

## **Socio-political impacts of Meteorological Droughts and their spatial patterns in Pakistan**

**Nausheen Mazhar**

*Lahore College for Women University, Lahore.*

**Muhammad Nawaz**

*Institute of Environment and Livelihoods, Australia*

**Ali Iqtadar Mirza**

*Government College University, Lahore.*

**Khalida. Khan**

*University of the Punjab, Lahore.*

### **Introduction**

Drought is often referred a creeping disaster as it takes time to mature, impacts may linger on for a considerably longer time period even after the termination of the event. Pakistan is climatically an arid to semi-arid country frequently in the grip of meteorological droughts. Since Pakistan has an agro-based economy, thus in drought years its economy cripples. The response of the government to this recurrently occurring disaster, has been reactive. This research delineates the pattern of meteorological droughts in Pakistan for the time period 1980-2010 and also defines droughts in the perspective of Pakistan's climatic conditions. Drought mapping has been a neglected area in Pakistan. This paper offers map showing the spatial pattern of meteorological droughts in Pakistan and reveals that Sindh and Balochistan are the most arid parts of the country and have a high probability of extreme meteorological drought

**Key words:** Meteorological droughts, spatial, threshold.

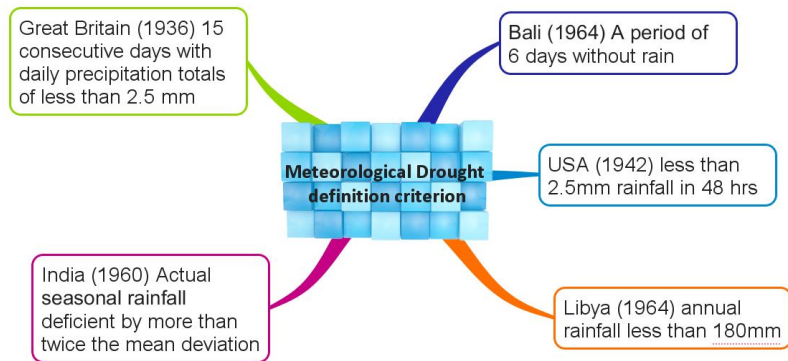
### **Introduction**

Droughts differ from other natural hazards in terms of their duration and impacts. This creeping disaster develops slowly over time and its impacts linger on for a longer period of time, i.e. from months to years. Droughts usually encompass a larger landmass, a region, and/ or an entire continent. Obasi (1994), Hewitt (1997) and Bryant (1991) claimed droughts to be the top most disaster as far as number of affected people was concerned. Droughts and heat waves are also misconceptually correlated, however these two are separate phenomena. Heat waves may linger on for a week while a drought may persist from months to years (Chang & Wallace, 1987). Drought episodes differ from one another based on their intensity, duration and area covered (Wilhite, Sivakumar and Pulwarty, 2014). According to Anjum, Saleem, Cheema, Bilal & Khaliq (2012) droughts are mostly defined as climatic episodes of an area where the moisture supply is below its average value for a

continuous period of time. According to Ahmad, Hussain, Qureshi, Majeed, & Saleem, (2004) Pakistan has recurrently been hit by droughts as this disaster is not new to the region of South west Asia.

### Defining Meteorological Drought

Mishra and Singh(2010),state that globally droughts are defined conceptually and operationally. Conceptual definitions are stated in relative terms, whereas operational definitions identify specifically the onset, severity and termination of drought periods. Figure 1 presents meteorological drought definition criterion in different parts of the world and presents the concept that droughts are a result of deficient rainfall.



**Figure 1: Meteorological drought definition criterion in different parts of the world**

Glossary of Meteorology (1959) defines drought as a period of abnormally dry weather sufficiently prolonged for the lack of water to cause serious hydrologic imbalance in the affected area. However, Palmer, 1964, affirms that drought is a meteorological phenomenon in which the affected area undergoes severe and extended moisture deficiency. According to World Meteorological Organization(WMO, 1986) report, ‘drought means a sustained, extended deficiency in precipitation.’ The Food and Agriculture Organization (FAO, 1983) of the United Nations defines a drought hazard as ‘the percentage of years when crops fail from the lack of moisture.’ There are several other definitions of drought based on distinct parameters but nearly all of them link this phenomenon with moisture deficiency. Generally an area experiences drought conditions when annual average precipitation is less than some particular percentage of normal (Mc Guier & Palmer, 1957).

