

Precipitation and Temperature Oscillation and its Effects on the Flow of Indus Water System and Adaptation in the Arid Region, Pakistan (1940-2000)

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Abstract : The study evaluates the water discharge of the Indus and its sub-rivers in the arid region of Pakistan from 1940-2004 using the annual changes in addition to seasonal flux and inconsistencies in culmination of the water flow. Currently, in Pakistan, the gross per capita water availability shows notable dwindle during 1951 till 2000. Owing to decline in precipitation (0.6inch or 15.2mm) and amplify in degree of hotness of 1.6⁰C for the period of 1960-2000, the water discharge throughout Pakistan particularly in the arid region reveals a susceptible stipulation from 1940-2004. During *Rabi season*, the decline in the water discharge of the Indus River and its tributaries show a drastic decline/reduction, while it remains stable in *Kharif* season and could do with adaptation instantly. The annual water discharge indicates a positive deviation in the Kabul River, while it is negative in Indus, Jhelum, Chenab, and Ravi rivers. Most of the rivers in Baluchistan are altered into seasonal torrents and the water scarcity for agriculture sector and domestic use will be at climax in the future. The decrease in the water discharge of the Indus drainage system will influence the crop pattern and its production in the rain fed as well as canals fed arid areas in the lower Punjab and Sindh province. The specific adaptations to cope with the problem are, improvement in the irrigation system, edifice of new water dams and reservoirs, construction of water course guards, innovation in sanitation and sewerage system, public awareness, policy and implementation, establishment of research and development fund, crop choices, glacier retreat and planning for water resources.

Keywords: Arid region, rabi season, Kharif season, precipitation, Indus water system, adaptation.

Introduction

The most valuable reserves for the subsistence of the human being is water, devoid of which it is inflexible to endure. The hydro-resources are playing an imperative function in the improvement of the creature throughout arid region of Pakistan. The water discharge in Indus river system is going to decline and it is expected that due to ongoing climate change particularly precipitation fluctuation, it will be further affected and reducing the crop production on national level. According to IPCC (2007), "By the 2050s, freshwater availability in large river basins, is projected to decrease. Climate change is going to compound the pressures on natural resources and the environment associated with rapid urbanization, industrialization, and economic development." The climate fluctuation has severe effects on different facts of the physical characteristics of plants and vegetation (agriculture) particularly water availability, soil fertility, forest sector and land use pattern etc. that required adaptation.

The mainly staid possible intimidation come to pass as of weather extremes is the insufficiency of water resources in the arid region of Pakistan. According to UNESCO (2006) and GoP (2000), the gross per capita water ease has about 5300-meter cube per year during 1951 that decreased to 2900-meter cube per year in 2000 that is almost a decline of 50 percent in fifty years. Generally, on national level, the availability of

water resources per capita is converse to the increase in population throughout the study period.

The decline in water reserves not only depends on the potential of climate fluctuations and water supply but also on the deteriorations in the demand of human and environmental factors. The required limits of water resources in Pakistan have influenced by a number of factors, in which the utmost comprises of human fertility, human capital, population distribution as well as usage. Generally, about 60% of the residence in the arid region of Pakistan is underneath soaring water anxiety particularly in eastern Sindh, Baluchistan and Southeastern Punjab province and it is hoped that this water stress is going to boost with passage of time (GoP, 2005).

Generally, an arid region is defined as, an area that receives an annual precipitation of less than 10 inches. In other words, it is explained as an area where the precipitation is not enough to support plants growth or where the degree of evapotranspiration is higher than precipitation (Critchfield, 1987). Aridity prevails over 676,400 square kilometers area of Pakistan. The current arid region of Pakistan comprises of Gilgit-Baltistan province in the north, southern Punjab, whole of Sindh, central and southern Baluchistan, and parts of Chitral and Dera Ismail Khan Districts in Khyber-Pakhtunkhwa province. The lofty Himalayas and Karakorum limited the study area in the North, Arabian sea in the South, a vast area of Indian

