (2011) dealt with site study of drought in Golestan Iran through SPI and geostatistic methods and their conclusions showed that each year 13% of the province faced drought. The widest drought was in 1984 to 1985; considering to the droughts and wetness with different intensity and to evaluate their procedure during statistical period.

## MATERIALS AND METHODS

### Site of study

Guilan province is located in north of Iran and in west south of Caspian Sea. With geographical of 36°C 34' to 38°C 27' North and 48°C 53' to 50°C 34' East. Guilan Province is limited to Caspian Sea and Azerbaijan Country from North, to Ardebil Province from West and North West, to Zanjan Province from West, to Ghazvin Province from South and to Mazandaran Province from East. Alborz Mountains partition Guilan Province from Iran Central Plateau from South (Figure 1).

In this research, data of 13 synoptic and climatological stations of General Administration of Aerology and Regional Water Authority of Guilan Province which support maximum area of the region were selected. These stations were included statistical period at least for 30 years. After completion, amendment and assimilation, they transformed to a common time scale. Statistical period used for this study is water years of 1978 and 1979 to 2007 and 2008. Figure 2 shows location of used stationed. At first, rainfall diagram of the province was provided to perceive the rainfall status. Figure 3 shows zoning of rainfall in the region. Then the SPI was used identify dry and wet periods of rainfall. SPI could be used to compute monthly rainfall or analysis total rainfall in each delight intervals (3 to 6-month). In this research, the annual timeframe and the following formula were used:

$$\mathrm{SPI} = \frac{p_{ik} - \overline{P}}{\varrho}$$

Where SPI is standard index, Pik is the ith station in Kth observation in millimeter, P is the average of rainfall in timeframe for each station, $\varrho$ is the standard deviation of each station in timeframe.

At first, precipitation data were transferred to the Excel software, and then SPI method was used for evaluation. Obtained values were transformed to GIS and after organizing data base for each station. Zoning map was based on SPI values for each statistical year. Finally, to draw frequency diagram for each SPI values, each layer was extracted using Boolean Logic through 0, 1 coding method. Then layers were sum by raster calculated tools in GIS software.

## RESULTS

The precipitation zoning map of Guilan Province is shown in Figure 3. According to this map, the most rainfall in the study area is in Northern parts and even moving more toward Southern regions, the rainfall decreases so, the average precipitation in Paroudbar station which is located in the south of the province is 305 mm during statistical period.

### Drought

In moderate drought, the most frequency is related to Ghaleh Roodkhan Station located in South west of study area and was recorded in the years 1994 to 1995,1999 to 2000, 2000 to 2001, 2005 to 2006 and 2007 to 2008. The most droughts in this station occurred on the second half of the timeframe which represent rainfall decrease in this station and the least frequency is related to the Hashtpar and Rasht stations (one occurrence). In severe drought status, the most frequency is related to Rasht and Ramsar stations in North and North West of the region which occurred in the years 1998 to 1999, 2005 to 2006 and 2007 to 2008. In 2007 to 2008 Astaneh Ashrafieh station and in 1979 to 1980 in Bijar Station severe droughts was recorded respectively. Figure 4 shows results of SPI diagrams for selected stations in the study area. According to this figure, Paroudbar station which is the station with the lowest rainfall shows an uptrend precipitation from 2001 and 2002 to 2006 and 2007. Masal station shows frequency of drought from 1997 and 1998 to 2000 and 2001 during statistical periods. In the other years, frequency of dry and wet periods are equal.

