EasyChair Preprint

№ 3625

Hydrological Analysis of Rainfall Data for Drought Investigation in Alaqiq City

Sami Tagalwi

June 17, 2020

مجلة العلوم الهندسية
FES Journal of Engineering Sciences
http://fes.oiu.edu.sd/

Hydrological Analysis of Rainfall Data for Drought Investigation in Alaqiq City

Sami Hassan Elsayed Taglawi*

Civil Engineering Department, Albaha University, Albaha, kingdom of Saudi Arabia
*Email1: samasim797@gmail.com
*Email2: shassan@bu.edu.sa

Article history: Received xx March 201X, Received in revised form xx July 201X, Accepted xx August 201X
Digital Object Identifier (doi): 10.1208/jes.2018.Doi Number

ABSTRACT Rainfall is a prime input for various engineering design such as hydraulic structures, bridges and culverts, canals, storm water sewer and road drainage system. The detailed analysis of each region is essential to estimate the relevant input value for design and analysis of engineering structures and for crop planning. A rainfall data record from Ministry of Water collected for Alaqiq city for hydrological analysis where agriculture is the prime occupation. The daily rainfall data for a period of 36 years used to understand normal rainfall, deficit rainfall, Excess rainfall and Seasonal rainfall of the Alaqiq city. From the daily record, annual, monthly, and seasonal rainfall were calculated. Extensive hydrological analysis had done comprising the maximum values of rainfall with the average one. Index of Wetness (I.W.) and Rain Deficiency (R.D.) calculated to check the rainfall variability. From the calculated results the amount of rainfall is decreasing below the average value and the number of arid years increasing (about 64% of records are arid years). The hydrological parameters (I.W. & R.D.) for annual, monthly and seasonally show that the rainfall in Alaqiq city is decreasing and the climate is changing to be drought (arid).

Keywords: Drought, season, Rainfall, Alaqiq, Index o Wetness, Rainfall deficiency.

1. INTRODUCTION

Rainfall is the most important natural hydrologic event and is a unique phenomenon varying in both space and time, the rainfall distribution is very uneven and it is not only varied considerably from place to place but also fluctuates from year to year. The rainfall is one of the most important and governing factor in the planning and operation strategies of any agricultural programme for any given area.

A comprehensive knowledge of the trend and persistence in rainfall of the area is of great importance because of economic implications of the rain sensitive operations and since it plays vital role of any agricultural and nonagricultural programme. If proper and comprehensive study of various rainfall data had analyzed, the severity and reoccurrence of drought can be known beforehand thus various measures can be taken to cope up with the problems and drought.

Because of the variety of needs of water, it is not practicable to define a drought specifically. In general drought implies of a deficiency of precipitation of sufficient magnitude over a significantly prolonged duration. Drought as such, is a "non-event" as opposed to a distinct event such as flood. Drought requires an extended period of time to develop. Extreme rainfalls or floods can occur several times in one year, whereas two or three years of subnormal

runoff may be required to develop a serious drought problem for basins having large volumes of storage. The information on drought is a viable tool for multi objective water resources planning problems and is implicitly of great value for the incumbent planners for designing of storage capacity reservoirs to store the water for contemporaneous irrigation requirement during such drought periods. The main cause of drought experienced in all places is the insufficient non-linear rainfall. Although precipitation for a few years may be abnormal, there is usually a tendency to return to the mean pattern. Hence, a period of abnormally heavy precipitation is sooner or later balanced by a dry period so that the mean over a long interval does not change appreciably.

2. Study Area

Alaqiq Governorate is one of the governorates of Albaha Region. It is famous of King Saud Airport located in the city. It is 45 km from the Al Baha area. It borders meet with Bisha province of Asir region and with the Region of Mecca. Alaqiq Governorate has the largest dam in the region, namely Wadi Alaqiq Dam, Wadi Tharad Dam, which built to provide the area with water. The climate of the province is moderate, rainy, warm and warm in winter, but recently the climate is changing. It is characterized by mountainous climate of fog, rain and wonderful weather and tends to cold in the winter. The population of the Governorate is about 70 thousand people.

3. Materials and Methodology

Keeping the above points (produced in the introduction) in view, the rainfall data records from Ministry of Water collected for Alaqiq city for hydrological analysis. The daily rainfall data for a period of 36 years had used. From the daily record, annual, monthly, and seasonal rainfall were calculated.

Extensive hydrological analysis had done comprising the maximum values of rainfall with the average one. Index of Wetness (I.W.) and Rain Deficiency (R.D.) had calculated to check the rainfall variability.

