

**AN ASSESSMENT TO VULNERABILITY, EXTENT, CHARACTERISTICS AND SEVERITY OF DROUGHT HAZARD IN PAKISTAN**

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**ABSTRACT:** Drought is a normal, recurrent climatic feature which has caused distress since the known history of mankind. Pakistan has been suffering serious droughts periodically due to below-normal precipitation, especially in arid and semi-arid regions. Although drought affects nearly all the climatic regimes and has pronounced consequences in both developed and developing countries but its effects are noticeably devastating in developing nations like Pakistan where rain-fed farming predominates. Assessing the onset of drought, extent, intensity and duration can limit drought-induced impacts and can provide a base to develop an effective drought mitigation response. Previous drought events in Pakistan and the magnitude of drought losses indicate the continuing vulnerability of Pakistan to drought due to lack of contingency planning. The integration of existing drought monitoring tools for Pakistan is essential to reduce the vulnerability of drought in this region. In order to reduce vulnerability to drought event in Pakistan, it is inevitable to assess relevant effects and identify their potential reasons. Due to spatial and temporal variability, it is imperative to enhance the data availability for mapping and monitoring this phenomenon on all scales. Drought related multidisciplinary information can be handled by using GIS. Government institutions look after potential drought-stricken victims and others living in potential drought areas by using spatial analysis in GIS that can lead to a decision support system.

**Key words:** Drought, Drought vulnerability, Drought severity, Pakistan.

## INTRODUCTION

Disaster has an adverse effect on human beings as well as plants and animals. These extreme events either natural or man-induced when exceed than tolerable magnitude, make adjustment difficult. These events aggravate natural environmental processes to cause disasters to human beings; continued dry conditions lead to prolonged droughts, atmospheric disturbance and floods etc. (Joshi 2008). On global level worst disaster were drought and famine (45%), followed by technological disaster (14%), floods (16%), windstorm (10%), earthquake (12%), temperature and others (3%). Economic losses due to those events average US \$880 billion per annum (CBSE, 2006).

A disaster occurs when a hazard affects vulnerable population causing damage and casualties. Greater loss to life and property occurs when any hazard along with greater vulnerability leads to disaster; eg an earthquake in an uninhabited desert is not a disaster. It would be disastrous only when it affects activities and properties of people. Disaster occur when hazards fall on a vulnerable population however, its consequences vary depending upon the ability of individual or population to face the hazard. Therefore, there is need to understand and asses the vulnerability for disaster management (Himayatullah and Abuturab, 2008).

**Drought- the concept:** Of all the natural disasters, drought has potential impact than other disasters. The earth quack, floods and tropical storms etc. come for short time on limited area but droughts affect large areas. Drought is often defined in climatic terms as a continuous interval of time during which the actual moisture supply at a given place is consistently less than normally is expected. Drought is an adverse environmental phenomenon that affects almost all aspects of society. It is a normal feature of climate and its occurrence is inevitable (Wilhite 2000; Rosenberg, 1978). Numerous definitions of drought have been proposed, and each involves diverse factors. There is great controversy in defining drought (Glantz and Katz, 1977) that can be seen in a review by the Meteorological Organization (WMO, 1975). Drought is classified as meteorological drought, agricultural drought, and hydrologic drought (Dracup *et al.*, 1980; Wilhite and Glantz, 1985 and Chang *et al.*, 1991). Meteorological drought is an atmospheric condition characterized by a deficit in the amount of precipitation that normally falls in a region over a specific period of time (Wilhite, 2000; Komuscu, 1999). Rosenberg (1979) reported that agricultural drought is a shortage of precipitation and below normal soil moisture conditions sufficient to adversely affect crop or range production (Rosenberg, 1979). Hydrologic drought is a period of below average water content in reservoirs, aquifers and soils (Yevjevich *et al.*, 1977). Hydrologic

drought occurs when adverse atmospheric conditions affect recharge of water bodies. An important characteristic of drought is its creeping nature, as its effects accumulate slowly (Sheikh, 2000). Its slow, creeping nature allows sufficient time to the policy planners to devise critical drought management strategies.

