Vol. 15, No. 1, pp. 63-68 (2015)
Journal of Agricultural Physics
ISSN 0973-032X
http://www.agrophysics.in

Research Article

Rainfall Zone and Its Trend Analysis in Haryana Using GIS

VINOD KUMAR, RAM NIWAS* AND M.L. KHICHAR

Department of Agricultural Meteorology, CCS Haryana Agricultural University, Hisar-125004, Haryana

ABSTRACT

A study was conducted to evaluate trends in rainfall recorded at different agro-meteorological stations in Haryana for a period of >30 years and delineate rainfall zones in the state. Annual rainfall are 815.0, 757.7, 611.0, 601.8, 490.7, 455.4 and 389.4 mm at Ambala, Karnal, Rohtak, Bawal, Narnual, Hisar and Sirsa with coefficients of variation of 9.0, 9.4, 9.8, 10.2, 9.8, 9.2 and 8.9%, respectively. Seasonal rainfall has increasing trends in all the seven stations during *kharif* season except at Karnal where the rainfall is decreasing. The *rabi* season rainfall shows increasing trends in all except Ambala and Rohtak stations, where rainfall is marginally decreasing over the years. Annual rainfall is showing increasing trends except the Karnal station, where annual rainfall is decreasing @ -1.2 mm yr^{-1}. The rate of increase is largest in Narnual (6.0 mm yr^{-1}) and lowest in Rohtak (0.7 mm yr^{-1}). Average rate of increase in rainfall is 2.52 mm yr^{-1}. Based on the analysis, the state Haryana was divided into three zones. Annual normal rainfall value varied from 389.4 to 815.0 mm and a decreasing trend in rainfall from north east to south west Haryana is evident.

Key words: Rainfall, trend analysis, climate zone, GIS

Introduction

The State of Haryana and its farmers, once at the centre stage of Green Revolution are facing several problems of sustaining agricultural productivity (Singh, 2000). The problems can be analyzed in many aspects. First, the rice-wheat cropping system, declining water table and overall resource degradation (soil and water); second, the canal irrigated zone, the cotton-wheat belt, is the region where ground water is brackish in nature, a factor limiting their exploitation for irrigation. Fall in groundwater table and heavy use of fertilizer and agro-chemicals related problems are limiting profitability of farmers, contributing to serious environmental, and health problems. The third, the ecologically fragile Bawal/ Mahendergarh region, is distinct in that the problems facing farmers relate to recurrent droughts and rainfall variability. In order to sustain agricultural productivity and efficiently use the scare resources of water, spatiotemporal analysis of rainfall is most essential. Study of rainfall trend over the years is most important for Indian agriculture (Kumar *et al*., 2010). Agroecological zoning based on historical rainfall data and using GIS has been done successfully in many occasions (e.g. Patel *et al*., 2000; Sharifan and Alaghmand, 2007). No recent study on rainfall trend and zoning with GIS has been reported in Haryana. The present study was conducted to evaluate trends in rainfall recorded at different agro-meteorological stations spread across the state of Haryana and to delineate distinct rainfall zones for proper water resources management.

*Corresponding author,
Email: ramniwas2022@gmail.com

Materials and Methods

The present investigation was carried out in Department of Agricultural Meteorology, Chaudhary Charan Singh Haryana Agricultural University, Hisar in collaboration with Haryana Space Application Centre (HARSAC), Hisar. Daily rainfall data for a period of > 30 years from seven agro-meteorological stations: Hisar and Sirsa (arid), Bawal, Narnaul, Rohtak and Karnal (semi arid), and Ambala (dry sub humid) were obtained from agrimet-observatory of the University and the India Meteorological Department, New Delhi.

