AN ASSESSMENT OF RAINFALL VARIABILITY FOR SEVEN METEOROLOGICAL STATIONS IN BALOCHISTAN FROM 1999 TO 2020

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Abstract

This study aims to investigate Rainfall variability in the province of Balochistan. Pakistan's largest province is Balochistan, but mostly it is a victim of disasters like drought and floods. Balochistan mostly receives rains from the western depression during winter only some of the stations receive monsoon rains during summer. High rainfall variability is shown in the area, which results in drought or floods. To avoid droughts and floods better management of rainwater is needed. So, rainfall data of seven meteorological stations of Balochistan from 1999 to 2020 are analyzed to find out the coefficient of rainfall variability. The results show that high rainfall variability prevails in the whole province.

Keywords: Rainfall variability, western disturbances, drought

Introduction

Concern about climate unpredictability and change, its effects, and its vulnerabilities are developing on a global scale (Naheed& Rasool,2011). Globally, climate variability and change have a significant impact on social and physical settings, with potentially significant and far-reaching effects on natural resources and industry. Global warming-related climate change has begun to affect not only Pakistan's agriculture industry but is influenced by weather patterns as well. Pakistan is an agricultural nation. Its agricultural sector supports most of the population. (Sajjad et al**.,** 2014) Water resource management, agriculture and forestry, tourism, and food production are just a few of the natural and socio-economic systems that depend on precipitation as one of the most crucial elements (Schmidli et al**.,** 2007). For the nation's agriculture as well as its economy, rainfall unpredictability and the pattern of extremely high or low precipitation are crucial factors. It is well recognised that changes in rainfall are being brought on by global

warming on both a global and regional level. (Hulme et al.**,** 1998; Lambert et al.**,** 2003; Dore, 2005; Rodriguez-Puebla et al.**,** 1998; Gemmer et al.**,** 2004; Kayano and Sans'golo, 2008).
Low rainfall results in natural disasters like drought (Rafiq**,** M**.** et al.**,**2022). Many studies were carried out all over Pakistan to investigate the spatial and temporal variability of rainfall (Dawood et al.**,** 2021, 2020, 2018, 2017; Ashraf, 2016; Ashraf and Routray, 2015; Ahmad et al**.,** 2014; Rasul et al**.,** 2012) Significant spatial-temporal variability is observed in Balochistan too. (Ahmad et al.**,**2014) More water needs to be stored because high rainfall variability means future water shortage. (Akhtar & Abbas, 2021).

Northern Balochistan mostly receives rainfall from western disturbances during winter, the areas close to Southern Punjab and southern KPK receive some summer rainfall also during monsoon. While Southern Balochistan mostly receives rainfall from the Arabian Sea through the summer monsoon. Some areas in Northern Balochistan show high rainfall variability of 242% from 1990 to 1999. While Southern Balochistan shows high rainfall variability of 130 to 150% from1960 from 1999 (Naheed& Rasool, 2011).The impacts of recent droughts have also been exacerbated by the increase in water demand and the fluctuation of hydro-meteorological variables caused by climate change (Mishra and Singh, 2011). So, the purpose of the study is to investigate Rainfall Variability to help not only the policymakers but also the stake holders plan for better management of water resources. Which will help in adaptation and mitigation measures against drought.

Study Area.

Baluchistan is the largest and most rugged province of Pakistan. The absolute location of Baluchistan is from 22°N to 32°N latitude and from 66°E to 70°E longitude Baluchistan has complex physical features having high mountains, low mountains, plains, and deserts. (Government of Balochistan2019). The climate of Balochistan ranges from Semiarid to Arid.200 to 350mm is the annual precipitation range, most of which falls during winter in the form of snow and rain (Ashraf &Routray, 2015). High-temperature variability is observed in the whole area. Northern high mountains have cold winters and warm summers. Some northern areas have extremely cold winters. Plains and deserts are very hot sometimes the temperature touches50 ◦C. (Jamro et al.**,** 2020**).**