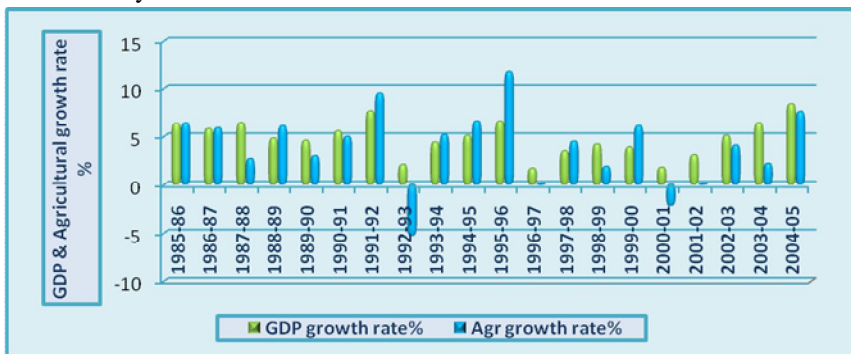
Eltahir (1992),defines meteorological droughts to be lack of precipitation in a given region over a period of time, thus precipitation data is generally used for such studies. Looking at such diversified definitions of droughts all over the world, an effort is made in this paper to define meteorological droughts in Pakistan according to its climate: “an extended dry period, when annual precipitation is less

**Socio-political impacts**

than 282.585mm, and moisture deficiency seriously affects water levels in surface and groundwater bodies, depletes soil moisture and causes crop damages”.

This is a proposed conceptual definition of meteorological drought in Pakistan. In this definition, the term ‘dry period’ covers a vast arena of meanings, i.e., it’s not just shortfall of precipitation, but a combined effect of precipitation shortfall, falling levels of water in reservoirs and declining soil moisture. This is the reason, why, in the continuation of this definition the term “moisture deficiency” is used. Although, it is a fact that moisture deficiency is caused by a shortfall of precipitation, but this term presents a combined effect of this deficiency on water reservoirs and soil moisture.

Pakistan is amongst those countries of the world that are frequent victim of droughts. Frequency of this creeping disaster in our country is 2-3 years in every 10 yrs. According to Anjum, Wang, Salhab, Khan & Saleem (2010) droughts are common in both the developed and the developing world, however this disaster leaves its long lasting impacts on the economy of the developing countries because their agriculture is mostly rain fed. Out of total 79.6 million hectares area of Pakistan, 88% consist of arid and semi-arid lands. According to facts provided in their paper only 9% of Pakistan’s land receive more than 508mm of rain, 22% receive between 254-508mm of rain, and 69% less than 254mm (Anjum et al.).The authors list some of the major sectors of Pakistan’s economy that are affected due to meteorological droughts: agriculture, forestry, livestock, fisheries, banking, energy and transportation; inflation rate, unemployment, etc. Figure 2 shows the GDP and agricultural growth rate of Pakistan from 1985-2005. Note that during drought years both the variables suffered a sharp decline, thus producing a drain on the economy.



**Figure 2: GDP and Agricultural Growth Rate of Pakistan, 1985-2005**  
Source: Economic Survey of Pakistan

Pakistan has often been in the grip of severe drought episodes. According to the depressing facts presented by World Disasters Report, (2003)6,037 people were killed and 8,989,631 were directly or indirectly affected by the drought spell that lasted from 1993-2002. Mishra and Singh(2010), declare 1999-2000 to be one of the worst multi-year drought episode for Central and South-west Asia, in which

Pakistan, along with Afghanistan, Iran, Tajikistan, Uzbekistan and Turkmenistan experienced terrible impacts.

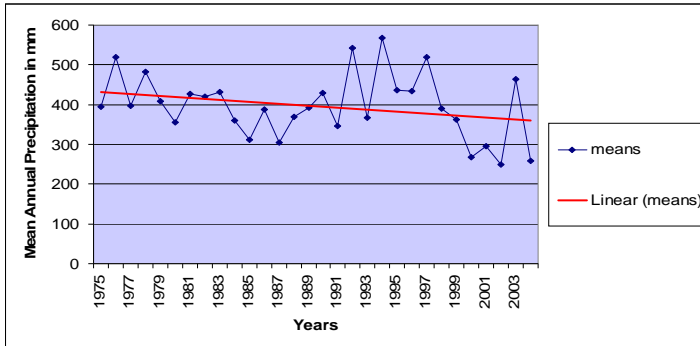


Figure 3: Mean Annual Precipitation of Pakistan, Linear Trend Line, 1975-2004

Figure 3 presents the linear trend line of Pakistan’s precipitation, for past thirty years, 1975-2004. It can clearly be concluded that the annual precipitation fluctuates tremendously from the average trend line. During 1999-2001, mean precipitation fell to most extremely low levels. The extremely low levels of precipitation correlate with meteorological drought episodes in Pakistan. At present Thar district is in a firm grip of drought, causing massive loss of life and property. The Pakistan Meteorological Department declared this drought to be a “socio-economic disaster”.