The rainy data for a period of 36 years collected and analyzed in the presented paper to study the magnitude and drought frequency in terms of rainy deficiency for Alaqiq city. The rainy data for period of 36 years of Alaqiq had collected from Ministry of Water. The mean value of rainfall monthly, annually and seasonally had consummately analyzed in this paper. The analyzed data had compared with mean monthly, mean seasonal and mean annually rainy. On the basis of above comparison, and In order to increase verification, Index of Wetness (I.W.) and Rain Deficiency (R.D.) had calculated using the formulas (1) & (2).

$$Index\ of\ Wetness\ (I.W.) = \frac{P_i}{P_{av}} \dots\dots\dots (1)$$

Where:

P_i: Rainfall in given time at given place

P_{av} : Average rainfall at that place

If $I.W. < 1$ that mean year is drought , and $I.W. > 1$ that mean year is rainy

$$\%Rain\ Deficiency = \%\ Index\ of\ Wetness - 10 \dots\dots\dots (2)$$

If % Rain Deficiency negative value that mean it is drought year and rainy year if rain deficiency positive value.

A. *Annual Rainfall Analysis*

From daily rainfall records for Alaqiq city monthly and annual records had formulated and illustrated in Fig.1.

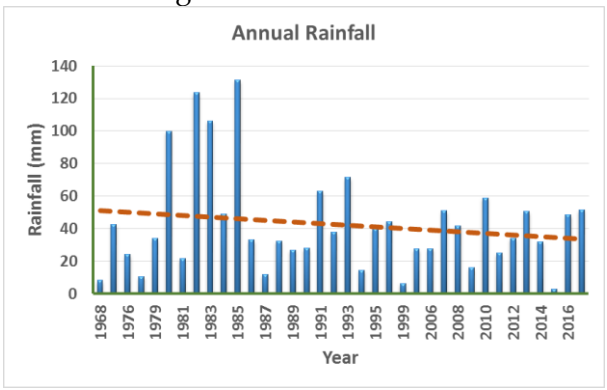

Fig.1 Annual Rainfall with trend line

In Fig.1, the trend line shows that the rainfall amount is decreasing that result encouraged to calculate the mean value of rainfall to find the years below the average value as shown in Fig.2.

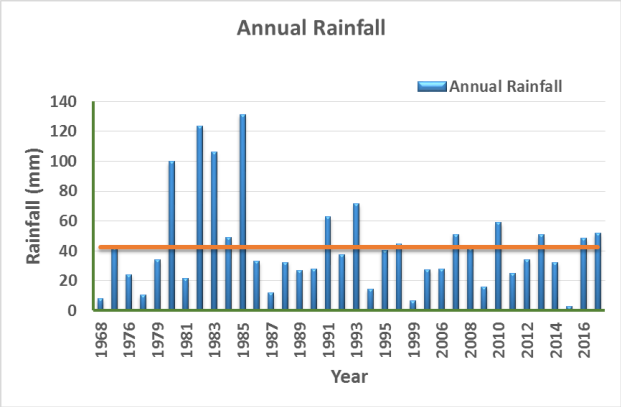

Fig.2 Annual Rainfall with mean rainfall line

In the Fig.2, 23 years of rainfall records is below mean value that mean about 64% of the records less than the mean.

It is noticeable that, from year 1968 the rainfall sequence changing is 6 years of rainfall less than the mean, and 5 years of rainfall more than the mean, this pattern continue until year 1985. Then the sequence is changed to be 6 years of rainfall less than the mean, and 2 year of rainfall more than the mean, this pattern continue till year 1993, and then the pattern changed again to be worse (11years less than the mean).

For further confirmation Index of Wetness (I.W.) and Rain Deficiency had calculate for annual rainfall as illustrated in Fig.3.and Fig.4.

