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DROUGHT RISK ASSESSMENT IN BALOCHISTAN FOR THE LAST TWO DECADES THROUGH STANDARD PRECIPITATION INDEX

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Abstract

Climate change has the worst impacts on the Balochistan province of Pakistan. The study aims to analyses drought intensity in Balochistan. For such purpose, monthly rainfall data of seven meteorological stations were obtained from Pakistan Meteorological Department (PMD) for the last two decades from 2000 to 2020. Standard Precipitation Index (SPI) is calculated for all stations for 20 years to categorise the intensity of drought. Results indicate that all seven stations show drought from mild dry to extremely dry spells because of high rainfall variability. Barkhan and Kalat droughts have longer spread out than others. Extreme dry months for almost all stations are from March to October. Lasbela's most wet periods were from 2018 to 2020. Climate variation in Balochistan ought to be monitored for drought preparedness, adaptation, and mitigation.

Keywords: Drought, Climate Change, Preparedness, Mitigation

INTRODUCTION

Droughts occur in a region experiencing a lengthy period of low rainfall and ultimately result in a temporary shortage of water (**Vogt and Somma 2013**). Drought has four different types (**Mishra & Singh 2016).** A meteorological drought occurs when rainfall in some region has fewer showers of rain than average. Gradually soil moisture reaches lower levels leading to agricultural drought. Hydrological drought is experienced due to the drying of water bodies. When the population is affected by food shortage, then it is called socioeconomic drought. Drought is a serious occurrence that has harmed ecosystems, water resource systems, and ultimately human survival on Earth **(Jahangir et al. 2013**). It is likely the worst natural disaster, causing the most economic damage, and affecting many facets of life with serious repercussions**. (Zhang et al.** 2011). According to Global Climate Risk Index **(GCRI**), Pakistan is one of the top ten countries most affected by climate change. Aridity and hyper aridity lead to drought. Pakistan is an agricultural country and must feed its huge population through agriculture which is mostly depending on rainwater. Agriculture production in arid and semiarid areas of Pakistan will

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decrease from 10% to 25**%. (Ahmad et al. 2016; Udmale et al. 2014)**. Balochistan is already experiencing the effects of drought. Most of the population in Balochistan depends on agriculture and livestock for their livelihood. Negative trends are visible at both the yearly and seasonal scales for more than 70% of the stations in Balochistan between 1975 and 2010. (**Ashraf & Routray 2015**)

Sindh and Balochistan, which are in the southern regions of Pakistan, receive less than 200 mm of rainfall annually (**Adnan and Khan 2009**). Past severe droughts in Balochistan province, including those in 1967–1969, 1971, 1973–1975, 1994, and 1998–2002, had a devastating effect on people's quality of life and the local economy. Nearly 80% of fruit plantations were damaged by these severe droughts **(Ashraf & Routray 2015).** Monthly rainfall data of seven stations in Balochistan were collected from Pakistan Meteorological Department (PMD), from 2000 to 2020. The standardized precipitation Index for every station is calculated. The final findings are anticipated to assist climate scientists, agro-meteorologists, agriculturalists, agronomists, policymakers, and stakeholders in improving drought preparedness and developing mitigation, adaptation, and contingency plans for drought in this region.

Study Area

Balochistan is the largest province of Pakistan in terms of area extent. Pakistan has borders with Iran and Afghanistan. The absolute location of Balochistan is from 22°N to 32°N latitude and from 66°E to 70°E longitude. Topographically it has a rugged terrain and has high mountains, plains, and deserts. Semiarid, arid, and hyper-arid are the three climatic regions prevailing in Balochistan (**Ahmed et al. 2019**). Pakistan receives rainfall from two major sources i.e., summer monsoon and western depressions (**Haider and Adnan, 2014**). The small semiarid area of Balochistan receives monsoon rainfall are district Zhob and District Barkhan. The rest of Balochistan falls in semi-arid and hyper-arid zones where the rainfall varies from 30 to 397 mm per year (**Ahmed et al. 2014).** Such aridity leads to droughts spatially and temporally.

