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Research Article

STUDY AND ANALYSIS OF TIME SERIES MODEL FOR ANNUAL PRECIPITATION (A CASE STUDY ON BAM- AS A CITY OF IRAN)

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ABSTRACT
Different climatic factors are volatile and various over period of time. It is supposed to carry out a study on these variations. Some of these variations follow a specific pattern and some of them do not have a regular pattern. These irregular patterns are called random change. In this research firstly, characteristics and variability of Bam precipitation are studied; then time series analysis model for annual precipitation of the weather station is analyzed and estimated. In order to reach the research objectives, statistic methods (descriptive and deductive) were used and concluded that mentioned series had irregular random change and average is the best criteria to predict the random change of this series.

Keywords: *Precipitation Variability, Bam Precipitation, Random Change, Time Series*

INTRODUCTION
Climate signifies the average of permanent weather conditions which is a crucial element in our environment. Climate change and climate variability are two main characteristics of different climates that hold unexpected climatic change. Climate change means the average of weather conditions change in a particular place (Hggett, 1997). In other words, climate change is the difference between averages of climatic data which is beyond the natural climatic variability (Obasi, 2000). Climate change is directly connected with directly connected with human activities, and has been concerned by environmental scientists and specialists in the recent centuries (Najaf, 2006). The term of climate change means the unusual variability of climatic elements of average amount within specific period of time such as month, season or year (Obasi, 2000). Climate variability includes characteristics affected by planets factors, and happens within regular specific time and location cycle (Najaf, 2006).

Time Precipitation Model in Bam Weather Station
Precipitation is the most variable climatic element. The average of annual precipitation of Bam according to Bam weather station was 61.4 millimeter. It is 188.6 millimeter less than Iran annual average precipitation which is 250 millimeter (Masoudian, 2011). It shows a big shortfall in precipitation of this station as compared with the whole country precipitation. According to the statistics, the least amount of precipitation was 20.4 millimeter in Bam in 1980. Big precipitation change can be observed in both long-term and in short-term at Bam station.

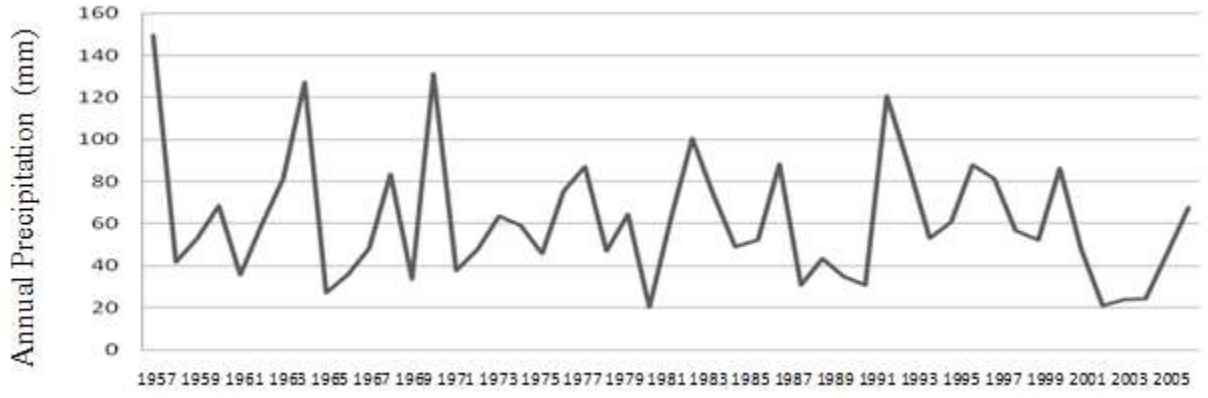

Figure 1: Annual Precipitation change from 1957 to 2005

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Rainy Days of Bam Weather Station

The number of rainy days in Bam on average was 21.7 days per year. As compared with the country's annual rainy days, it is 31.3 days less than the annual number of rainy days in Iran which was 53 days. The average number of rainy weather does not exceed 4.2 days per month. The number of rainy days in August and September is the least with the average of 0.1 days per month and it is the most in January, February, March and April with average of 3.3 days per month. And the top number of rainy days in Bam is in March with the average of 4.2 days a month.

