Rainfall Variability in Asir Area – Abha and KhamisMushait Stations (1978 -2014)

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Abstract

Saudi Arabia has an extremely dry climate, but in the southwest region, comparatively, more rainfall events occur within the effects of topography and seasonality.

This article focuses on studying and analysing the rainfall variability in Asir area. Data for rainfall variability was collected from the Metrological Station in Abha and Khamis Mushait for the period from 1978 to 2014. Statiscal analyses were carried to determine variability in annual rainfall among years for each station separately. The mean, standard deviation, and coefficient of variation were used to calculate the rainfall variability on long-term annual basis.

Present results for Abha and khamis separately: Abha showed rainfall varied and fluctuated over the time, with lower value of 84.8 mm in 2009, and higher value of 639.5 in 1983.and mean of 254.0.mm over the years, and Khamis showed rainfall varied with lower value of 34.1 in 2009, and higher value of 355.9 in 1997and mean of 178.7mm. The average annual rainfall reached more than 202.9 mm. Variation among the years was high with a coefficient of variation for equal to 0.64 and the standard deviation was 110.2 and the standard error of the mean was 102.8.

Key words: Water deficiency, Rainfall, Fluctuation.

Introduction:

Rainfall variability refer to the degree to which rainfall amounts vary across an area or over time, it is one of the climate indicators to the trends of changes within the earth's environment. The internal variability in the rainfall system can be recognized as a form of shock, meaning that the current state of rainfall reflects consequences upon the human life.

The rainfall characteristics of the study area reported by many researchers, Al-Jerash, 1985, Al-Taher1994 stated that the Saudi Arabia is considered one of the driest countries in the world. With the exclusion of the southwestern coast, the Saudi Arabia climate is described by extreme heat throughout the day, a sudden fall in temperature at night, and little, and irregular precipitation. Subyani 2010 mentioned that, the aridity index classifies Saudi Arabia as having desert conditions and a water deficit except the mountainous regions, which can be described as semiarid. Al Jerash, 1985, Ahmed 2015 used a multivariate technique o illustrate the rainfall's regime of southwestern region of Saudi Arabia. Climate of Saudi Arabia was studied by Abdullah1998, Subyani 2004, who discussed the aridness of the region and the rainy seasons. The southwestern area is described by having precipitation during the year, wherever the geography increases local convective precipitation (Subyani 2004, Al-Mazroui 1998). The precipitation in most areas of the Saudi Arabia is scarce, infrequent, and generally falling from October through April throughout other months, there is almost no precipitation with the exception of the southwestern region of Saudi Arabia (Almazroui, 2009). The spatial variation of the precipitation in the southwestern region is high due to mountainous regions. The southwestern region of Saudi Arabia is characterized by

rainfall events during the entire year due to the topographically driven convective rain (Abdullah1998, Al-Mazroui1998).

This study examines the temporal and spatial distribution of rainfall in the city of Abha and Khamis Mushait.

The Study Area

The country is characterized by distinct climatic regions, due to high spatial and temporal temperature variability. According to the Köppen classification the major parts of Saudi Arabia are hot and dry (Köppen, 1936), where precipitation is infrequent and temperature is high (Al-Jerash, 1985, Al-Taher1994). On the other hand, the southwestern area of the Saudi Arabia is classified as semi-arid (Köppen, 1936).

In Saudi Arabia, rainfall has very low total magnitude during a specific time interval and is unpredictable with irregular but very intense local storms. The southwest region lies within the subtropical climate zone of Saudi Arabia and receives the highest amount of rainfall in comparison to other regions, because it is mountainous with elevations reaching to over 2000 m.