Daily rainfall data was summed up to find out monthly, seasonal and annual rainfall for each year of time data series. Their normal values were computed by taking the average of all the years in time series taken of respective stations as per formula given below:

(1) Monthly rainfall $= \sum_{i=1}^{n} Ri$

(2) Kharif rainfall $= \sum_{j=May}^{September} Rj$

(3) Rabi rainfall $= \sum_{j=October}^{April} Rj$

(4) Annual rainfall $= \sum_{j=1}^{12} Rj$

(5) Normal rainfall $= \sum_{k=1}^{l} Rk/l$

where, Ri and Rj = Rainfall of i-th day and j-th month, n = Last day of the month, Rk = Monthly, seasonal and annual rainfall of k-th year; l = Number of years in data time series.

Trends in rainfall for all agro-meteorological stations were analyzed by fitting a linear trend line in Microsoft Excel worksheet. Rainfall map was prepared in the GIS environment using Arc Info 10.1. Rainfall data of all stations was entered in attribute table along with coordinates and attached to the point file coverage already generated. The point file coverage was then converted to the raster format through krigging method. Zoning divides the area into units based on spatial distribution of rainfall data. Zones are spatial units related to rainfall within the same mapping unit.

Results and Discussion

Daily past rainfall data of >30 years were used for computing monthly, seasonal, annual and normal values for seven meteorological stations (Ambala, Bawal, Hisar, Karnal, Narnaul, Sirsa and Rohatak) of Haryana and results and presented as under:

Table 1. Normal annual rainfall (mm) at different meteorological stations in Haryana

Month	Hisar	Sirsa	Rohtak	Bawal	Narnual	Karnal	Ambala
January	12.0	9.0	17.1	10.6	14.0	24.7	27.0
February	17.8	18.9	16.3	15.5	16.7	31.3	40.4
March	12.7	12.7	21.7	10.9	7.6	25.9	26.3
April	11.5	8.1	13.6	11.2	8.2	14.4	19.8
May	30.7	23.5	32.9	33.6	32.2	27.5	34.6
June	55.5	54.8	53.0	69.4	75.8	92.5	100.5
July	127.1	107.2	159.6	158.3	148.5	206.2	235.1
August	106.7	75.4	183.1	172.9	112.3	194.5	175.9
September	63.9	66.1	74.8	100.2	59.6	106.7	114.8
October	9.8	8.9	16.9	9.6	8.9	15.1	11.4
November	3.4	2.5	12.6	4.4	2.3	5.6	8.9
December	4.4	2.5	9.5	5.0	4.5	13.4	20.4
Mean	455.4	389.4	611.0	601.8	490.7	757.7	815.0
SD	41.8	34.6	59.6	61.4	48.3	71.4	73.5
CV (%)	9.2	8.9	9.8	10.2	9.8	9.4	9.0

1. Normal rainfall

Annual rainfall was 815.0, 757.7, 611.0, 601.8, 490.7, 455.4 and 389.4 mm at Ambala, Karnal, Rohtak, Bawal, Narnual, Hisar and Sirsa with coefficients of variation 9.0, 9.4, 9.8, 10.2, 9.8, 9.2 and 8.9 per cent, respectively (Table 1). Seasonal rainfall showed increasing trends at all the stations during *kharif* season except at Karnal where, a decreasing trend was observed. In *rabi* season also, increasing trend were observed at all stations except at Ambala and Rohtak (decreasing trends). Normal value of annual rainfall was highest at Ambala, followed by Karnal, Rohtak, Bawal, Narnual, Hisar and Sirsa stations. This might be due the fact that Ambala is situated near Siwalik range and Sirsa is located far away. The average normal annual rainfall in Haryana was 588.7 mm.

2. Rainfall trend

Seasonal rainfall trends were quantified for different stations and are presented in Fig. 1. In all cases, the rainfall is increasing in *kharif* (all stations), and in *rabi* (all except in Ambala and Rohtak, where it showed decreasing trend). The rate of increase in rainfall in *kharif* was 4.7, -1.3, 1.2, 5.9, 4.8, 1.6 and 2.7 mm yr^{-1} in Ambala, Karnal, Rohtak, Bawal, Narnual, Hisar and Sirsa, respectively. The corresponding values for *rabi* rainfall were -2.9, 0.1, -0.1, 0.1, 1.2, 0.2, 0.01 mm yr^{-1}, respectively; the rate of change in annual rainfall over years were 1.8, -1.2 , 0.6, 5.9, 6.0, 1.7 and 2.5 mm yr^{-1} in Ambala, Karnal, Rohtak, Bawal, Narnual, Hisar and Sirsa, respectively.

