Int. J. Environ. Res., 1(3): 231-236, Summer 2007
ISSN: 1735-6865

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

Rowshan, G. R. [1], Mohammadi, H.[1], Nasrabadi, T. [2*], Hoveidi, H.[2] and Baghvand, A.[2]

[1]Department of Geography, University of Tehran, Tehran, Iran
[2]Faculty of Environment, University of Tehran, Tehran, Iran

Received 10 Feb. 2007; Revised 5 April 2007; Accepted 25 April 2007

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

*Corresponding author: Email-tnasrabadi@gmail.com

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.

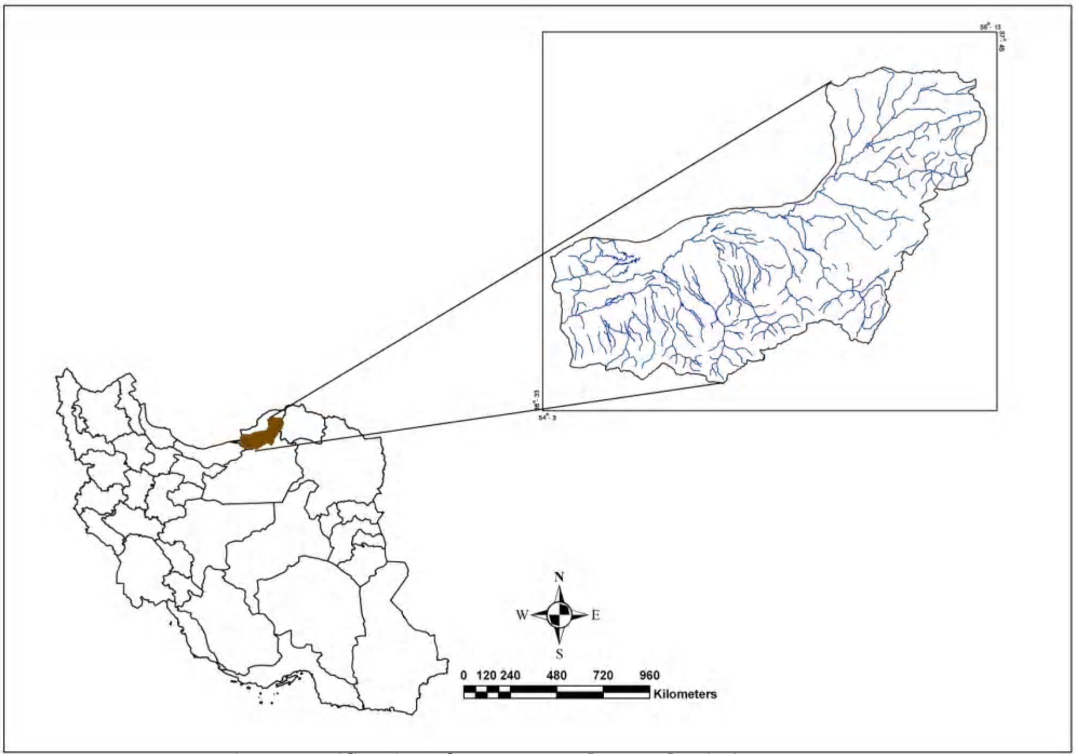

Fig.1. Specification of Gorganroud water basin in Iran's map

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^{o} 16' east longitude and 36^{o} 51' north latitude. Specification of the study area is schematically shown in Fig.1.

A 33-year period (1970-2003) was taken in to 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 in to 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):

$$IA = P / T+10$$

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 1. Climate categorization according to De Martin method

De Martin index (IA) range	Type of climate
IA<10	Arid
10<IA<19.9	Semi - Arid
20<IA<23.9	Mediterranean
24<IA<27.9	Semi- humid
28<IA<34.9	Humid
IA>35	Hyper Humid

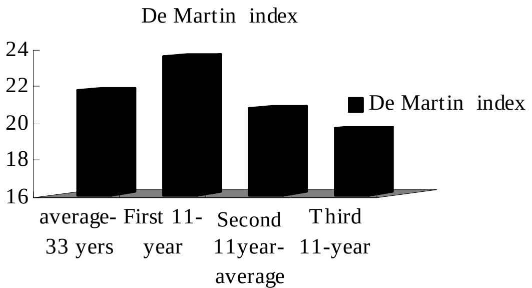

Fig.2. Change rate of De Martin index in Gorgan station for three 11-year periods