Cholistan desert in the east, the dry Afghanistan and Iran in the west. It is located between $23^{\circ}1/2'N$ to $37^{\circ}N$ latitudes and $60^{\circ}E$ to $75^{\circ}E$ longitudes (Figure-1). It comprises of approximately 63 districts having major drainage system of Indus, Chenab, Jhelum, Ravi, Sutlej, Gilgit, Hub, Porali, Hingol, Zhob, and Dasht river (Kureshy, 1988). A number of workers have studied the impact of climate change and its adaptation to water resources, in which the most outstanding are Yue *et al* (2008), Yee *et al* (2000), Yadav (2007), Smakhtin, Kauarachi and Kim (2008), Singh and Sontakee (2000), Patel *et al* (2005), Panday (2005), Pal (2010), Muhammad (2002) and Moore, et al., (2002), Khan and Hasan (2017).

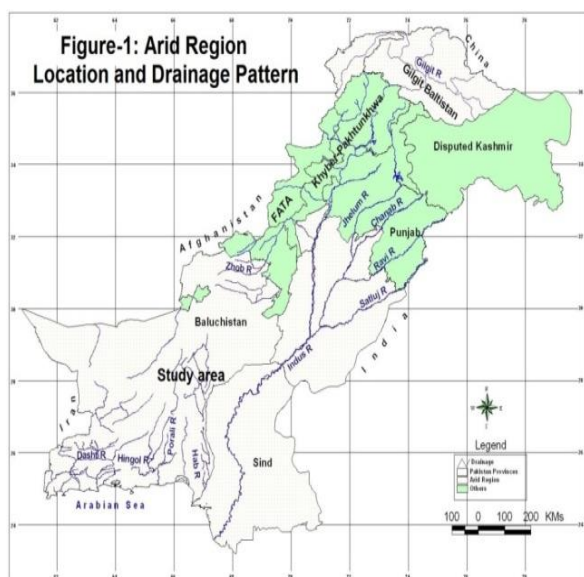


Fig.1 Arid region, location and drainage pattern.

Materials and Methods

The specific objectives of the study are to analyze the effects of temperature and precipitation on the water discharge data of Indus drainage system and to discuss how to mitigate with the issue. The annual and monthly weather data of temperature and precipitation have been considered for the purpose to evaluate the climate fluctuation covering time duration from 1961-2000 collected from Pakistan Meteorological Department Karachi. The discharge data (1940-2004) of different major rivers of the Indus water system (Indus, Chenab, Jhelum, Ravi and Sutlej River) has been collected from Agriculture Research Council, Islamabad. Furthermore, the rivers discharge data of Khost, Hub, and Polari rivers in Baluchistan province and Gilgit and Hunza rivers in Gilgit Baltistan province have been downloaded from NOAA, USA for a specific time period of 1968 to 1972. The variables of the study consist of precipitation, temperature and river flow. During data evaluation, it has noted that the mean monthly weather data of some locations have not available for a specific month/year for few observatories or these locations may fall outside the arid region and omitted for the purpose to reach the

actual results. About twelve meteorological stations having complete weather observations have considered for the analysis and its average per month/year has been crossed matched with the annual and monthly flow of the different rivers.

For more reliable results, the deviation from the mean was calculated for precipitation, temperature and river flow. The total of which represents a positive or negative vacillation in the shape of extreme, moderate and low events of precipitation, temperature and rivers flow. The data was classified into five years, 10 years, 15 years, and 20 years class intervals respectively. The series anomalies were plotted on the graphs and a trend line was highlighted on it for the purpose to observe the extreme as well as minor concentrations of temperature, precipitation and river flow in the arid region of Pakistan. The data is auxiliary abbreviated into two cultivation seasons that is Kharif (April to September) and Rabi (October to March). The time duration of both cultivation seasons were considered same as presented by Agriculture Research Council, Government of Pakistan, Islamabad (2000). The boundary of arid region has been demarcated on the basis of total precipitation using the criteria of Critchfield (1987) that observatories having total precipitation of less than 10 inches or where the rate of evapotranspiration is higher than the total precipitation. The results achieved from the analysis of data are discussed as follow.

