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Hydrological Analysis of Rainfall Data for Drought Investigation in Alaqiq City

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ABSTRACT This paper had based on the data and results of the research project funded by Albaha University entitled "Analysis of Rainfall data of Albaha Region" and the scientific paper had written by Khalid A. Alkhuzai entitled "Hydrological Analysis of Rainfall Data for Drought Investigation in Albaha City". Rainfall may be the main input for various engineering design like hydraulic structures, bridges and culverts, canals, storm water sewer and road drainage system. The detailed analysis of every region is important 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 and environment collected for Alaqiq city for hydrological analysis where agriculture is the main 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 of Wetness, Rainfall Deficiency.

1. INTRODUCTION

This paper had based on the data and results of the research project funded by Albaha University entitled "Analysis of Rainfall data of Albaha Region" and the scientific paper had written by Khalid A. Alkhuzai entitled "Hydrological Analysis of Rainfall Data for Drought Investigation in Albaha City" [Alkhuzai 2019]. Khalid Alkhuzai had studied in his paper Albaha city which located in Albaha region, and it seem to be valuable to study another city in Albaha region to check the climate change regime in the region and to confirm the results obtained by Alkhuzai, Alaqiq city is selected to be studied in this paper following the same methodology of analysis had done by Alkuzai in his paper.

Rainfall is the utmost 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 put but also fluctuates from year to year. The rainfall is one of the utmost important and governing factors 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 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 dams 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 (introduced in the introduction) in view, the rainfall data records from the Ministry of Water and Environment had collected for Alaqiq city to be used for hydrological analysis. The daily rainfall data for a period of 36 years had used. From the daily record, monthly, annual, and seasonal rainfall were calculated and formulated. Extensive hydrological analysis had done comprising the maximum values of rainfall with the average one. The term 'Index of Wetness' as it applies to the area of the weather can be defined as ' The ratio of precipitation for a given year over the mean annual precipitation'.

Following the same methodology of analysis had done by Alkuzai in his paper, Index of Wetness (I.W.) and Rain Deficiency (R.D.) had calculated to check the rainfall variability.

The rainfall 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 data had collected from Ministry of Water and Environment. 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 rainfall. 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).

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

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

$$\%Rain\ Deficiency = \%\ Index\ of\ Wetness - 100 \quad (2)$$

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

A. *Annual Rainfall Analysis*

From daily rainfall records for Alaqiq, city monthly and annual records with trend line had formulated as shown in Fig.1.