Annual rainfall showed increasing trend at all meteorological stations except at Karnal, where a decreasing trend in rainfall was recorded (-1.2 mm yr^{-1}) (Fig. 2). It was maximum (6.0 mm yr^{-1}) in Narnual and minimum in Rohtak (0.64 mm yr^{-1}) in Haryana. Average rate of increase in rainfall of all stations was 2.52 mm yr^{-1} (25.2 mm $decade^{-1}$) in Haryana. This is supported by Kaur and Hundal (2006) who reported an increase in rainfall (10.5 mm yr^{-1}) in Ludhiana, Punjab. The

Table 2. Statistics for significance of slope values of linear trend line of rainfall

Sr. No.	Meteorological stations	Seasons	Slope	Standard error	t value	Significance
1	Ambala	Rabi	-2.90	1.195	-2.429	0.021
		Kharif	4.739	3.789	1.251	0.220
		Annual	1.834	3.834	0.479	0.635
2	Narnual	Rabi	1.217	0.993	1.225	0.215
		Kharif	4.784	4.648	1.029	0.295
		Annual	6.001	0.893	1.225	0.200
3	Bawal	Rabi	0.062	0.776	0.081	0.934
		Kharif	5.896	4.401	1.340	0.176
		Annual	5.958	4.734	1.268	0.200
4	Rohtak	Rabi	-0.097	0.817	-0.119	0.906
		Kharif	1.156	3.417	0.333	0.741
		Annual	0.639	3.766	0.281	0.780
5	Hisar	Rabi	0.146	0.470	0.654	0.516
		Kharif	1.598	1.811	1.305	0.199
		Annual	1.730	1.940	1.377	0.176
6	Karnal	Rabi	0.129	0.932	0.139	0.890
		Kharif	-1.286	3.213	-0.400	0.691
		Annual	-1.157	3.448	-0.336	0.739
7	Sirsa	Rabi	0.011	0.819	0.014	0.989
		Kharif	2.703	3.470	0.779	0.443
		Annual	2.522	3.69	0.752	0.458