Drought affects most of region on earth (Wilhite and Buchanan, 2005). So, the social aspect of drought is equally important (Wilhite and Glantz, 1987). Indeed, drought is defined by the people who experience it. Drought in winter may not show immediate effects but less recharge during fall and more runoff during spring can cause water shortage.

**Brief history of hazards in Pakistan:** Pakistan continues to suffer natural and human induced hazards that threaten to affect the lives. Natural disasters include cyclones, drought, floods, landslides, earthquakes and drought. While human induced disasters include fires, terrorism, civil unrest, refugees and internally displaced people, industrial accidents, transport accidents and war. The severity of these disasters in Pakistan is evident by the fact that 6,037 people were killed and 8,989,631 were affected from 1993 to 2002 (World Disasters Report, 2003).

**Table 1: Frequency of significant hazards in Pakistan (1954-2004)**

Overall rank	Natural Disaster	Degree of Severity
1	Avalanches	1
2	Cyclones	16
3	Droughts	4
4	Earthquakes	18
6	Floods	33
8	Landslides	3
9	Pest Attakes	1
10	Extreme Temperature	12

Source: Disaster Risk Management, TWG Working Group Meeting, United Nations, May 17, 2007.

The droughts and the associated famines have been affecting the Indus Basin from time to time and from 19<sup>th</sup> to first half of 20<sup>th</sup> century, famines averagely occurred after every 7 to 8 years. Historical climatic data indicate that the frequency of drought occurrence has been much higher in Balochistan and Sindh provinces which lie in hyper-arid climate as compared to Punjab and KPK. The worst drought occured in 1899, 1920 and 1935 in the punjab province, 1902 and 1951, in the KPK and in 1871, 1881, 1899, 1931, 1947 and 1998 in the Sindh province (Ahmad *et al.*, 2004).

**What is Vulnerability:** Vulnerability is defined as “The extent to which a community, structure, services or

geographic area is likely to be damaged or disrupted by the impact of particular hazard, on account of their nature, construction and proximity to hazardous terrains or a disaster prone area.” According to Dewey (1996), the world’s vulnerability to drought has increased steadily over the centuries primarily because of an ever-increasing population that puts heavy demand on water and natural resources. All portions of the world experienced several extended severe droughts as well as many short-term droughts, resulting in considerable losses over the past century (Hayes *et al.*, 1999; Svoboda *et al.*, 2002). Vulnerability can be categorized into socio-economic and physical vulnerability. Physical vulnerability includes notions of whom and what may be damaged or destroyed by natural hazard such as droughts, floods and earthquakes. It is based on the physical condition of people and elements at risk, e.g buildings, nature and proximity of the hazard. It also relates to the technical capability of subjects to resist the forces acting upon them. Whereas, socio-economic vulnerability means the degree to which a human population is affected by a hazard; it will not merely depend on the physical components of vulnerability but also on the socioeconomic conditions of the people. For example, poor people who are living in the sea coast don’t have the money to construct strong concrete houses. They lose their shelters whenever there is strong wind or cyclone near sea coast. Because of their poverty they are not able to rebuild their strong concrete houses to combat to hazards like cyclone and strong wind (Himayatullah and Abuturab, 2008).

Vulnerability, on the other hand, is determined by some factors such as population, technology, demographic characteristics, water use, land use patterns, policy, economic development, social behavior, cultural composition and diversity of economic base. So vulnerability will change in response to these changes because these factors change over time.

Higher population density may expose an area to a hazard and can be worst with limited health facilities and low income. Demographically if the ratio of mud houses will increase it may reduce the coping capacity and increase the potential damage of area against hazard. Furthermore, it is typically believed that people having high income are considered less sensitive than those with low wealth (Staines 2002). The degree of dependency within household structures either children or old persons regarded most vulnerable groups during disaster period. It is assumed that people with a low literacy level do not find, seek or understand information concerning risks which ultimately increase the vulnerability. Research and experience have shown that land use plays an important role in coping capacity of the vulnerabilities of communities to natural disasters.

Characteristics of a society change when consecutive droughts in the same region have different

effects, even if they are identical in intensity and duration. However, much improvement is possible to minimize vulnerability to drought. Understanding of climatology will provide information on the intensity and frequency of past events. Identifying the factors that explain who and what is at risk and why can lead to the implementation and development of a variety of mitigation actions and programs to reduce impacts from future droughts.