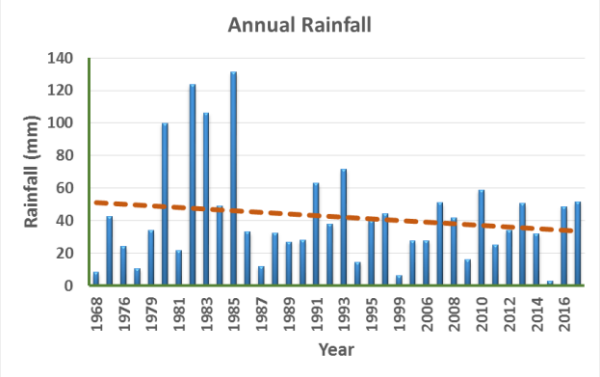

Fig.1 Annual Rainfall with trend line

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

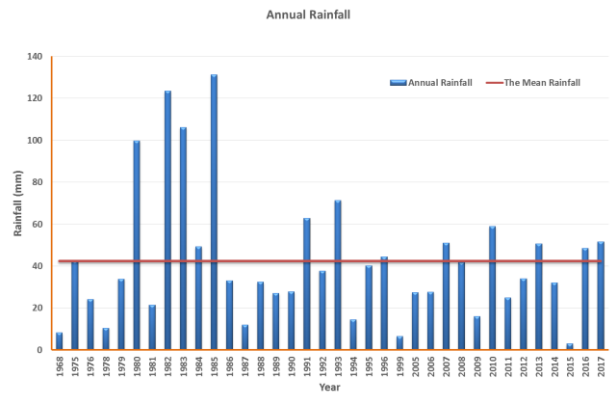

Fig.2 Annual Rainfall with mean rainfall line

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

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

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

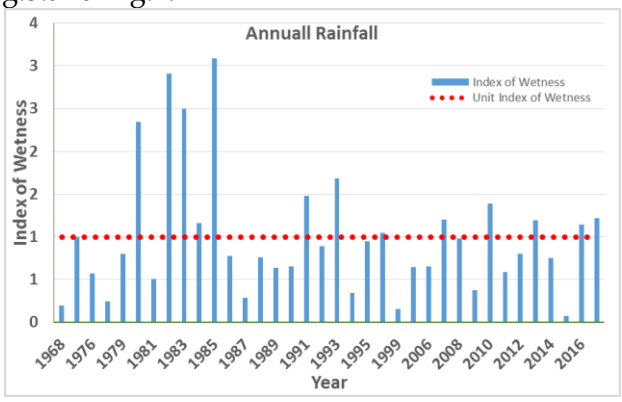

Fig.3 Index of Wetness for annual rainfall

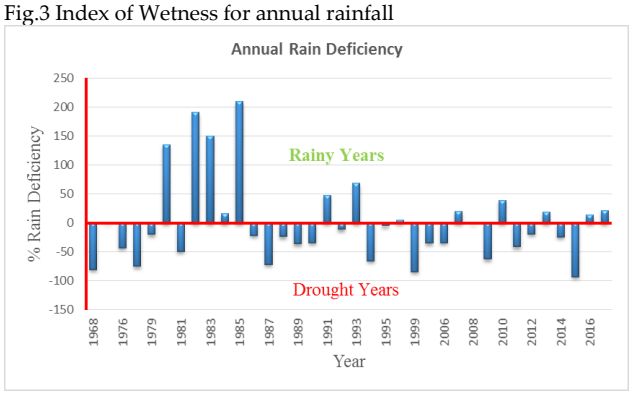

Fig.4 Annual Rain Deficiency

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*

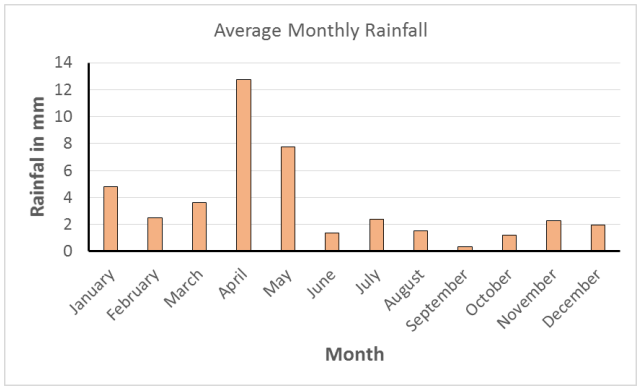

Fig.5 Average Monthly Rainfall

Fig.5 shows the average monthly rainfall, can be deduced the season of rain in Alaqiq city starts in winter in November with the average amount of rain equal to the 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 occurs in summer in the last month of the season (October) with an average value of 1.23 mm.

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

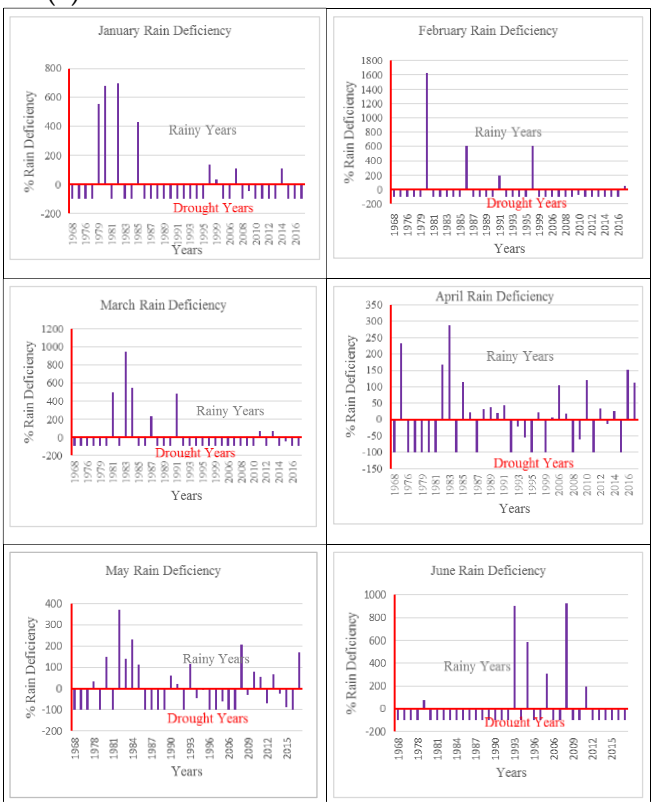

Fig.6 (a) Rain Deficiency for six months

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
February	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	
Septemb	1	3		35	97	
October	5	14		31	86	
Novemb	6	17		30	83	
Decembe	5	14		31	86	

Fig.6 (b) Rain Deficiency six months

TABLE1. CLASSIFICATION OF MONTHS DUE TO RAINFALL AMOUNT

From table1 and Fig.6 can deduces 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% (Although it is classified as a rainy month in the monthly data analysis as shown in Fig.5). The total percent of the rainy years is 20% while the percent of the drought years is 80%, this is an indicator the climate of the city is extremely changing to be arid.