The study area lies between latitudes 18°14′and 18°18′N and longitudes 42°39′and 42°45′E (Fig. 1). It is located in the southwestern region in Saudi Arabia. This region is bounded by the Red Sea to the west, Jeddah to the north, desert highlands to the east, and the Yemen border to the south (Fig.1). As described above, this region is mountainous, composed of mesa, buttes, deep valleys and plateaus. The high elevation is often referred to as the “escarpment". The escarpment rises abruptly from the Red Sea to a maximum elevation of around 2800 m

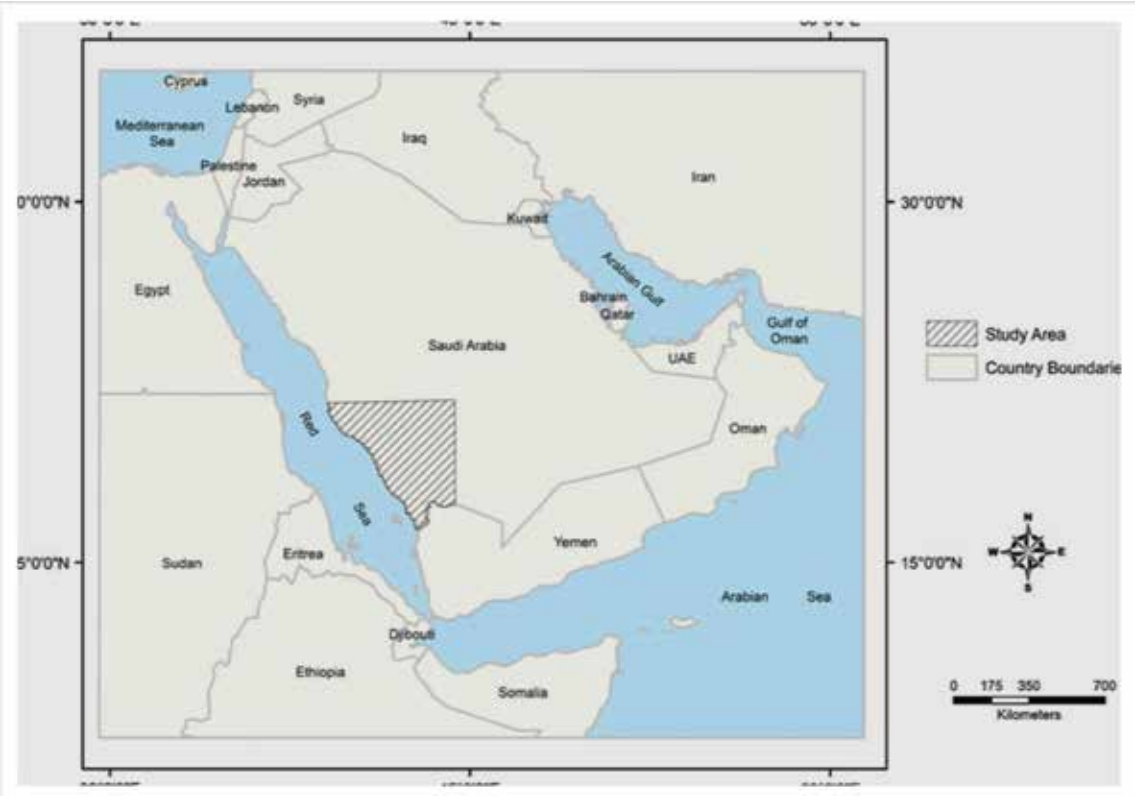

Figure (1) Geographical location of the Study area.
Source:-Khalid Al-Ahmadi & Sharaf Al-Ahmadi (2013)

The average annual rainfall can reach more than 600 mm in the mountains, and decreases towards the coast in the west to 120 mm, and on the leeward side of the mountains to the east to 100 mm (Ali M. Subyani 2007)

In general, rainfall in the southwest region occurs in every season of the year. Autumn rainfall is related to local diurnal circulation, summer rainfalls to the monsoons, and winter and spring rainfalls to the interaction between African-Mediterranean air flows.

Materials and Methods

The historical annual rainfall amounts in, two stations (Abha and Khamis Mushait) in Saudi Arabia were used in this study. The data used for Abha and Khamis Mushait was for 37 years for the period of 1974 through 2014. Figure 2 shows a time series plot of the annual rainfalls at the two stations.

In order to achieve study objectives, several steps were followed:-.

1) Mean annual rainfall data of Abha station (Lat. 18°14'N/Long. 42°39' E) for the period 1974- 2014 were obtained from the NATIONAL METEOROLOGY & ENVIRONMENT CENTER. Also, mean annual rainfall of Khamis Mushait station (Lat. 18°18 'N/Long. 42°48'E) for the same period was collected.

2) Standard deviation (SD) was used to calculate long term rainfall variability.