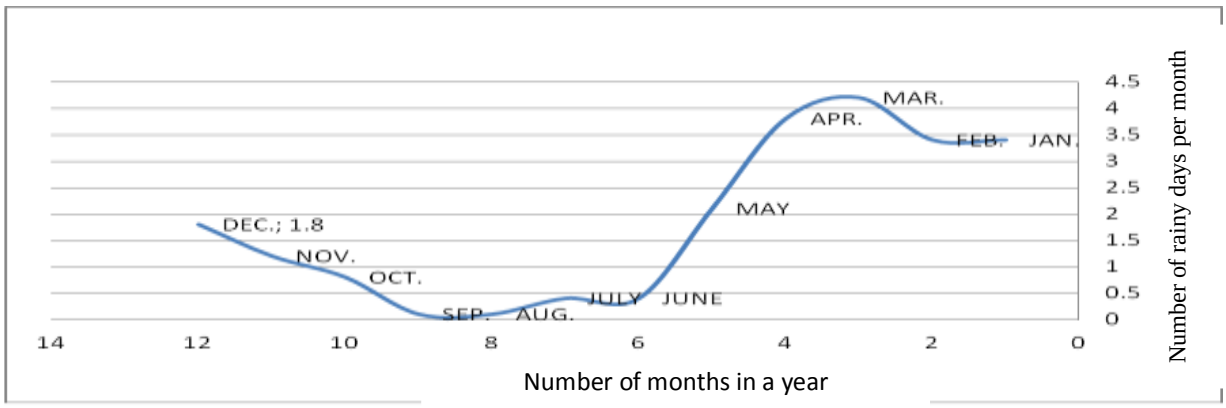

Figure 2: Monthly average number of rainy days in Bam

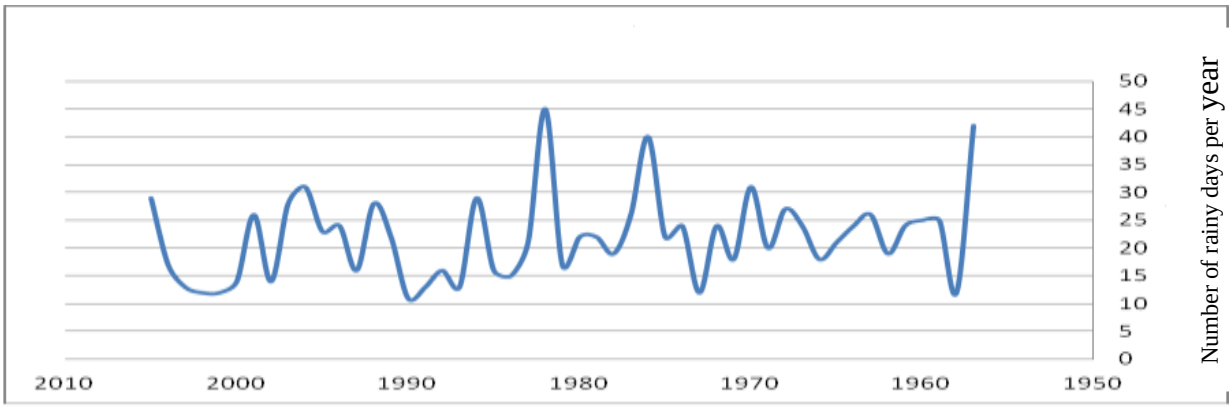

Figure 3: Annual average number of rainy days in Bam

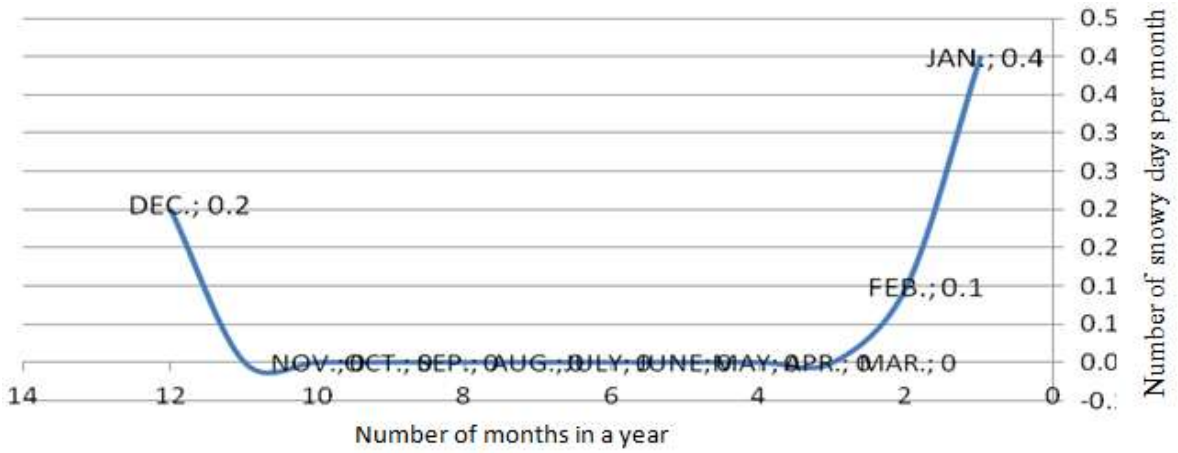

Figure 4: Monthly average number of snowy days in Bam