Results and Discussion

Generally, the temperature and precipitation are the main variables of weather and climate. The fluctuation in these two weather elements are not only affected the different sectors of physical environment but also caused changes in the surface flow of different rivers that otherwise affected the economic, social, agriculture as well as health sectors in the arid region of Pakistan. It is therefore, required to present the impact of temperature and precipitation fluctuation on the surface flow of Indus and its main tributaries in the arid region of Pakistan and to discuss how to mitigate with the issue and to save the physical environment from it severe affects in the future.

Temperature Fluctuation

Zhu and Qian (2001) have stated that during 1908 to 2007, the mean temperature in China has increased by $1.1^{\circ}C$ and a decreasing trend has observed in the water discharge in Yellow River and North China Plain areas. Furthermore, they have concluded that during the last 30 years, there has a rise of 90mm in the sea level and almost $0.9^{\circ}C$ increased in the temperature condition, correspondingly. In Pakistan, the sum of deviation from the mean condition of temperature shows an increase of $1.6^{\circ}C$ all through the study period.

The twelve-monthly tendency of average degree of hotness shows rise and fall throughout 1961-2000. In

few occasions, the temperature shows an increase of about 22.9°C (1963), followed by a decrease of 22.2°C during 1966. Moreover, the annual pattern illustrates a rise of 22.8°C within 1971 and dwindles in the next seven to ten years. During 1961, the normal temperature reached to 22.3°C, as compared to 22.1°C during 1974 having rising pattern of 23.1°C during 1977. Consequent to 1977, insignificant pattern be able to observe intended for five years, although it turn downs to 22°C during 1983 and get higher unto 23.2°C during 1988. The trend turned to decline yet again near 22.2°C during 1997 but subsequently, it demonstrates incessant augment turn over 2000. The minimum digression of -0.7°C has noted in 1972 and deemed as a coldest year of the cycle, while the optimistic divergence of 0.8°C has observed during 1988 and asserted as the warmest time of the series over the arid region in Pakistan (Fig. 2).

The temperature condition of the arid region reveals a total increase of 0.3°C after each five years. The average trend of the data shows a decline of 22.2°C from 1971 to 1975 and mull over as a coldest stretch of time of the series. The highest temperature of 22.8°C observed during 1996 to 2000 and considered as a warmest time period. The summation of the variation from the average of ten and fifteen years indicates a sum of 0.2°C increase per period, respectively. During primary 20 years interval (1961 to 1980), the temperature of the area remained high, while it has converse in the excluding years of the series (1981-2000).

Precipitation Fluctuation

The average yearly values regarding precipitation of the parched region has been considered and processed for about twelve meteorological stations covering time duration of 1961 to 2000. The yearly tendency of the cycle shows a diminishing pattern in precipitation throughout the time series. The figure 2 indicates up to been ups expectations had or downs in the annual trend of precipitation during 1961-1970 and plodding rise all through 1971-1990 including minor changes of high and low trend in particular years and then slacken till 1991-2000. The weather observations indicate an aggregate fall of -0.05 inches (1.3mm) throughout the study period. The excessive precipitation of 2.71 inches (68.8mm) has been noted 1982, while the base concerning -1.06 inches (-26.9mm) during 1971.

The fall commencing the average condition reveals so much out of 1961-74, the rainfall recorded below the normal circumstance or increased to optimistic tendency during 1975-1983. All through 1984-89, the precipitation of the arid region is less than mean level and up lifted above till 1995 and afterward turned into pessimistic trend until 2000. Commonly, the rainfall of the arid region suggests a squat alteration in the tendency after every five years and an excessive meditation after 10 years. For minor level evaluation about rainfall undulation, weather data has been

abbreviated in five, ten, fifteen- and twenty-years class ranges. The mean data concerning five years trend divulges of 1.2 inches (28.4mm) during 1996 to 2000 yet presumed to be the parched years throughout the annual trend of precipitation. The total deviations of the average state of precipitation of the five years trend is 1.5 inches (37mm) having moist epoch of 2.3 inches (56mm) is between 1981-85. Normally, the mode of the trend suggests so as to a minor dwindle during 1961-75 as overturned in 1976 in conformity with 1985. The trend inversed at some point of 1986-90 and turned higher again in 1995-2000. The average rainfall of ten years indicates a shrink of about -0.001 inch (-0.03mm). The minimum rainfall throughout ten years average series is 1.3 inches (31mm) for the duration of 1961-70 along with moist about 1.7 inches (44mm) has been noted between 1981-90. Obviously, the rainfall condition of the arid region shows an enhanced trend in the primary three five years average periods and then suddenly fall into negative trend in the remaining periods of the series till 2000 (Fig. 2).