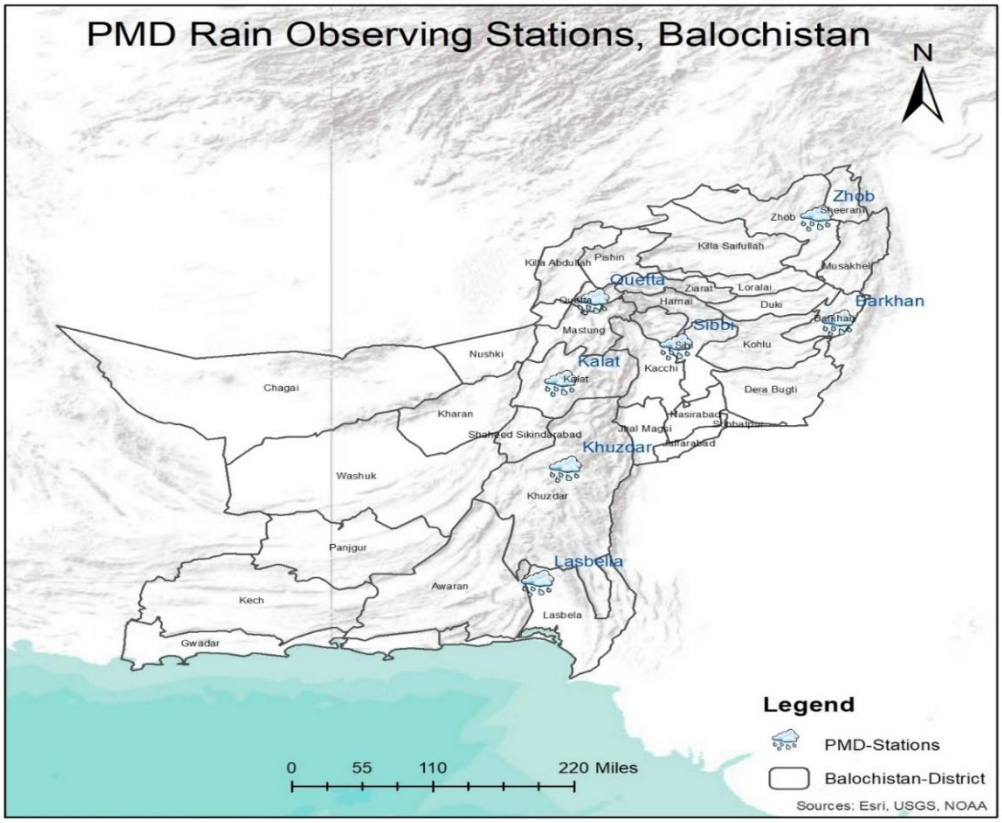

Fig.1 Study Area

Data &Methods

From 1999 to 2020, data on ground-level monthly precipitation were gathered from the Pakistan Meteorological Department, for 7 meteorological stations in Balochistan. They are Zhob,Quetta,Qalat,Barkhan,Sibi,Khuzdar and Lasbella. Annual Mean was calculated. Deviations from Mean and Standard Deviation for every station for every year of 21 years were calculated.The data were statistically analyzed using XLSTAT software. For the research purpose coefficient of Variability of precipitation in percentage was calculated.

The coefficient of variability is calculated using the mathematical formula below.

$$CV=SD/R*100$$

Where SD, Monthly standard deviation

R, Monthly Rainfall average

The coefficient of variation for every year of every station for 21 years was calculated.

Results& Discussion

Precipitation data from 1999 to 2020 was used for seven stations in Balochistan.These stations are Zhob, Barkhan, Quetta, Sibbi, Kalat, Khuzdar and Lasbela.This data was provided by Pakistan Meteorological Department.Data was in monthly average form,so annual averages were calculated,Deviations from Mean,Standard Deviation and in the last Coefficient of Variation was calculated in percentage. In all calculations, XLSTAT was used.According to the results, high rainfall variability is observed in all parts of Balochistan.

Coefficient of Variation for Barkhan

Barkhan is one of the areas which receives summer monsoon rainfall sometimes otherwise it also receives rains from Western depressions during winter. Fig. 2 shows that the coefficient of variance (CV) for Barkhan ranges from 80% in minimum to 140 % in maximum. In the year 2013 CV is 80% which after three years of fluctuations rises to 140% in 2016 and again dropped to the lowest of 90%.