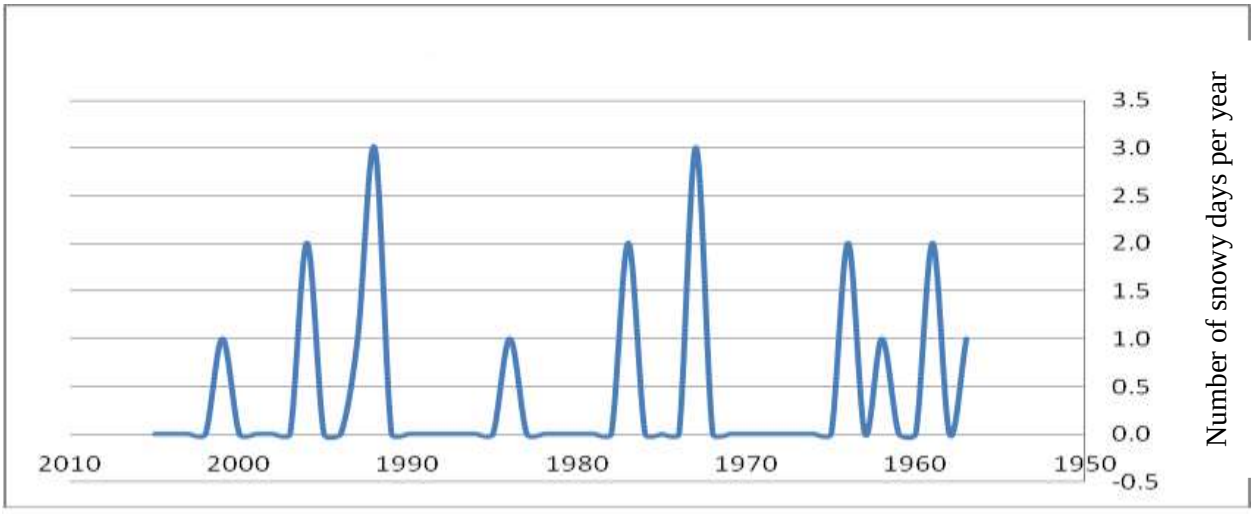

Figure 5: Annual average number of snowy days in Bam

Snowy Days of Bam Weather Station

The rate of snowy days follows the temperature rate. In the first nine months of year (from March to September) there was no snow recorded at the station.

