Journal of Geography and Social Sciences, 2020, 2 (2), 110-121.
http://www.jgss.com.pk

Original Article OPEN ACCESS

Assessment of drought occurrences in Zhob District using Standardized Precipitation Index from 1981-2018

Shaista Khan[1]*, Mohammad Ashraf[2] and Sanaullah Khan[3]

[1] MPhil Scholar, Department of Disaster Management and Development Studies, University of Balochistan, Quetta, 87300, Pakistan
[2] Ph.D., Assistant Professor, Disaster Management and Development Studies, University of Balochistan; ✉ mashrafh75@gmail.com
[3] MS. Geography and GIS, University of Balochistan; ✉ sana.geo1@gmail.com

ABSTRACT

Background: It is valuable for the policy makers to configure and assess the severity of drought in a particular area having arid climate, remote rural settlements and history of prolonged drought spells.

Objective: This study identifies and assesses the onset and extent of drought in the Zhob district by studying its spatio-temporal pattern using geospatial techniques.

Methods: In a longitudinal timeframe study (1981-2018), the precipitation data was collected from two rain gauge stations across Zhob district to assess the precipitation trends and calculate Standardized Precipitation Index values at multiple timescales. The values were then projected spatially as well as temporally to study the subsequent patterns and spatio-temporal extent of drought.

Results: The findings revealed that over the past 38 years, the Zhob district has experienced waves of dry and wet spells out of which the two prolonged drought spells were identified as 1998-2002 and 2015-2018. Both the periods differentiate in pattern and extent of spread; however detailed study of the later drought period was carried out to configure the differences in category and extent of the drought when compared on multiple timescales.

Conclusions: The spatio-temporal drought trends of past 38 years in the study area revealed how differently the drought expands over an area when assessed on various timescales. The precipitation anomaly when studied in conjunction with frequency of drought recurrence in the study area, revealed patterns indicating onset and other characteristics of drought. Such indications if rightly pointed out by the government agencies would help farmers and local populace to timely ascertain the approaching drought.

ARTICLE HISTORY
Received: 9 Aug 2020
Accepted: 28 Sep 2020
Published: 31 Dec 2020

KEYWORDS
Disaster;
Drought:
Drought Assessment;
Standardized Precipitation Index;
SPI;
Balochistan;
Pakistan

1. INTRODUCTION

Pakistan is considered as one of the relegated states encountered with the climate change and has already started experiencing the consequences of the inevitable phenomenon (IUCN, 2009). The National Disaster Management Authority (NDMA) has also declared that the results of climate change would continue to appear with more severity and recurrence in coming years(NDMA, 2015). Similarly, growing rainfall variability and temperature rise are also very common and may cause major threat of drought if this trend continues depleting towards less precipitation and higher recordings of temperature. This occurrence might have radical impacts on the arid areas of Pakistan(Sajjad & Raza, 2007).

By examining the rainfall trends we may deduce that Pakistan experiences grave coercions of drought after almost every half decade. In the last mid-century, the period from 1998-2002 is stated as the most severe drought in the climatic history of the country. This is mainly because very fewer rainfalls were

***CONTACT** Shaista Khan ✉ shaistakhan117@gmail.com

recorded all across the country throughout this period as compared to previous years. Resultantly, Balochistan was declared as the most affected area during this drought, damaging 88% of the province area. As per the Government statistics, the drought damaged almost 80 % of fruit orchards and out of 29 districts it creeped into 22 districts of the province (Government of Balochistan, 2007).

Balochistan has remained a drought affected area (Ashraf, 2019; Rehman et al., 2019), and due to its inherent aridity the phenomenon appears much severe. The disaster itself and its various aspects have been amply studied by scholars, researchers and institutions in the past, out of which the prominent works on Hydrological Drought and Ground Water Depletion include research by Kakar and Ahmad (2016) and van Steenbergen et al. (2015), Meteorological drought (Ashraf & Routray, 2015), Agricultural Drought and its Impacts (Ashraf et al., 2014), Drought Risk Assessment (NDMA, 2015) etc. Contrary to conventional drought assessment and monitoring, the Remote Sensing technology has not been very widely used in Balochistan, therefore a very limited research work is available on the use of Remote Sensing in the context of Drought. The research work by Ashraf et al. (2011) and Khan et al. (2016) focus on a study of particular geographic areas within Balochistan, whereas, the actual potential of the Remote Sensing technology lies in its use on a wider spatial scale. In a study on spatio-temporal characteristics of drought in Balochistan by Ashraf and Routray (2015), it was revealed that the mild droughts when spatially distributed indicate that within the province, the droughts are more recurrent for which they carried out a number of Standardized Precipitation Index (SPI) projections on different timescales of three, six, and twelve months. In summary of their results they identified that lesser frequent mild droughts tend to occur across Balochistan as the timescale increases (Ashraf & Routray, 2015).

This study attempts to assess the expanse and recurrence of drought in Zhob district on a longitudinal timeframe from 1981-2018, using a detailed precipitation record. Further, by calculating the multiple time scaled SPI values, the study projects the drought pattern of the district with its spatio-temporal extents. Hence, such a detailed monitoring of drought assessment at district level would prepare the stakeholders with early warning and identification of drought far ahead of local farmers. Thereby, emphasizing on the need to equip the district level meteorological and irrigation departments with early warning and update mechanism so that the district administration is timely warned of creeping drought coercion as a drought risk reduction mechanism.

2. METHODS

2.1 Study design

This study has adopted the longitudinal research design for the collection and processing of data. Quantitative techniques were used for statistical analysis of the data.

2.2 Selection of Study Area

Zhob district is located at 31.39 – 30.48 latitude and 69.48 – 69.21 longitude in the north of Balochistan province of Pakistan covering an area of 20,297 sq km and very sparse population of about 0.32 million. The district of Zhob is northern district of Balochistan that joins boundaries with KPK in the north, Afghanistan in the west, Sherani and Musakhel districts in the east and Qilla Saifullah district in the south. The district is administratively distributed into four Tehsils/ Sub-Tehsils as Zhob, Qamardin Karez, Sambaza and Ashwet and has two rain gauge stations at Zhob and Badinzai respectively (Figure 1).