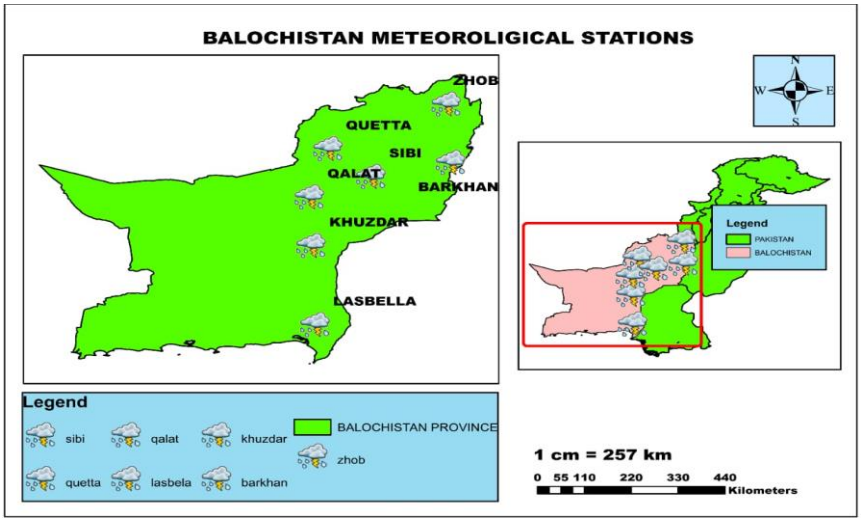

Figure 1: Study Area

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METHODOLOGY

Data Collection

To understand extreme weather events, long-term data preferably spanning decades is necessary.

In this case, monthly rainfall data for the two last decades were obtained from Pakistan Meteorological Department. The data consists of 7 meteorological stations in Balochistan. The study period spans from 2000 to 2020. The stations include Barkhan, Kalat, Khuzdar, Lasbela, Sibbi, Quetta and Zhob. The selection of stations was based on the availability of rainfall data in the province.

Standardized Precipitation Index

SPI (Standardized Precipitation Index) is an Index commonly used to sort out meteorological drought on short or longer timescales (**Keyantash and John 2018).**

$SPI = X - Xm \div \sigma$

Where: X = recorded rainfall at the station

Xm = mean of rainfall

σ = standard deviation

3-month SPI for each station was obtained by use of SPEI (standard evapotranspiration-precipitation index) package in R-Studio, applying this to the SPI series gives drought characteristics in graphical form. Only SPI was calculated via precipitation input and no temperature data. SPI is considered reliable enough to study droughts because of its robustness and reliability (**Hassan et al. 2014**).

Table 1: Index values and classification of SPI (Mckee et al. 1993).

SPI Index	Category
2.0 and above	Extremely wet
1.50 to 1.99	Very wet
1.00 to 1.49	Moderately wet
0.00 to 0.99	Mildly wet
-0.99 to 0.00	Mildly dry
-1.00 to -1.50	Moderately dry
-1.50 to -1.99	Very dry
-2.00 and below	Extremely dry

RESULTS AND DISCUSSION

SPI Index is used to calculate drought on temporal scale. For drought identification in Balochistan, monthly rainfall data for the last two decades is used for seven stations of Balochistan. These stations are Barkhan, Kalat, Khuzdar, Lasbela, Quetta, Sibbi and Zhob. Looking at all the SPI time series shown in the graphs below, all stations show Mild dry, moderate dry, very dry and extremely dry periods of precipitation during the study timescale. Barkhan show drought events with more spread-out drought pattern that lasted

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longer compared to the other stations. The extremely dry months were observed typically from March to October in 2000 to 2003, 2009, 2016, 2017 and a short-lived very dry period in 2020 (Fig.2). More severe drought occurrences occurred at Barkhan's easternmost station than at the other sites. In 2000 to 2004, 2009, 2016, and 2017, the months with the worst droughts were primarily March to October. (**Naz et al. 2020)**. Kalat show drought events that are extremely like Barkhan and show a more spread-out drought pattern that lasted longer compared to the other stations. The extremely dry months were observed typically from March to October in 2000 to 2003, 2009, 2016, 2017 and a short-lived very dry period in 2020 (Fig.3).