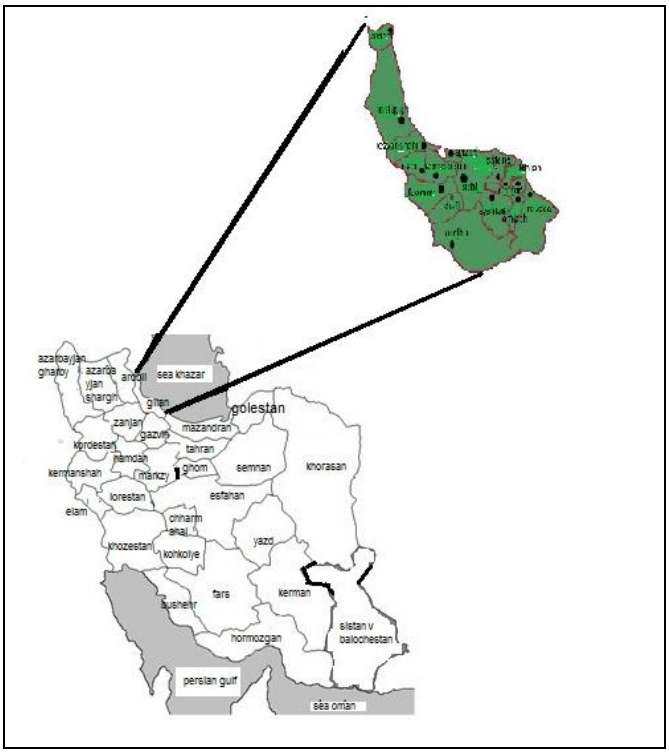


**Figure 1.** Location of the study area.

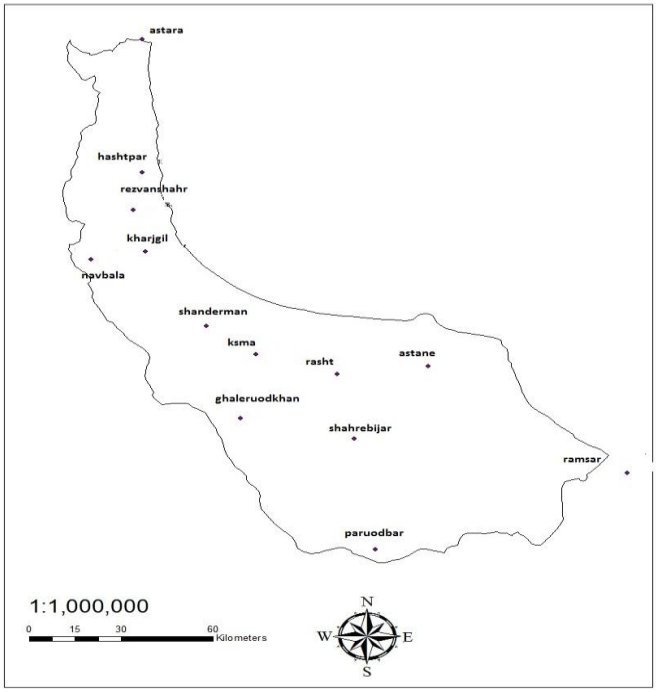


**Figure 2.** Location of used stationed.

Kharjgil station has the most continuity of wetness in the years 1991 to 1992, 1992 to 1993, 1993 and 1994. Figure 5 shows zoning of moderate drought frequency for the considered region. Regions which have the most and the least frequency are shown with red and green respectively. Coastal regions show the least moderate