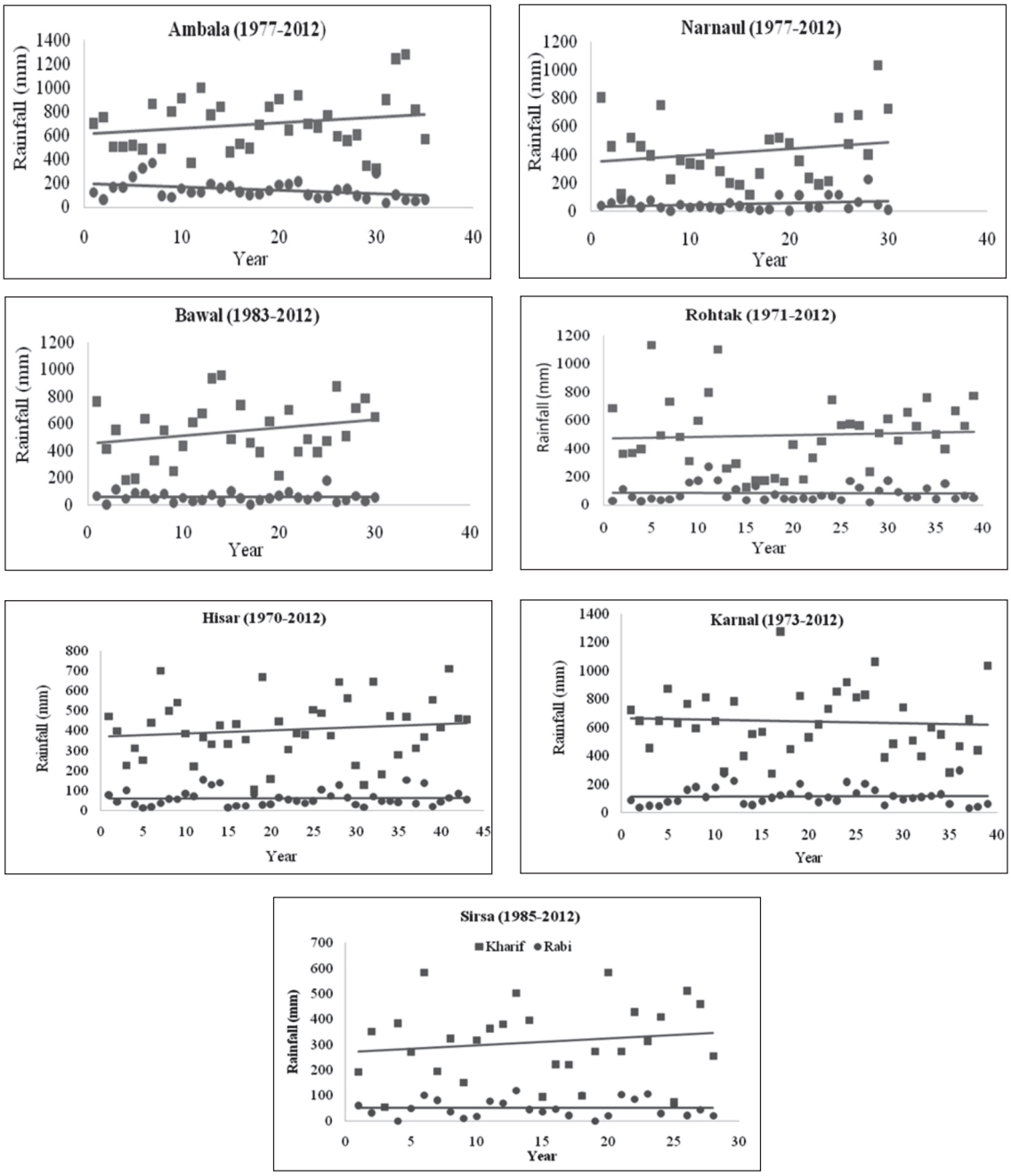

Fig. 1. Seasonal rainfall trend at different meteorological stations in Haryana

slope values of the regression line were not significant, as revealed through statistics (Table 2). However, rising trend in rainfall may be visualized by bio-indicators like khajari, zall *etc* (arid vegetation), which have shifted to border areas of Rajasthan, sometime which was the main vegetation of southern and western in Haryana.

Spatial variation map of annual rainfall in Haryana was prepared using the normal annual rainfall of all the stations using GIS. Rainfall map indicates that rainfall decreased from north-east to south–west in Haryana. This decrease in rainfall might be attributed to physiography of Haryana (topography-relief decreases from north-east to south-west parts of Haryana). Normal annual rainfall varied as 815.0 to 389.4 mm. The map shows distribution and spread of zones across the districts of Haryana (Plate 1).