Khuzdar station showed 4 extremely dry periods, often from May to October, in the years 2001, 2002, 2009, and 2014 with a positive uplift from then on till 2020. (Fig.4). Lasbela also show extremely dry periods in, 2004, 2008 and 20017, throughout the study period. Although, a very dry period can be observed from 1999 to 2003. Relatively Lasbela had the wet periods without any dry periods from 2018 to 2020. (Fig5). Quetta, the capital, and most populous city of Balochistan is shown to have experienced three extremely dry periods in March and April of 2000 2004, 2008 and 2017. However, it faced moderately dry to very dry periods from December to July in different years, the longest stretch being from 2016 to 2019 without a particularly wet period. (Fig.6) In Sibbi extreme dry weather events were also seen mostly in March and July to October. An Extremely dry period was observed in 2002. Less drought periods were observed from 2004 onwards. (Fig7). Zhob had dry periods that mostly took place in March and July to October one notable extremely dry period took place in the year 2011. There was observed to be a very dry period that lasted from 1999 to 2002 and another stretch from 2015 to 2017 without significant rain. (Fig.8). Major droughts (SP<0) that affected more than 50% of the province's entire area were recorded in the years 1981, 1986, 1987, 1988, 1994, 1997, 2000, 2001, 2002, 2003, 2004, 2006, and 2010. (**Ashraf & Routray 2015**).

The years 2000, 2001, 2002, and 2004 are regarded as the most severe drought years in the province because they coincided with the worst drought years in the history of the country as a whole and affected more than 80% of the province's land. As a result, crop production and livestock were severely affected, which had serious repercussions for the food security and way of life of a significant portion of the population. (Ahmed **et al., 2004; GoB 2007).**

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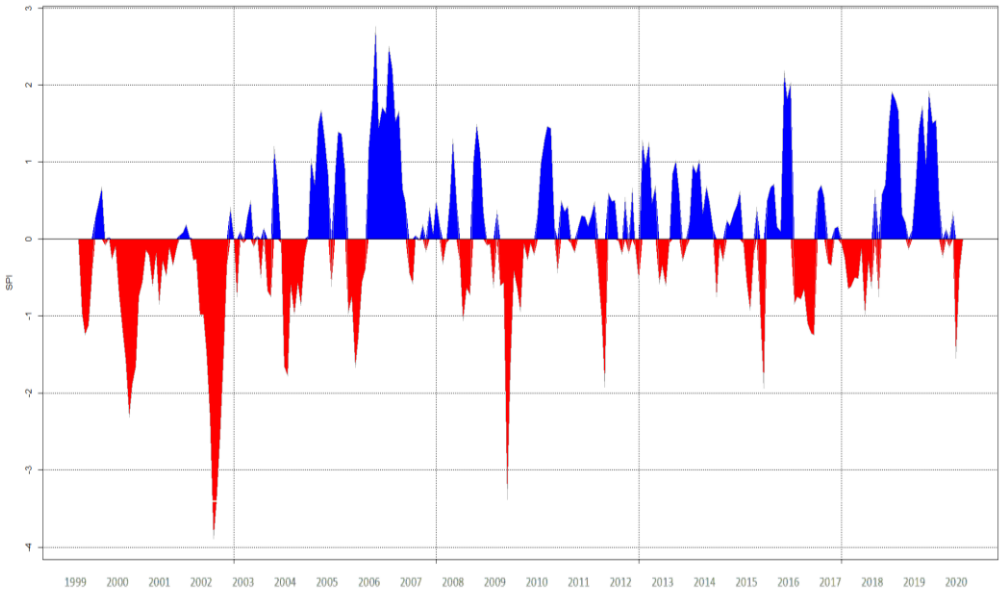

