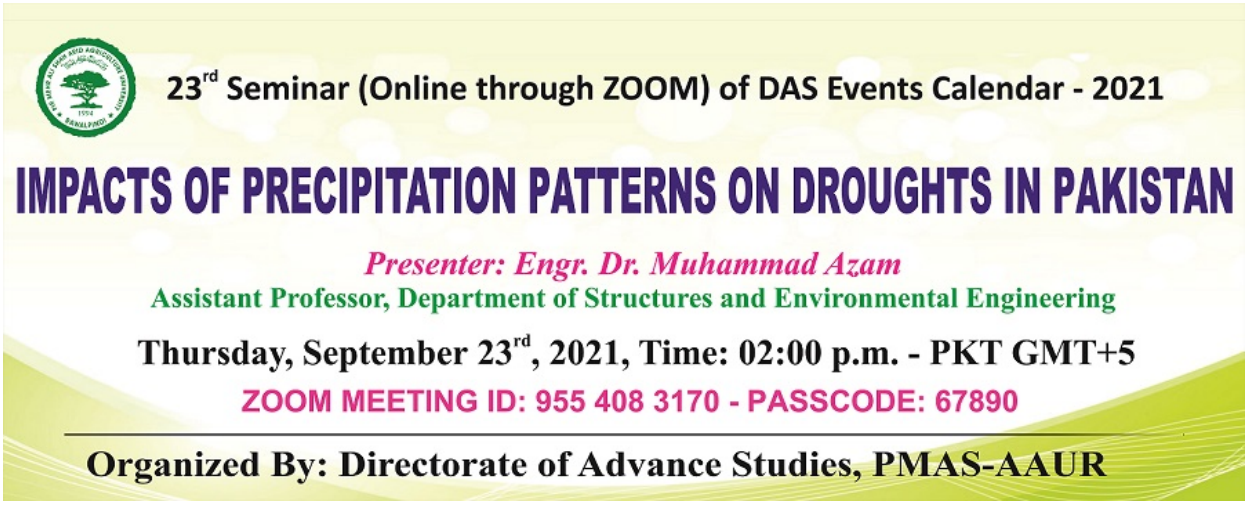
DIRECTORATE OF ADVANCED STUDIES

EVENT CATALOGUE

2021

23RD SEMINAR OF DAS EVENTS CALENDAR – 2021

IMPACTS OF PRECIPITATION PATTERS ON DROUGHTS IN PAKISTAN



ACTIVITIES

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Introduction

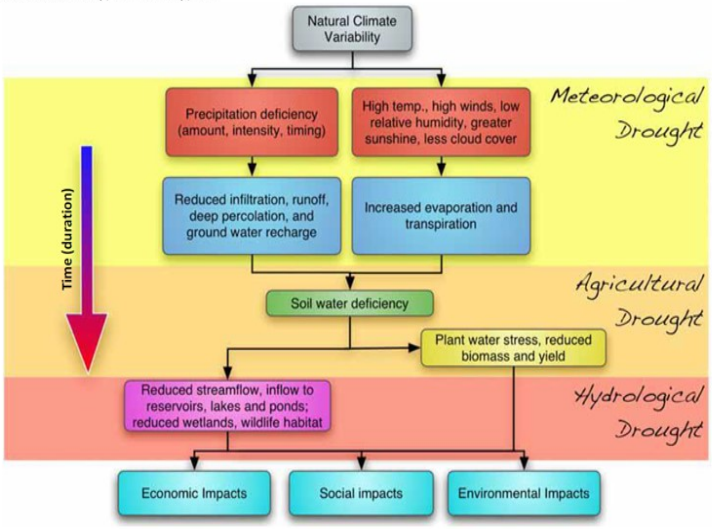
- Drought is natural phenomenon of the climate and occurs with different frequency and duration anywhere in country.
- Lack of precipitation lead to create drought whereas excessive precipitation lead to flooding.
- Trends in drought frequency, duration or severity can be expressed through the changes in precipitation.
- Precipitation is a highly important climatic variable and has a direct impact on the occurrence of drought.

Introduction

- Precipitation in Pakistan has high spatial and temporal variability.
- Climatic variability is problem for water resource management in Pakistan, especially during water shortage periods.
- To cope with this problem, the spatial and temporal variation of precipitation has been analyzed in previous studies in Pakistan.
- Variability of drought based on Principal Component Analysis (PCA) to compare the temporal behavior of regional drought patterns has never been studied before.

Introduction

- Meteorological droughts are usually expressed as the precipitation departure from normal condition over a period of time.
- Agriculture drought occurs when there is not enough soil moisture to meet the requirement of crops at a particular time.
- Hydrological droughts refer to lack of surface and subsurface water supplies due to lack of precipitation over a period of time (Yevjevich, 1967).
- This study deal with Meteorological droughts.