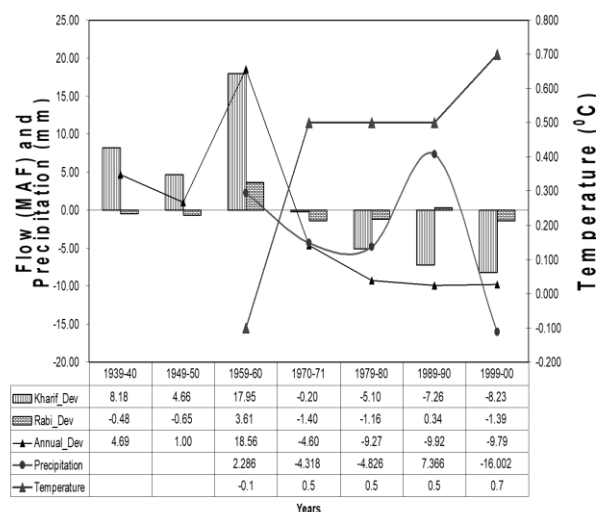


Fig. 2 Indus river deviation from the mean flow, temperature and precipitation.

As for as the fifteen years mean condition of the precipitation has concerned, it shows a lowest trend of 1.3 inch (31mm) during 1961-75 having a maximum of 1.7 inches (43mm) between 1976-90. The total fluctuation of rainfall after each fifteen years is -0.01 inch (-0.025mm). The trend reveals that there has a periodic change in the precipitation condition of the arid region in Pakistan after each 16 years. During 1991 to 2005, the rainfall of the arid region has decreased and then turned into positive trend till 2020 having ups and downs in some years. Furthermore, the minimum of twenty years mean is 1.3 inches (34mm) noted during 1961-80, while the maximum of 1.6 inches (41mm) all through 1991-2000. Generally, the decrease in rainfall every 20 years is 0.0004 inch (0.01mm). The annual pattern of precipitation shows a clear trend of increase all through the last twenty years; however, it is hard to make some future prediction by considering the period of 20 years' time duration.

Impact on Water Flow

Water is the basic component of life both for flora and fauna and without water, it will impossible to run the system of human being. By and large, the contemporary local weather and climate fluctuation in the dry land of the country reveals a worst change in the surface as well as underground water availability, which will affected the water discharge on seasonal as well as annual basis with passage of time. The dilemma will keep on further farthest if the swell within daily as well as monthly temperature is communal with the decline in rainfall. Resultantly, the sum of annual flow in the rivers and water supply will decline throughout the arid region of Pakistan, if imperative measures are not taken into consideration on national level.

Indus River

Obviously, the Indus river is most important bases of water resources in the arid region of Pakistan that surpasses all the way through the nucleus of the dry lands in Gilgit Baltistan, Southern Punjab, Eastern Khyber-Pakhtunkhwa and Sindh province. The exoneration flow data of the Indus River noted at Terbella dam is placed on (Fig. 2 and Table 1) shows that the yearly records concerning the Indus river flow used to be under the average state in the course of 1940 in imitation of 1960 that turned to depressing departure adjacent to 1961-90. For the period of Kharif cropping season, the water discharge indicates affirmative digression throughout 1940 to 1960 as well as 1990-2000 excluding years of the time period. During Rabi cultivation epoch, the water discharge signifies an affirmative divergence as of 1950 to 1960 along with 1990-2000, but in the remaining years, it remained below the average situation.

Generally, the yearly water discharged of Terbella dam indicates a decline of -0.02 million acres feet (MAF) throughout the study period. As far as, the Kharif cultivation season has concerned, the digression from the average flow is 21 million acres feet, though in Rabi cropping period, the deviation of water flow is -0.03 million acres feet. Consequently, the yearly water discharge in the Indus River is going to decline through course of time owing to decline in the rainfall and intensity in temperature condition at the catchment areas of the river. Besides, the decrease in the flow of the river is directly proportional to precipitation, while there is no correlation between temperature and the flow level (Figure-2). The impacts on water flow are higher in the Rabi season (winter precipitation) while there is an increasing trend in the Kharif season due to stable monsoon precipitation.

