Seasonal Variation of Rainy Days in Pakistan

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ABSTRACT

Monsoon precipitation (one of the major rainfall systems of the country) is the lifeline of Pakistan's water resources which falls in summer from July to September. It not only caters the peak power supply demands but also fulfills the highest water demands of field crops and gathers the reserves to meet the requirements during low flow periods in next 4-5 months. Winter brings lot of snow over the northern mountains which melts in early summer and maintains the sustainable river flows for power generation and irrigation before the onset of the summer monsoon. Climate change has imposed rather negative impacts on the rainfall systems of the country, mainly by demolishing the seasonal rainfalls or by modifying its intensity. El~Nino induced shortfall of precipitation triggered Pakistan history's worst drought in terms of length and intensity, afterward a rising trend is being followed, embedded by increased frequency of heavy downpour events. In the present study the main focus was on the rainfall frequency by incorporating the rainy days equal to or more than 2.5 millimeters. Daily data of last 50 years for all the available meteorological stations was incorporated. All parts of the country were analyzed equally and it revealed that the upper parts of Khyber Pakhnoonkhwa province and the northern areas are the main vulnerable, with slope of trend line more than "2" either positive or negative. The said areas are not only vital for the agriculture sector as well as for the hydrological cycle of the country.

Introduction

One of the principal natural resources that Pakistan is endowed with is 'arable land'. About 28% of Pakistan's total land area is under cultivation and is watered by one of the largest irrigation systems in the world. In addition, out of a total land area of 79.6 million hectares, only 16 million hectares are suitable for irrigated farming in Pakistan. According to Pakistan's agroclimatic classification (Chaudhry et al., 2004), two-third of Pakistan lies in semi-arid to arid zones. Hence, majority of the people depend on arid and semi-arid areas to support their livelihoods through agro-pastoral activities. Pakistan like most of the developing world, is faced with the challenges of being affected by land degradation and desertification, which are causing environmental problems, including soil erosion, loss of soil fertility, flash floods, salinity, deforestation and associated loss of biodiversity and carbon sequestration (Economic Survey, 2007-08).

Agriculture has always been the most important sector of Pakistan's economy. A large proportion of population (about 70 %) is living in rural areas, where most gain their livelihood from agriculture related activities. Approximately 50% of the total national labour force is directly engaged in agriculture (Dowswell, 1989). Higher rainfall variance seems to be the main factor behind dry-land yield fluctuations. Amount and distribution of Rainfall during crop season are important. Distribution of rainfall becomes more significant for the lands with low water holding capability and also in the seasons with adequate soil moisture available at planting (Pratley, 2003).

Studies conducted by Pakistan Meteorological Department (Chaudhry et al., 2009) have revealed the trends in annual and seasonal patterns of precipitation regime over the last several decades. It shows that the decade of 1960s was much drier than the recent decades and that low rainfall episode continued till mid 1970s followed by a wetter period until El~ Nino 1998. Under the influence of El Nino, precipitation dropped drastically throughout Pakistan resulting into scanty rainfall both in the summer and winter seasons. That El~Nino induced shortfall of precipitation triggered Pakistan history's worst drought in

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terms of length and intensity which prevailed from fall of 1998 to spring 2003. Afterward a rising trend is being followed but this rise is embedded by increased frequency of heavy downpour events.

Monsoon precipitation is the lifeline of Pakistan's water resources which falls in summer from July to September. It not only caters the peak power supply demands but also fulfills the highest water demands of field crops and gathers the reserves to meet the requirements of low flow periods in next 4-5 months. Being the agro-based economy, it is highly sensitive to any shock wave in the form of weak monsoon or mismanagement of available water resources. Deviation of precipitation in summer (monsoon season) during 2001 to 2007 has been found more or less, similar to the annual pattern which depicts that southern half has got slightly wetter than normal but northern half has reduced its share significantly and went drier than its long term average.

Winter brings lot of snow over the northern mountains which melts in early summer and maintains the sustainable river flows for power generation and irrigation before the onset of the summer monsoon. In addition to solid precipitation over hilly areas, winter rain bearing systems yield substantial rainfall in sub-mountainous and low elevation plains including arid plains of Baluchistan. Generally northern half gets about five times more precipitation in winter than southern half.

Past analysis of precipitation data has shown a slightly decreasing trend for the northern parts of the country. On the other hand the situation for southern parts of the country is becoming better, in terms of precipitation and temperature as well. But the northern belt is the major source of producing water to the Indus, the leading river in the country. The present increase in temperature may be major augmenting force behind the sharp decrease in this treasure of solid water (Kazmi and Rasul, 2009). Recorded extreme events during the last decade of 20th century depict consistency in terms of intensity and frequency. The history's worst drought with extremely high air temperatures and without snow cover during winter 2001, history's worst flash floods in July 23, 2001 in Rawalpindi /Islamabad due to Cloud burst, are the few sound evidences of increased intensity of extreme events (Chaudhry et al., 2001).