Introduction

- There are many drought indices used for monitoring and assessment because they simplify complex interrelationships between many climate and climate-related parameters.
- Over the years, several indices have been proposed to detect and monitor droughts such as Palmer Drought Severity Index (PDSI) (Guttman, 1998), Standardized Precipitation Index (SPI) (Mckee et al., 1993).
- Drought Area Index (DAI) (Bhalme and Mooley, 1980), Surface Water Supply Index (SWSI) (Shafer and Dezman, 1982).
- Vegetation Condition Index (VCI) (Kogan, 1990), Reclamation Drought Index (RDI) (Weghorst, 1996), Aggregate Drought Index (ADI)) (Keyantash and Dracup, 2002).
- Among all above stated drought indices, SPI is the wide spread applied drought index because it can compare between two locations and climates(Khan et al., 2008).
- In addition, SPI can be computed on different timescales and allows monitoring most of the drought types (i.e. meteorological, agricultural, hydrological) (Raziei et al., 2009).

Introduction

- Global warming have strong impact on precipitation.
- Global warming results in higher the rate of evaporation, and drought frequency and duration are also increased.
- The rates of variation and the nature of the consequences differ across the country due to droughts and its bad impact on people of pakistan
- No comprehensive research has been conducted on drought severity trends in pakistan

Objectives

This research has following objectives.

1. To assess the spatial characteristics of temporal trend for monthly and annual precipitation
2. To assess the regional analysis of spatial and temporal behavior of drought
3. To calculate the relative frequency of drought using Standardized precipitation index SPI-12

MATERIALS AND METHODS

- Spatial interpolation was performed to visualize the spatial patterns of the drought
- Inverse Distance Weighting (IDW) method were used because it has higher interpolation accuracy.
- ArcGIS 10.1 software was used for the interpolation of the trend statistics.
- Temporal analysis of trends was accomplished using the development of codes in R software.

MATERIALS AND METHODS

Statistical tests for trend detection

- Mann-kendall (MK) Test
- Theil–Sen's Estimator
- Linear Regression Estimator
- Principal Component Analysis (PCA)
- Effect Of Serial Correlation On Trend Analysis

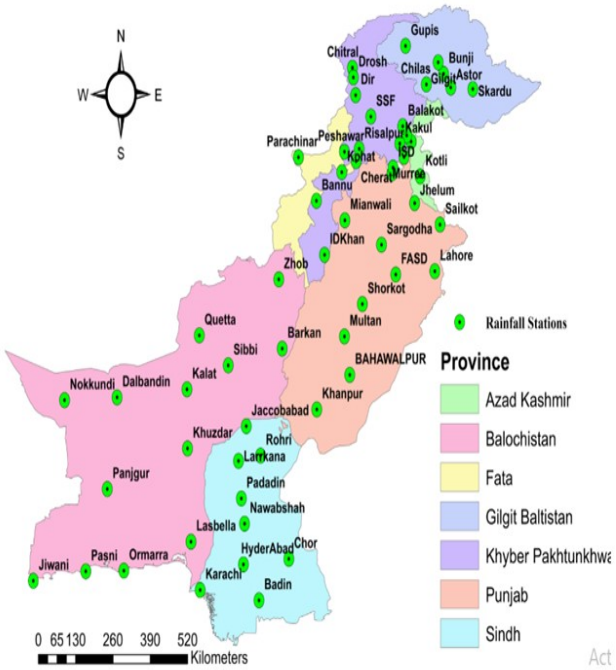
i. Pre-whitening
ii. Trend-Free Pre-whitening
iii. Variance Correction Approach

- Standardized Precipitation Index (SPI)

MATERIALS AND METHODS

Study area and data

- Western part of South Asia Pakistan is geographically situated between latitudes of 24-37 ° N and longitude 62-75 ° E.
- In Boundaries of Pakistan 58 stations were selected for the analysis of trend.
- Precipitation data from 1981 to 2018 (38 years), were selected.
- Data is collected from Pakistan Meteorological Department (PMD).