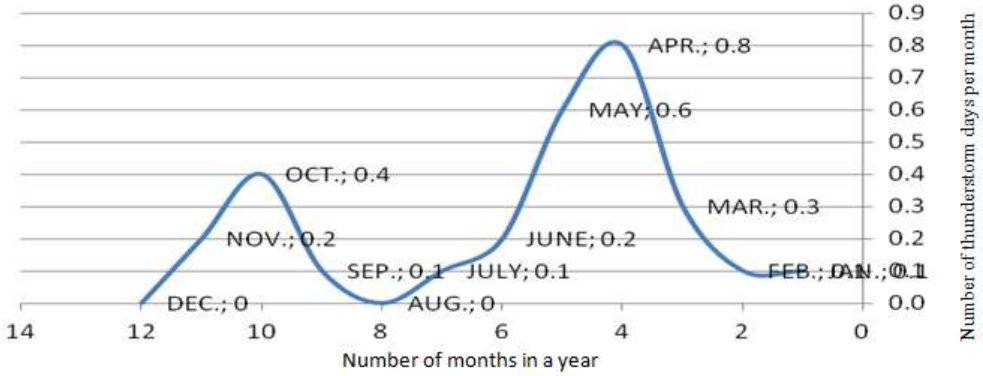

Figure 6: Monthly average number of thunderstorm days in Bam

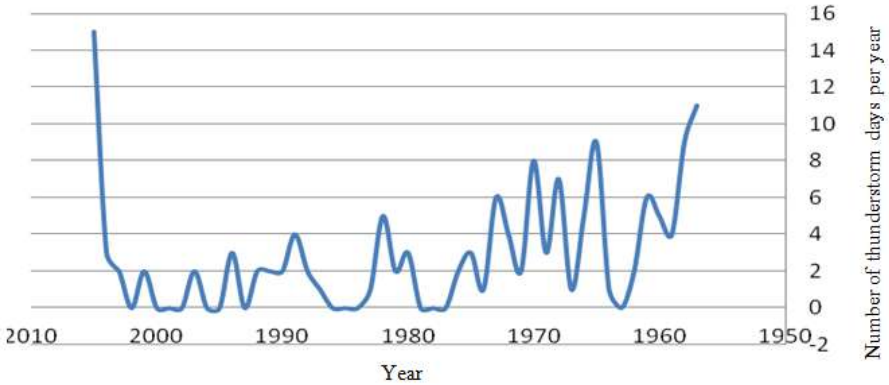

Figure 7: Annual average number of thunderstorm days in Bam

The snow was recorded only in months of October, January and February (with the average of maximum 0.4 days in a month in January). The average of snowy days in Bam is 0.7 days per year. As compared

with the country's annual snowy days, it is 8.3 days less than the annual number of snowy days in Iran which was 9 days (Masoudian, 2011). So, it means that it does not snow much in this city.

Thunderstorm Days of Bam Weather Station

Thunderstorm days represent a great deal of variation in climate. Thunderstorm is a rare occurrence in Bam. The average of thunderstorm days in Bam is 2.9 days per year. As compared with the country's annual thunderstorm days, it is 7.1 days less than the annual number of thunderstorm days in Iran which was 10 days (Masoudian, 2011). The maximum monthly average number of thunderstorm days in Bam belongs to March with 0.8 days a month. The emergence of thunderstorm mostly results from surface heating and local convection. That is why the number of thunderstorm days in Bam is more in spring.

Precipitation Regimes of Bam Weather Station

Precipitation is a climatic phenomenon and its amount changes according the time and place. However, precipitation regimes represent relative distribution of precipitation in different seasons or months. It has more time and location stability comparing with the amount of precipitation. In other words, the natures of these two climatic characteristics (precipitation amount and regimes) are different. That is why precipitation regimes result from consistent synoptic pattern which provides precipitation for the region (Masoudian, 2011). Bam weather station has winter precipitation regimes and the shares of different seasons are as follows: Winter 58%, spring 25%, summer 2%, fall 15%.