According to the report of IPCC (2012), nations need to have national drought policy that is well coordinated. This policy must consist of monitoring, early warning systems, impact assessment procedures, risk management and drought preparedness plan and finally a concrete emergency response plan. Unless nations do not start taking a mitigation approach, they shall continue to respond to droughts in a reactive mode.

### Drought Mapping

According to Eriyagama, Smakhtin & Gamage (2009) some mapping projects on desertification have been carried out by some international organizations, but they are not focused on droughts. Mapping has also been completed on various characteristics that are often associated with droughts, for e.g. Mean Annual Evapotranspiration, Global Humidity Index, Mean Annual Precipitation and Temperature, Socio-economies, disaster vulnerability maps, etc., but the need to map drought severity, in Pakistan, on district level, using a threshold value of precipitation that could decide the degree of drought intensity, still remains. Thus this research work focuses on this kind of focused mapping.

## **Materials and Methods**

The study area for this study was Pakistan and period chosen was from 1980-2010. Precipitation, temperature and economic data was acquired from Pakistan Meteorological Department and Economic Survey Reports of Pakistan. Keeping in view the aridity of Pakistan's climate a threshold value for meteorological drought definition was chosen based on the literature review. Thurow and Taylor (1999) concluded in their research that 3/4<sup>th</sup> departure from normal precipitation leads to meteorological drought. Precipitation average of 282.585mm was used as the threshold annual precipitation in this paper, based on the value of mean annual precipitation of Pakistan for the period of 1985-2012 acquired from Pakistan Meteorological Department. Any area receiving annual precipitation less than 282.585mm would be experiencing meteorological drought in Pakistan. Using this value, precipitation averages were related and 5 drought intensity classes were formulated in order to emphasize the severity and variations of drought intensity in Pakistan. The drought classes were presented on Pakistan district map in Arc Map 9.3.

## **Threshold Precipitation for Defining Meteorological Droughts**

The onset of meteorological drought is marked by the 3/4<sup>th</sup> departure from normal precipitation (Thurow and Taylor, 1999). Thus while delineating the spatial pattern of meteorological droughts 3/4<sup>th</sup> departure from normal precipitation is critical to decide the threshold precipitation value. According to World Bank Report (2010), average precipitation in depth in Pakistan in 2009 was 494 mm; thus 3/4<sup>th</sup> of precipitation departure according to this value is 370.5 mm. Mean annual rainfall figure calculated from the data acquired from PMD for the time period 1985-2012 was 376.78mm and 3/4<sup>th</sup> departure calculated from this data is 282.585 mm. Another research conducted by Faisal and Ghaffar (2012) concludes that the mean area weighted rainfall of Pakistan for a 50 year time period, i.e. 1961-2010, is 297.6 mm. The 3/4<sup>th</sup> departure from annual average rainfall value in this case is 223.2 mm. Keeping in view the varied climatic conditions of Pakistan, meteorological droughts have been defined in this paper taking 282.585mm (11.12 inches) as the threshold precipitation value, since it has been calculated using the reliable data collected by PMD.