In order to ascertain the role of atmospheric systems in conformation of regional floods, the ratio of the number of snowy days on rainy days as well as the ratio of temperature and snowy days in the study period have been analyzed separately. The result of this analysis is shown in Fig.5. As it is seen in Fig. 5, the ratio of snowy on rainy days is decreasing in a slight manner, while the ratio of temperature on snowy days increases with a relative rapid rate during the specified 33-year period. This fact does reinforce the flood potential in the mentioned watershed. Considering hydrologic fluctuations in Gorganroud watershed, maximum peak flow as a major effective parameter in determination of flood behavior has been considered. Accordingly, the average maximum of annual peak flow during recent decades in the watershed is identified and illustrated in Fig.6. According to Fig. 6, peak flow parameter has undergone an ascending rate during recent years. In order to highlight the increasing rate of this parameter quantitatively, the 21-year is divided into three 7-year periods and the average annual peak flow is determined for each period separately.

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.

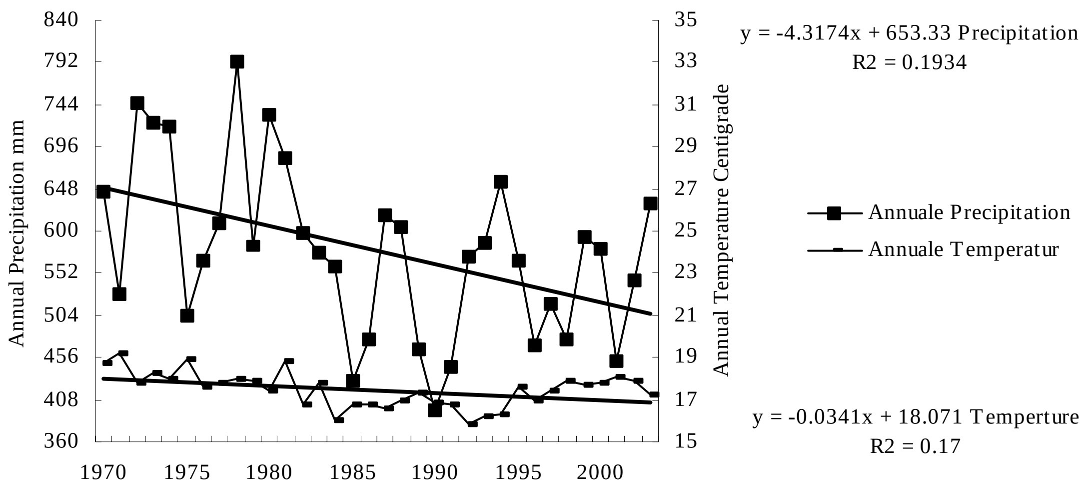

Fig. 3. Annual temperature and precipitation ambrothermic diagram of Gorgan station