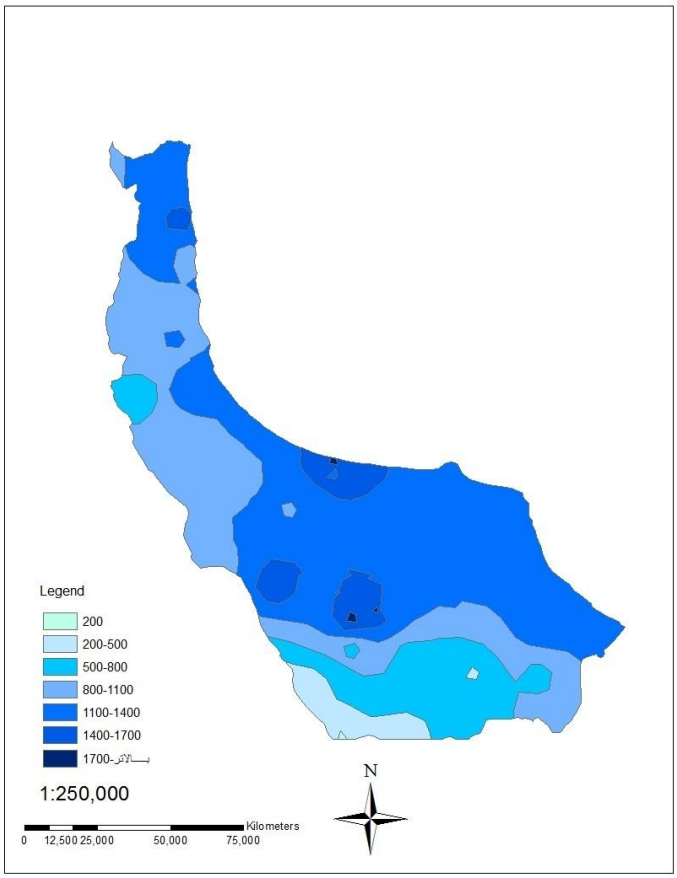


**Figure 3.** The precipitation zoning map of Guilan Province.

drought during the statistical period. These regions have the most values in North and North West in comparison with other regions. It mentioned that moderate drought have the least frequency in coastal regions. Figure 6 shows severe drought zoning. According to this figure, North, North West and West regions faced more severe drought that Southern and Western regions. Severe drought status occurred just twice.

Once it was in Astaneh Ashrafieh station in water year of 2007 to 2008 and once it was in Bijar station in water year of 1979 to 1980. As it has shown in Figure 7, some regions in west parts vary in severe drought during statistical period.

### Wetness

Figure 8 shows frequency of moderate wetness for Guilan province. The most frequency of this kind of wetness was six times in statistical period and occurred in western regions. Guide map shows the least frequency toward the most frequency of wetness respectively by colors. Figure 9 shows severe wetness for the considered region. According to the map, the most wetness (twice per statistical period) was related to the regions with low altitude. It means all central regions toward east and discretely some of the western regions. Figure 10 shows very severe wetness status for the considered region. According to the map, western and southern regions discretely in the region under study faced very severe wetness during statistical period.

## DISCUSSION AND CONCLUSION

As among climatic elements, rain has the most fluctuation, observing droughts and wetness with different severity and frequency based on rainfall data in climatic studies of each region, specially regions where agricultural center is necessary. This research dealt with the evaluation of time and local changes in drought and wetness in Guilan province through SPI and IDW of interpolation method in the environment GIS. Regarding SPI just uses rainfall parameter to identify severity of drought and wetness, so it may have some defect because factors such as temperature, evaporation and transpiration may effect on severity of drought and wetness. Most coastal stations in 2007 to 2008 faced very