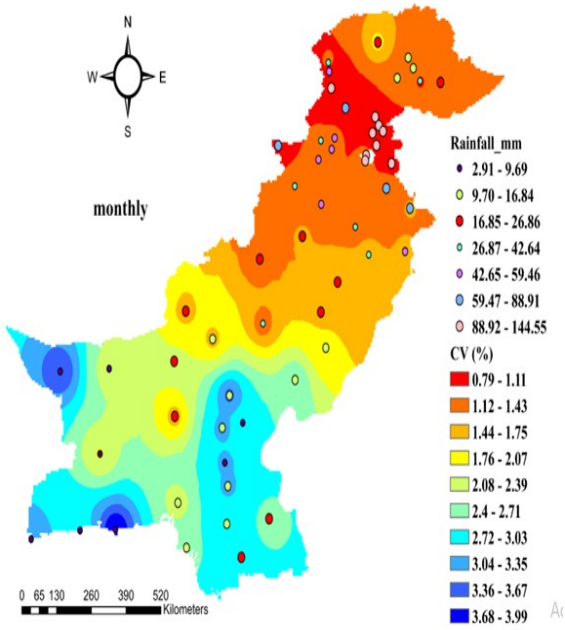


RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

Spatial Variability of Monthly Precipitation

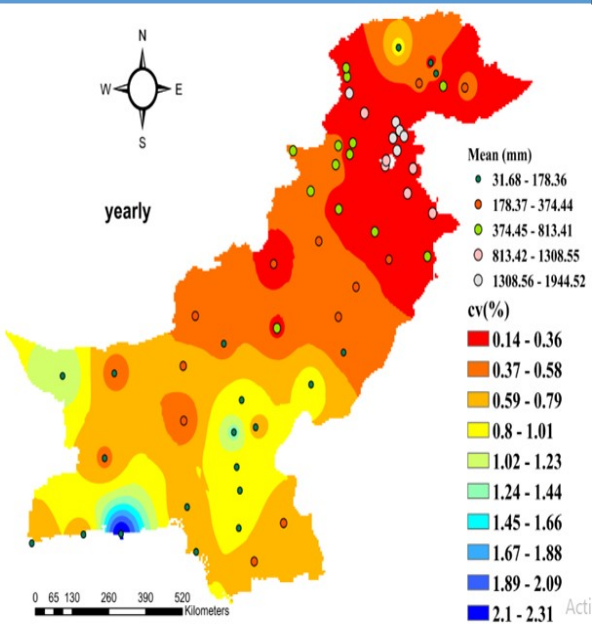
- The data range is from January 1981 to December 2018 at 58 meteorological station.
- Lowest monthly mean precipitation less than 10mm, occurred at nokkhndi, Dalbandin, jiwani, Pasni Ormarra, Panjgur, Rohri and Padadin this is because low altitude also this areas lies in subtropical region where temperature is high and air is dry.
- Highest MMP greater than 90mm occurred at Rawalpindi, Islamabad, Murree, Kakul and Kotli this is because of higher altitude CV ranges from 0.79% to 3.99% and mean of this is 2.39%.



RESULTS AND DISCUSSION

Spatial variability of annual precipitation

- The lowest yearly precipitation were 31.68 mostly in the areas of Baluchistan and Sindh this is due to same reason as described earlier that is lower altitudes
- Highest annual precipitation (higher than 1308 mm) recorded at Islamabad and Kashmir.
- In annual CV% value from 0.14% to 2.31% and the mean of this is 1.22%



RESULTS AND DISCUSSION

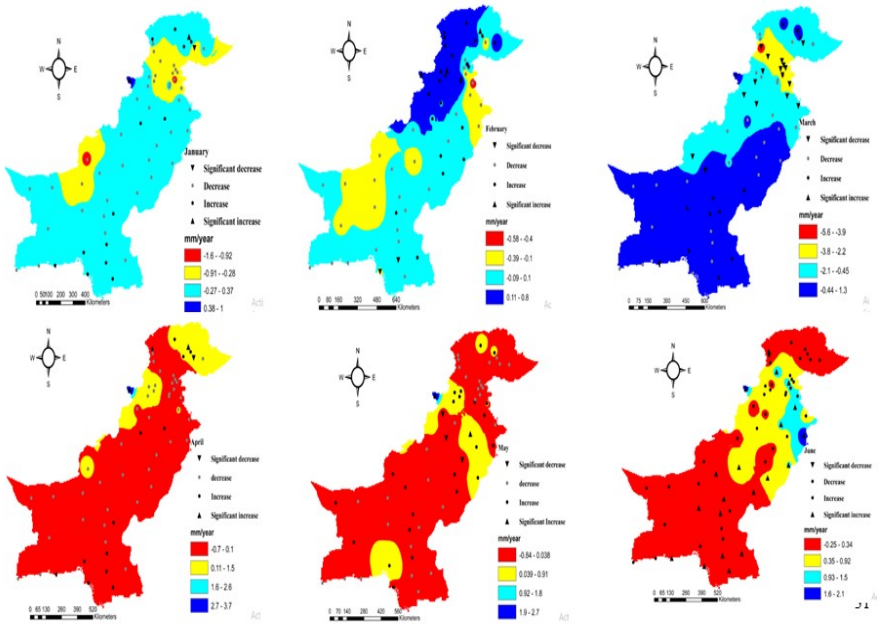
Spatial Pattern Of Temporal Trends In Precipitation

- The data range is from January 1981 to December 2018 at 58 meteorological station.
- Pattern of temporal trend and magnitudes was achieved with the help of modMK test and Thiel-sen's.
- The value of Z divided in to four groups and if Z<-1.96 it shows that a remarkable decreasing trend and If -1.96<Z< 0 it means that there is a decreasing pattern. Also if 0< Z<1.96 it means that increasing pattern in the trend and if it shows a Z >1.96 it shows a significant increasing pattern.
- Results showed that most stations in Pakistan had no major monthly and annual trends in precipitation at a confidence level of 95 percent.
- The color of this map shows a magnitude of the trend and this is represented as mm/year