Zhob is one of the higher recipients of precipitation both from winter snow and summer monsoon rains. However, due to recurrent drought coercions the local farmers have suffered from drought impact in the past. The district being an under developed area with marginalized disaster risk management setups, has meager drought assessment and monitoring facilities. In most of the cases, the agricultural drought based Early Warnings are generated by the farmers themselves rather than District Disaster Management Authorities (DDMAs).

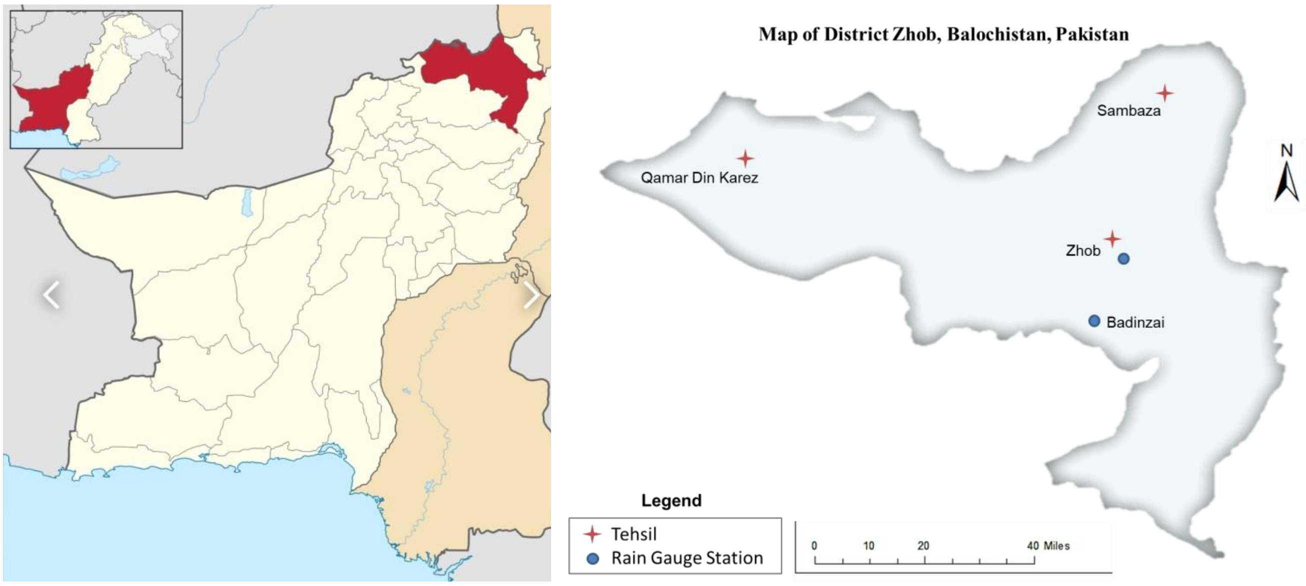


Figure 1 Map of the study area: Zhob District, Balochistan and its administrative distribution.

Zhob has extreme temperature variability. Summers are mild in highland areas and hot in lowland areas ranging on an extreme gauge of high and low temperature scales. The winters are comparatively cold with average minimum temperatures close to zero in January, whereas the absolute minimum temperature may fall down to -15oC in highland areas. The district falls within the climatic region which has climate ranging from hyper-arid to semiarid with an annual precipitation ranging from 50-400mm, predominantly the winter rain and snow along with additional rain pour from summer monsoon. The snow cover is not permanent therefore; the adequate water does not reach the Zhob River and other streams. Only small natural springs provide the perennial water supply in some areas (Kidd et al., 1988).

Since the research relies on the collection of secondary meteorological data being made available through established meteorological stations, therefore collection of primary data is not considered as part of this research.

2.3 Variables

The study adopts a quantitative approach to analyse the onset and extent of drought in the study area on a longitudinal timeframe involving time as the independent variable while precipitation as the explanatory variable.

2.4 Data sources

The average monthly precipitation data of two rain gauge stations of last 38 years of the study area was acquired from Pakistan Meteorological Department (PMD) (Pakistan Meteorological Department, 2018).

2.5 Research instrument: Standardized Precipitation Index (SPI)

This SPI was first introduced by McKee et al in 1993 to measure the shortage of precipitation at a specific location for a number of time periods (Jr, 2002), and has gained increasing value in the last two decades being a potential drought indicator allowing comparisons across space and time by calculating actual rainfall as the standardized depletion from the function of average rainfall distribution (Naresh Kumar et al., 2009). It is measured by calculating the difference of precipitation out of the average for a defined period of time and then divided by the standard deviation. The problem of abnormal distribution of precipitation is catered for by applying the transformation of gamma function to distribution (Jr, 2002).

The SPI was designed to quantify the precipitation deficit for multiple timescales. These timescales reflect the impact of drought on the availability of the different water resources. Soil moisture conditions respond to precipitation anomalies on a relatively short scale. Groundwater, streamflow and reservoir storage reflect the longer-term precipitation anomalies. For these reasons, McKee et al. (1993) originally calculated the SPI for 3, 6, 12, 24 and 48-month timescales. The SPI calculation for any location is based on the long-term precipitation record for a desired period. This long-term record is fitted to a probability distribution, which is then transformed into a normal distribution so that the mean SPI for the location and desired period is zero (Edwards, 1997). The positive SPI values indicate greater than median precipitation and negative values indicate less than median precipitation. Because the SPI is normalized, wetter and drier climates can be represented in the same way; thus, wet periods can also be monitored using the SPI McKee et al. (1993) used the classification system shown in the SPI value table below (Table 1) to define drought intensities resulting from the SPI. They also defined the criteria for a drought event for any of the timescales. A drought event occurs any time the SPI is continuously negative and reaches an intensity of -1 0 or less. The event ends when the SPI becomes positive. Each drought event, therefore, has a duration defined by its beginning and end, and intensity for each month that the event continues. The positive sum of the SPI for all the months within a drought event can be termed the drought's magnitude (WMO, 2012).