Fig.2: SPI of Barkhan

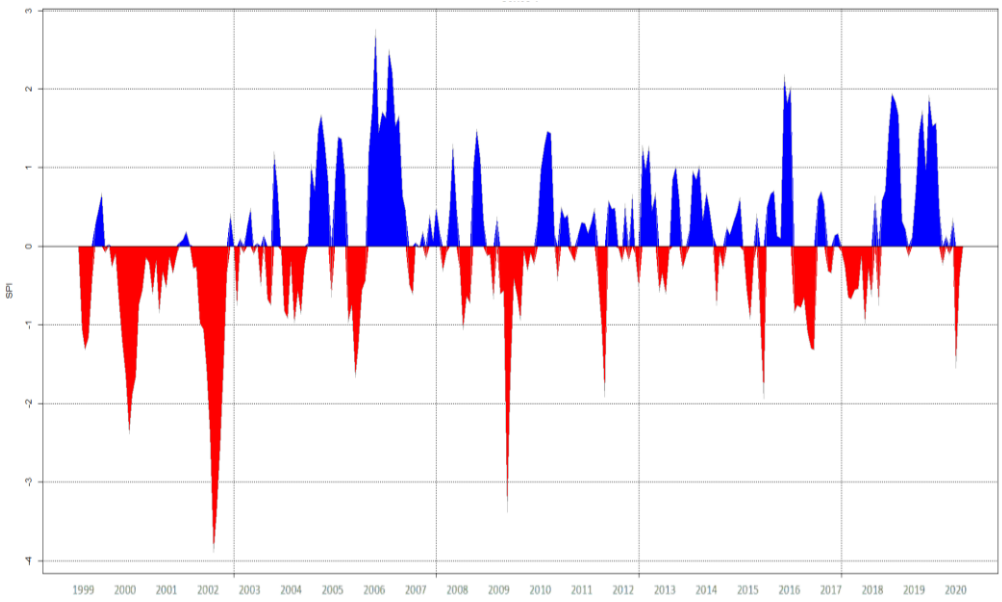

Fig.3: SPI of Kalat.

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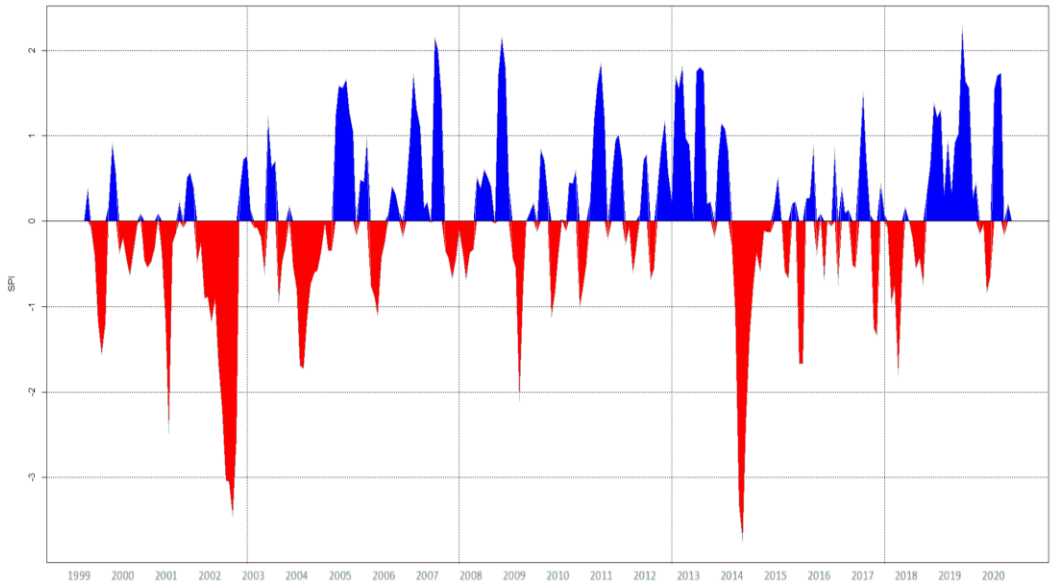

Fig.4: SPI of Khuzdar.