RESULTS AND DISCUSSION

Spatial Pattern Of Temporal Trends In Precipitation

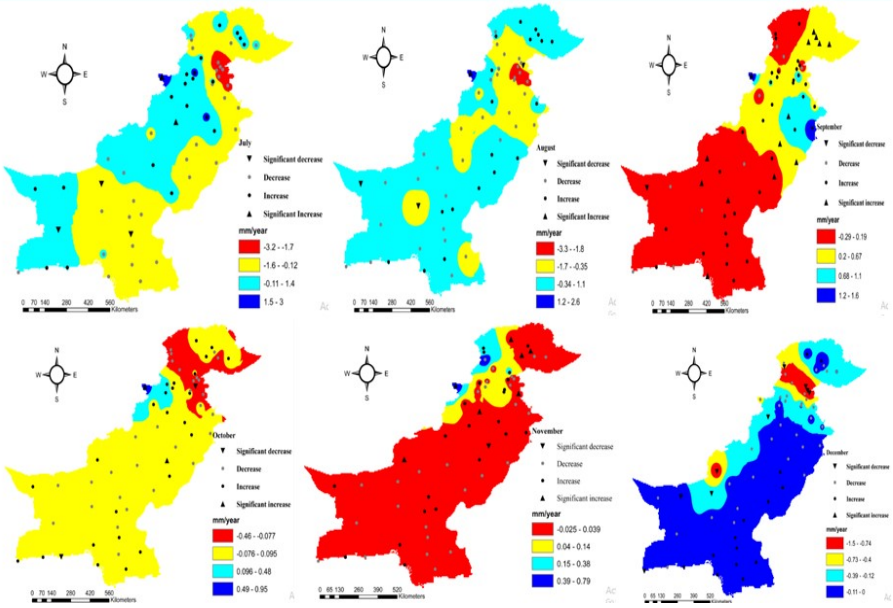
- Results showed that most stations in Pakistan had no major monthly trends in precipitation at a confidence level of 95 percent
- During the month of June and September (monsoon season), more than 32%, and 24% of the stations, respectively, showed an increasing trend.



RESULTS AND DISCUSSION

Spatial Pattern Of Temporal Trends In Precipitation

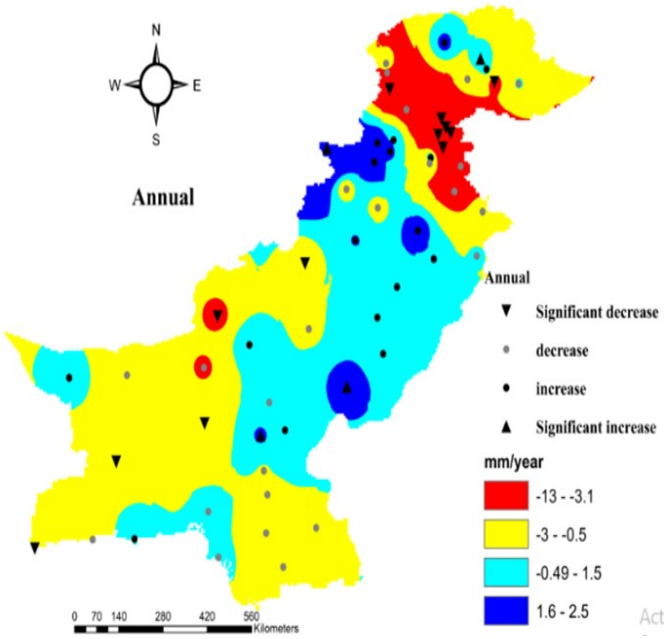
- In summer season annual precipitation is approximately the 60% of the total rainfall in our country.
- And only the 10% precipitation occurred in the winter season. Therefore we can say that summer rainfall have direct influence on annual rainfall.



RESULTS AND DISCUSSION

Spatial Pattern Of Temporal Trends In Precipitation

- annual analysis tells us about that only twelve station shows a significant decreasing trend and four station (Parachinar, Gilgit, Khanpur, Larrkana) have significant increasing trend.
- Results showed that most stations in Pakistan had no major annual trends in precipitation at a confidence level of 95 percent



RESULTS AND DISCUSSION

	Significant autocorrelation		No Significant auto correlation	Significant Trends		No Significant trends	
Vari.	+	-		Inc. [1]	Dec. [2]	Inc. [1]	Dec. [2]
Jan.	1	0	57	2	1	13	42
Feb.	2	4	52	3	2	24	29
Mar.	5	0	53	0	19	11	28
Apr.	3	0	55	2	1	13	42
May.	1	1	56	2	3	23	30
Jun.	0	1	57	19	0	33	6
Jul.	2	0	56	2	3	21	32
Aug.	0	1	57	1	3	19	35
Sep.	4	0	54	14	0	36	8
Oct.	1	0	57	2	2	26	28
Nov.	0	8	50	7	1	29	21
Dec.	3	1	54	0	9	14	35
Yearly	4	1	53	4	12	18	24

Summary of stations showing autocorrelation across Pakistan

[1] Increase. [2] Decrease

RESULTS AND DISCUSSION

Spatial Variability of Drought Using (PCA)

- SPI was calculated on a 12-month time scale for 58 meteorological stations to analyze the regional conditions of drought over 456 months from 1981 to 2018.
- Principal component analysis applied on SPI-12 series indicated that the whole of Pakistan divided into four sub regions with the different temporal drought behavior, and corresponding representative stations were identified for future drought monitoring
- The rotated loading of the leading four RPCs for drought time series was computed for 58 meteorological stations and interpolated to characterize them by mapping .
- The leading four RPCs were able to extract approximately 100% of the temporal variation of the drought across the region as shown in table.