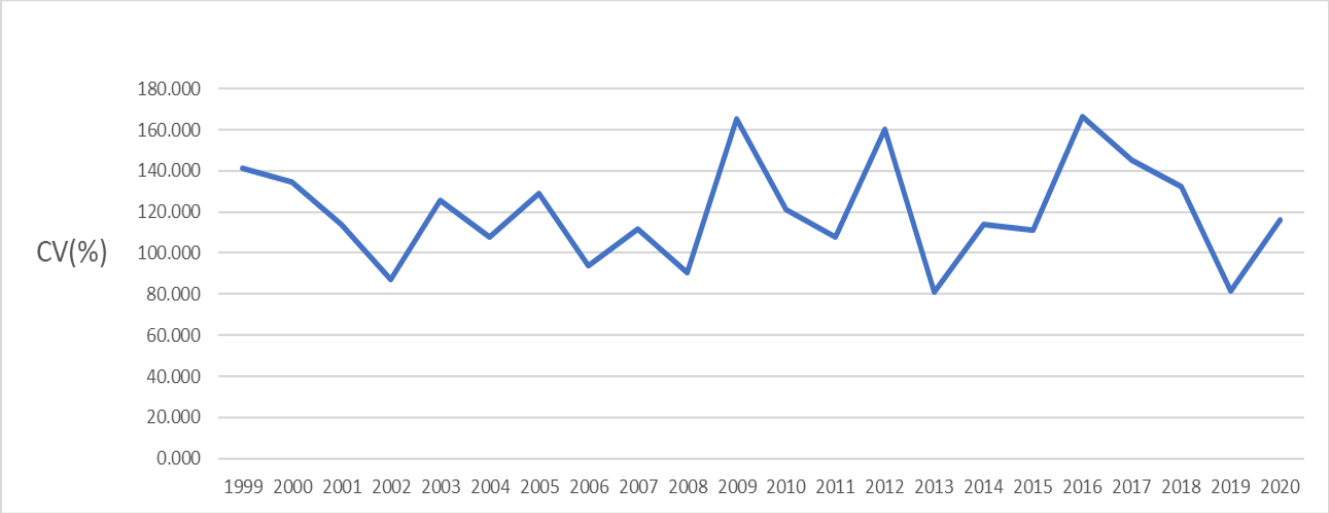

Fig.2Coefficient of Variation for Barkhan

Coefficient of Variation for Kalat

From 1999 through 2020, Kalat's interannual variability is shown in Fig. 3. According to the calculation, 80% is the lowest number seen in 2013 and 2019, while 165% is the greatest figure seen in 2016. Other years exhibit a wide range of variation as well.

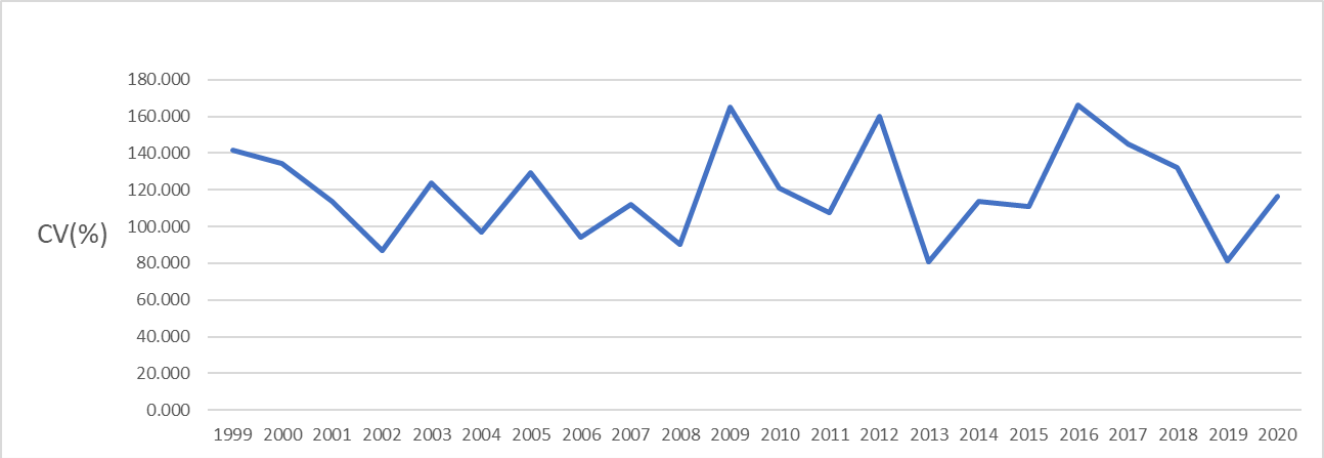

Fig.3Coefficient of Variation for Kalat

Coefficient of Variation for Khuzdar

Figure.4 illustrates the variation in rainfall, with a minimum of almost 50% and a maximum of between 250% and 400%. Between the maximum and least, there is a vast variation. Nevertheless, it varies over various years. There is a large range of fluctuations overall.