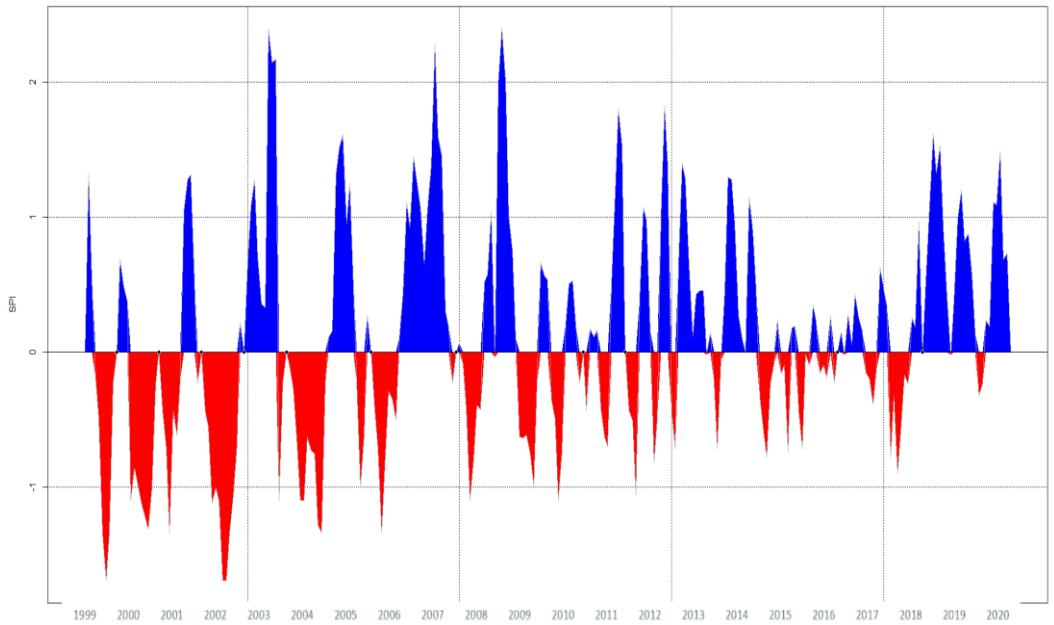

Fig.5: SPI for Lasbela

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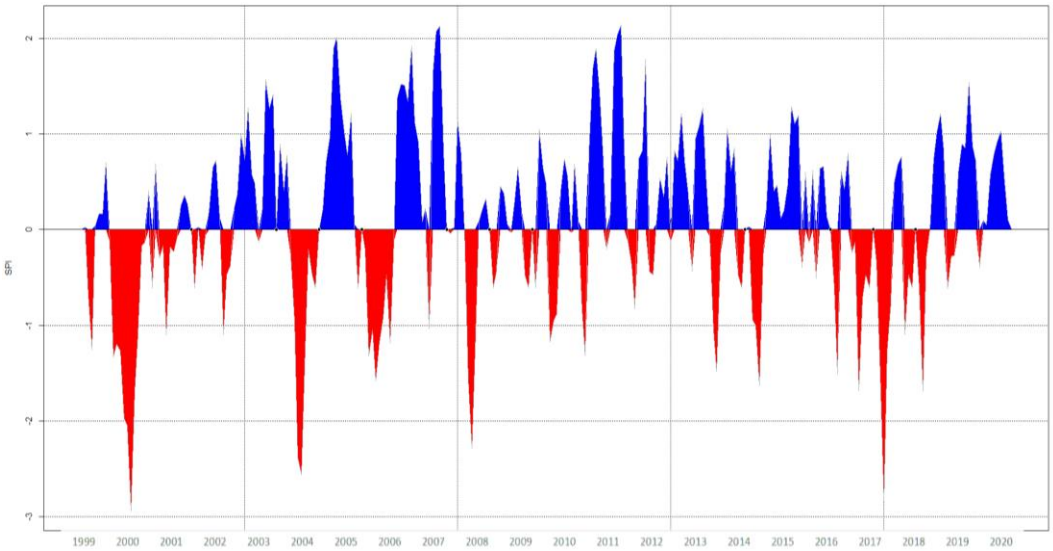

Fig.6: SPI for Quetta.