RESULTS AND DISCUSSION

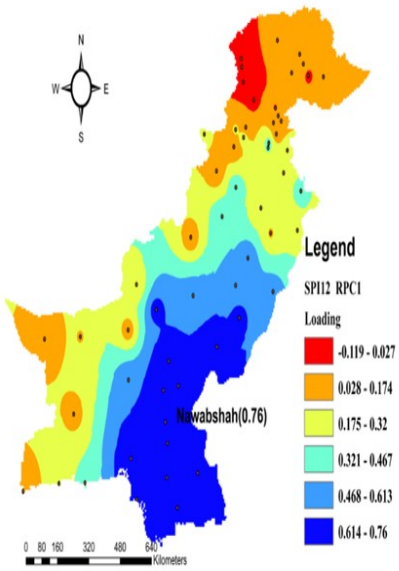
Principal Component Analysis Applied On (SPI) For 58 Stations In Pakistan.

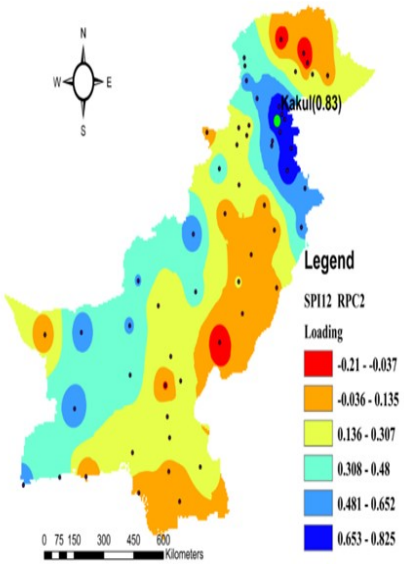
Principal Components	Eigen Value for Unrotated	%Variance Explained Unrotated	Eigen Value for Rotated	%Variance Explained Rotated
PC1	17.29	53	10.08	31
PC2	6.87	21	9.31	29
PC3	4.76	15	6.54	20
PC4	3.41	11	6.4	20
Cum. Vari.		100		100

RESULTS AND DISCUSSION

Spatial Patterns Of Temporal Trends In Drought

- The rotational loading of the leading RPC for drought time series was measured and mapped to characterize 58 meteorological stations.
- In Pakistan's Sindh province, the first RPC (RPC1) shows the positive loading, with a maximum value of 0.76 on the Nawabshah station
- Results of this study match well with the previous study conducted in Pakistan i.e., Adnan et al., (2015) showed that Sindh is a very vulnerable area for drought and this study showed that 10 district of Sindh have high vulnerability to drought.
- In KPK Province of Pakistan a strongly positive load with a value of 0.83 at Kakul the spatial distribution of first RPC (RPC2)

