The Role of Climate Study in Analyzing Flood Forming Potential of Water Basins

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ABSTRACT: Internationally recognized Golestan forests are among the most endangered features threatened by anthropogenic activities. Being located in north-west of Iran, south-east of Caspian Sea, Gorganroud watershed is mostly influenced by deforestation activities. In this study the identification of regional atmospheric and hydrologic patterns and their role in conforming floods in Gorganroud water basin are discussed. A 33-year period (1970-2003) was taken in to consideration in the process of data gathering. Gradual change from Mediterranean to Semi-arid climate during recent decades in Gorganroud watershed indicates regional climate change. Increased share of 24-hour precipitation in average annual precipitation in one hand and decreasing rate of snowy on rainy days ratio on the other hand stipulate this climate change. The relatively sharp ascending pattern of annual peak flow of the basin during recent years may be considered as an alarming factor concerning streams inundation. Climate study in suspected water basins may provide invaluable data concerning flood forming potential of regional precipitations. The results of this study confirm the fact that precise analysis of climatic and hydrologic in watersheds threatened by flood-forming run-offs may be used efficiently in monitoring such areas and saving human lives.

Key words: Gorganroud watershed, Climate change, Precipitation pattern, Iran

INTRODUCTION

Considering ascending rate of population growth accompanied by technological improvements and consequent human requirement to raw materials and housing, anthropogenic environment exploitation and deterioration are widely observed all around the world. This demolition procedure has been reinforced during recent decades (Gumbricht et al., 2004). Continual use of fossil fuels is among the most outstanding man-made features that have resulted in climate change, global warming, glacier melting, reinforcing the continental hurricanes and changing the precipitation patterns (Heratha and Ratnayake, 2004; Costelloe et al., 2003; Huntingford et al., 2003). Domestically in Iran, environment exploitation has undergone a more rapid rate in recent years. According to the reports issued by the ministry of interior, internationally recognized Golestan forests are among the most endangered features threatened by anthropogenic activities. Being located in north-west of Iran, (south-east of Caspian Sea) Gorganroud watershed is mostly influenced by deforestation activities. Destructive floods in Northern Khorasan and Golestan provinces in August 2001 and particularly in August 2005 are considered as major consequences of exploitation in internationally preserved zone of Golestan national park. Considering several floods occurred in Gorganroud watershed in recent years, a study was run on regional atmospheric and synoptic systems which are among the most effective features in conforming heavy precipitation. In this study the identification of regional atmospheric and hydrologic patterns and their role in conforming floods in Gorganroud water basin are discussed.
MATERIALS & METHODS

In this study, Gorgan station is considered for climatic data collection. This station is located in south-east of Caspian Sea and in 54° 16' east longitude and 36° 51' north latitude. Specification of the study area is schematically shown in Fig. 1.

A 33-year period (1970-2003) was taken into consideration in the process of data gathering. Furthermore, the climatic change rate through this period is also discussed. In other words, this 33-year period is divided into three 11-year subdivisions and the data are analyzed separately for each span of time.

In order to determine annual climate type of the station, De Martin method with following equation is used (Alizadeh, 2002):

\[ IA = \frac{P}{T+10} \]

Here:
- IA: De Martin index
- P: Average Annual Precipitation (millimeter)
- T: Average Annual Temperature (degrees centigrade)

De Martin categorization of different types of climate is illustrated in Table 1.

The IA equated from 33-year period data equals 21.64 and consequently shows that regional climate locates in Mediterranean categorization. But if 11-year period subdivisions are considered with IA amounts of 23.5, 20.7 and 19.66 respectively, it is observed that the type of climate in last 11-year period is changed from Mediterranean to semi-arid category. This change rate is schematically shown in Fig. 2. with a bar diagram. The IA equated from 33-year period data equals 21.64 and consequently shows that regional climate locates in Mediterranean categorization. But if 11-year period subdivisions are considered with IA amounts of 23.5, 20.7 and 19.66 respectively, it is observed that the type of climate in last 11-year period is changed from Mediterranean to semi-arid category. This change rate is schematically shown in Fig. 2. with a bar diagram.