Data & Methodology

Daily rainfall data for all the available meteorological stations in Pakistan (Pak Met. Stations) for the period 1961-2009, is utilized to calculate the frequency of rainfall occurrence. If the rainfall $\geq$ 2.5 mm then this will be considered as a rainy day (WMO defined). The myth behind this pattern was to consider all the significant locations of the country for an extended span of time. In order to portray a realistic picture all the four provinces were divided into two parts and Gilgit Baltistan (GB) treated separately as well. Moreover, all the four meteorological seasons of the region (winter, pre-monsoon, monsoon & post-monsoon) have been discussed separately to obtain a better understanding. The time span or duration for these four seasons climatologically is designated as;

- **Winter**: December- February
- **Pre-Monsoon:** March-May
- **Monsoon:** June -September
- **Post-Monsoon:** October-November

Seasonal data for a particular area (part of province or GB) were made on pentad (five years) basis and then the outcome fed to MS-Excel for graphical projection. Bar format was incorporated for graphical projections and the equation of line is shown as well, as the slope expresses the strength of the trend line.

Results and Discussion

After the seasonal based analysis of frequency of precipitation data for different patches of the country it revealed that the most significant area are the northwestern province "Khyber Pakhnoonkhwa" (KP) and GB. However the Punjab and Sindh provinces are also observed some variation in the frequency trend.

The precipitation of northwestern parts (upper KP) and GB of Pakistan is very important for the consistent flow of major rivers which irrigate the major agricultural plains located in the downstream areas. According to Naheed and Rasul, 2011; winter brings lot of snow over the northern mountains which melts in early summer and maintains the sustainable river flow for power generation and irrigation before the onset of the summer monsoon. Moreover, in addition to solid precipitation over hilly areas, winter rain producing systems are yield substantial rainfalls in sub-mountainous and low elevation plains including arid plains of Baluchistan. Generally northern half gets about five times more precipitation in winter than southern half.

Therefore not only amount, the occurrence time and duration of the rainfall system are also equally important for the agriculture sector in Pakistan. It is important to note that the rainfall system that produces the most of water i.e. Summer Monsoon, affects KP but not the GB. Whereas the winter rainfall system or western disturbances in the country affects both the KP and GB. Therefore for a comprehensive study only the discussion regarding these two areas KP and GB is being conducted.