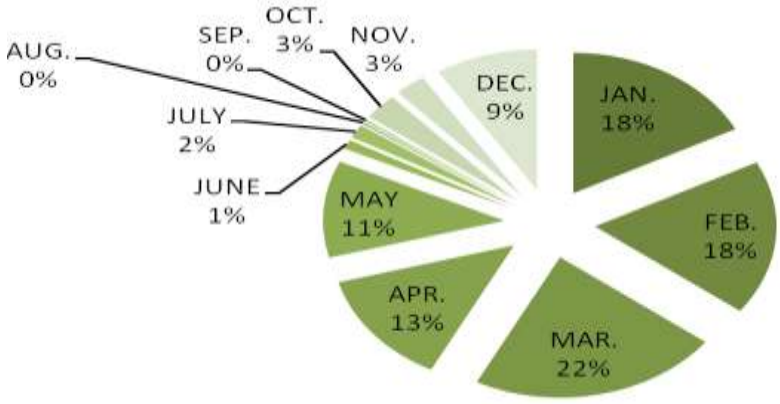

Figure 8: Relative distribution of precipitation in Bam in different months from 1990 to 2005

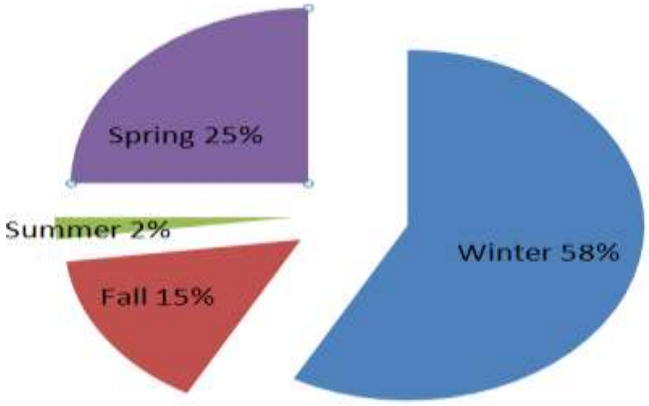

Figure 9: Relative distribution of precipitation in Bam in different seasons from 1990 to 2005

MATERIALS AND METHODS

Methodology

Collected time series of data are considered in short or long term. In fact, time series are samples of a big society which are gathered over period of time. Most of climatic data have such characteristics. It means the data have been collected over equal time intervals (Farjzadeh, 2007).

Classic elements of time series are as follows:
1) ***Trend:*** A general and long-term tendency that shows time series. In fact, upward trend is ascending time series and downward trend is descending time series.
2) ***Seasonal Fluctuations:*** They are frequent short term changes which occur in a period of less than a year.
3) ***Periodic Changes:*** The periodic or cycle changes are the repetitive ascending or descending changes which occur in a period of more than a year. Periodic changes usually take 5 to 9 years.
4) ***Irregular or Accidental Changes:*** Irregular or random changes are the subject of the present research. They are a kind of irregular and scattered changes that do not follow any specific pattern. Infact, they remain in the series after other elements calculation of time series (trend, seasonal fluctuations and periodic changes) (Javeri, 2009).

Table 1: Time series of annual precipitation of Bam weather station (1957-2005)

Row	Year	Precipitation (mm)	Row	Year	Precipitation (mm)	Row	Year	Precipitation (mm)
1	1957	149.5	18	1974	59	35	1991	120.8
2	1958	41.6	19	1975	45.6	36	1992	87.9
3	1959	53.2	20	1976	75.2	37	1993	53.2
4	1960	68.3	21	1977	87	38	1994	60.7
5	1961	35.2	22	1978	47.2	39	1995	88.1
6	1962	59.5	23	1979	64.5	40	1996	81.4
7	1963	81.5	24	1980	20.4	41	1997	56.9
8	1964	127	25	1981	62.2	42	1998	52.3
9	1965	27.3	26	1982	100.3	43	1999	86.3
10	1966	35.7	27	1983	73.5	44	2000	47.7
11	1967	48.3	28	1984	49	45	2001	21.1
12	1968	83.5	29	1985	52.1	46	2002	24
13	1969	33.6	30	1986	88.4	47	2003	24.3
14	1970	131.2	31	1987	30.6	48	2004	45.9
15	1971	37.5	32	1988	43.3	49	2005	67.8
16	1972	48	33	1989	34.7			
17	1973	63.6	34	1990	30.8			

Reference: site of weather forecast offices of Chaharmahal and Bakhtiari Province