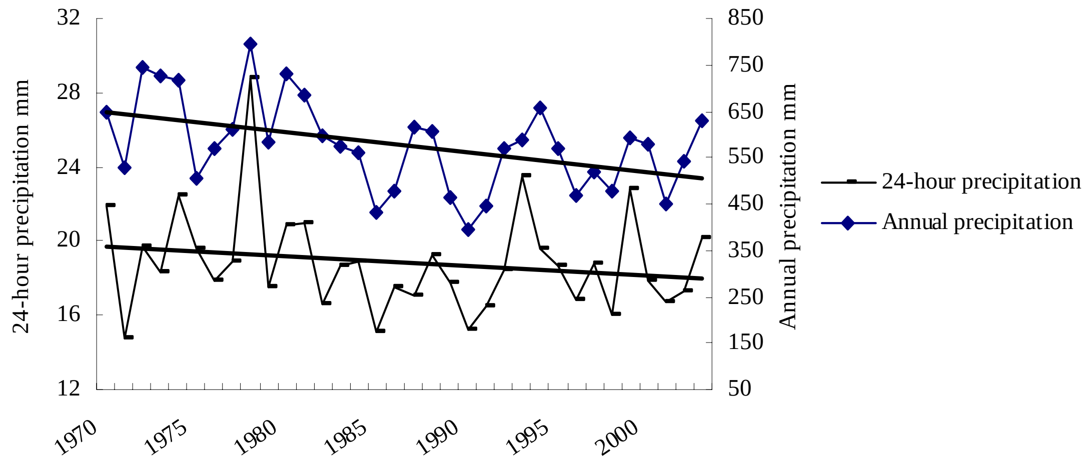

Fig. 4. A comparison between 24 hr and annual precipitation of Gorganroud watershed

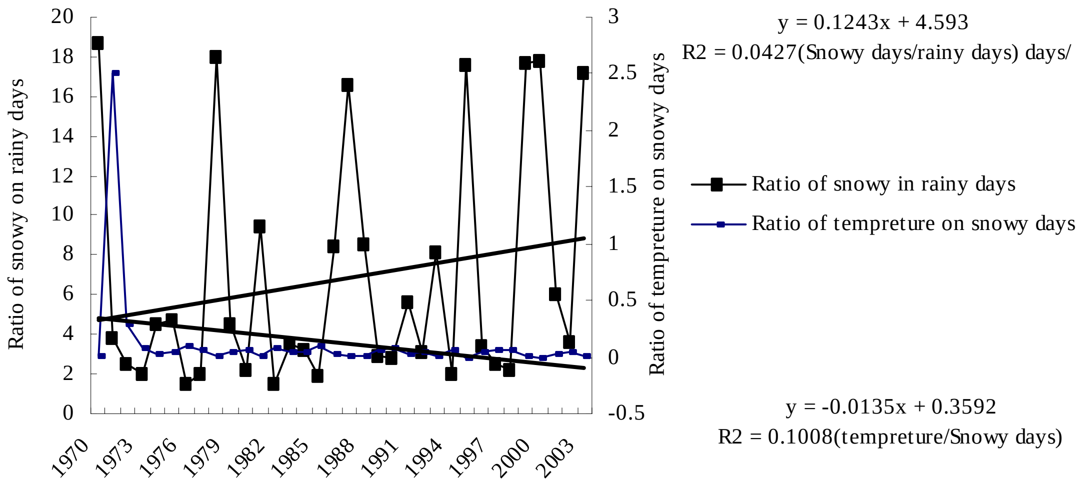

Fig. 5. The ratio of snowy and rainy days compared with the ratio of temperature and snowy days in study period

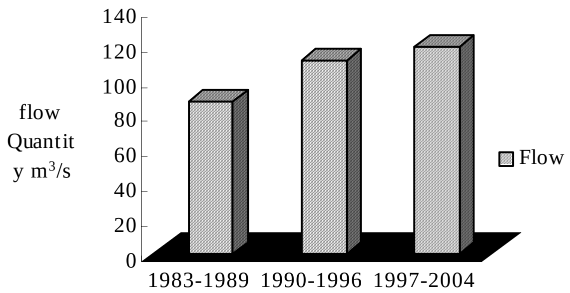

Fig. 6. Annual average of peak flow in Gorganroud watershed during recent decades

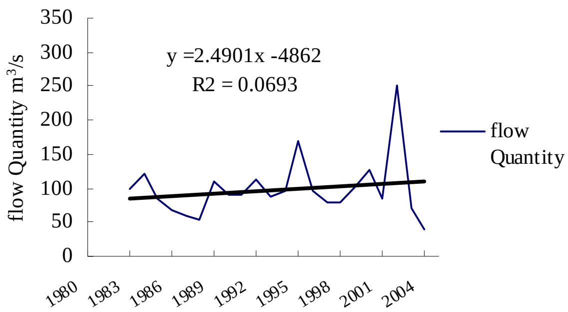

Fig. 7. Amounts of average annual peak flow for three 7-year periods in Gorganroud watershed

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.