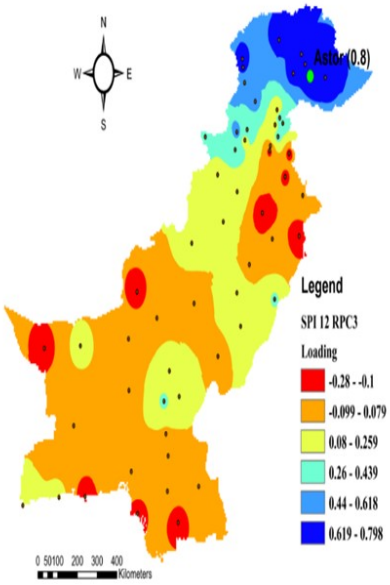


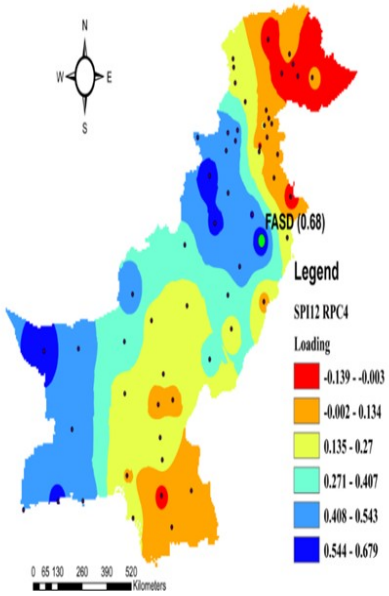


RESULTS AND DISCUSSION

Spatial Patterns Of Temporal Trends In Drought

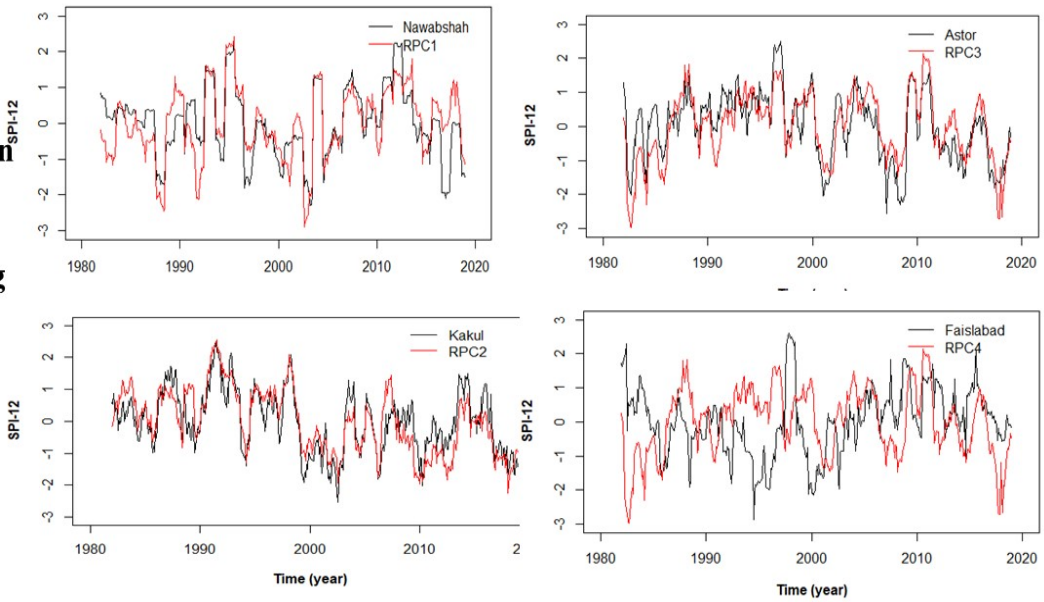
- In Gilgit Baltistan Province in Pakistan, the spatial distribution of the first RPC (RPC3) shows a positive loading with a maximum value of 0.8 in Astor station
- And the RPC4 shows that low positive loading with a maximum value (0.68) at Faisalabad station.





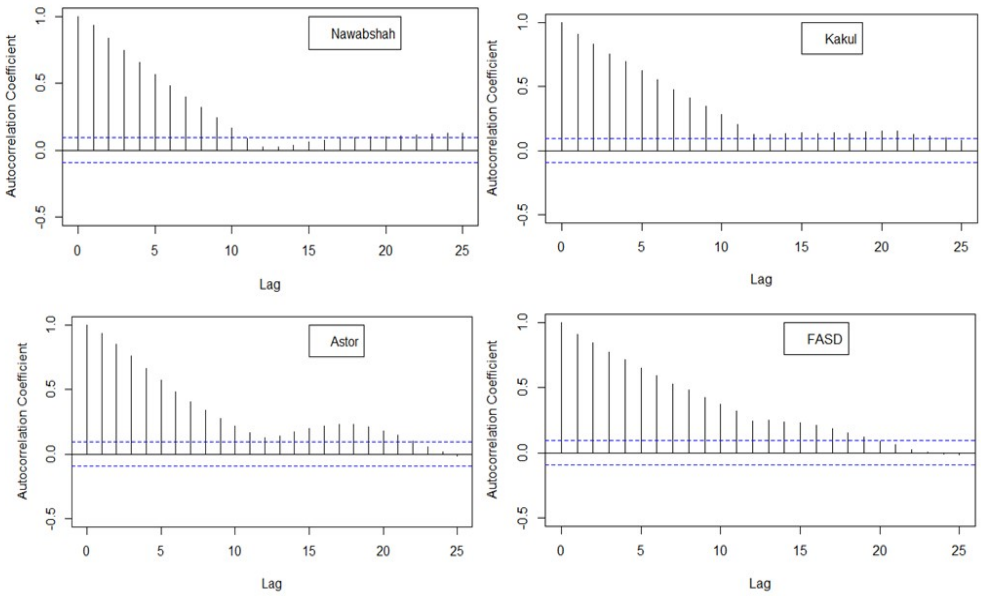
RESULTS AND DISCUSSION

Temporal patterns of drought time series based on SPI-12 and their corresponding rotated principal component scores