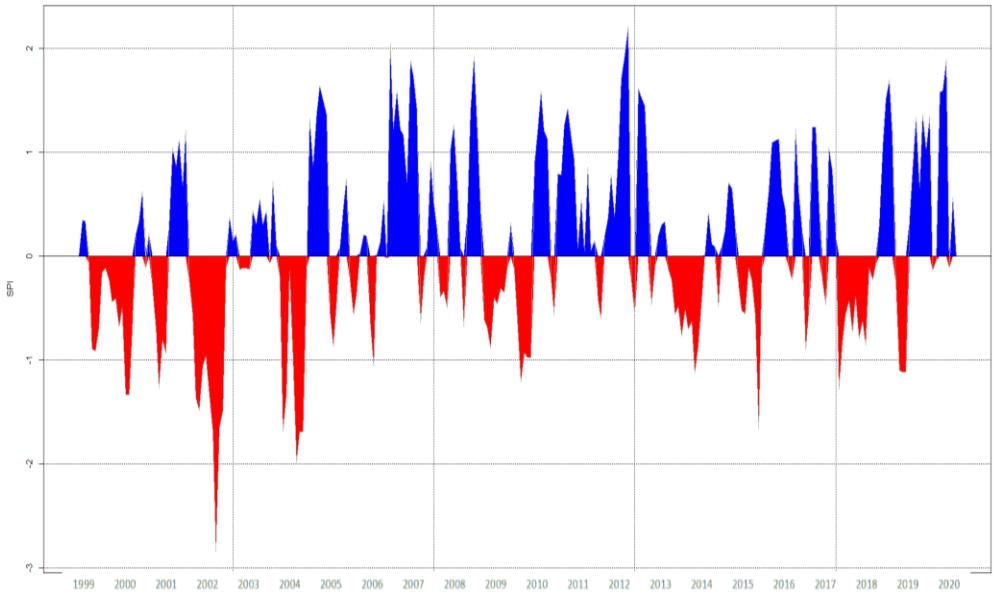

Fig.7: SPI for Sibi.

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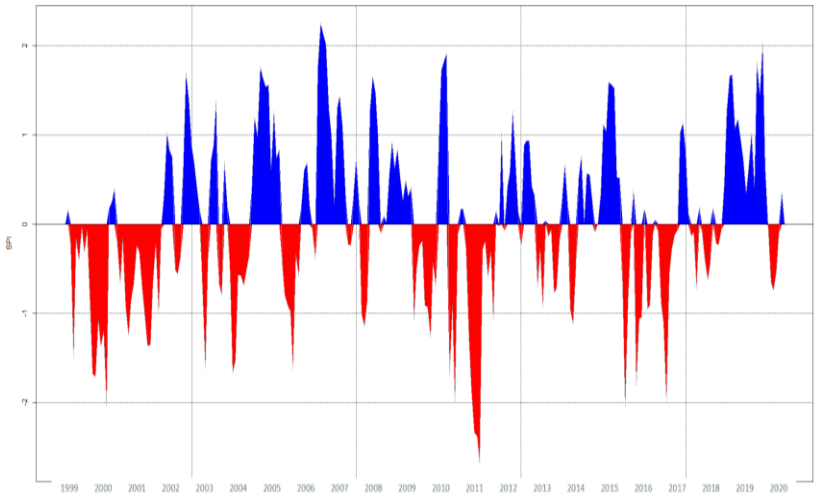

Fig.8: SPI for Zhob.

CONCLUSIONS

Aridity is associated with the Balochistan the largest province of Pakistan in area. Continuous spells of drought were experienced here from past many decades. Such drought spells have negative impacts on the livelihood of the population. Due to the absence of proper monitoring, adaption, and mitigation. Drought hit the socioeconomic condition of the people very badly. This area is famous for livestock herding and for its fruit orchards. Both sectors are badly hit by the drought. In these studies, an effort is made to investigate the severity of drought temporally. For achievement of such goal monthly precipitation data for seven meteorological stations has been used from 2000 to 2020.Such stations are Barkhan, Kalat, Khuzdar, Lasbella, Quetta, Sibbi and Zhob. Standardized Precipitation Index was calculated which is shown with the help of graphs. The results depict that all stations show mildly dry, moderately dry, very dry, and extremely dry periods of precipitation during the study timescale. The driest months are from March to October mostly. It means no or fever monsoon rains. This study has limitations too as, only seven stations data were made available by Pakistan Meteorological Department (PMD) which mostly cover the upper half of the Balochistan Plateau. There were no data available for lower half. Such kind of studies would be very helpful in future with more data and more intensive analysis to manage resources particularly water resources. However, adaptation and mitigation measures have to be taken for better future planning.