Extreme weather events only become disasters when converging with vulnerabilities. Whether a population gets its water from a well, rainfall or other reliable source, is a very key aspect to drought vulnerability.

**Table 2: Estimated number of people impacted/killed and the financial losses associated with various selected disasters in Pakistan: 1926-2006**

Disasters	Number of Events	Casualties	Damages (Million USD)
Drought	4	223	247
Earthquake	22	142812	5200
Epidemic	10	283	0
Flood	53	11767	6000
Landslides	13	413	0
Windstorms	21	11654	4
Transport	19	420	179

Source: Disaster Risk Management, TWG Working Group Meeting, United Nations, May 17, 2007.

Population that is using rainfall for the source of water is more vulnerable to food insecurity during of drought, due to lack of water for domestic purposes and agriculture. Drought has a differential impact by wealth status. In Ethiopia result of a study showed that poor households achieved three times lesser yield during drought years than wealthier households. The poor households changed their food intake but wealthier people did change their diet.

Vulnerability to drought is influenced by many factors, including increasing and shifting population, government policies, technology, desertification processes, water use trends, land use, increasing environmental awareness and other natural resource management practices. Increased frequency of occurrence of the natural event (i.e., meteorological drought), changes in the factors that affect vulnerability, or a combination of these elements, therefore the magnitude of drought impacts may increase in the future.

**Why Pakistan is extremely vulnerable to drought?:**

Pakistan, with most of its land area classified into arid and semi arid is extremely vulnerable to the permanent menace of drought. Pakistan lies between latitudes 24° & 37° N and longitudes 61° & 76° E.

The total land mass of Pakistan is 79.6 mha, out of which 70 mha is arid to semi-arid which is about 88% of its total geographical area (PADMU, 1983). The 41 mha land mass of Pakistan is classified as arid area, out of which 11 mha falls under main deserts where climate is hyper arid (Kahlowan and Majeed, 2004). The major deserts (Thar, Thal, Cholistan, and Chagi-Kharan) of Pakistan being categorized as hyper arid are permanently vulnerable to drought. Only 9% of Pakistan receives more than 50 cm of rain per year. A further 22 % receives between 20 to 50 cm and the remaining 69% receives less than 25 cm. Rainfalls primarily occur in the monsoon months of July, August and September which is 70 to 80 % of the total rainfall of Pakistan (UNO, 2000). In each season some regions of the country are extremely dry and always suffer from drought. If following seasons do not receive sufficient precipitation, in the absence of rainfall the drought conditions emerge in these areas and gaining severity. So that drought has become an intermittent phenomenon in the country.

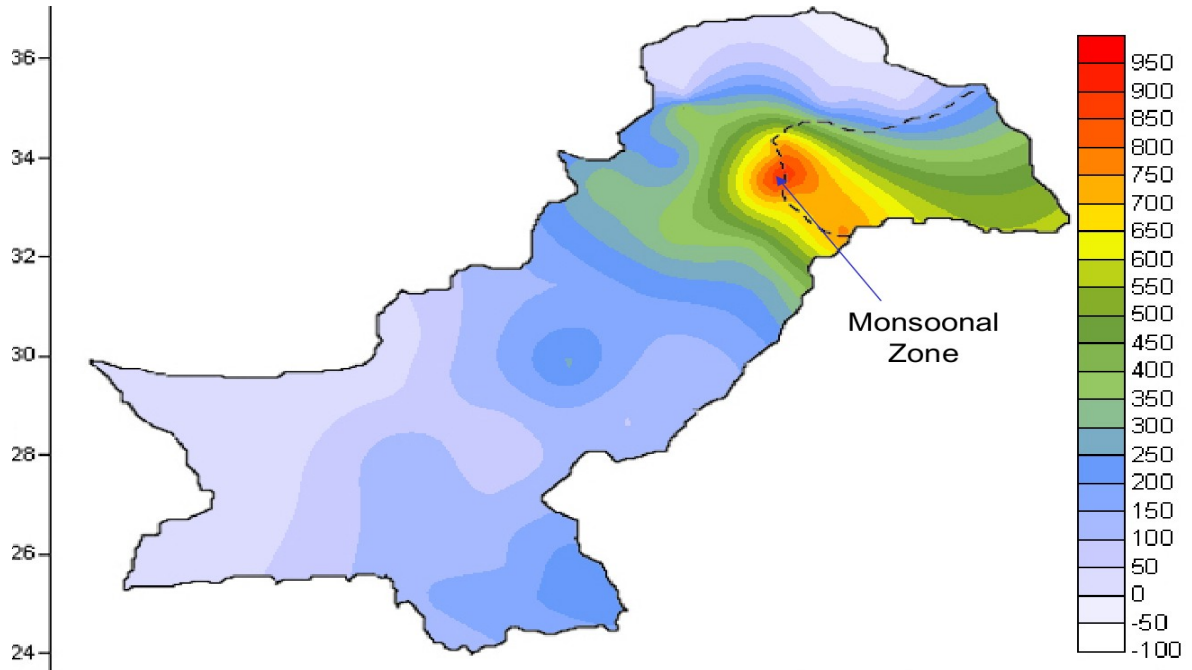
**Extent and status of drought in Pakistan:** Drought has become a frequent phenomenon in Pakistan due higher pollution and climatic changes.