The study used Standardized Precipitation Index (SPI) in order to estimate drought onset, duration and frequency:

SPI = (Xik - Xi) / Ói (1)

Where,
Ói = Standardized deviation for the i^{th} station
Xik=Precipitation for the i^{th} station and kth observation
Xi = Mean precipitation for the i^{th} station

The SPI calculation needs long term precipitation data to determine the probability distribution function which is then transformed to normal distribution with mean of zero and standard deviation of one. Thus, the values of SPI are expressed in standard deviations with positive SPI values indicating greater than median precipitation and negative values indicating less than median precipitation (Edwards, 1997). Since SPI values fit a typical normal distribution, these values fall within one standard deviation at approximately 68% of the time, within two standard deviations 95% of the time and within three standard deviations 98% of the time.

The index has the advantages of being easily calculated, having modest data requirements and being independent of the magnitude of mean rainfall and hence comparable over a range of climatic zones. It does, however, assume the data are normally distributed, and this can introduce complications for shorter time periods (Agnew, 2000).

2.6 Reliability of the instrument

The SPI quantifies observed precipitation as a standardized departure from a selected probability distribution function that models the raw precipitation data. The raw precipitation data are typically fitted to a gamma or a Pearson Type-III distribution, and then transformed to a normal distribution. The SPI values can be interpreted as the number of standard deviations by which the observed anomaly deviates from the long-term mean. The SPI can be created for differing periods of 1-to-36 months, using monthly input data. Wherein, precipitation is the only input parameter(Keyantash, 2018). SPI Software is a reliable tool to acquire the SPI values by processing the precipitation data (WMO, 2012).

2.7 Sample design

The samples were collected from the only available resources without confining into limitations of reliability. Therefore, collection of primary data is deliberately not involved due to resource constraint and thereby research is based on the input of secondary precipitation data from two rain gauge stations only. Thus, the research will not involve sampling for collection, distribution and analysis of primary data.

2.8 Data analysis methods

The 38 years monthly average precipitation data was initially processed to acquire different precipitation trends in graphical form. Basing on these trends the data was further processed using SPI calculator to obtain SPI values of the two rain gauge stations at multiple timescales of 1, 2, 3, 6, 12, 18 and 24 months separately. The SPI measurement was carried out using SPI Calculator (Naresh Kumar et al., 2009).

ArcMap 10.1 was further used to transform data and subsequent results into thematic choropleth maps for the precipitation and SPI as input parameter using IDW interpolation technique. Finally, the desired maps of a particular timeframe were overlaid to estimate differences in drought frequencies and categories.

Table 1 SPI Measurement (McKee et al., 1993)

Standardized Precipitation Index (SPI)	Drought Category
2.0+	Extremely Wet
1.5 to 1.99	Very Wet
1.0 to 1.49	Moderately Wet
-.99 to .99	Near Normal
-1.0 to -1.49	Moderately Dry
-1.5 to -1.99	Severely Dry
-2 and less	Extremely Dry

3. RESULTS

3.1 Precipitation trends in study area

A trend represents a significant change displayed by a random variable over time, which can be detected by parametric and nonparametric statistical techniques. The study used monthly precipitation data in order to compute annual precipitation trends and their spatial coverage through two rain gauge stations in study area namely Zhob and Badinzai. Summaries of the results of trend analysis from annual precipitation data are presented in Figure 2. During the period from 1981–2018 the average rainfall of Zhob district is recorded as 21.3 mm.

The Figure 3 signifies the average monthly representation of rainfall of last 38 years in study area. It can be noted that that the period of May and Sep-Dec are the driest periods of Zhob throughout the year reason being that district receives significant precipitation from Jan-Apr in the form of winter rains and snowfall, and also receives Monsoon rains from Mid Jun-Aug. Hence the crop production trend in the district also relates to the traditional climatic cycle. Correspondingly, the spatial precipitation trend of dry and wet periods of study area are acquired by plotting the average monthly precipitation values of the two rain stations by using IDW technique of interpolation. The spatial precipitation trend of two dry months (May and Oct) and two wet months (Feb and Jul) are shown in Figure 4. The spatial trend in wet period depicts that during the winter period (Dec-Feb), district being north western part of the province received the rain and snowfall mainly due to western disturbances while during summer period (Mid Jul-Aug) only the complete eastern part of the district received rainfall as part of monsoon rains.