## **Major Droughts of Pakistan**

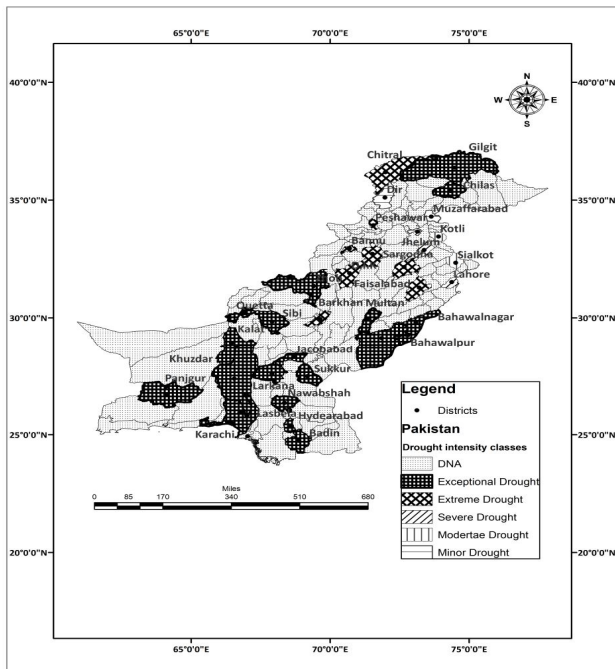
Drought of 2000-2002 is considered the most severe drought episode of Pakistan that resulted in deaths, large-scale migrations and crop failures. This drought resulted in the death of 10 people and affected 2,200,000 people across the country (Anjum et al. 2010). According to Anjum et al. (2012), during 2004-2005 a periodic drought attacked lower parts of Pakistan. In the winter of 2005 these areas

experienced 40% less rainfall and 25% less snowfall than normal. The authors also classify the mid of 2009 and 2010 as weak drought episode in which the northern parts of the country and northern Balochistan were affected.

## Results and Discussions

### Meteorological Drought Conditions in Pakistan

Figure 4 presents the long term drought situation of Pakistan during the years 1980-2010. This 31-year time period has been selected due to some defined reasons. It is a common practice, of the drought analysts, around the world, to define drought on the basis of departure of normal precipitation in comparison with the average precipitation of that area.



**Figure 4: Meteorological Drought in Pakistan, 1980-2010**

For calculating this average, usually a thirty year time period is selected, since minor and some of the major climatic changes can be observed during this time span. The threshold, on the basis of which this map has been created, is 282.585mm.

Areas receiving annual precipitation less than this threshold are termed as meteorologically drought-hit areas. Depending upon the intensity of drought, these districts have been classified into five classes. This classification of meteorological drought clarifies the trend of droughts that prevails in Pakistan. The names of the classes have been suggested based on the similar practice carried out by the

### **Socio-political impacts**

National Drought Mitigation Center of the United States. This map visually presents the spatial pattern of meteorological droughts in Pakistan. The pattern intensifies from north to south with moderate drought pockets in Punjab and KPK. In Balochistan province district Panjgur, Lasbela, Kalat, Quetta, Khuzdar and Sibi: In Sindh province district Larkana, Jacobabad, Sukkur, Nawabshah, Badin and Hyderabad: In Punjab province, district Bahawalpur, Multan and Bahawalnagar: In northern areas of Pakistan, district Gilgit and Chilas suffer from extremely severe drought.

The meteorological drought intensity map shows Sindh and Baluchistan to suffer most critically by droughts. However, it can be concluded by the map that Punjab and KPK have also become drought-affected provinces. However as far as severity of meteorological droughts in Sindh and Balochistan is concerned, our results are consistent with Anjum et al. (2010). These provinces lie in hyper arid climatic region and thus are most vulnerable to droughts. Ahmad et al. (2004) also conclude in their research work that the water table in both the severely affected provinces has declined considerably due to frequent droughts and over exploitation of groundwater.

### **Conclusion**

Currently, the frequency of droughts remain the same, however the duration of its stay is increasing. The economic and social impacts of drought are worsening. The proposed definition is based on the threshold precipitation which has been selected keeping in view the annual mean precipitation of Pakistan. The map shows most drought prone regions of Pakistan where drought conditions have persisted for 31 years (1980-2010). This map may be helpful for the authorities to make policies about drought mitigation and preparedness and implement them in the danger zones. The south eastern portions of Pakistan are desert regions and are currently in the grip of a severe drought. Anjum et al.(2010), mention rightfully in their research that Thar receives 100-500 mm of rainfall annually. Akhtar and Arshad (2006) state that mean annual rain in Cholistan ranges from less than 100mm to 200 mm, which implies that drought threshold defined in this paper is clear declaration of meteorological drought state. Thus, we conclude that the current drought episode of Thar is creeping into Cholistan too and suggest the government to take necessary precautionary measures to minimize the loss of life and property in these areas. The crisis management policy of the government needs to be urgently changed to drought preparedness. According to Bates, Kundzewicz, Wu, Palutikof (2008), drought frequency around the world is going to increase, thus it is important to understand the phenomenon, identify its causes and quantify drought patterns. Thus, it is hoped that this research work will prove as a threshold for further research in drought studies

## Recommendation

We recommend that the government should also alter its drought policy from crisis management to risk management. In Baluchistan and Sindh provinces, canals must be dug from rivers to conserve water in the local reservoirs for irrigation purposes. Additional reservoirs must also be constructed. General public must be educated about the sensitive issue of water conservation; this can be done through media.