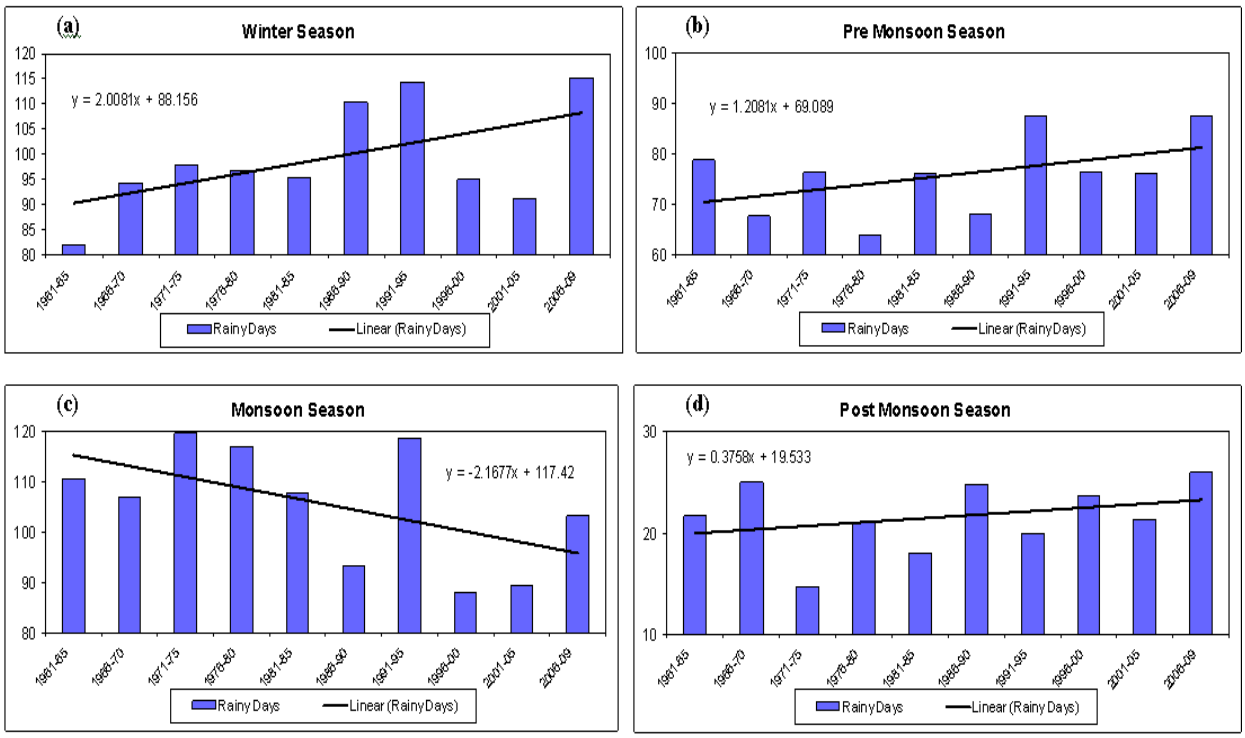

Figure 1 (a - d): Rainy days on pentad basis for upper Khyberpakhtoonkhwa, for all the four seasons. Linear trend line with equation is shown for 49 years data set.

It can be seen from the above figures (for upper Khyberpakhtoonkhwa) that the trend line equation for winter and monsoon season has shown the most significant results. For both these seasons the slope for the trend line remained more than "2" (an optimum value) where as for pre-monsoon it was 1.2 and for post monsoon about 0.4. The reason behind Figure 1(c) may be increasing frequency of El-Nino events, which impose negative impacts on summer rainfall of this region. In the same way, La-Nina has generally positive impacts on the winter rains in the particular area.

The climate change has also imposed some positive impacts in terms of temperature as well as precipitation. For example, rising temperatures have positive impacts on agricultural crop production in mountainous areas (Hussain and Mudasser, 2004). In the same way it has been observed from the post data analysis that in terms of precipitation only the frequency and duration modified. In Pakistan besides the local or orographic rainfall systems there are two types of major rainfall systems; summer and winter monsoon. The summer monsoon is the most dominant rainfall system stand for about 60 % of the annual

total, fed not only the standing Kharif crops but helps to improve the optimum soil moisture for upcoming Rabi crops. But the time period at which it occurs having intense solar radiation with highest values of ETo, which adverse the soil moisture feeding at the particular time. On the other hand, the winter monsoon is although very low in amount and intensity but it provides the water requirements for the standing Rabi crops like Wheat etc. Therefore the time span or rainy days for both these seasons are equally important.

As we can see in the above graphs that in case of summer monsoon the rainy days have decreasing trend where as for winter season the matter is totally opposite and the rainy days are increasing.