**Extreme drought of 1998 – 2002:** The drought of 1998-2002 is considered worst in history of Pakistan. The drought began in 1997 but gained intensity in 1998 and reached its peak in 2000 till 2001 and then gradually weakened in 2002. The severely affected provinces were Balochistan and Sindh. 26 districts of Balochistan suffered from severe famine as a result of the drought. One of the worst-affected areas was Nushki, which had not seen any drizzle for 5 years. Drought in Balochistan affected more than 1.5 million people and killed about two million animals. In Sindh, 127 people died, mostly in the Tharparkar region, as a result of extreme water shortage and dehydration, about 60% of Sindh people moved to irrigated area.

**Table 3: Estimated 30 years province wise precipitation in Pakistan (mm)**

Period	KPK	Punjab	Balochistan	Sindh
Dec to Mar	228.8	81.1	69.3	14.2
Jun to Sept	252.9	260.3	64.2	137.5
Apr to May	106.5	36.5	20.1	5.5
Oct to Nov	37.7	11.3	4.8	4.4

Source; Sheikh, M. Drought management and prevention in Pakistan, Karachi: Jang Publishers (2000).



**Figure 1: Average Annual Rainfall Distribution in Pakistan.**

Source: Water related Disasters in Pakistan (Flood 2010) Current Gaps and Future Challenges, Pakistan Meteorological Department.

**Moderate drought of 2004 till 2005:** Periodic drought of 2004 and 2005 gripped the lower parts of Pakistan mainly Balochistan and Sindh, however no damage or death occurred; this might be due to 2003's flooding. In 2005, the drought conditions continued in the Sindh and Balochistan province including Karachi city, but a post-monsoon low pressure resulted in heavy rains during September. In winter of 2005 average rainfall was 40 % less and snowfall was 25 % less than normal.

**Weak drought of mid 2009 – mid 2010:** Light drought of 2009 and 2010 occurred in upper parts of Pakistan that is Punjab, KPK, Gilgit, Kashmir and Northern Balochistan. Sindh was unaffected by this drought. The drought caused 30% less rain in monsoon.. The farmers were worst affected, as it had impact on crop production. Lack of winter rains also increased the chances of drought in Punjab and Khyber.

Drought is the most complex but least understood of all natural hazards, affecting more people than any other natural hazard. A total of fifty eight out of one hundred and six districts of Pakistan due to drought were affected during 1998-2002. Severe drought periods affected livelihoods, caused crop failure and human deaths, killed large number of cattle and pushed tens of thousands people to migrate. The drought has severely hit the barani (rainfed) areas of Pakistan. The severity of drought reached its climax in low rainfall zones, including most of southeastern parts of Punjab, Balochistan and southern parts of Sindh. The rainfall during these periods over Pakistan was much below the normal and largely below normal. In Sindh and Balochistan, some of the areas didn't get rain at all. This deficiency of rainfall caused complete crop failure, shortage of water in rivers and reservoirs, depletion of underground water and severe drought conditions. Agriculture sector had grown at an average rate of 4.54