C. *Seasonal Rainfall Analysis*

To check the results of monthly rainfall analysis, analysis for seasonal rainfall took place. The year was divided into 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 had illustrated in Fig.7. Table 2 formulated from Fig.7.

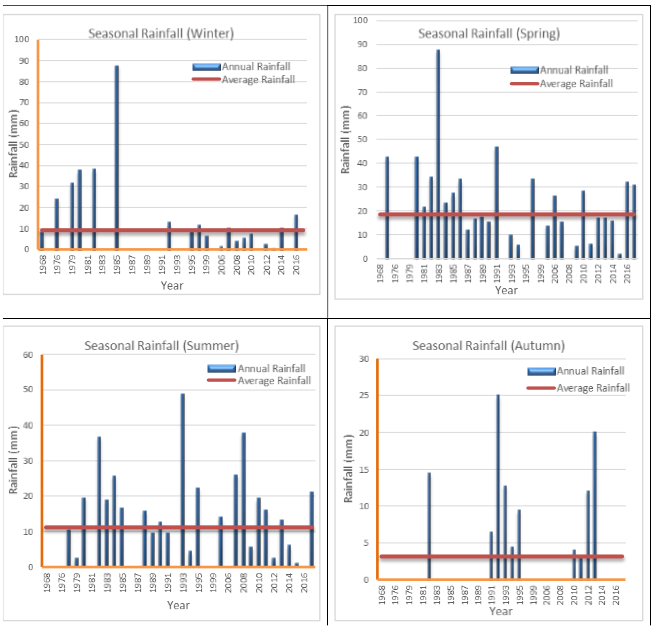

Fig.7 Seasonal rainfall with average rainfall value

TABLE2 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	28	78	Drought
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 dry in winter season while the percent decreases in the spring and summer season to be 58% and 53% respectively that mean all seasons in the city can be classified as drought (the percent of rainfall deficiency 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 dry as illustrated in Fig.8.

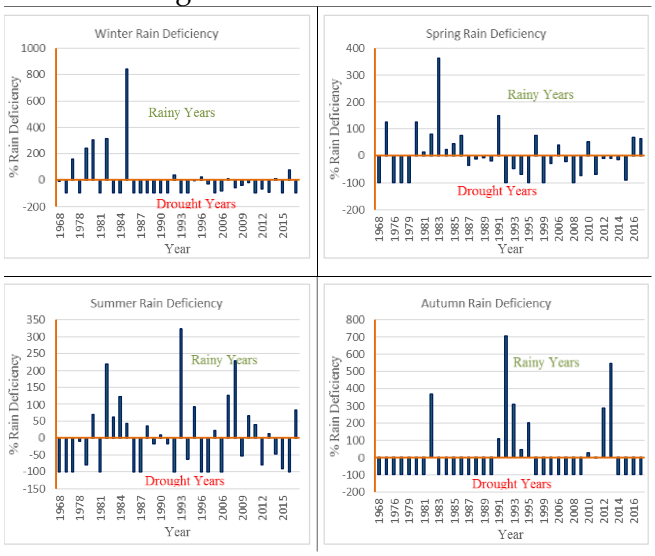

Fig.8 Rain Deficiency for seasonal rainfall

4. RESULTS AND DISCUSSION

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

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

The analysis started first with annual records for drought investigation by calculating mean rainfall, Index of Wetness (I.W.) and Rain Deficiency (R.D.), 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 give 50% as a percent of drought for April (Although it is classified as a rainy month in the monthly data analysis as shown in Fig.5) and the maximum percent with 97% for September, but the serious percent is the percent of April because of 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 are greater than 58% especially in the rainy seasons (Winter & Spring).

5. CONCLUSION

If a proper analysis and detailed study of various rainfall data have done, this leads to knowing the drought severity and occurrence beforehand. Thus, various measures can be taken to cope up with the problems of drought.

In a present paper of Alaqiq, drought analysis based on 36 years of rainfall records had done. The observed data shows that in the months of September, October, December, and February maximum frequency of drought had occurred, while the drought is maximum in winter and autumn seasons and, the minimum drought in summer and spring seasons. The severity of the drought was minimum in the year 1985 and maximum in the year 2015. It can be concluded that the rainfall mode in Alaqiq city is going in a drought direction as in Albaha city, this confirmed the results had obtained by Alkhuzai in his paper [Alkhuzai 2019]. For this the decision-maker in the field of water resources can take the results of this paper into consideration in planning for each water project in the city, also it's a call for scientists to study the reasons for climate change in Alaqiq city.

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