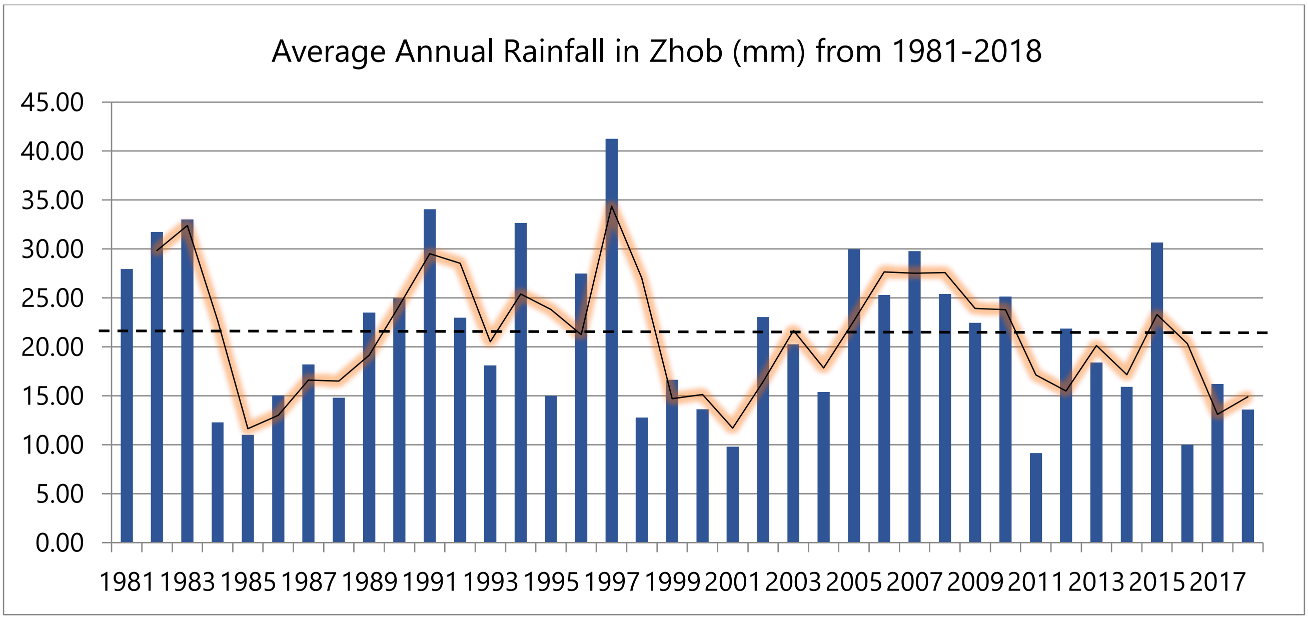


Figure 2 Average Annual Rainfall in Zhob District from 1981-2018

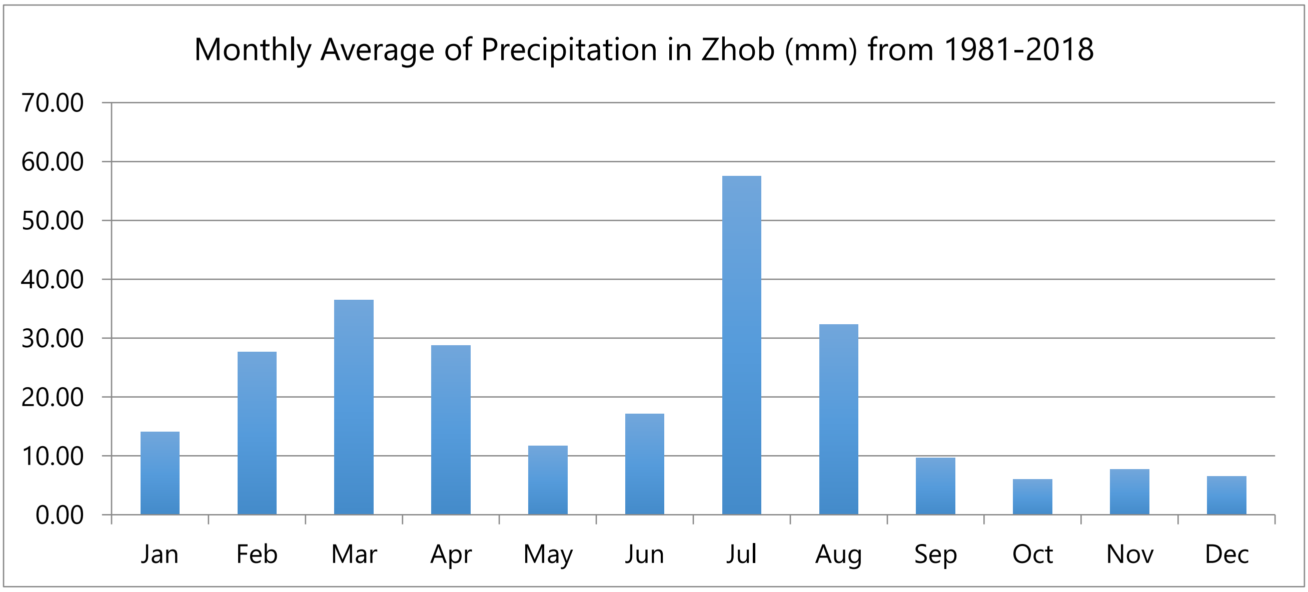


Figure 3 Monthly Average of Precipitation in Zhob District from 1981-2018

3.2 SPI based assessment of Zhob District

SPI is a useful tool for computing the normal distribution of precipitation values of varying timescales which further helps in the determination of drought recurrence and frequencies of prolonged timescales of the study area. In the course of research study, a 38 year (1981-2018) secondary precipitation data of two rain gauge stations of Zhob district was used for calculation of 1, 2, 3, 6, 9, 12, 18 and 24-months SPI values on a longitudinal timeframe. The 1-month SPI results are similar to the monthly precipitation values, whereas 2 and 3 months SPI values show the short term availability or unavailability of precipitation in the environment after a rainy or dry season respectively. The 6 and 9 month SPI values show mid-term presence or absence of precipitation which mostly affects cropping and agriculture in an area. The 12, 18 and 24 month SPI values are more helpful in determination of long term effects of dry periods resulting into fatal droughts (Ashraf et al., 2014). During the course of research, SPI-12 is widely used to determine long term effects of drought in study area.