Very few studies have been conducted about irregular or random changes in Iran. Among the available researches, there are two cases with the related subject. One of them is "Prediction of temperature random changes in Iran" (Mohammadi and Javeri, 2005) and the other one is "Temporal changes in precipitation of Iran" (Mohammadi and Javari, 2006).
Data of this research are time series of annual precipitation of Bam weather station from 1957 to 2005 and were analyzed by statistics method (descriptive-deductive). According to Mohammadi and Javeri's research findings and excluding, the whole country is inside the precipitation area excluding provinces of

west Azerbaijan, east Azerbaijan and Ardebil. So in the present research, precipitation data of Bam weather station which is included in the mentioned precipitation area will be analysed. Process to study time series changes of climatic elements are as follows: evaluation, analysis, prediction and control. Evaluation is the most important process to study time series changes of climatic elements. Evaluation process means that researcher has to evaluate whether series has enough credit to be analyzed or not? If it does, he has to describe it as model. The researcher performs the evaluation process in two steps. The first and the second steps of evaluation are done as mode (Javeri, 2009).

Series Evaluation

The first step of evaluation to apply the test is to evaluate precipitation data whether they have normal condition or not. In order to evaluate the normal condition, there are two ways including graphic and quantitative evaluation. In this research by using normal distribution diagram and Kolmogorov–Smirnov test, normality of precipitation series is analyzed. Normal distribution diagram of series (diagram 10) signifies that series have normal distribution. Also evaluation of precipitation series normality of Bam weather station by Kolmogorov–Smirnov test (Table number 2) represents its normal distribution.

Table 2: K-S test results

		Bam precipitation
N		49
Normal Parameters[a,b]	Mean	61.373
	Std. Deviation	29.6049
Most Extreme Differences	Absolute	.119
	Positive	.119
	Negative	-.083
Kolmogorov-Smirnov Z		.833
Asymp. Sig. (2-tailed)		.492

a. Test distribution is Normal.
b. Calculated from data.

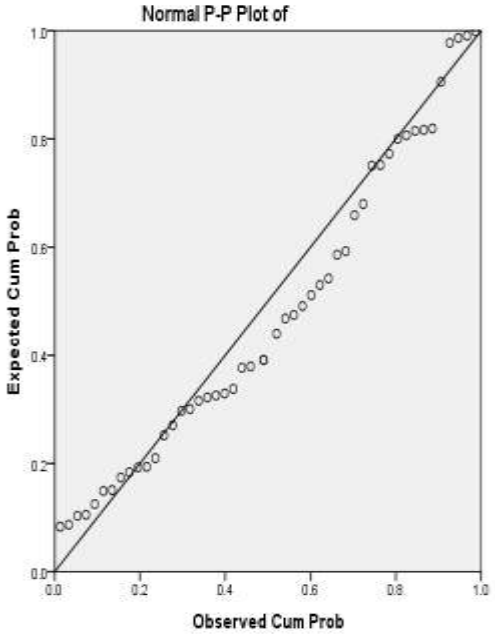

Figure 10: Normal distribution precipitation series

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In the second step by using parametric tests and non-parametric tests, series are studied in the form of a model in order to come to this point whether Bam precipitation series can be evaluated or not by using random models. Regarding the result of first step (normality of Bam precipitation series) parametric tests should be used to evaluate stochasticity or randomness of Bam precipitation series. Thus, by using autocorrelation function test which is one of parametric test, autocorrelation of the mentioned series with pause 3 is evaluated with the help of SPSS software.

RESULTS AND DISCUSSION

Autocorrelation Function Test

When a time series is independent, correlation coefficient between a series is considered sequentially. It should be noted that stationary series are zero without seasonal fluctuations or autocorrelations (rests are random). Or they are close to zero in the pauses. When simple autocorrelation coefficients are measured and drawn in different pauses, they are called simple autocorrelation function and are showed with an abbreviation of ACF (Fatemi-e-Ghomi 1994).