References

1. Adnan, S., and A. H. Khan, (2009): Effective rainfall for irrigated agriculture plains of Pakistan. Pakistan J. Meteor., 6, 61–72.
2. Ahmed K., Shahid S., Wang X., Nawaz N., Najeebullah K. (2019) Evaluation of gridded precipitation datasets over arid regions of Pakistan. Water 11:210. https://doi.org/10.3390/w11020210

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3. Ahmad, I., Ambreen, R., Sultan, S., Sun, Z.B. and Deng, W.T. (2014). Spatial-Temporal Variations in January Precipitation over the Period of 1950-2000 in Pakistan and Possible Links with Global Teleconnections, Geographical Perspective. American Journal of Climate Change: 3: 378-387.
4. Ahmed, K., Shahid, S., Harun, S., Wang X., (2016) Characterization of seasonal droughts in Balochistan Province, Pakistan. Stoch Environ Res Risk Assess. **30**, 747–762 https://doi.org/10.1007/s00477-015-1117-2
5. Ahmed, S., Hussain, Z., Qureshi, A.S., Majeed, R., Saleem, M. (2004) Drought mitigation in Pakistan: current status and options for future strategies. Working paper 85. International Water Management Institute, Colombo
6. Ashraf, M., Routray, J.K. (2015): Spatio-temporal characteristics of precipitation and drought in Balochistan Province, Pakistan. Nat. Hazards, 77, 229–254.
7. Hassan, I. H., Mdemu, M. V., Shemdoe, R. S., & Stordal, F. (2014). Drought pattern along the coastal forest zone of Tanzania. Atmospheric and Climate Sciences > Vol.4 No.3.
8. Baum, D. (2018). Global Climate Risk Index 2019-Who Suffers Most from Extreme Weather Events? Weather-related Loss Events in 2017 and 1998 to 2017.
9. Government of Balochistan (GoB) (2007) Provincial disaster risk management plan, Balochistan disaster management authority government of Balochistan
10. Naz, F., Dars G.H., Ansari K., Jamro, S. and Krakauer, N., Y,. (2020) Drought Trends in Balochistan. Water 2020, 12, 470;
11. Haider, S., Adnan, S., (2014) Calssification and assessment of aridity over Pakistan provinces (1960-2009). Int J Environ 3:17–3
12. Jahangir, A.T.M., Sayedur, R.M., and Saadat, A.H.M., (2013) Gamma distribution and its application of spatially monitoring meteorological drought in Barind, Bangladesh. International Journal of Geomatics and Geosciences, 3, 511–524
13. Keyantash, John & National Center for Atmospheric Research Staff (Eds). Last modified 07 Aug 2018. "The Climate Data Guide: Standardized Precipitation Index (SPI)." Retrieved from https://climatedataguide.ucar.edu/climate-data/standardized-precipitation-index-spi.
14. McKee, T. B., N. J. Doesken, and J. Kleist, 1993: The relationship of drought frequency and duration of time scales. Eighth Conference on Applied Climatology, American Meteorological Society, Jan17-23, 1993, Anaheim CA, pp.179-186.
15. Mishra, A. K., & Singh, V. P. (2010). A review of drought concepts. *Journal of hydrology*, *391*(1-2), 202-216.
16. Udmale, P., Ichikawa, Y., Manandhar S., et al (2014) Farmers' perception of drought impacts, local adaptation and administrative mitigation measures in Maharashtra State, India. Int J Disaster Risk Reduct. https:// doi.org/10.1016/j.ijdrr.2014.09.011
17. Vogt, J. V., and Somma, F., (2013): Drought and Drought Mitigation in Europe. Springer Science & Business Media, 328 pp.
18. Zhang Jianming, Zhang Xinping, Li Zuxian, et al., 2011: Spatial distribution and variation tendency of droughts and floods in Hunan Province during the past 36 years. J. Tropical Meteor., 17, 385–391.