Kabul River

The Kabul River is main river that joins the Indus River at the western course at attack. It has originated

from Afghanistan as well as Pamir Knott, Chitral district and go into Pakistan through the western border in Hindu Kush mountain ranges. The predominant dam constructed on Kabul River is Warsak dam that covers the irrigation system as well as power resources of the Peshawar vale in Khyber Pakhtunkhwa, Pakistan and Jalalabad province, Afghanistan. The river discharge at Attack observatory reveals an increase of 0.02MAF annually from 1937-2000. For the duration of Kharif cultivation, the increase in river discharge indicates a rise of about 8.12MAF, as within Rabi epoch, there is a decrease in the flow of about -0.06MAF (Table-1).

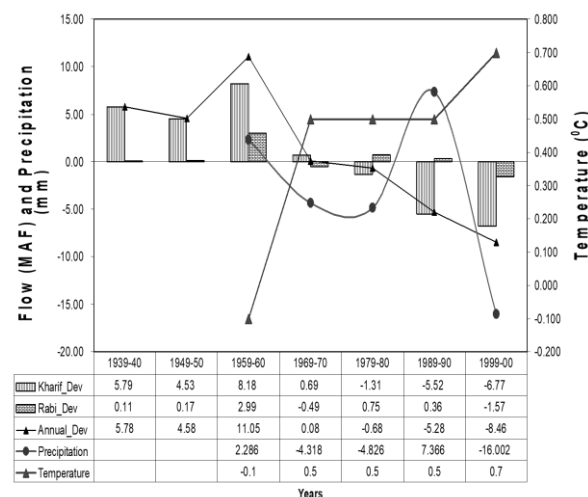


Fig. 3 Kabul river deviation from the mean flow, temperature and Precipitation.

The data shows that the water discharge of the river increases during Kharif season, while it is converse in Rabi season and required adaptation. The annual trend of deviation from the mean of Kabul river flow plotted on figure 3. The trend shows the yearly drift on the Kabul watercourse used to be upon the average level commencing 1940-1970, then remained under the low bent during 1971-2000. The tendency of river discharge illustrates dwindle pattern during 1970-2000. All through Kharif cultivated period, the river discharge remained satisfactory since 1937-1970 then that stays under the ignoble level within 1971-2000. The drop off in discharge of the Kabul river is deadly towering during Kharif season as much in contrast to Rabi season. Within Rabi spell, the water discharge of Kabul River is remains high from the average level during the series apart from 1960-70 as well as 1990-2000, where the water level remain below the mean level.

It is concluded that the water discharge of Kabul River remained stable all through the study period, however during 1970 to 2000 (20 years), it has remained low with passage of time. The evaluation reveals that the Kabul river water discharge has vulnerable to the current weather and climate fluctuation in Pakistan and required major steps for the stability of the surface hydrology of the river. As far as the precipitation and

temperature condition of the area has concerned, the trend shows a direct relationship with the water discharge of the Kabul River with precipitation, however it has converse to the annual trend of temperature condition in the area. This might be the result of glaciers retreated in the catchment area of the Kabul river at a faster rate due to increase in temperature condition and deforestation on the mountains slopes.

Jhelum River

Normally, the Jhelum river swathes the canals fad areas in upper and central Punjab province, Pakistan. The main hydro-storage system over the Jhelum River is placed at Mirpur, Azad Kashmir as a principal foundation of power resources to almost of the Punjab as well as Azad Kashmir. The sum of yearly water discharge of the Jhelum River reveals a decline of about -0.12MAF from the mean condition comprises of 0.14MAF within Kharif period and -0.26MAF in Rabi time (Table-1).