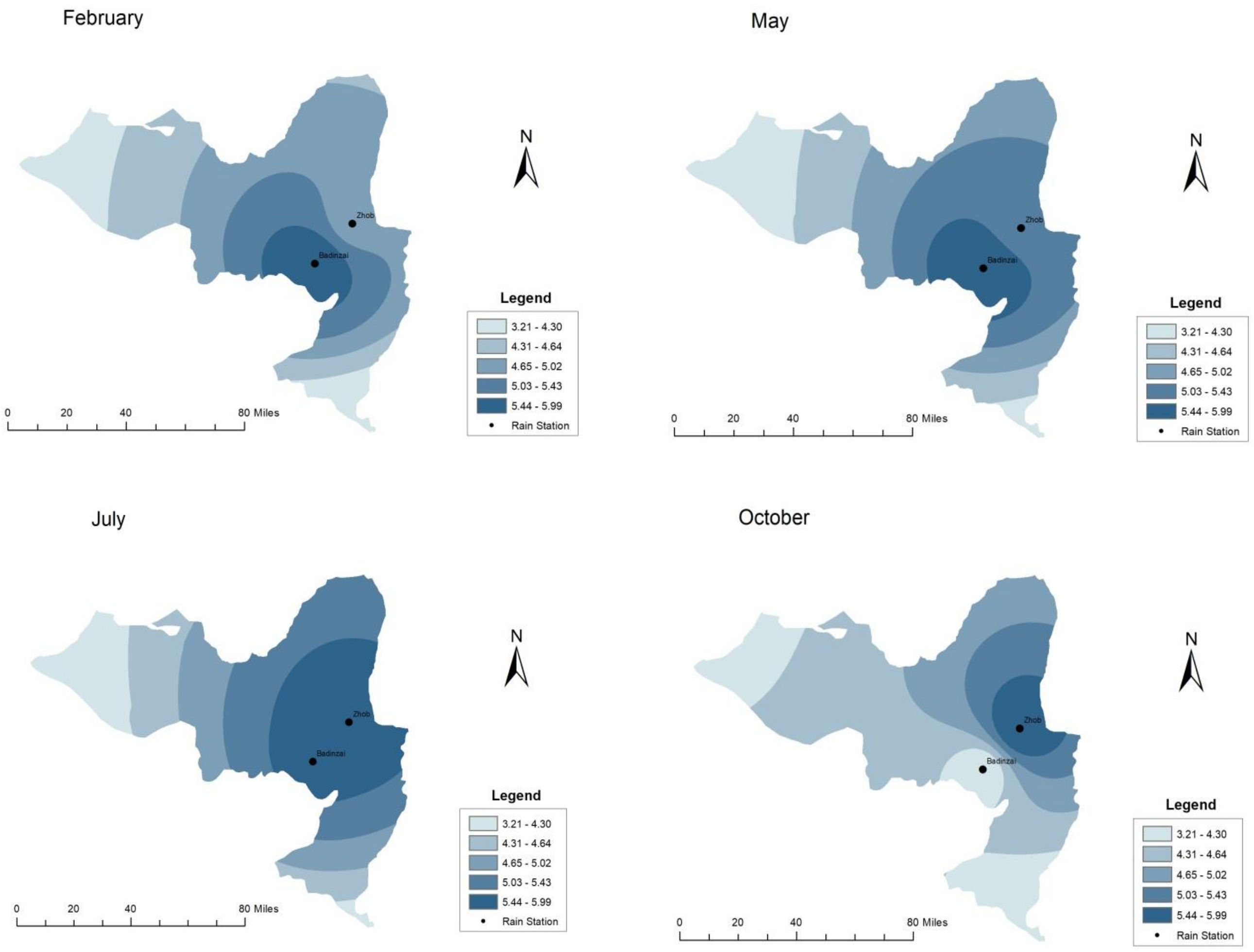


Figure 4 The 38 Years Average Rainfall Map of dry (May & Oct) and wet (Feb & Jul) months

3.3 Temporal drought patterns

The monthly precipitation data for the period covering 1981–2018 for both stations in the study area are used in order to compute SPI for multiple timescales (i.e., 3, 6 and 12 months). The 3-month SPI calculated for February uses the precipitation total for December, January and February. The 6-month SPI calculated for September uses the precipitation total for April to September, while 12-month SPI calculated for February uses the precipitation total for March to February (Ashraf & Routray, 2015). The 3-month SPI shows winter drought, while 6-month SPI represents precipitation deficit in Kharif cropping season. The 12-month SPI shows the drought condition during dry and wet periods together in the study area. The time sequence is done in line with the seasonality and crop production system. December to February is the rainy season, while April to September is the main cropping season. The period from February to March is the transition with dry and partially wet sometimes between these two important time periods. The transition period may indicate the criticality of precipitation and implication for the cropping season.

Time series plot of SPI output for the multiple timescales for Zhob district for illustrative purpose as shown in Figure 5. The Figure shows that only one extreme drought event (SPI<-2) occurred at Zhob based on SPI-6 time scale. However, in case of severe drought events (-2<SPI<-1.5), Zhob witnessed four drought events basing on SPI-12 and 3 drought events as per SPI-3 timescale.

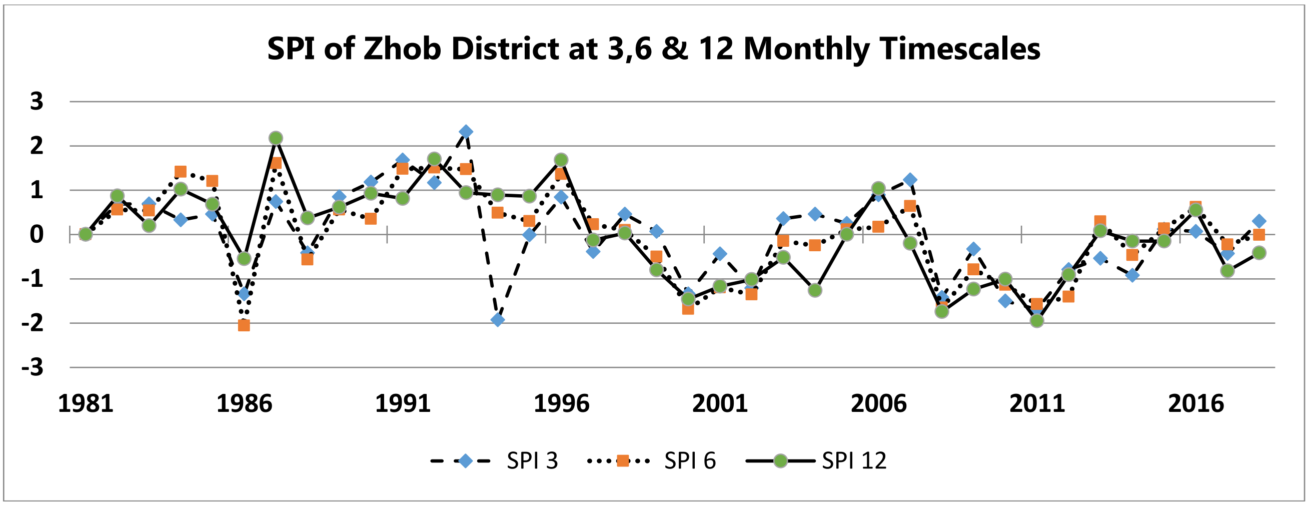


Figure 5 Temporal variation of drought in Zhob district at multiple Timescales scales.