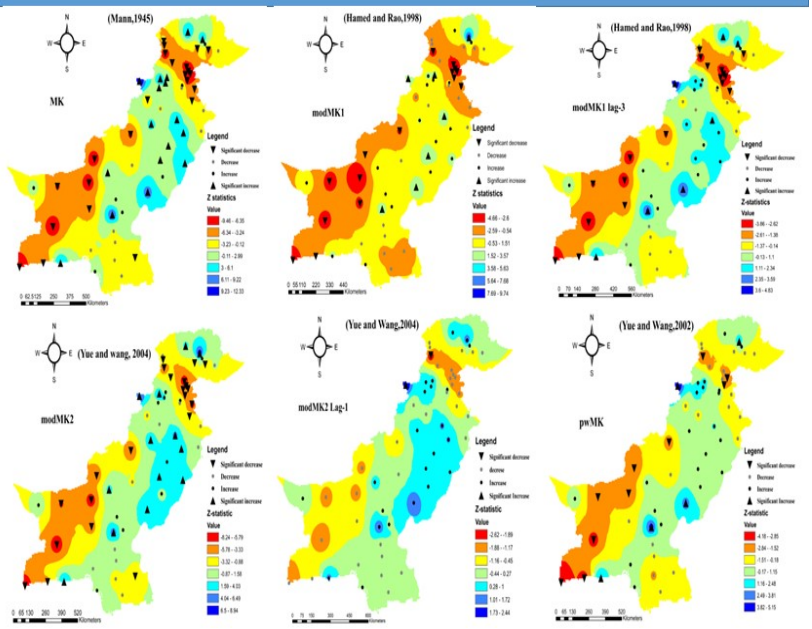
RESULTS AND DISCUSSION

Correlation coefficients of the SPI-12 at a critical value ᾱ= 0.05. at four stations

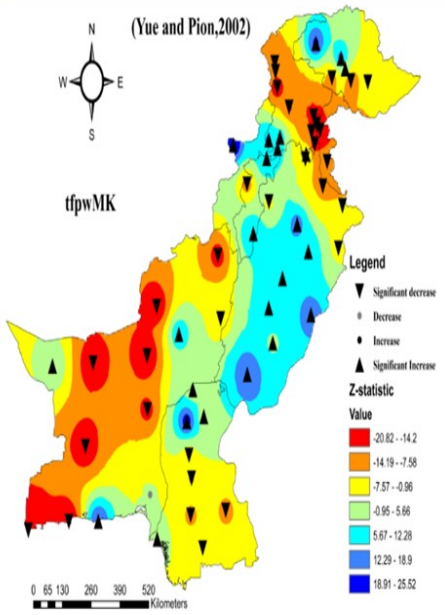


RESULTS AND DISCUSSION

- **Changing Spatial Trends Of Drought Severity Based On The SPI-12 Detected By Different Test**
- Previous literature shows that serial structure of the time series directly affects the ability of trend identification tests to identify trends.
- The MK test is not robust against serial correlation , sample size, seasonal components and other periodic fluctuations of time series.
- Therefore, trends in drought series were evaluated using various trend tests, such as modMK1, modMK2, pwMK, and tfpwMK.
- Every test leads to different results because of differences in their adopted methods to eliminate the effect of serial correlation.



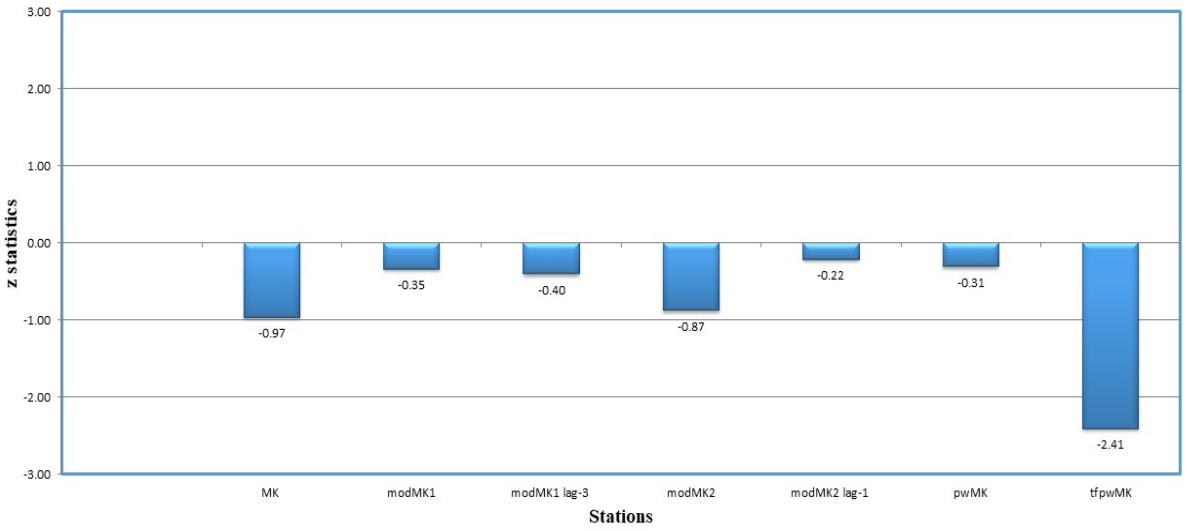
RESULTS AND DISCUSSION



Summary of stations for SPI-12 time series across Pakistan

Trend Approach	Significant Trends		No Significant Trends	
	increase	decrease	increase	decrease
MK	17	23	7	11
modMK1	7	15	17	19
modMK1 lag-3	7	18	17	16
modMK2	13	21	11	13
modMK2 lag-1	1	1	23	33
pwMK	5	10	21	22
tfpwMK	24	33	0	1