<table>
<thead>
<tr>
<th>De Martin index (IA) range</th>
<th>Type of climate</th>
</tr>
</thead>
<tbody>
<tr>
<td>IA&lt;10</td>
<td>Arid</td>
</tr>
<tr>
<td>10&lt;IA&lt;19.9</td>
<td>Semi - Arid</td>
</tr>
<tr>
<td>20&lt;IA&lt;23.9</td>
<td>Mediterranean</td>
</tr>
<tr>
<td>24&lt;IA&lt;27.9</td>
<td>Semi- humid</td>
</tr>
<tr>
<td>28&lt;IA&lt;34.9</td>
<td>Humid</td>
</tr>
<tr>
<td>IA&gt;35</td>
<td>Hyper Humid</td>
</tr>
</tbody>
</table>

Table 1. Climate categorization according to De Martin method
RESULTS & DISCUSSIONS

Average annual precipitation versus average temperature is studied in order to find any contingent correlation (Durman et al., 2001; Hulme et al., 2002). As it is seen in Figure 3, annual precipitation of the region is descending remarkably with a slope of -4.31, while the average temperature is ascending with a negligible rate of 0.006. Accordingly, overall warming of the region in the considered period may play a key role in increasing the flood risk by reinforcing convective precipitations with high intensity and short periods. A comparison between annual and 24-hour precipitation pattern is shown in Fig. 4. The objective of this comparison is determining the share of 24-hour precipitation in the annual average one. According to Fig. 4, the behavior of both types of precipitation (24-hour and annual) is convergent specifically by the end of the period. This convergence is a typical characteristic of arid climate. Fig. 7, illustrates the increasing behavior of this parameter in recent years. Such condition indicates a reinforced tendency towards regional flood conformation. In order to analyze meteorological systems of the region, the latest synoptic maps before the flood occurrence in August 2005 in three different levels of 700 hectopascal, 850 hectopascal and ground level have been considered. Such selection has been used in similar studies (Ferraris and Reale, 2001). These maps are illustrated in Figures 8, 9 and 10 (NOAA, 2005). In the map of ground level pattern, the existence of north and north-west flows accompanied by sharp flow gradient highlights the maintenance of a cold front in the study area.
The interaction between a high-pressure system from north-west (Europe) and a low-pressure one from south-east (India) is observed in this level. In considered period, a sharp pressure gradient is observed in southern part of Caspian Sea. In the map indicating 850 hectopascal levels the direction of advections on Caspian Sea is seemed to be north and north-west ward. Furthermore, a high-pressure system is drawn in to northern Iran from Scandinavia is also designated. The average height of elevation curves is around 1485 goe-potential meter. Finally, in the map of 700 hectopascal level the most outstanding features are the existence of a blocking high-pressure on northern Caspian, a deep trough on central and particularly eastern parts and a high-pressure ridge on western parts.
The major direction of curves is north-west – south-east and the average height of them is about 3140 geo-potential meter. High pressure centers are observed on Caspian Sea in all maps. Not only high pressure centers but also cyclone systems in southern coastline of Caspian Sea are contributed in formation of high intensity precipitations and consequently increasing the regional flood potential.

CONCLUSION
Climate study in suspected water basins may provide invaluable data concerning flood forming potential of regional precipitations. The results of this study confirm the fact that precise analysis of climatic and hydrologic in watersheds threatened by flood-forming run-offs may be used efficiently in monitoring such areas and saving human lives. Gradual change from Mediterranean to semi-arid
climate during recent decades in Gorganroud watershed in addition to constant decrease in amount of average annual precipitation indicates the climate change in the region. This change automatically imposes its own characteristics to the local atmospheric and hydrologic situation. Increased share of 24-hour precipitation in average annual precipitation in one hand and decreasing rate of snowy on rainy days ratio on the other hand stipulate this climate change. Consequently, hydrologic behavior of the basin was highly influenced by newly imposed condition. The relatively sharp ascending pattern of annual peak flow of the basin during recent years may be considered as an alarming factor concerning streams inundation. Finally, recent synoptic maps before flood occurrence in August 2005 indicate the existence of high-pressure centers on Caspian Sea. Paying more attention to gathered information in this study could save hundreds of people’s lives. Similar studies are highly recommended for other water basins specially those who are threatened by flood potential.

REFERENCES