## Acknowledgements

The author would like to acknowledge and thank the selfless support and guidance of her Father, Mother, Husband, Mother in law and Ms. ZaynahSohail.

## References

- Ahmad, S., Hussain, Z., Qureshi, A. S., Majeed, R., & Saleem, M. (2004). Drought mitigation in Pakistan: current status and options for future strategies: International Water Management Institute.
- Akhter, R. and M. Arshad (2006). "Arid rangelands in the Cholistan desert (Pakistan)." *Science etchangementsplanétaires/Sécheresse*17(1): 210-217.
- Akhter, R., & Arshad, M. (2006). Arid rangelands in the Cholistan desert (Pakistan). *Science et changementsplanétaires/Sécheresse*, 17(1), 210-217
- Anjum, S. A., Saleem, M. F., Cheema, M. A., Bilal, M. F., & Khaliq, T. (2012). An Assessment to Vulnerability, Extent, Characteristics and Severity of Drought Hazard in Pakistan. *Pakistan Journal of Science*, 64(2).
- Anjum, S. A., Wang, L.-c., Salhab, J., Khan, I., & Saleem, M. (2010). An assessment of drought extent and impacts in agriculture sector in Pakistan. *Journal of Food, Agriculture & Environment*, 8(3&4), 1359.
- Bates, B. C., Kundzewicz, Z.W., Wu, S., Palutikof, J.P. (2008). *Climate Change and Water. Technical Paper*, International Panel on Climate Change (IPCC) Secretariat, Geneva.
- Bryant, E.A., 1991. *Natural Hazards*. Cambridge University Press, Cambridge.
- Chang, F.C., Wallace, J.M., 1987. Meteorological conditions during heat waves and droughts in the United States great plains. *Mon. Weather Rev.* 115 (7), 1253–1269
- Eltahir, E. A. B. (1992). Drought frequency analysis in Central and Western Sudan. *Hydrological Sci. J.*, 37((3)), 185-199.
- Eriyagama, N., Smakhtin, V., & Gamage, N. (2009). *Mapping drought patterns and impacts: a global perspective (Vol. 133)*: Iwmi.
- Faisal, N. and A. Gaffar (2012). "Development of Pakistan's new area weighted rainfall using Thiessen Polygon method." *Pakistan Journal of Meteorology (Pakistan)*.
- Field, C. B. (Ed.). (2012). *Managing the risks of extreme events and disasters to advance climate change adaptation: Special report of the intergovernmental panel on climate change*. Cambridge University Press.
- Hewitt, K., 1997. *Regions at Risk: A Geographical Introduction to Disasters*. Addison-Wesley Longman, UK
- McGuire, J. K., & Palmer, W. C. (1957). The 1957 drought in the eastern United States. *Monthly Weather Review*, 85(9), 305-314.
- 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.



**Socio-political impacts**

- Mishra, A. K., & Singh, V. P. (2010). A review of drought concepts. *Journal of Hydrology*, 391(1), 202-216.
- Obasi, G.O.P., 1994. WMO's role in the international decade for natural disaster reduction. *Bull. Am. Meteorol. Soc.* 75 (9), 1655–1661
- Palmer, W. C. (1965). *Meteorological drought: US Department of Commerce, Weather Bureau Washington, DC, USA.*
- Rachel Frost, M. S. U. (September 10, 2012). *Rangeland, climate and drought.*
- Thurrow, T. L., & Taylor Jr, C. A. (1999). Viewpoint: the role of drought in range management. *Journal of Range Management*, 413-419
- Wilhite, D. A., Sivakumar, M. V. K., & Pulwarty, R. (2014). Managing drought risk in a changing climate: The role of national drought policy. *Weather and Climate Extremes*.

**Biographical Note**

**Nausheen Mazhar** Department of Geography, Lahore College for Women University, Lahore, Pakistan.

**Muhammad Nawaz** Research Institute of Environment and Livelihoods, Charles Darwin University, Australia.

**Ali Iqtadar Mirza** Department of Geography, Government College University, Lahore, Pakistan.

**Khalida. Khan** Director, CIMR, University of Punjab, Lahore.

---