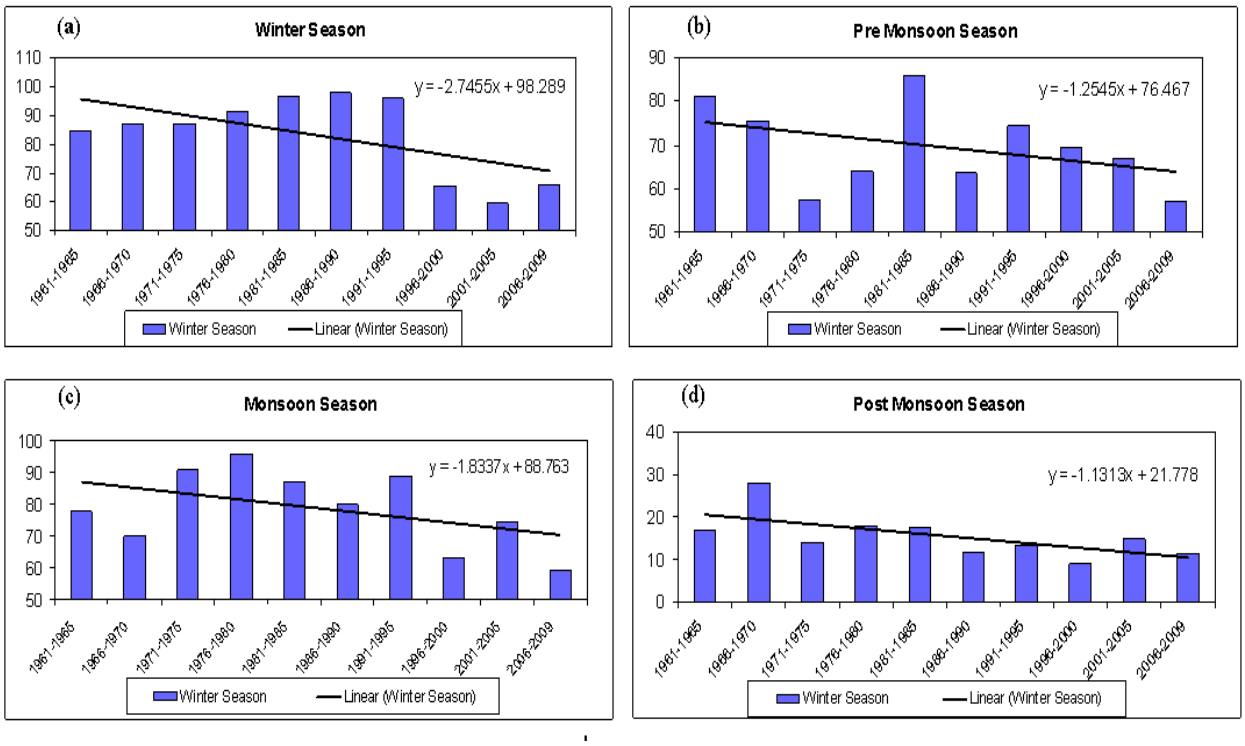

Figure 2 (a-d): Rainy days on pentad basis for Northern Areas and Gilgit Baltistan, for all the four seasons. Linear trend line with equation is shown for 49 years data set.

For Northern areas and Gilgit Baltistan as we can see from the above figures, all the four seasons have decreasing trend in terms of rain frequency. Particularly for the winter season the trend line has slope greater than 2.5 for 10 data points (50 years data on pentad basis), which is very significant. This area is very important for winter precipitation as it holds the world largest frozen water reservoir, which is the major contributor to the major river system (Indus) in Pakistan. Holepoto, 2009, says; The water availability in Pakistan's rivers is highly erratic and unreliable. The highest annual water availability in the recorded history 1922 to date was 186.79 MAF (million acre feet) in the year 1959-60 as against the minimum of 95.99 MAF in the year 2001-2002. The Kabul River contributes a maximum of 34.24 MAF and a minimum of 12.32 MAF with an annual average of about 20.42 MAF to Indus main.

The frequency and intensity of heavy rainfalls has increased along the foothills of Himalayan southern slopes. Consequently, several lives have taken and huge damage to the infrastructure incurred due to the events like landslides and lightening etc (Chaudhry et al., 2007). Both the areas under discussion are very important for hydrological cycle of the country. KP is more important for agriculture productions as well as the western parts of the province are having very fertile agricultural lands, famous for agricultural crops and many kinds of fruit production like Peech , apple, pomegranate etc. On the other hand GB holds the world biggest water reserves very important for hydrological cycle of Pakistan.

Conclusion

Pakistan is an agrarian country with major rivers flow from north to south. The precipitation systems mainly during summer & winter as well as the water from these rivers help sustaining the agriculture lifecycle. Due to climate change impact sometimes rain occurred heavily resulting in to the flooding through the said rivers while sometimes it diminishes imposing drought conditions in the downstream areas. The outcome of the present study shows that the northwestern and northern areas of the country are most significant in terms of rainfall frequency. The said areas are not only vital for the agriculture sector as well as for the hydrological cycle of the country. Therefore the situation demands a deep consideration for future planning in the core sectors of economy and development.

References

Chaudhry, Q. Z., A. Mahmood, G. Rasul and M. Afzaal, 2009: Climate Change Indicators of Pakistan, Pakistan Meteorological Department, Technical Report No. PMD 22/2009.

Chaudhry, Q. Z. and G. Rasul, 2007: Global Warming and Expected snowline shift along Northern Mountains of Pakistan. Proceedings of 1st Asiaclic symposium, Yokohama, Japan.

Chaudhry, Q. Z. and G. Rasul, 2004: Agroclimatic Classification of Pakistan, Science Vision (Vol.9, No.1-2&3-4), (July-Dec, 2003 &Jan-Jun, 2004), 59-66.

Chaudhry, Q. Z., M. M. Sheikh, A. Bari and A. Hayat, 2001: History's Worst Drought Conditions Prevailed over Pakistan. http://www.pakmet.com.pk/journal/ historyworstdrought2001report.htm.

Dowswell, C. 1989: Wheat Research and Development in Pakistan, Pakistan Agriculture Research Council/ CIMMYT 1989, Collaboration Program.

Ghazala, N. and G. Rasul, 2011: Investigation of Rainfall Variability for Pakistan. Pakistan Journal of Meteorology, Vol.7. No.14, 25-32.

GOP, 2008: Economic Survey of Pakistan (2007-08), Ministry of Finance, Government of Pakistan.

Holepoto, Z., 2009: Water Scarcity and Disputes, Daily Dawn, 06 July, 2009.

Hussain, S. S., M. Mudasser, 2004: Prospects for wheat production under changing climate in mountain areas of Pakistan-An econometric analysis. Water International, 2004, Vol. 29, No. 2, 189-200.

Kazmi, D. H. and G. Rasul, 2009: Early Yield Assessment of Wheat on Meteorological Basis for Potohar Region, Pak. Jr. of Meteorology, Vol. 6, No. 11, 73-87.

Pratley, J., (2003): Principles of Field Crop Production, Oxford University Press, Australia.