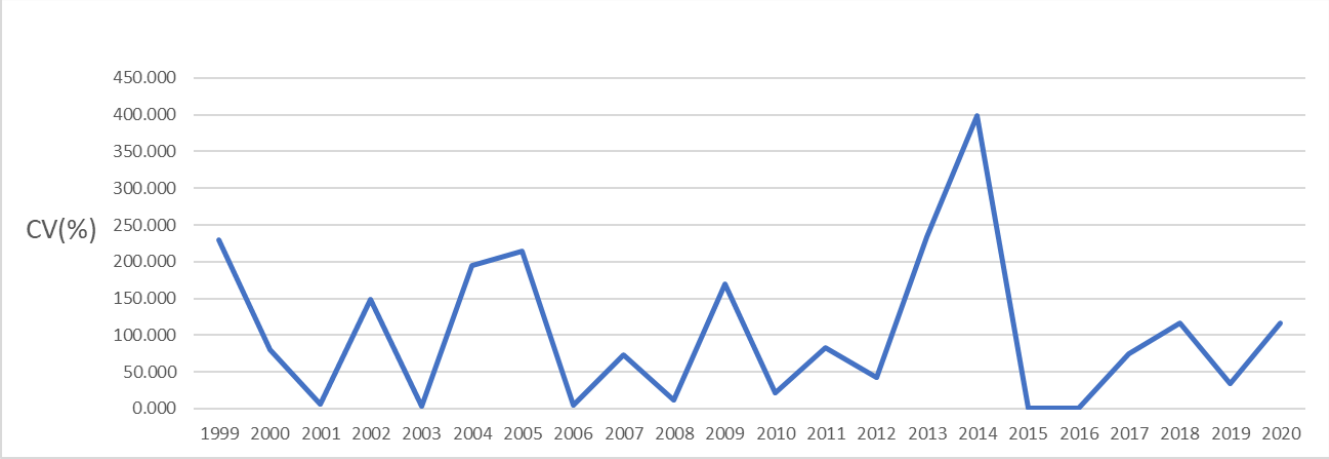

Fig.4Coefficient of Variation for Khuzdar

Coefficient of Variation for Lasbela

Rainfall varies from a minimum of 80% in 2019 to a maximum of 310% in 2002, as seen in Fig. 5. It meets the definition of extreme rainfall variability. The variability coefficient is found to be high. Various other years also change. 2002 marks the peak. The variability coefficient, on the other hand, often falls between 80% and 190%.