3) Correlation coefficients were calculated between rainfall amounts in the two stations.

4) The coefficient of variation for rainfall was calculated in each station as follows:

5) The ratios between rainfall means of Abha and Khamis Mushait stations were calculated.

Results and Discussion

The outputs of calculation are summarized in table (1). Data on rainfall for the period of 1974-2014 shows an average equal to 202.9mm, standard deviation equal to 110.2 and coefficient of variation equal to 0.39, and rainfall range from 34.4 as minimum level in 2009 and 639.5 as the maximum level in 1983.

The data for the rainfall records for the period 1978- 1990 was generally low and moderately deviated from the mean (Standard deviation = 116.1). The results showed that the rainfall ranges between 78.8mm at the minimum level and 639.5 at the maximum level with an average of 237.9mm as shown in Table 1.

Table 1: Rainfall Indicators and Dispersion in the Study Area Statistical Parameters of the Stations

Years	Maximum amount	Minimum amount	Average	SD	CV	STEXY
1978-1988	639.5	78.8	237,9	116.1	.33	132.4
1989-1999	582.1	51	215.12	120.13	.104	78.9
2000-2014	263.8	34.1	146.6	62.5	.124	57.2
1978-2014	639.5	34.1	202.9	110.2	39.6	102.8

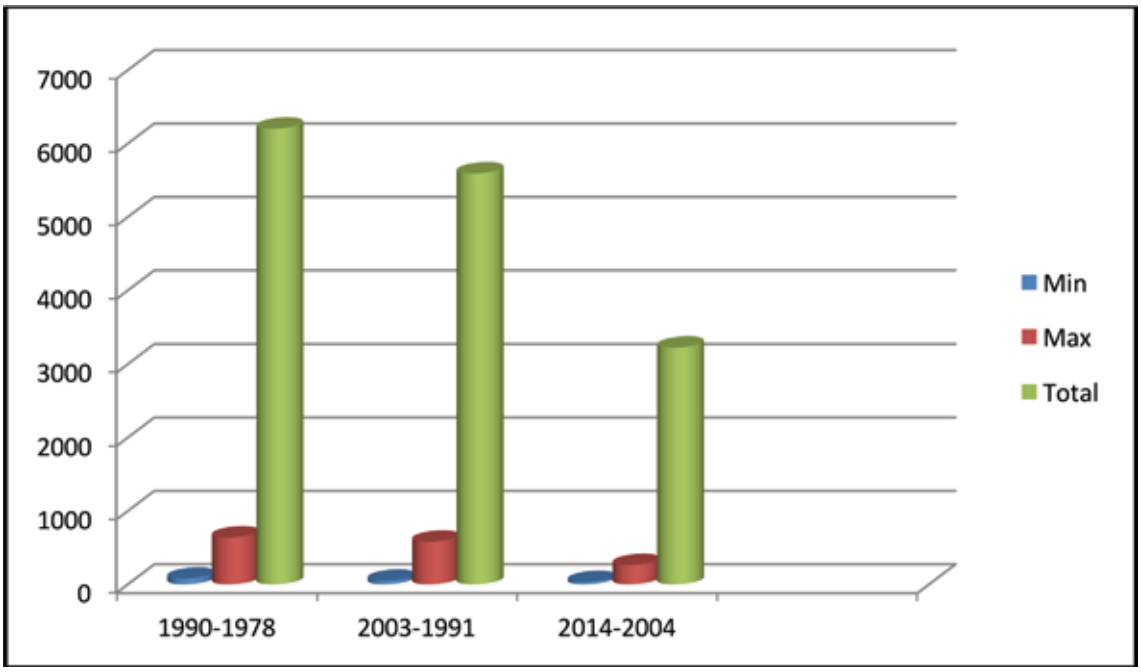

Figure 2: Fluctuation of rainfall in the study area.

For the time period of 1978- 1990 the rainfall was relatively higher than the time period 1991-2003 as reflected by the rainfall average equal to 237.9mm and standard deviation of 116.13 with the maximum rainfall amount of 639.5 and minimum rainfall amount of 78.8mm

Comparing periods (2004-2014), the rainfall records for this period was generally low (Figure 2), rain fall average equal to 146.6 with 263.8 as maximum amount and 34.1 as minimum amount, which also recorded as the most dried year in area.