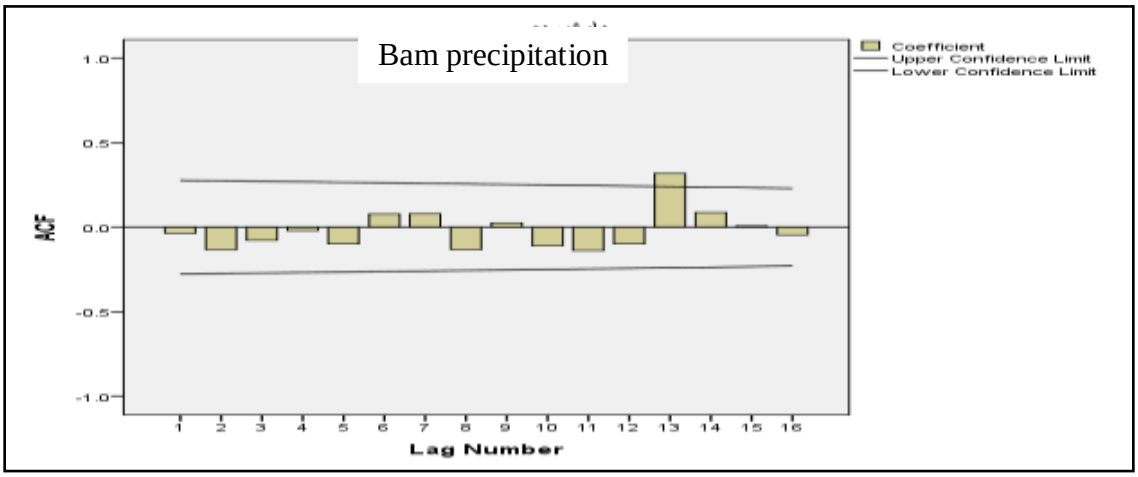

Figure 11: Autocorrelation function of Bam precipitation series

Test rule: H_0: $r_k = 0$
H_a:$r_k \neq 0$
Rule for decision-making: Reject:H_0if $| r_k | > 2/\sqrt{n}$
According to the test:-.078 = r_3
Reject: H_0if $|r_k| > 2/\sqrt{49} = 0.28$
Reject: H_0 if $| -.078 | < 0.28$

With regard to pause 3 of series and all other pauses of Bam precipitation series (excluding pause 13 which equaled 0.319 and was more than 0.28 and also was specified in diagram 11), null hypothesis is not rejected and series do not have a complete autocorrelation with probability of 95%. Thus series do not have a trend, or annual precipitation series of Bam weather station have a random form because of lack of autocorrelation. Therefore they are predictable through random models.

Criteria to Predict Random Changes

The following criteria are used in order to predict precipitation random series of Bam weather station (Javeri, 2013)

1) Zero error average: ZAE = $\hat{Y} = \sum Y / N$
2) Equivalent abundance: EF = $\hat{Y} = Y_{(n+1/2)}$
3) Simple domain or maximum-minimum criteria: Mini Max = $Y^* = (y_{min} + y_{max}) / 2$
4) Minimum mean absolute deviation: Min MAD = $\hat{Y} = Y_{(n+1/2)}$
5) Minimum squares: LS = $\hat{Y} = \sum Y /N$

Categorization of prediction criteria for random changes with regard to above formulas:

1) Numerical values of first and fifth criteria are same and simple mean is the base ($C_{1,5}$).
2) Numerical values of second and fourth criteria are same and simple median is the base ($C_{2,4}$).
3) The third criterion is independent and simple domain is the base (C_3).

Calculation of prediction criteria for random changes of Bam precipitation:

$C_{1,5} = \sum Y/N = 3007.3 / 49 = 61.37$

$C_{2,4} = Y_{(n+1/2)}) = 53.2$

$C_3 = (y_{min} + y_{max}) /2 = 20.4 + 149.5 /2 = 84.95$

Calculation of Precision Indexes

Measurement precision evaluation is the most important step to choose prediction model. So, precision indexes should be used to choose the most appropriate criterion to predict random series for Bam weather station (Javeri, 2009).There are several indexes to measure the prediction precision. In the present research, three following indexes are applied by using SPSS software.

1) Mean index of absolute errors: $MAD = \sum | e_t | / n$ (Table 3)

In order to reach e_t (error value), the formula $e_t = Y - \hat{Y}_t$ is used. The following formulas are calculated in the SPSS software.