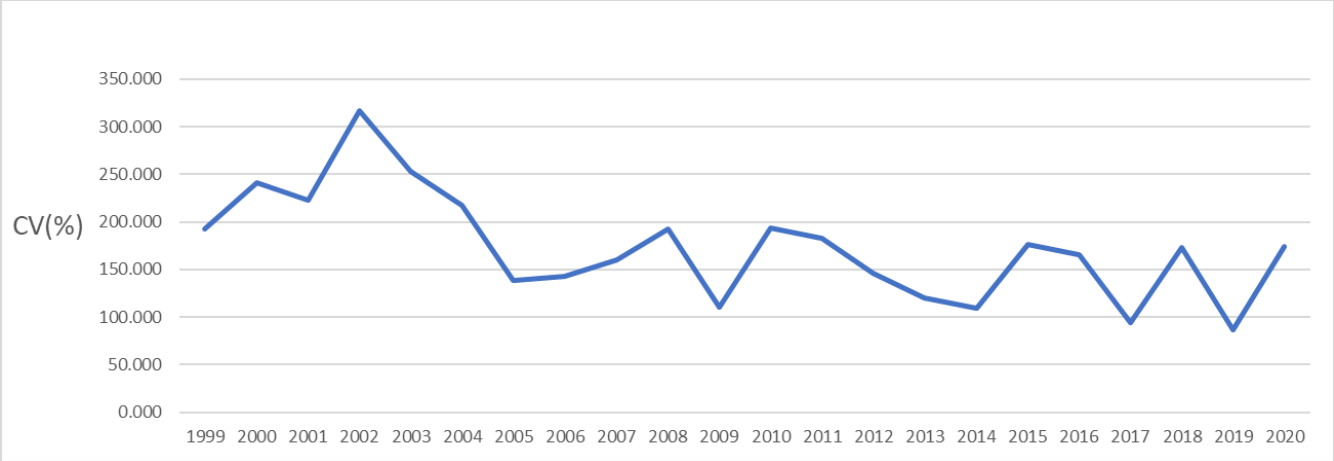

Fig.5.Coefficient of Variation for Lasbela

Coefficient of Variation for Quetta

Quetta does not experience abnormal extremes. In 2006, the Coefficient of Variance was 120%; in 2008, it was over 200%. The investigation has found that the variation coefficient's lowest value meets the definition of extremely high.

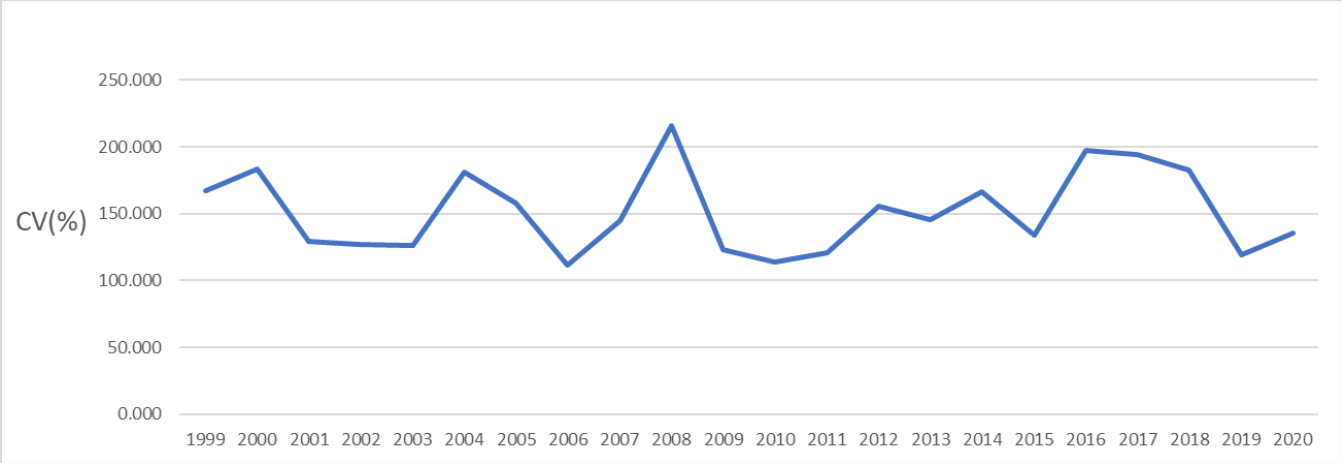

Fig.6.Coefficient of Variation for Quetta

Coefficient of Variation for Sibbi

The fluctuation in rainfall according to Sibbi's coefficient ranges from 100% in 2011 and 2015 to 250% in 2000. There is a range of 100% to 250%. Other years' variability coefficients vary less widely.