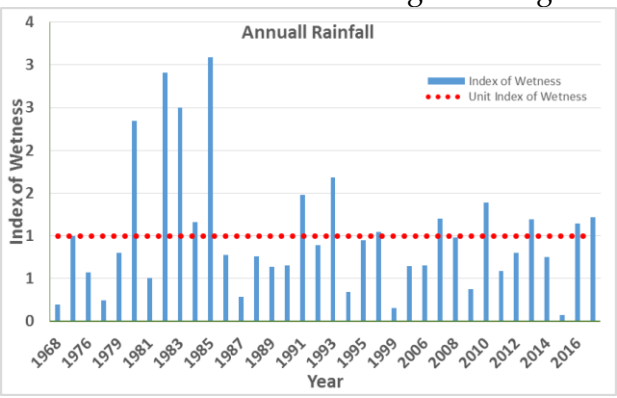

Fig.3 Index of Wetness for annual rainfall

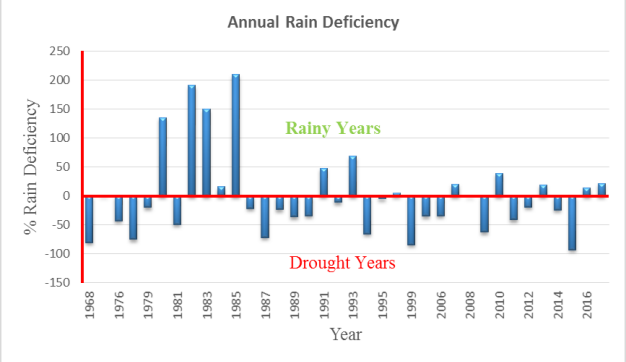

Fig.4 Annual Rain Deficiency

From Fig.3 and Fig.4, it is clear that that index of wetness for 64% of records less than one and about 23 years located in part of rain deficiency.

B. *Monthly Rainfall Analysis*

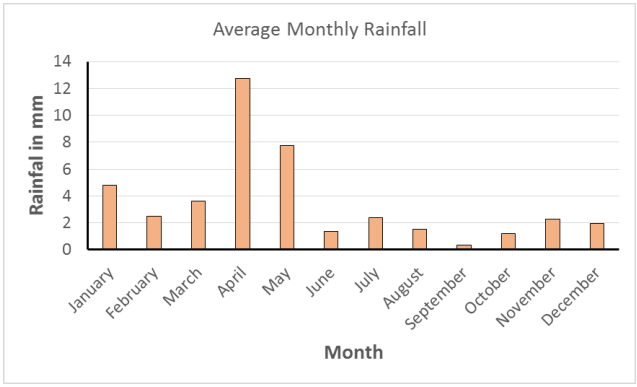

Fig.5 Average Monthly Rainfall

In the Fig.5 it is clear that the season of rain in Alaqiq city starts in winter in November with average amount of rain equal to average value 2.27 mm and the amount of rain increasing to reach the maximum value in Spring (April) with average value 12.74mm. The minimum amount of rain occur in summer in the last month of the season (October) with average value 1.23 mm.

According to the information presented in Fig.4, our analysis will concentrate in the rainy months to detect the change in their pattern. In the Fig.6 the Index of Wetness (I.W.) had be calculated then the percent of rain deficiency for every month had calculated and the result and listed in table (1).