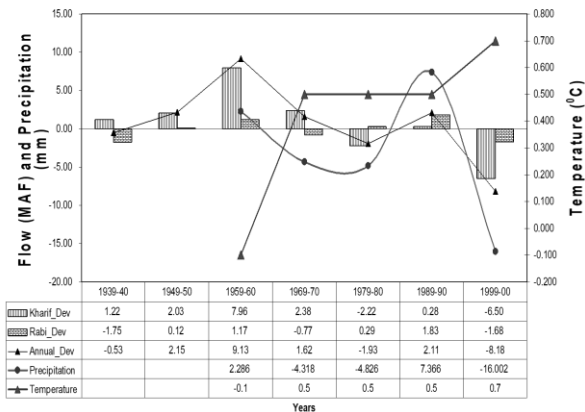


Fig. 4 Jhelum river deviation from the mean flow, temperature and Precipitation.

As far as figure 4 has concerned, the annual trend of water discharge at Jhelum river remained high from the average level between 1950 to 1970 as well as 1981 to 1990, however it is below the mean condition in the excluding years of the study period. During Kharif season, the water discharge is over the average line at some stages in 1940-1970 that turned into unenthusiastic trend during 1971-2000. The water discharge of Jhelum River shows rise and fall in the course of the series during Rabi age with a cyclic pattern.

It is evident that the yearly water discharge of Jhelum river watercourse declines all through the study period owing to reduced rainfall and weather fluctuation in Pakistan. The decrease in the water discharge has extra ordinary in Rabi period owing to decline in the winter rainfall in the entire area. Obviously, the overall water flow condition of the Jhelum River indicates a direct liaison by means of decrease in rainfall and converse relationship with the temperature throughout the study period.

3.3.4 Chenab River

The tributary swathes the canals network of the innermost Punjab province particularly Gujrat and the contiguous agriculture lands of Jhang and Multan divisions. The observations of water discharge of Maralla headwork shows sum of -0.31MAF decline annually with -0.21MAF in Kharif season as well as -0.10MAF during Rabi period all through the study period (Table-1). The digression from the average observations reveals so as to the yearly water discharge of Chenab River has remained below the average stipulation ever since 1940-2000 except between 1950-1960, whereas it is above the mean condition. The surge during Kharif as well as Rabi cultivation periods are lower than the average right through the interlude and sternly impinge on the enduring weather and climate changes in the entire region (Figure-5). Also one of the major causes is the control of water flow by the Indian Government of India. The decline in the flow of water will affect the agriculture activities in central Punjab and it is expected that there will be decline in the production of crops in the entire region. It is evident that the annual flow in Kharif and Rabi seasons is going to decline from 1937 to 2000 and the Chenab tributary is highly susceptible to the continuing weather and climate changes and be in charge of water by India that could do with adjustment on an insistent basis. The water flow of the Chenab river is unswervingly relative to rainfall and indicates a converse condition towards temperature.

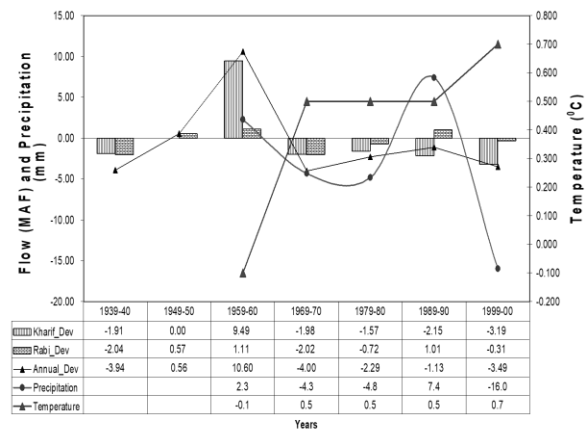


Fig. 5 Chenab river deviation from the mean flow, temperature and precipitation.

Baluchistan Rivers

Baluchistan is the largest province by area and covers most of the arid region in Pakistan. The area is a network of natural drainage systems but most of the torrents remain dry/seasonal throughout the year. During 1968 to 1972, the annual flow of Gilgit River was 11.3 thousand MAF with a depletion of 7 thousand MAF. During 1968, the average flow of Gilgit River was 15.1 thousand MAF that dropped to 7.7 thousand MAF during 1972. The Hunza River was recorded an average flow of 13.1 thousand MAF having highest of

Table 1 Arid Region, Pakistan Water Flow of Major Water ways (MAF) 1940-2000.