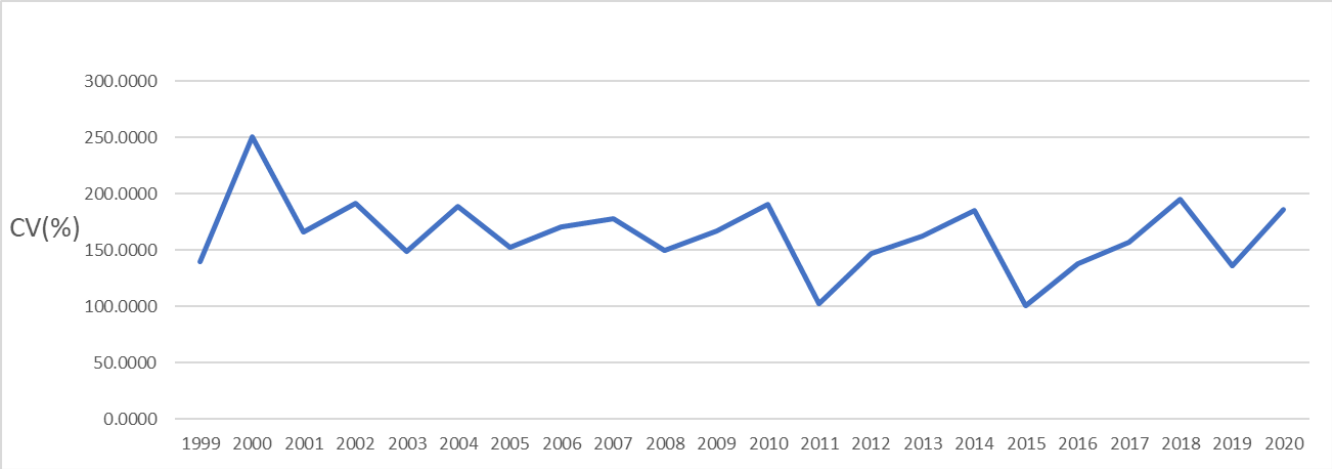

Fig.7.Coefficient of Variation for Sibbi

Coefficient of Variation for Zhob

Fig.8 rainfall variability coefficient for Zhob ranges from 70% in 2002 to more than 170% in 2010. The graph depicts the variation in rainfall for practically every year. But as compared to other stations, the difference between the minimum and maximum is not very large.

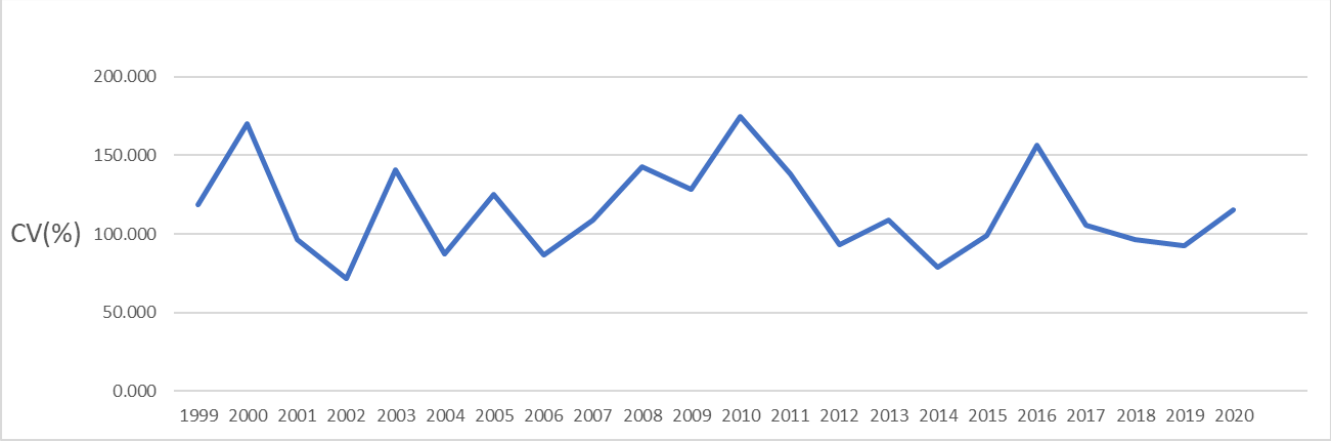

Fig.8.Coefficient of Variation for Zhob

Coefficient of variation for all stations

The seven meteorological stations in Balochistan display various coefficients of rainfall variability from 1999 to 2020 (Figure 9). All stations experience a decline in variability from high to extremely high. No station fits into the low or moderate variability categories. Some stations, like Khuzdar, exhibit wildly divergent readings. The range of minimum and maximum rainfall variability is less at stations like Zhob, Kalat, Quetta, and Sibbi.According to (Naheed& Rasool, 2011) studies from 1960 to 1999 shows high rainfall variability from 130% to 150% for the entire province ofBalochistan.

The Pakistan Meteorological Department has undertaken studies (Chaudhry et al., 2009). El Nino had a significant impact on Pakistan's precipitation, which caused a severe decline in both

summer and winter rainfall. The worst drought in Pakistani history, which lasted from fall 1998 to spring 2003, was caused by an El Nino-induced shortage in precipitation in terms of both length and intensity.