percent per annum during the decade of the 1990s and growth was negative 2.64 and 0.07 percent during 2000-01 and 2001-02 respectively (Govt. of Pakistan, 2002). Drought affected about 43 percent livestock in Punjab, 40 percent in Balochistan and KPK, and 66 percent in Sindh. The cumulative loss was estimated at 43 percent of the country's livestock population. Balochistan has been hit more severely as 23 out of the 27 districts had been declared as calamity zones. The impact of drought was more prominent on agricultural sector. Elsewhere, especially in lands fed with Indus Valley River and canal system, the problem caused sharp reduction in water levels. All of this has seriously affected people's livelihood in drought affected areas and posed a threat to the social fabric. Many others, who were surviving in drought prone areas, faced inadequate supply of water and food that resulted in starvation and disease.

**Drought Characteristics and Severity:** Hazard characteristics used for evaluation of drought include the degree of severity, length of event, total loss of life, social effects, long-term impact, suddenness, total economic loss, and occurrence of associated natural disasters. The total loss of life due to drought may have been overestimated because it has included deaths associated with famine. Drought damages food production systems and is one of natural triggers for famine; other social triggers, such as inequity and frustrations, further lead to social tension and extremism.

Further, hazards events have been categorized by Bryant (1991) on the basis of their features and effects. Because of the intensity, duration, and spatial extent of drought events and the magnitude of impacts, drought ranks very high. The total life loss pertaining to drought may have been overestimated because of deaths with famine.

**Table 4: Severity levels of natural disasters**

<b>Overall rank</b>	<b>Event</b>	<b>Degree of Severity</b>	<b>Length of Event</b>	<b>Total arial Extent</b>	<b>Total loss of life</b>	<b>Total economic loss</b>	<b>Social effect</b>	<b>Long-term impact</b>	<b>Suddenness</b>
1	Drought	1	1	1	1	1	1	1	4
2	Tropical Cyclone	1	2	2	2	2	2	1	5
3	Regional Flood	2	2	2	1	1	1	2	4
4	Earthquake	1	5	1	2	1	1	2	3
5	Volcano	1	4	4	2	2	2	1	3
6	Tropical storm	1	3	2	2	2	2	2	5
7	Tsunami	2	4	1	2	2	2	3	4
8	Dust storm	3	3	2	5	4	5	4	1
9	Landslide	4	2	2	4	4	4	5	2
10	Tornado	2	5	3	4	4	4	5	2
11	Snowstorm	4	3	3	5	4	4	5	2
12	Flash Flood	3	5	4	4	4	4	5	1

Source: Bryant (1991).



A drought event, however, is a multivariate event characterized by its duration, magnitude, and intensity (Salas, 1993), which are mutually correlated. A general approach used in drought related frequency analyses is to derive the distributions of drought duration and severity separately (Stedinger *et al.*, 1993). There was non-significant relationship among drought characteristics. A joint distribution of drought duration and severity will describe these characteristics in better way (Shiau and Shen, 2001). Drought intensity refers to the degree of shortfall in precipitations, while another distinguishing feature of drought is its duration which indicates the magnitude of drought and is closely related to the timing of the onset of the precipitation shortage. As droughts extend from one year to another, and from one season to another the consequences become more dangerous since surface and subsurface water supplies continue to be depleted and a larger number of users are affected. From agricultural point of view, consecutive years of drought deplete farm income and place in serious jeopardy. Drought impacts are generally classified as economic, social, and environmental; impacts often linger for months or years beyond the termination of the event. Human or social factors often aggravate the effects of drought. In contrast to floods and earthquakes the drought is a creeping phenomenon, seldom results in structural damage. So, the quantification of impacts, and the provision of relief are far more difficult tasks than in the case of other natural hazards.

**Conclusions, Future Challenges and Recommendations:** By providing drought information in time, through the use of advanced and latest tools, it is possible to minimize damages and maximize crop production. Although duration, intensity and spatial extent determine the severity of drought, it will also depend upon water demand of a region vegetation. In short due to its complex nature, it is very difficult to quantify the impact of drought in social, economical or environmental context. This is a great challenge to scientists involved in climate assessment. Pakistan Government should adopt National Drought Policies that move towards a strategy to mitigate the impacts of drought, improve public awareness and increase coordination for better response to drought.

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