Year	Indus River		Kabul River		Jhelum River		Chenab River	
	Mean	Deviation	Mean	Deviation	Mean	Deviation	Mean	Deviation
1940	70.15	4.69	29.49	5.78	22.07	-0.53	22.61	-3.94
1950	66.46	1.00	28.29	4.58	24.75	2.15	27.11	0.56
1960	84.02	18.56	34.76	11.05	31.73	9.13	37.15	10.60
1970	60.86	-4.60	23.79	0.08	24.22	1.62	22.55	-4.00
1980	56.19	-9.27	23.03	-0.68	20.67	-1.93	24.26	-2.29
1990	55.54	-9.92	18.43	-5.28	24.71	2.11	25.42	-1.13
2000	64.98	-0.48	15.25	-8.46	14.42	-8.18	23.06	-3.49
Mean	65.46	-0.02	23.71	0.02	22.60	-0.12	26.55	-0.31

Source: Pakistan Agriculture Research Center, Islamabad, 1940-2000.

13.9 thousand MAF during 1968 and lowest of 11.3 thousand MAF in 1972. The flow of the river indicates about 1000 MAF during 1968 to 1972 (Table-2).

The Khost river shows decline from 14MAF in 1968 to 6MAF in 1972 (Table-2). If this trend of flow continues then may be the river will be dry by the year 2000 and the land may only be able to absorb water during flood. The Hub and Polari rivers show increasing trend during this period but it is expected that the flow of water in these rivers will also decrease by the year 2000. It is concluded that the rivers in Baluchistan are more vulnerable to the ongoing climate change especially the decline in precipitation during Kharif and Rabi seasons.

water stress in the entire populated areas of the province.

It is suggested if we logged the Indus River at a suitable place at Punjab Rahimyar Khan or Rajanpur districts and drop a canal to the nearby valley in Baluchistan province through a tunnel. This way we will have the opportunity to utilize the extra flow that falls into Arabian Sea of the Indus River and also to save the arid Baluchistan from the drought and desertification processes.

Adaptation to Water Sector

- The basic significant dynamics to deal with the effects of climate fluctuation on the hydrology in

Table 2 Arid region Gilgit-Baltistan (2000) and Baluchistan rivers flow 1968-1972 (MAF).

Name	Location	Year	Jan	Feb	Mar	April	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Gilgit	Gilgit	1968	2.2	1.8	1.75	2.2	6.1	33.2	35.3	28.1	11.0	53.3	3.3	2.6	15.1
		1969	2.2	1.9	1.8	2.2	5.7	26.4	38.8	30.1	10.7	5.8	3.7	2.9	11.0
		1972	2.1	1.8	1.5	1.5	2.1	12.5	28.3	20.1	11.0	5.2	3.3	2.6	7.7
		Average	2.2	1.9	1.7	1.9	4.6	24.1	34.2	26.1	10.9	21.4	3.5	2.7	11.3
Hunza	Dainyor	1968	1.5	1.4	1.3	1.6	4.4	26.4	51.3	53.7	16.1	4.8	2.6	2.0	13.9
		1969	1.6	1.5	1.5	2.2	5.2	20.7	51.0	54.2	16.1	6.6	2.9	2.4	13.8
		1972	1.7	1.6	1.4	1.4	2.4	5.8	52.2	23.5	30.8	8.3	3.3	3.0	11.3
		Average	1.6	1.5	1.4	1.7	4.1	17.6	51.5	43.8	21.0	6.6	2.9	2.5	13.1
Khost	Chappar Rift	1968	8	49	55	12	6	5	4	5	4	4	5	7	14
		1969	6	6	6	7	5	4	30	13	4	3	3	4	7
		1972	3	3	15	11	6	5	3	5	3	3	4	8	6
		Average	6	19	25	10	6	5	12	7	3	3	4	6	9
Hub	Bund Murad	1968	62	32	15	1	0	0	61	60	5	0	0	0	20
		1969	0	0	0	0	0	0	193	194	38	6	0	0	36
		1972	0	191	0	27	0	70	446	171	2	0	0	0	76
		Average	21	74	5	9	0	23	233	142	15	2	0	0	44
Porali	Sinch Bent	1968	0	0	49	59	140	66	282	314	20	19	16	39	84
		1969	13	15	26	28	117	151	660	93	5	12	8	11	95
		1972	0	0	0	2.000	10	347	1240	90	80	10	11	8	316
		Average	4	5	25	696	89	188	727	166	35	14	12	19	165