3.4 Spatial drought patterns

In order to show the spatial extent of drought at varying timescale in the study area, drought indices obtained by employing SPI procedure are used as input to Arc map. To define the drought intensities resulting from the SPI at varying timescale, the classification system given in Table 1 is used. The longitudinal time series based on 12 months SPI values from 1981-2018 indicate that the study area experienced two major drought events during the study period i.e., 1998-2002 and 2015-2018, where more than 60% of the district was affected by the drought events (-2<SPI<-1.5) or extreme drought conditions (SPI< -2).

3.5 Assessment of drought in study area

In this section, drought occurrences in Zhob have been analysed based on the frequency of the events for varying drought categories at 3, 6 and 12 months timescales.

3.6 Occurrence of droughts in study area

The purpose of this analysis to mark areas prone to drought at multiple timescales based on their frequency of occurrences. Table 2 below describes the analysis for Zhob station, which is located in upper upland Balochistan (north), where semi-arid climate predominates. Drought occurrences are obtained by taking the ratio between the frequency of the event in each timescale (3, 6 and 12 months) to the total frequency of the event in the same timescale and drought category (McKee et al., 1993).

Table 2 Drought occurrence in Zhob and surroundings from 1981-2018.

SPI Values	Drought Category	Occurrences (%)		
		3 months	6 months	12 months
0.00 to – 0.99	Mild drought	34.8	32.3	35.7
– 1.00 to – 1.49	Moderate drought	10.3	9.6	9.8
–1.50 to – 1.99	Severe drought	4.2	3.5	3.9
– 2.00 and less	Extreme drought	1.9	2.4	1.7

3.7 Overall trend of drought occurrences in study area

Overall, mild drought occurrences tend to occur across the district, however the percentage is slightly reduced when jumped from 3 months to 6 monthly time steps, while it noticeably increases when checked on 12 months scale. The distribution of moderate droughts shows a relatively decreased percentage of occurrences as compared to mild drought with a marginal difference in percentages over various time scales. The study area is found to have lesser potential for severe drought at 3, 6 and 12 months timescales. Moreover, the distribution of extreme drought shows a further reduced recurrence as compared to previous categories of drought, though has a relatively increased tendency at six monthly timescale as compared to other time steps. Hence, as the timescale increases from 3 to 6 months, extreme droughts tend to occur more frequently in the study area**.**

3.8 Analysis of identified drought period

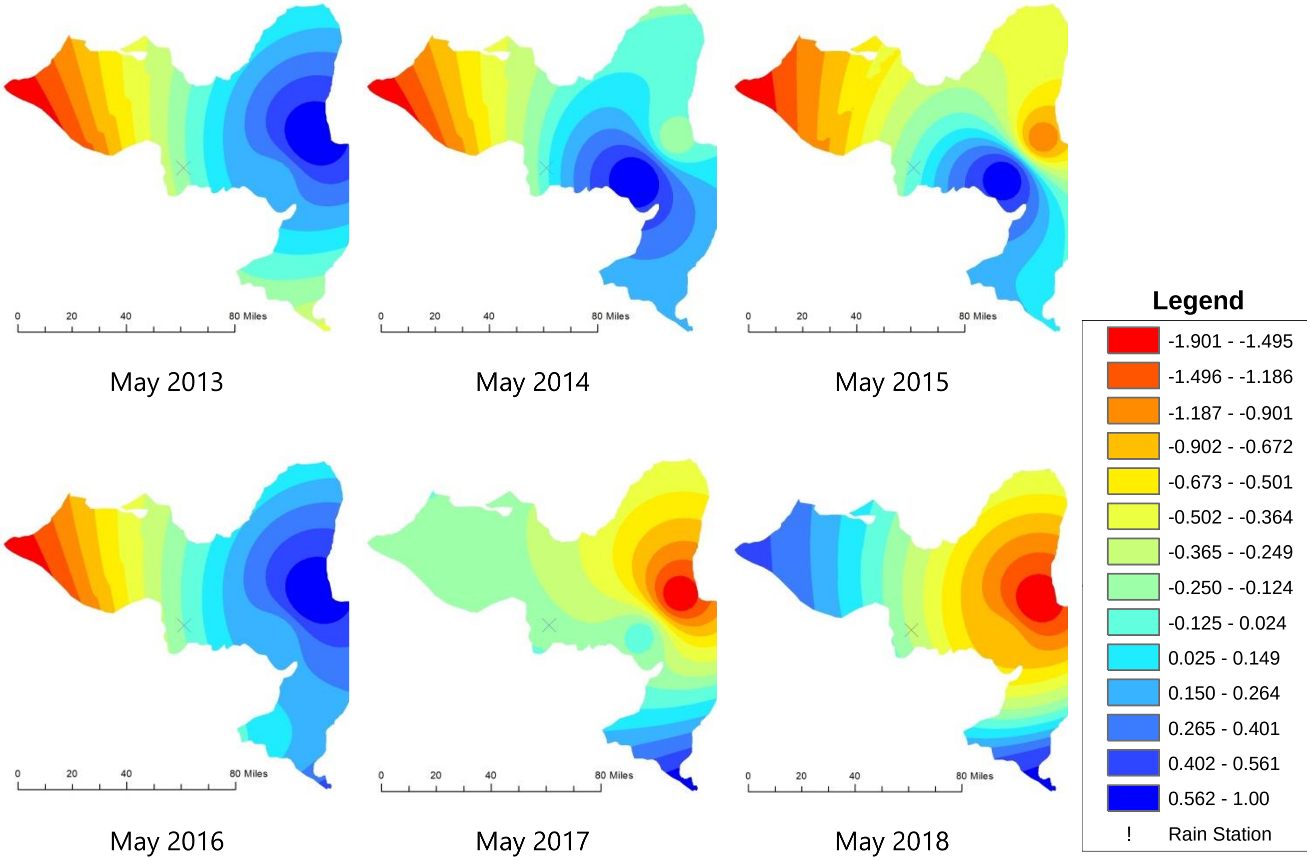
From the monthly precipitation analysis of last 38 years in study area, it can be concluded that the month of Oct has shortest rainfall reception (6 mm) amongst the dry months span (Sep-Dec). Similarly, month of May has the lowest precipitation average as compared to neighboring months of Mar (36.5 mm), Apr (28.8 mm), Jun (17.1 mm) and Jul (57.5 mm) (Figure 3). Similarly, years 2015-18 have been identified as the drought spell in the last 10 years (Figure 1). Therefore, in order to study the spatial stretch of the identified drought spell and to understand the gradual reduction of precipitation from study area on a 12-month timescale, the IDW interpolation technique was used to obtain the 12 monthly SPI stretch for the month of May from 2013-2018 (Figure 6).