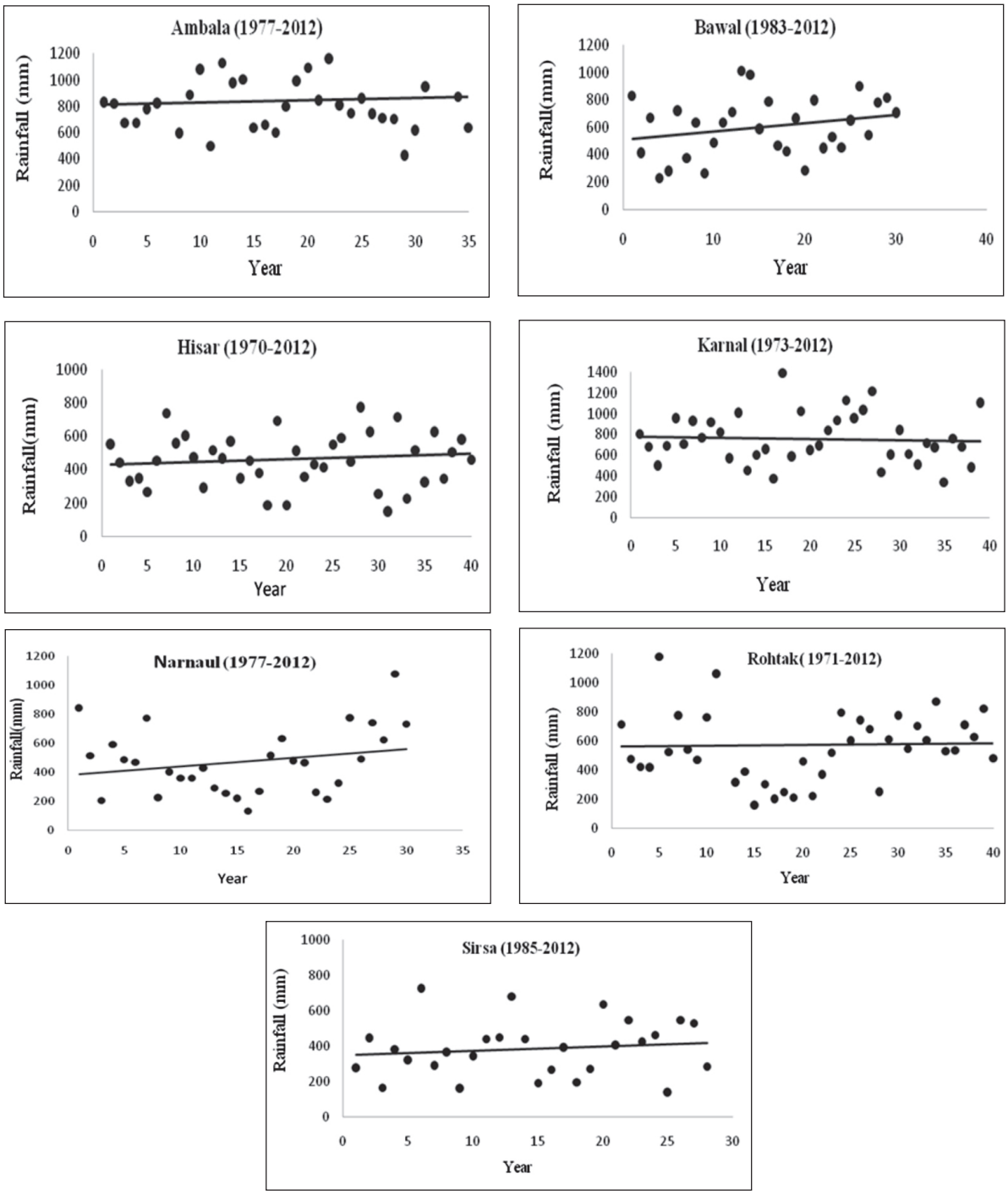

Fig. 2. Annual rainfall trend at different meteorological stations in Haryana

Conclusions

Based on the above results it may be concluded that the *kharif* rainfall shows increasing trend at most of the stations, while rainfall in *rabi* is decreasing at Rohtak, Sirsa, and Ambala and increasing in rest of the stations. Annual rainfall although has been increasing with an average rate of 2.52 mm yr^{-1} in Haryana but it is statistically not significant.