Another major problem faced by the river's flow in the area is the negligible recharge of the water table due to drought and process of desertification in the region. Most of the river flow is sunk by the ground for the recharging of the water table. The inland rivers of the Baluchistan are going to dry with passage of time or may convert into seasonal torrents that will create a

the arid zone of Pakistan is increasing of water reserves and to open avenues for new ventures in this sector.

- To cope with the dearth of water discharge, it is required to put up bonus water basins so as to overcome the deficiency of the water reserves in

the future in different parts of the arid zone of the country.

- Pakistan frequently faces flood in Indus drainage system that not merely destroys properties of crops and affects infrastructure and residential areas. It is therefore, recommended to construct by pass reservoirs on Indus and its tributaries.
- There is a need to construct small dams to mitigate the adverse impacts of the climate fluctuation in the arid areas of Pakistan particularly on the seasonal torrents of Baluchistan.
- Pakistan is astonishingly reliant on its hydrological network, and required to invest in this sector. Owing to what has appropriately been named the, "Fabricate/Abandon/Remodel" attitude of communal, a large amount of the water network is disintegrating and necessitated enhancement.
- Raising stakeholder awareness through well-organized campaigns, education, mass media etc. are be a prerequisite to any progress in the arid region.
- The Pakistan regime has to perk up course of action for the hydrological management observed the requirements of the nation, cultivation, catastrophes, underground water, power resources, country economy and the existing climate fluctuation.
- There is a need for determining research and development department in water sector that should identify different problems of surface flow in Pakistan.
- The study of impacts and adaptation to the climate change in the arid region of Pakistan is essential for the future usage of the water resources. The adaptation strategy of any issue in future and for the vital issue of water resources planning, development and management in particular has to be sustainable, technologically advanced and visionary.

Conclusion

The annual anomalies from 1961-2000, reveal that the average showers of the arid region is 1.48inches (37.6mm) and the total fall in precipitation is - 0.05inches. The heaviest mean precipitation of the series is 4.19inches (106.4mm) recorded in 1982 and the lowest of 0.42inches (10.7mm) in 1971. November with 0.11inch (2.8mm) is the driest month of the region, whereas July with 1.4inches (35.6mm) is the rainiest month of the area. The total precipitation of the arid zone is 6.53inches (165.9mm) having highest of 0.52inch (13.2mm) at Quetta and the lowest of - 0.5inch at Dalbandin. The heaviest precipitation of the arid region per day is 10.3inches (261.6mm), recorded

on 2nd July 1972 at Nawabshah, and lowest is 1.9inches (48.3mm) recorded on 17th February 1954 at Dalbandin.

The water sector is more vulnerable to the impacts of climate change in the arid region. These impacts could be reduced with the help of construction of new water reservoirs and inland dams, river embankments, public awareness, control on water logging, improvement in the irrigation system, and the water supply and irrigation system, planning for the use of water resources and utilization of the flood water, revise policy of the water management, implementation, and establishment of research and development funds. The general trend of water flow in Indus and its right bank rivers are directly proportional to precipitation and inversely proportional to the temperature condition. But this trend is reversed in the Gilgit and Hunza rivers, which is directly proportional to temperature condition. To make evergreen the arid land of Baluchistan, it is required to construct water reservoir at Rajanpur/Dera Ghazi Khan districts and dropped the extra flow of the Indus river (Falling into Arabian Sea) during flood or rainy season into any dry torrent of Baluchistan by constructing tunnel in the Suleman-Khirthar mountains with the help of a link/divert canal. This will make the arid region of Baluchistan a live and evergreen and play a vital rule in the national economy by increasing agriculture production and recharging of water table. Besides, it will also play a vital rule in the stability of the energy crises in Pakistan.

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