From the Figure 6 below, it can be assessed that in May 2013, the study area possessed sufficient precipitation from winter rains and snowfall, particularly in the areas adjoining Koh-e-Suleman mountain ranges. In case of May 2014, the precipitation spread lowered in the north eastern edges of the district and spatial stretch of the drought affected circles has marginally increased. In May 2015, it can be observed that the north eastern and western portion has been dominated by the drought stretch and the precipitation condition of the district has deteriorated towards dryness. In May 2016, the wet conditions of the district recovered to its precipitation level. However, the next two years witnessed dramatic fall in dryness of the district as the area already started experiencing the drier conditions and physical effects of drought. While in May 2017, the situation worsened towards severe drought conditions where complete northern and central parts of the district suffered from a mix of severe and extreme droughts, while remaining southern areas experienced no drought conditions. Finally, in May 2018, the improved precipitation level from south and west pushed away apparent conditions of drought from northern and central portions in the subsequent years as witnessed by all. The Figure 6 illustrates that in 2013 and 2016, the precipitation levels were above normal yet due to the lowered precipitation levels in their subsequent years i.e., 2014 and 2017, the possibility of trending drought existed which was materialized in 2017 and 2018. Hence, the emerging drought conditions if timely identified by the stake holders could have generated an early warning for the local farmers and populace to take risk reduction measures at their end.

4. DISCUSSION

This study has explored the precipitation anomaly over the period of 38 years (1981-2018) in study area district Zhob. The varying precipitation reception caused spells of drought in two main periods identified during the course of study as 1998-2002 and 2015-2018 respectively. The secondary data collected during the study comprised precipitation data from two rain gauge stations in the district namely Zhob and Badinzai rain gauge stations.

The findings of the present study revealed that over the course of 38 years; the district of Zhob experienced a series of dry and wet spells, each of varying length in time and spatial extent. The main periods thus identified are from 1998-2002 and 2015-2018. Both the periods fall below the average precipitation value of 21 mm and span over a period of four years having min rainfall recorded as 10 mm in years 2001 and 2016. The findings of this study show that from 1981-2018, the months of Feb-Mar and Jul-Aug received highest average precipitation in the form of winter rains and snow (35mm) and as part of summer monsoon rains (50 mm) respectively (Figure 3). From this assessment, the IDW interpolated maps of wet months (Feb & Jul) and dry months (May & Oct) were prepared using Zhob and Badinzai as two-point station (Figure 4). The Figure further verifies the spatial extent of average monthly precipitation recorded by both the rain gauge stations. However, due to absence of rain gauge stations in Qamar Din Karez or towards Sambaza Tehsils, the precipitation rings are not ideally plotted to shown spatial extent of precipitation.


May 2013

May 2014

May 2015

May 2016

May 2017

May 2018

Figure 6 Analysis of Identified Drought Period on 12 monthly SPI scale of May (2013-2018)

The findings of this study are consistent with those of Ashraf and Routray (2015) who reported that only one extreme drought event (SPI<-2) occurred at Zhob based on SPI-6 time scale. However, in case of severe drought events (-2<SPI <-1.5), Zhob witnessed four drought events basing on SPI-12 and 3 drought events as per SPI-3 timescale (Tabel 2 and Figure 5). The study further assesses that the drought occurrences in Zhob have been analysed basing on the frequency of the events for varying drought categories at 3, 6 and 12 months timescales. Overall, mild droughts across the District tend to occur less frequently as the time step increases. The distribution of moderate droughts shows completely different patterns from the mild droughts. Hence, an overall percentage of drought occurrences increase as the timescales change from 3 to 6 months. The study area is found to have high potential for severe drought at 3, 6 and 12 months timescales. However, the distribution of extreme drought shows a completely different picture as compared to mild, moderate and severe drought occurrences at multiple timescales. Therefore, as the timescale increases from 3 to 6 months and 12 months, extreme droughts tend to occur more frequently in the study area.

The findings of this study support the findings of the previous studies conducted by Ashraf and Routray (2015) who reported that from the monthly precipitation analysis of last 38 years in study area, it can be concluded that the month of Oct has shortest rainfall reception (6 mm) amongst the dry months span (Sep-Dec). Similarly, month of May has the lowest precipitation average as compared to neighbouring months of Mar (36.5 mm), Apr (28.8 mm), Jun (17.1 mm) and Jul (57.5 mm) (Figure 3).

Similarly, years 2015-18 have been identified as the drought spell in the last 10 years (Figure 2). The present study pinpoints that in 2013 and 2016, the precipitation levels were above normal yet due to the lowered precipitation levels in their subsequent years i.e., 2014 and 2017, the possibility of trending drought existed which was materialized in 2017 and 2018 (Figure 6). Hence, the emerging drought conditions if timely identified by the stake holders could have generated an early warning for the local farmers and populace to take risk reduction measures at their end.

4.1 Limitations of the study

The present study has two limitations. First, the data is collected by the available rain gauge stations which are not ideally plotted in the study are, leaving behind the north eastern and western zones of the district blank. Therefore, during the IDW interpolation the nearest neighbor factor may have disturbed the projection of the actual spread of drought. Second, the study area is not a geographically or climatically detached zone; rather it shares physical contiguity with adjoining districts and provinces. Therefore, in this case the precipitation data and its subsequent SPI values of multiple timescales are not independently confined to the study area only. Hence, the interference from various geographical and climatic factors cannot be overlooked in the results, which is not discussed during the course of study.