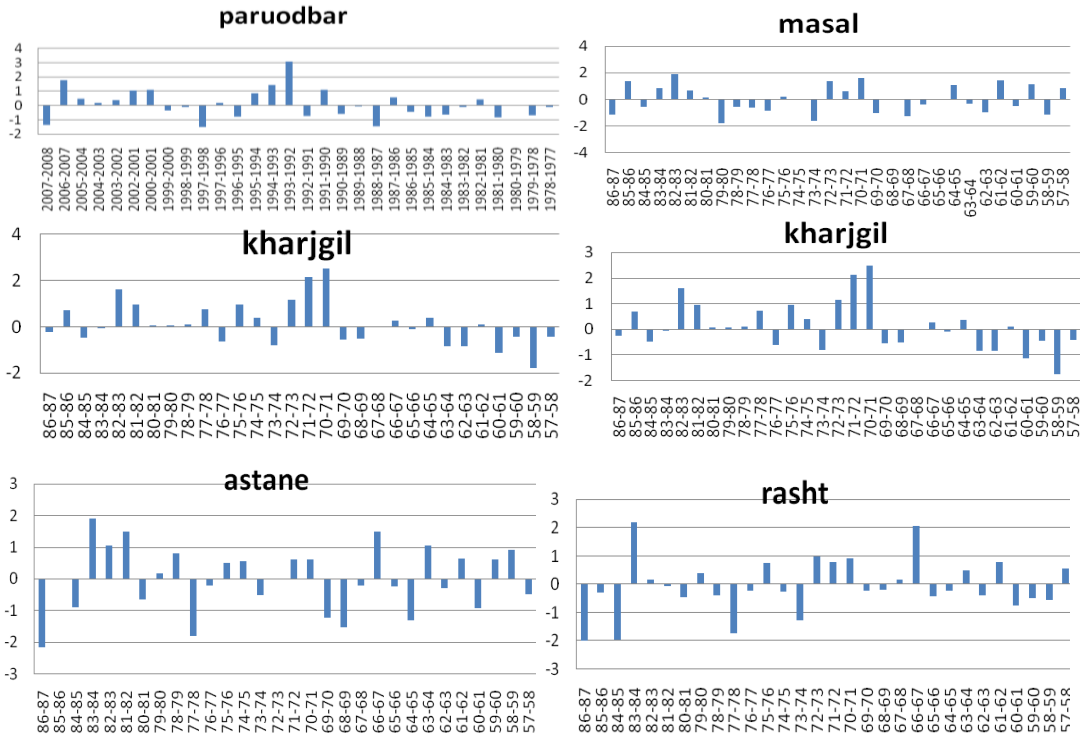


**Figure 4.** SPI diagrams for selected stations in the study area.

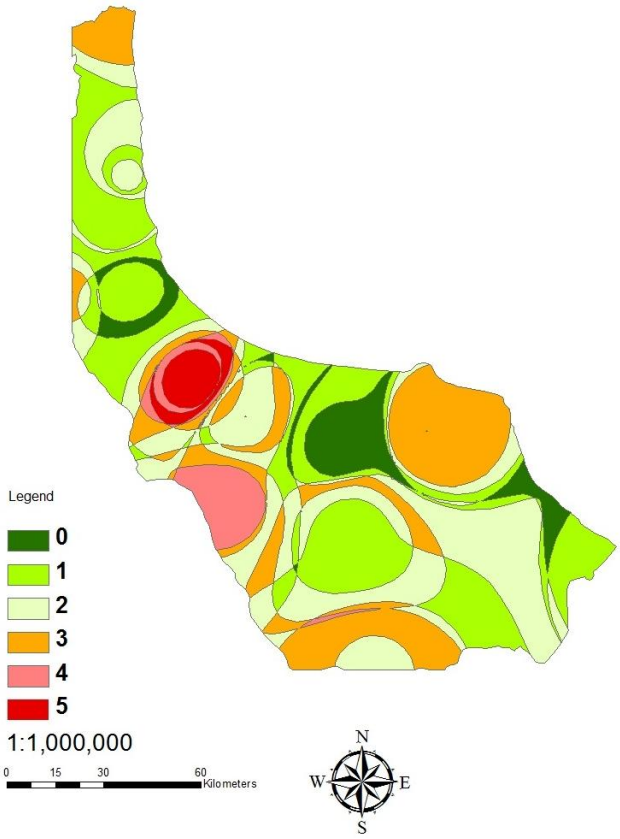


**Figure 5.** Moderate drought zoning.

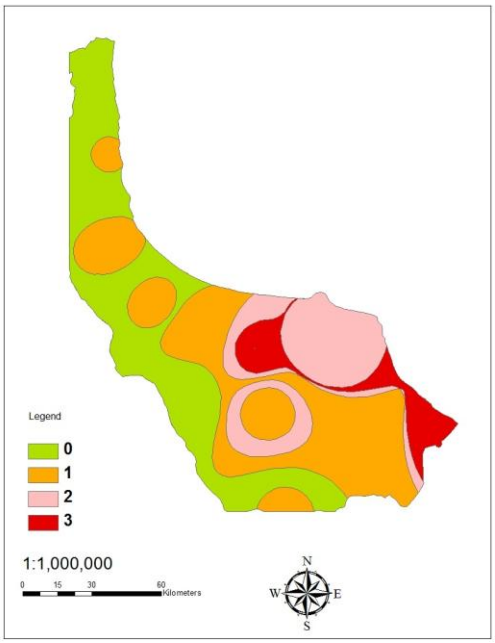


**Figure 6.** Severe drought zoning.

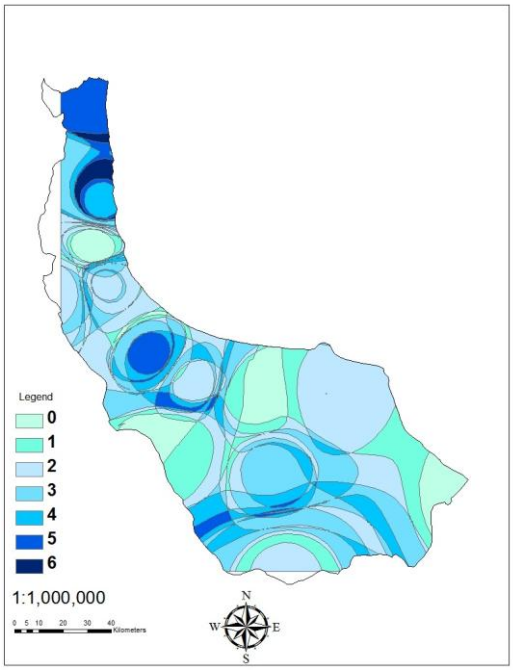


**Figure 8.** Moderate wetness.

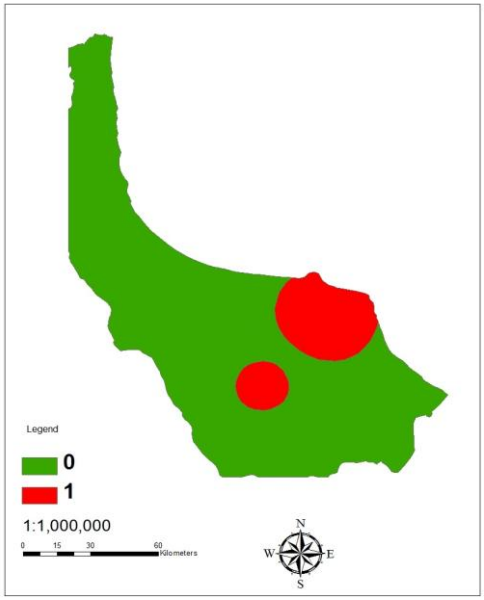


**Figure 7.** Very severe drought zoning.

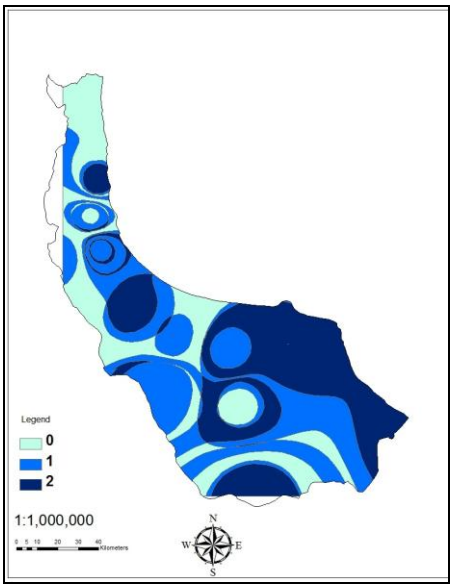


**Figure 9.** Severe wetness.

severity drought. Droughts and wetness occurred in the considered stations did not follow a specific order. Obtained results from zoning showed that the most droughts specially severe and very severe occurred in Northern and