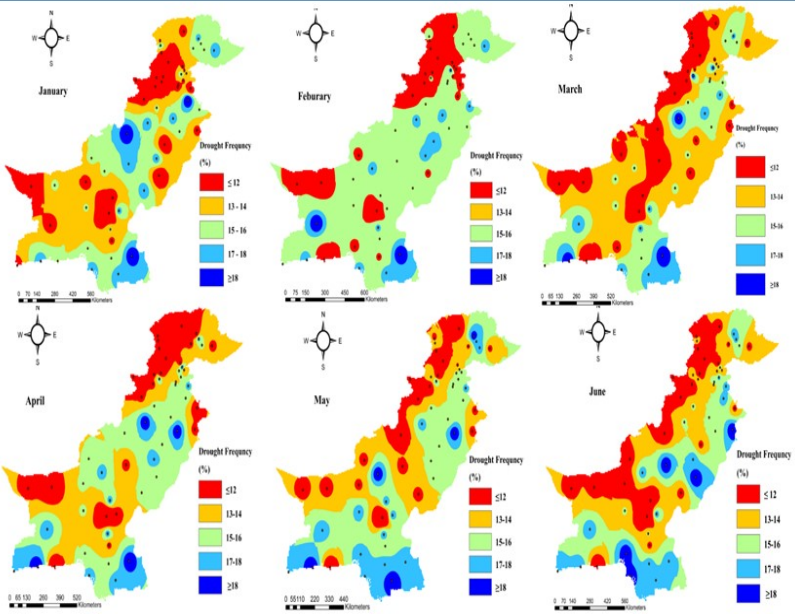
RESULTS AND DISCUSSION



RESULTS AND DISCUSSION

Spatial Patterns Of Drought Frequency

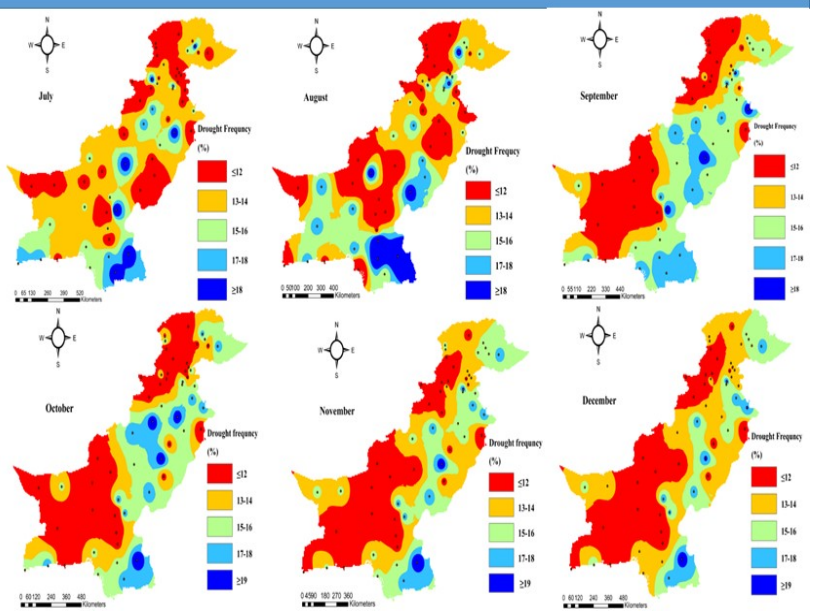
- In January middle portion of map and some of the lower portion showing a drought frequency.
- In month of February and march lower portion is effected due to drought.
- in April, may and June some portion of Punjab and Baluchistan is effected due to drought



RESULTS AND DISCUSSION

Spatial Patterns Of Drought Frequency

- From July to September we faced a monsoon season
- In autumn (October, November and December) showed the same pattern
- Drought mostly occurred in winter duration, early spring period and sometimes in early autumn period and it is less frequent in the season when high rainfall occurred (monsoon season).
- Monthly drought frequencies showed that the areas with the highest drought frequencies were in the southeast areas.



CONCLUSIONS

- Precipitation in Pakistan have great effect on the variation of spatial and temporal behavior of drought.
- In this study precipitation trend analysis were observed at 58 station across Pakistan for the duration of 1981 to 2018.
- For trend examination modified Kendall test is applied.
- Result highlight that most of the significant trend of precipitation were observed in the areas where higher altitude that is called the northern areas of Pakistan
- In summer highest significant trend were observed in the northern part of the country
- The slope of the trends were increased in monsoon season and decrease in winter season
- Principal component analysis were used to check the drought severity and it is applied on (SPI) at a 12-month time scale
- Highest Drought severity were observed at Nawabshah station in Sindh.
- mostly drought vulnerable areas are in the province of Sindh and Baluchistan
- Relative frequency of drought indicates that the mostly drought were showed in winter season, early spring period and early autumn period and less drought in summer (monsoon season).

FUTURE RECOMMENDATIONS

- Natural disaster such as meteorological droughts could not be stopped. Each disaster gives us a lesson to do better planning, management and taking some precautionary measures to minimize its impacts in future.
- Pakistan dam's water storage capacity is much less than the neighboring countries like India. Therefore, it is the need of the hour to build large and small dames in catchments areas to store the rainfall water during monsoon period.
- Increase in storage capacity will lead to decrease the impacts of floods and droughts.
- The stored water will protect food security to fulfill the water requirements of crops during drought period in the country.