Therefore, the recent precipitation trends over the study area have decreased; these might be related to the extended droughts, which have happened across the entire Saudi Arabia in the last decade. Hence, the rainfall distribution is not uniform in time or in space; it should be treated and analyzed as spatiotemporal phenomena due to the spatial and temporal variations in rainfall, especially in arid and semiarid regions.

The statistical analyses of rainfall data from these two stations indicate that rainfall is variable in space and time. Although the Abha station is only some kilometers north of the Khamis Mushait station, the geographical variability can be seen when one compares rainfalls in the stations. In 1998, for example, rainfall at the Abha station totaled 582.1 mm, whereas the Khamis station received 275 mm. Correlation coefficients(0 .65) shows that no perfect positive relationships between rainfall variables between rainfall in the stations and it become useful in describing the degree of spatial variability.. However, the relationship between annual rainfall in Abha and Khamis stations, with a correlation coefficient (r) of 0.65, does indeed suggest a close association between annual rainfalls in Abha. On the other hand, correlation coefficients of annual rainfall at the stations show low relationships between annual maximum rainfall are poor (639.5, and 355.9). The negative relationship between two nearest stations is an interesting result supporting the concept of spatial variability of rainfall within a small geographical area.

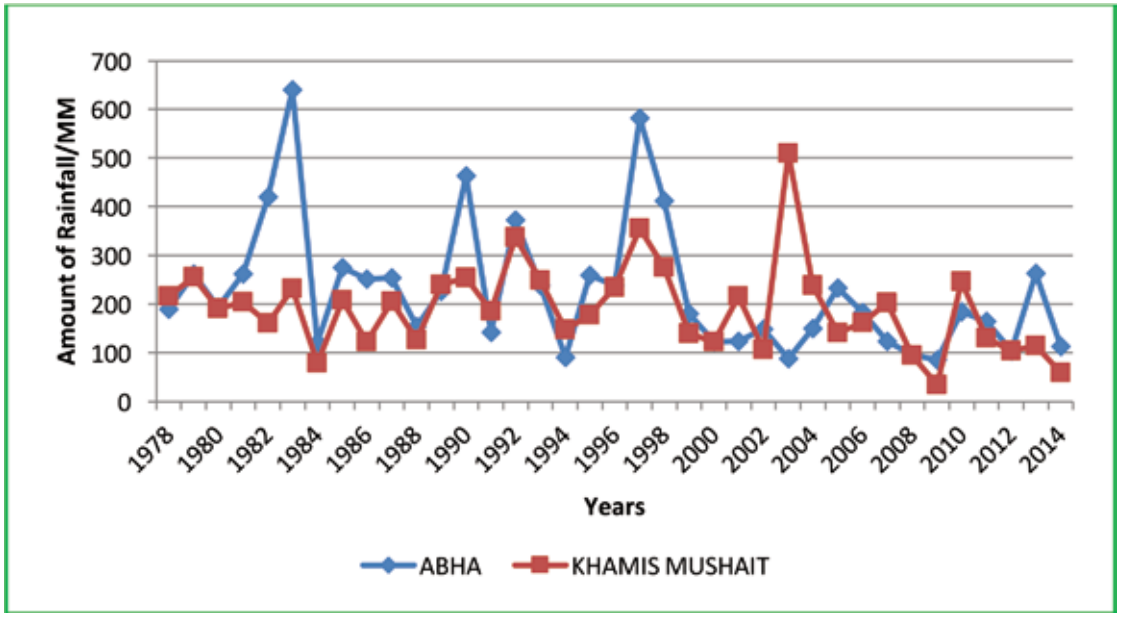

Figure 3 Annual time series of rainfall (mm) in the study area.

Conclusion:

Spatial and temporal variations of rainfall amounts in study area have been quantitatively assessed. The results show that rainfall in Abha and Khamis Mushait area expose spatial and temporal variability. Although the distance between two stations is only some kilometers, the geographical variability can be seen when one compares rainfall values from the stations. The relationship between annual rainfalls in Abha and Khamis Mushait stations with a correlation coefficient (r) of 0.65 manifest no perfect positive relationships.

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