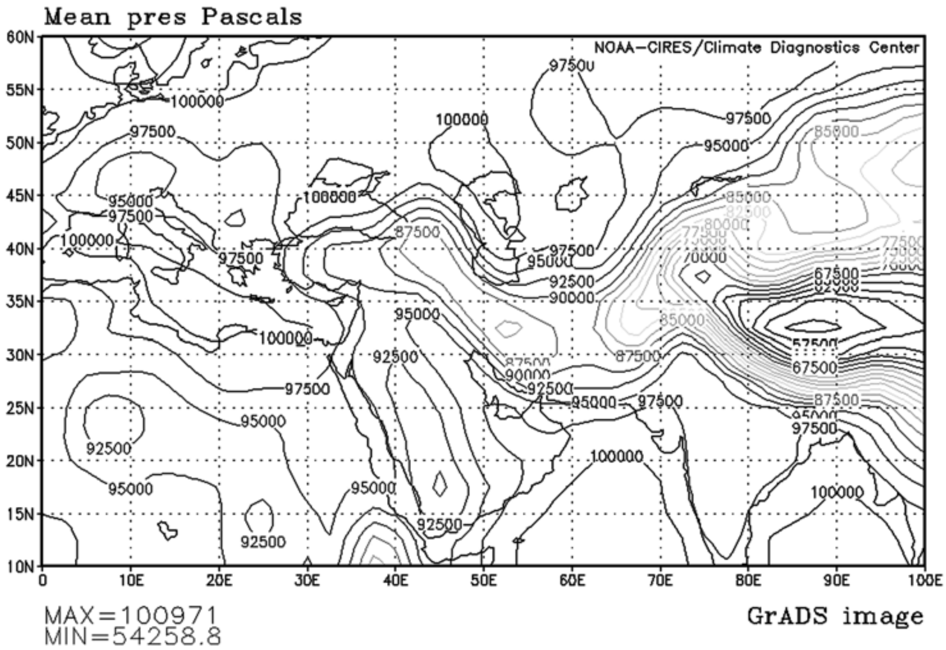

Fig.8. Synoptic map in ground level

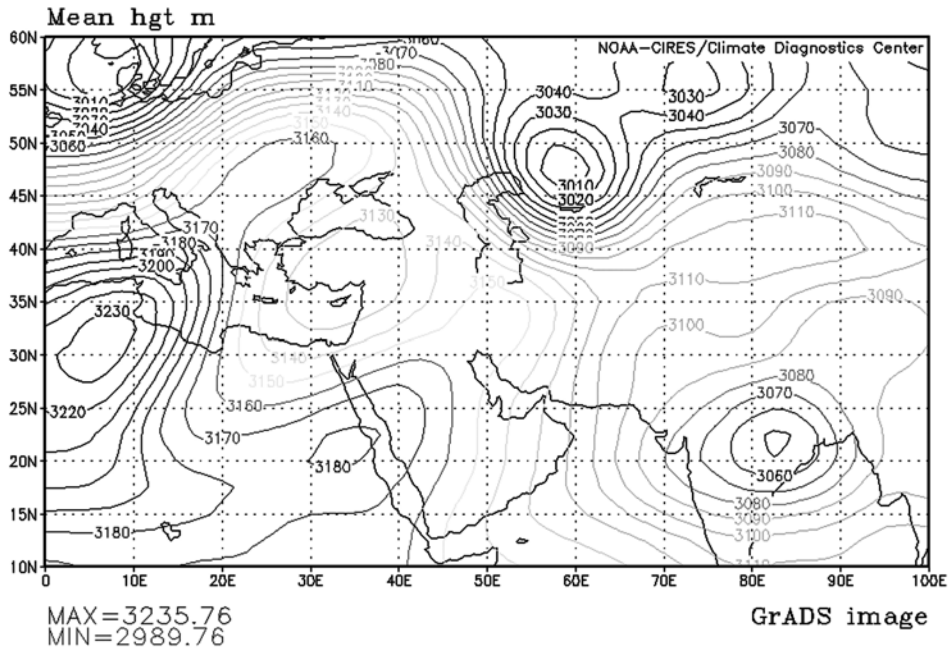

Fig.10. Synoptic map in 700 hectopascal level

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

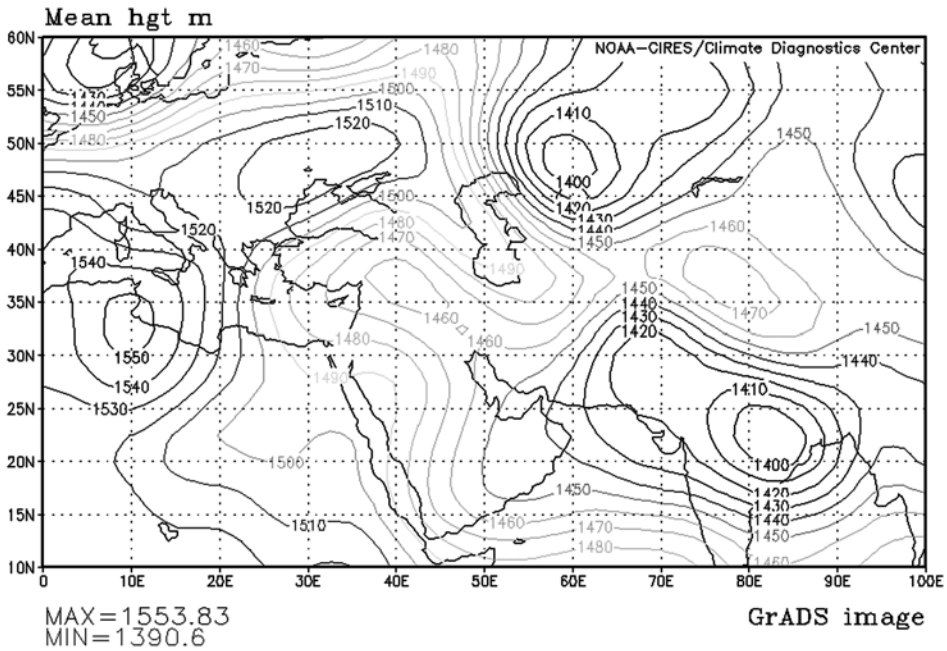

Fig.9. Synoptic map in 850 hectopascal level

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

Alizadeh, A., (2002). Principles of Applied Hydrology, Imam Reza University publication, 14th. Ed. Costelloe, J.F., Grayson, R.B., Argent, R.M. and McMahon, T.A., (2003). Modeling the flow regime of an arid zone floodplain river, Diamantine River, Australia, Environ. Model. Software, **18**, 693-703.

Durman, C. F., Gregory, J. M., Hassell, D. C., Jones, R. G. and Murphy, J. M., (2001). A comparison of extreme European daily precipitation simulated by a global and a regional climate model for present and future climates, Quarter. J. Royal Mete. Soc., **127** (573), 1005-1015.

Ferraris, L. and Reale, O., (2001). Synoptic and hydrological analysis of a flood event, Physics Chemi. Earth, **26**(9), 655-661.

Gumbricht, T., Wolski, P. and McCarthy, T.S., (2004). Forecasting the spatial extent of the annual flood in the Okavango Delta, Botswana, J. Hydrol. **290**, 178-191.

Heratha, S. and Ratnayake, U., (2004). Monitoring rainfall trends to predict adverse impacts, a case study from Sri Lanka (1964–1993). **14**, 71-79

Hulme, M., Jenkins, G.J., Lu, X., Turnpenny, J. R., Mitchell, T. D., Jones, R. G., Lowe, J., Murphy, J. M., Hassell, D., Boorman, P., McDonald, R., Hill, S., (2002). Climate Change Scenarios for the United Kingdom: The UKCIP02 Scientific Report. Tyndall Centre for Climate Change Research, School of Environmental Sciences, University of East Anglia, Norwich, UK.

Huntingford, C. Jones, R.G. Prudhomme, C. Lamb, R. Gash, J.H.C. and Jones, D.A., (2003), Regional climate-model predictions of extreme rainfall for a changing climate, Quarter. J. Royal Mete. Soc., **129** (590), 1607–1621.

NOAA, (2005). National Center for Environmental Prediction, http://www.cdc.noaa.gov