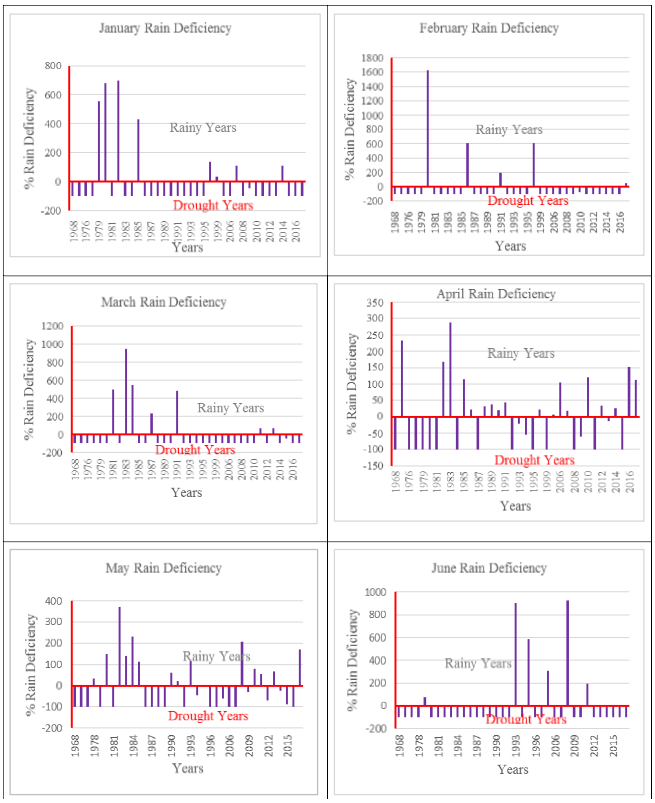

Fig.6 (a) Rain Deficiency all months

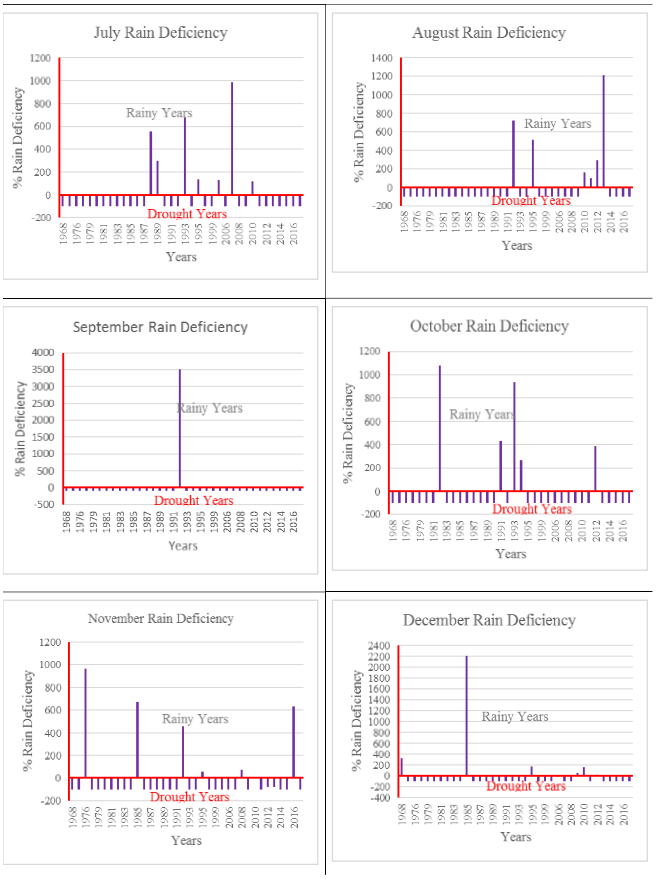

Fig.6 (b) Rain Deficiency all months

TABLE1. CLASSIFICATION OF MONTHS DUE TO RAINFALL AMOUNT

Month	Number of Rainy Years	% of Rainy years	Classification	Number of Drought Years	% of Drought years	Classification
January	8	22	Rainy Years	28	78	Drought Years
Februar	5	14		31	86	
March	7	19		29	81	
April	18	50		18	50	
May	14	39		22	61	
June	6	17		30	83	
July	7	19		29	81	
August	6	17		30	83	
Septem	1	3		35	97	
October	5	14		31	86	
Novemb	6	17		30	83	
Decemb	5	14		31	86	

From table 1 and Fig.6 it is clear that the percent of drought years (Rain Deficiency) is high in comparison with the rainy years its range between 50% to 97% and this percent for April about 50% (classified as rainy month). The total percent of the rainy years is 20% while the percent of the drought years is 80%, this is a good indictor the climate of the city is extremely changing to be drought.

C. *Seasonal Rainfall Analysis*

To check the results of monthly rainfall analysis, analysis for seasonal rainfall took place. The year was divided in to 4 seasons, Winter (November, December and January), Spring (February, March and April), Summer (May, June and July) and Autumn (August, September and October). The amount of rainfall and the mean of rain had calculated for each season and the results illustrated in Fig.7. Table 2 formulated from Fig.7.

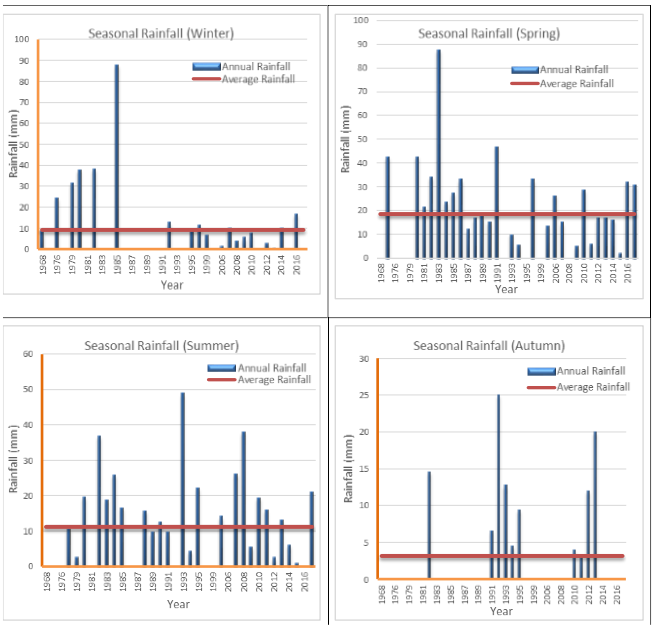

Fig.7 seasonal rainfall with average rainfall value

TABLE 2 CLASSIFICATION OF SEASONS DUE TO RAINFALL AMOUNT

Season	Average Rainfall in (mm)	Number of Years more than Average	% of Years more than Average	Classification	Number of Years less than Average	% of Years less than Average	Classification
Winter	9.28	8	22	Rainy Years	28	78	Drought Years
Spring	18.84	15	42		22	58	
Summer	11.51	17	47		20	53	
Autumn	3.1	9	25		27	75	