$e_1 = y - 61.37$ $MAD_1 = | e_1 |$

$e_2 = y - 53.2$ $MAD_2 = | e_2 |$

$e_3 = y - 84.95$ $MAD_3 = | e_3 |$

Y = principle data of Bam precipitation

If a decision should be made according to mean index of absolute errors about which criterion is more suitable for changes prediction, smaller number whose error is less than other criteria should be chosen. Thus second and fourth criteria, it means the equivalent abundance criteria and the minimum mean absolute deviations are suitable to predict random changes of Bam precipitation. It should be noted that precision index of mean absolute errors is the simplest precision index and RMSE precision index is the most important one.

Table 4: Results from index of mean squared errorsTable3- Results from index of mean absolute errors

Descriptive Statistics

	N	**Mean**
MSE_1	49	858.5620
MSE_2	49	925.3676
MSE_3	49	1414.4147
Valid N (listwise)	49	
MAD_1	49	22.8782
MAD_2	49	22.3286
MAD_3	49	32.4337
Valid N (listwise)	49	

2) Index of mean squared errors: $MSE = \sum e_t^2 / n$ (Table4)

The following formulas are calculated in the SPSS software.

$MSE_1 = e_1^2$

$MSE_2 = e_2^2$

$MSE_3 = e_3^2$

3) Index of root mean squared errors: $RMSE = \sqrt{MSE}$

The following formulas are calculated in the SPSS software.

$RMSE_1 = \sqrt{MSE_1} = 29.30$

$RMSE_2 = \sqrt{MSE_2} = 30.42$

$RMSE_3 = \sqrt{MSE_3} = 37.61$

Choosing the Most Appropriate Prediction Criterion of Random Changes of Bam Precipitation

According to the results of precision index of RMSE, first and fifth criteria, it means zero error average and the least squares are the most suitable criteria to predict random changes of precipitation at weather station. In other words, simple average is the most appropriate criteria. And the reason is that $RMSE_1$= 29.30 and its prediction error is less than other criteria.

Conclusion

The results in this research show that, annual average of Bam precipitation is 61.4 millimeter and it is 188.6 millimeter less than country's annual average. And the share of Bam precipitation regimes in winter is 58% of whole year precipitation. The annual average number of rainy days, snowy days and thunderstorm days in Bam are 21.7 days, 0.7 days and 2.9 days respectively.

In this research, normality of annual precipitation series in Bam was analyzed with the help of graphic and quantitative methods. Then, it was concluded by autocorrelation function test that annual precipitation series have a random form. And final results were concluded by calculation of precision indexes for prediction criteria that average is the best and most suitable criterion to predict random changes of Bam annual precipitation.

REFERENCES

Farajzadeh M (2007). *Climatology Techniques* (Samt pub.) Tehran 114.

Fatemi e Ghomi M (1994). *Prediction and Analysis of Time Series* (Danesh-e-Emrouz pub.).

Hggett RJ (1997). *Environmental Change*, Routledge, London.

Javeri M (2009). *Quantitative Analysis Methods in Climatology (with an Emphasis on Process Modeling)* spring edition of 2010 (Piamresan pub.) Tehran 22-26.

Javeri M Spring (2013). Time series analysis. M.Sc. Piam e Nour University of Esfahan, Available: http: // Ims.pnu.ac.ir.

Masoudian A (2011). *Climate in Iran*, First edition (Sharieh Tous pub.) Mashhad 132-144.

Mohammadi H and Javeri M (2005). Analysis and prediction of temperature random changes in Iran. *Geographical Magazine (Scientific-research Journal of Iranian Geography Association)* (6,7) 15-31.

Mohammadi H and Javeri M (2006). Temporal changes of Iran precipitation. *Ecology Magazine* **40** 87-100.

Najaf pour B (2006). Role of climate in environmental planning and management (emphasis on Iran). Scientific information database, Available: www.sid.ir.

Obasi GOP (2000). The Impact of Climate change to Socio-Economic Development in the Third World", 12th General Meeting of Third World Academy of Science (TWAS), Tehran, Iran.

Site of Weather Forecast Office of Chaharmahal and Bakhtiari Province (2012). Available: www.chaharmahalmet.ir.

Site of Weather Forecast Office of Kerman Province (2013). Available: www.weather.kr.ir.