North East of the study area. In these regions, moderate drought has more frequency in comparison with other values of SPI. Also, present finding was supported by the other results such as Yousefi et al. (2007) and Eivazi and Mosaedi (2011). In conclusion, it should be mentioned that most droughts and wetness are moderate.

In most of the years, the considered region was in normal status. This study showed that even wet regions are not safe from natural disaster of drought and also drought and wetness could not be predicted in wet regions, likely damages is more than dry and semi-dry regions.

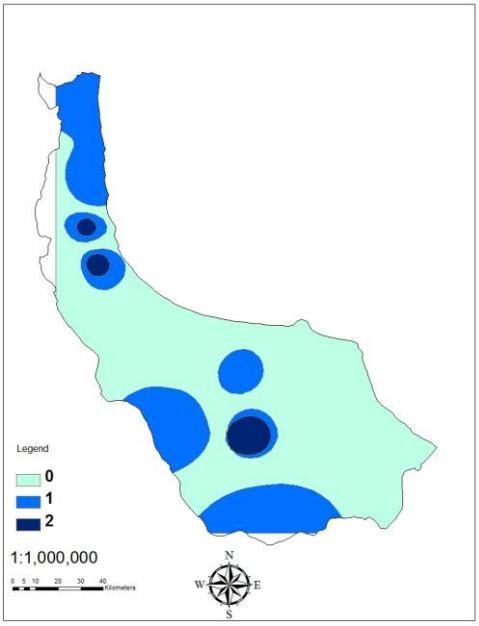


**Figure 10.** Very severe wetness.

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