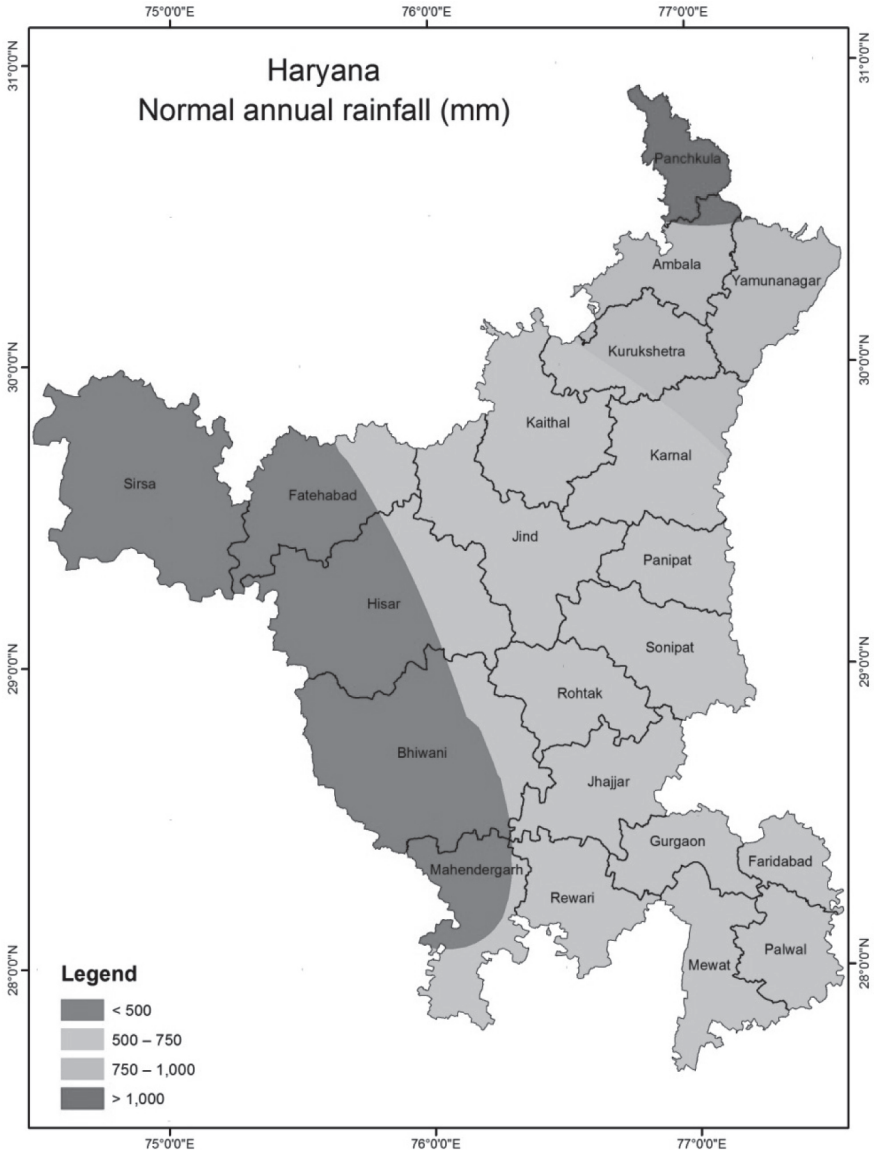

Plate 1. Normal annual rainfall (mm) of Haryana

References

Kaur, P., and Hundal, S.S. 2006. Effect of possible futuristic climate change scenarios on productivity of some kharif and rabi crops in the Central Agroclimatic Zone of Punjab. *J. Agric. Physics* **6**: 21-27.

Patel, N.R., Mandal, U.K., and Pande, L.M. 2000. Agro-ecological zoning system-A Remote Sensing and GIS perspective. *J. Agrometeorol.* **2**(1): 1-13.

Sharifan, H. and Alaghmand, S. 2007. Zoning of the 10-Days, Monthly and Annual Rainfall Using GIS: A Case Study on Golestan Province, Iran. Map Asia (alaghmand_sina@yahoo.com)

Singh, R.B. 2000. Environmental consequences of agricultural development: a case study from the Green Revolution state of Haryana, India. *Agric. Ecosys. Enviro.* **82**: 97-103.

Kumar, V., Jain, S.K. and Singh, Y. 2010. Analysis of long-term rainfall trends in India. *Hydrol. Sci. J.* **55**: 484-496.

Received: January 23, 2015; Accepted: April 29, 2015