From Fig.7 and Table 2, more than 78% of the years are drought in winter season while the percent decreases in spring and summer season to be 58% and 53% respectively that mean all seasons in the city can classified drought (the percent more than 50%). For more accuracy index of wetness and rain deficiency for the seasonal rainfall records had calculated and the results show that all seasons are drought as illustrated in Fig.8.

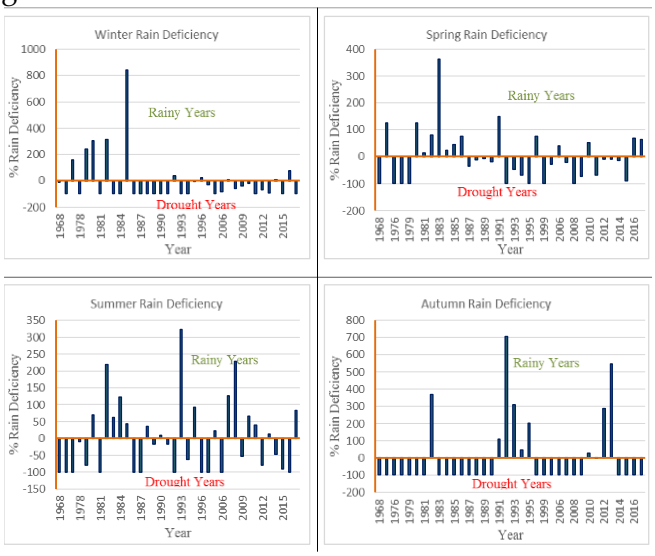

Fig.8 Rain Deficiency for seasonal rainfall

4. RESULTS AND DISCUSSION

The concept of this paper based on hydrological analysis of the daily rainfall records for Alaqiq city.

Monthly records, annual records and seasonal records of rainfall had formulated from the maximum daily rainfall records.

Analysis started first with annual records for drought investigation by calculating mean rainfall, Index of Wetness (I.W.) and rain deficiency, the results of this analysis gives 64% of rainfall records had classified as drought and the sequence of drought getting worse (11 drought years continuously).

Secondly the analysis takes the monthly rainfall records, the results gives 50% as percent of drought for April (classified as rainy month) and the maximum percent with 97% for September, but the serious percent is the percent of April because its higher rainy month (50%) . The percent of drought had ranged between 50% to 97% and this is high values (it means that drought took place).

Finally, the seasonal rainfall records analyzed and the percent for each season is greater than 58% especially in the rainy seasons (Winter & Spring).

5. CONCLUSION

It can be conclude that the rainfall mode in Alaqiq city is going in drought direction. For this the decision maker in field of water resources can take the results of this paper in consideration in planning for each water project in the city, also it's a call for the scientists to study the reasons of the climate change in Alaqiq city.

REFERENCES

[1] *Jeddah Regional Climate Center. "Climate Data for Saudi Arabia". Archived from* the original *on 2012-05-12*. Retrieved January 26, 2016.

[2] https://en.wikipedia.org/wiki/Al_Bahah

[3] K Subramanya, Engineering Hydrology, 2008

[4] Nyatuame M, Owusu-Gyimah V and Ampiaw F 2014 Statistical Analysis of Rainfall Trend for Volta Region in Ghana. Int. J. Atmos. Sci. 67(2) 1-11.

[5] V.T. Chow, R.R. Maidment, L.W. Mays, "Applied Hydrology", McGraw Hill Education (India) Edition 2010.

Sami Hassan Elsayed Taglawi received his **bachelor** of science degree in Civil Engineering from Omdurman Islamic University, Sudan in 2000; the master of science in Civil Engineering from Karary University, Sudan, 2002; Higher Diploma in Hydraulics Engineering in River Basins from IHE, ITC (Netherland) and HRI Egypt, December 2002 and **Ph.D** of science in Civil Engineering from Moscow State University for Environmental Engineering (**Hydraulics and Engineering Hydrology**), 2010.