5. CONCLUSION

The study has overviewed the precipitation and drought conditions of Zhob district over a period of 38 years which help studying the generalized pattern of precipitation in the district. This further helped us find out the SPI based drought coercions on three, six and twelve monthly precipitation values. The overall projection of the SPI generated results as a parameter to Arc Map and the resultant precipitation and SPI maps were far better illustrative as compared to the numeric value interpretations. Overall, this study opened new dimensions for the agricultural scientists, environmentalists, geologists and meteorologist and policy makers to study the environmental components of the other districts of Balochistan province and then study the region as whole to configure the climate related changes and their impact on the social life of the affected population. Furthermore, by integrating and comparing the results of the ground data with the remote sensing data, an innovative research design can be worked out to further elaborate on the environmental components involved in the climate change of the region.

DECLARATIONS

Acknowledgement: The principal author extends his gratitude to the Faculty of Disaster Management and Development Studies, University of Balochistan with special thanks to the supervisor Dr. Muhammad Ashraf for his able guidance and consideration during the research. My sincere gratitude goes to Mr. Sanaullah Khan for his guidance on the use of Arc GIS and Dr. Kher Muhammad for providing his inputs on the manuscript. I am also thankful to the reviewers for their invaluable comments and suggestions, particularly Dr. Sanaullah Panezai who noticeably augmented the value of this study.

Author contributions: Mr. Shaista Khan deliberated the complete study and generated the article. While Dr. Mohammad Ashraf supervised the entire process of study design, write up and analysis. Mr. Sanaullah Khan's main contribution was to assist in GIS related functions and analysis.

Funding: This research received no external funding.

Conflicts of interest: The authors declare no conflict of interest

Ethical Approval: No ethical issues concerned.

Cite this article as;

Khan, S., Ashraf, M. & Khan, S. (2020). Assessment of Drought Occurrences in Zhob District using Standardized Precipitation Index from1981-2018. *Journal of Geography and Social Sciences*, 2(2): 78-92.

REFERENCES

Agnew, C. (2000). Using the SPI to identify drought.

Ashraf, A., Naz, R., & Mustafa, N. (2011). Evaluating drought impact on vegetation cover of Rarkan Rod-Kohi Area, Balochistan using remote sensing technique. *Pak Acad Sci, 48*(3), 143-150.

Ashraf, M. (2019). Farmers' coping and adaptive strategies towards drought in Pishin District, Balochistan. *Journal of Geography and Social Sciences, 1*(1), 1-16.

Ashraf, M., & Routray, J. K. (2015). Spatio-temporal characteristics of precipitation and drought in Balochistan Province, Pakistan. *Natural Hazards, 77*(1), 229-254.

Ashraf, M., Routray, J. K., & Saeed, M. J. N. h. (2014). Determinants of farmers' choice of coping and adaptation measures to the drought hazard in northwest Balochistan, Pakistan. *73*(3), 1451-1473.

Edwards, D. C. (1997). *Characteristics of 20th Century drought in the United States at multiple time scales Master of Science degree in Atmospheric Science, Colorado State University.* (Master of Science degree in Atmospheric Science, Colorado State University Master of Science degree in Atmospheric Science, Colorado State University), Master of Science degree in Atmospheric Science, Colorado State University, Retrieved from Master of Science degree in Atmospheric Science, Colorado State University

Government of Balochistan. (2007). *Provincial disaster risk management plan.* . Retrieved from Quetta: Balochistan Disaster Management Authority:

IUCN. (2009). *Policy gap analysis. Islamabad: IUCN Pakistan*. Retrieved from

Jr, R. R. H. (2002). A review of twentieth-century drought indices used in the United States. *Bulletin of the American Meteorological Society, 83*, 1149-1166.

Kakar, Z., & Ahmad, M. (2016). Study on the causes of Water Scarcity in Pishin Lora Basin of Balochistan. *Journal of Applied Emerging Sciences, 4*(2), pp135-140.

Keyantash, J. (2018). The Climate Data Guide: Standardized Precipitation Index (SPI). Available: https://climatedataguide.ucar.edu/climate-data/standardized-precipitation-index-spi,. *National Center for Atmospheric Research Staff, 8*.

Khan, S., Qasim, S., & Ambreen, R. (2016). Spatio-temporal analysis of landuse/landcover change of district pishin using satellite imagery and GIS. *Journal of Geographic Information System, 8*(3), 361-368.

Kidd, C. H. R., Rees, D. J., Keatinge, J. D. H., Rehman, F., Samiullah, A., & Raza, S. H. (1988). Meteorological Data Analysis of Balochistan Research report no.19. Quetta, Pakistan: Intl Centre of Agricultural Research in Dry Areas (ICARDA).

McKee, T. B., Doesken, N. J., & Kleist, J. (1993). *The relationship of drought frequency and duration to time scales.* Paper presented at the Proceedings of the 8th Conference on Applied Climatology.

Naresh Kumar, M., Murthy, C., Sesha Sai, M., & Roy, P. (2009). On the use of Standardized Precipitation Index (SPI) for drought intensity assessment. *Meteorological Applications, 16*(3), 381-389.

NDMA. (2015). *National Disaster Risk Management Framework Pakistan*. Retrieved from Islamabad:

Pakistan Meteorological Department. (2018). *Monthly Precipitation Data*. Quetta: Balochistan

Rehman, T., Panezai, S., & Ainuddin, S. (2019). Drought perceptions and coping strategies of drought-prone rural households: A case study of Nushki District, Balochistan. *Journal of Geography and Social Sciences, 1*(1), 44-56.

Sajjad, S., & Raza, A. (2007). *Climate Variability and Drought Threats in Sindh and Balochistan Provinces of Pakistan.* Paper presented at the 3rd International Conference on Agriculture Education and Environment.

van Steenbergen, F., Kaisarani, A. B., Khan, N. U., & Gohar, M. S. (2015). A case of groundwater depletion in Balochistan, Pakistan: Enter into the void. *Journal of Hydrology: Regional Studies, 4*, 36-47. doi:https://doi.org/10.1016/j.ejrh.2014.11.003

WMO. (2012). SPI user guide. WMO No 1090 (pp. 1-16). Geneva: Chair Publications Board WMO.