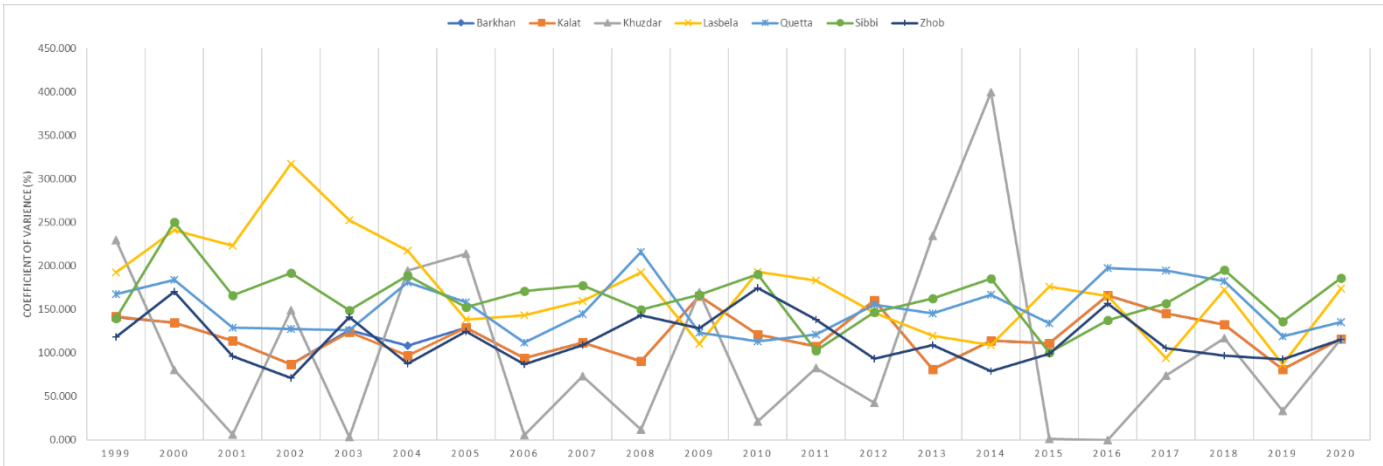

Fig.9: Combined Coefficient of Variation for all stations

Conclusions

As far as Balochistan is concerned all comes in the criteria of aridity. Only Zhob and Barkhan are two stations that fall in semi-arid because sometimes they receive summer monsoon. While rest of Balochistan either falls in arid or hyper-arid depending on winter rains due to western disturbances. Some parts of Southern Balochistan obtain rains from the Arabian Sea in a form of a summer monsoon. It has been noted that rainfall has fluctuated continuously, particularly in Southern Baluchistan, regardless of the season (Naheed& Rasool, 2011).

Monsoon rainfall variability appears as a disaster in the Southern part of Pakistan, especially Baluohistan. Rainfall during the monsoon season helps to maintain a stable water table and reduce moisture stress, particularly in southern Pakistan (Chaudhry and Rasul, 2004). One of the main causes of hydrological disasters, such as floods or drought, especially in the southern regions of the country, is the variability of this monsoonal rainfall (Adnan et al., 2015).In the summer of 2022 flash floods are experienced in Balochistan after a long seasonal drought, which is a sign of monsoon rainfall variability, which is already claimed in different research. The explanation for variations in rainfall intensity is provided by CV (Farhana and Rahman, 2011). Balochistan is largely an arid region with an annual rainfall of less than 250 mm. (Rafiq et al., 2022). Climate variability will pose a greater threat than climate change, as predicted by the rising trend in precipitation variability across temporal and spatial scales. Runoff variability, or variations in a major drought and flood frequency, will result from variations in rainfall variability (MacMahon et al., 1987).

To mitigate such disasters as floods and drought which are a serious threat to the social and economic condition of the province serious steps need to be taken by the government and non-governmental organisations. Rainwater is a precious resource that should not be wasted. It must

be stored in a clever way to combat future water shortages.Farmers are encouraged to take into consideration using supplemental irrigation measures in addition to their single reliance on rainfall in light of rainfall uncertainty and even drought occurrences. To keep this information useful, we also advise that research on rainfall variability should be conducted continuously as and when new rainfall data become available.

Only seven meteorological stations, predominantly on the northern and eastern sides of Balochistan, were one of the study's limitations. In terms of climate data, large portions of Balochistan go unobserved. Therefore, regular temporal and spatial monitoring of climatic variables is required in the future.

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