THE INFLUENCE OF LA-NINA PHENOMENA ON PAKISTAN'S PRECIPITATION

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Abstract:

Pakistan has a long latitudinal extent, and the rainfall variability during different seasons is considerably high. Pakistan experience bi-model rainfall behavior termed as Monsoon rains and winter rains. Winter rains are normally confined to above 30° Latitude. In some years, winter rains fail and pose serious threat to hydro-meteorological resources and agriculture. Such conditions are seen to have close relation with fluctuations in Sea Surface Temperatures in Pacific Ocean. The country recently remained under the grip of a severe drought during the period 1998 to 2001 which disrupted the economy badly besides human and live stock killings.

This was the period of cold episode in Pacific Ocean termed as La Nina phenomena and it was believed that history's worst drought conditions over South Asia were triggered by La Nina phenomena.

In this study, effort has been made to investigate the behavior of winter rainfall over Pakistan in relation to La Nina phenomena and provide a qualitative tool for predicting winter rains on the basis of SST forecast over the Pacific.

Introduction:

Drought, floods and other manifestations of climate extremes are not recent phenomena. What is new is the knowledge to link a pattern of simultaneously occurring climate extremes within a global framework. This knowledge, with a developing capability to predict a season or more in advance in some regions is providing new tools for preparedness and early warnings to reduce e the risk and better manage the impacts of climate extreme, and to underpin strategies for sustainable development.

The pattern of drought has recurred many times in latter part of the nineteenth and in twentieth centuries. During 1998-2001, Pakistan experienced history's worst drought conditions. It was believed that it was triggered by La Nina phenomena. Accordingly an analytical study has been made to find the relationship between La Nina phenomena and rainfall amounts over Pakistan.

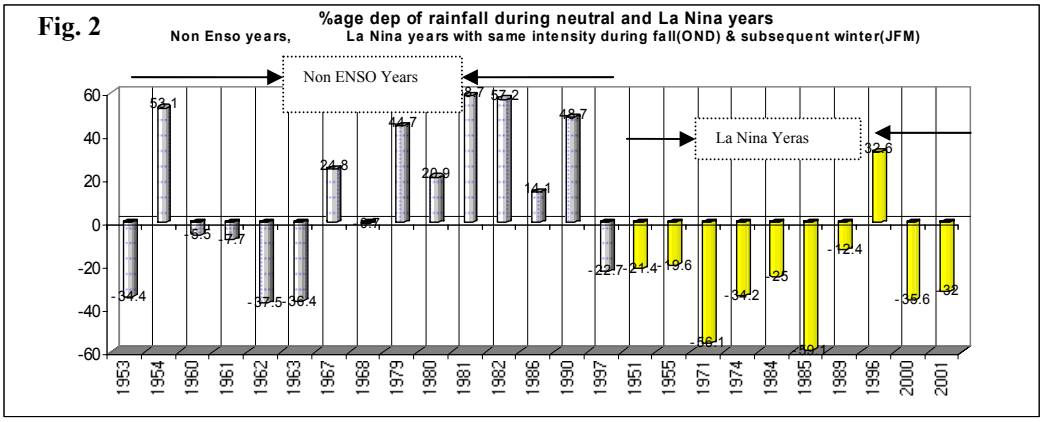
Methodology:

A determination first had to be made in regards to what constitutes a La Niña, or cold event. Different sources list different years for La Niña events. Ultimately, Climate Prediction Centre list for ENSO and non-ENSO years was incorporated into this study because it provides a season-by-season breakdown of conditions in the tropical Pacific. This list classifies the intensity of each event by focusing on a key region of the tropical Pacific (along the equator from 150°W to the date line). The process of classification was primarily subjective using reanalyzed sea surface temperature analyses produced at the National Centres for Environmental Prediction/Climate Prediction Centre and at the United Kingdom Meteorological Office.

In a strict sense, La Niña is an extreme cooling of the central and eastern equatorial Pacific over a period of several months. It is not just any drop in temperature below (i.e., cooler than) the long-term average.

List of events classified as La Niña in Climate Prediction Centre date back to 1950 and end with the last well documented event of 1998-2001. Precipitation records for Pakistan are readily available since 1950. The first La Niña event on the CPC list is 1950. Thus, the years of this study range from 1950 to 2001. Of the 52 years in this study, 16 are La Niña years. Seasonal precipitation departures were calculated for all of the La Niña years of this study. Also, average seasonal precipitation totals for La Niña years were compared to average seasonal precipitation totals for the non-La Niña years of this study.

Fig. 2



The two sets of calculations were to be performed to show that La Niña does indeed have a direct negative effect (decrease) on the Pakistan precipitation record.

The winter season was classified from January to March and Monsoon season as July to September.

Data Analysis and Discussions:

Since seasons of precipitation maximum are determined by seasonal changes in regional seasonal circulations, which govern the processes by which precipitation is produced, therefore primary focus remains on the analysis of departure of seasonal precipitation in individual years from long term average.

Various La Nina cases were segregated according to the intensity of La Nina phenomena published by Climate Prediction Centre on three month basis. Following segments were analyzed.

1. La Nina with strong intensity during fall (OND) and subsequent winter(JFM).
2. La Nina with moderate intensity during fall (OND) and subsequent winter(JFM).
3. La Nina with weak intensity during fall (OND) and subsequent winter(JFM).
4. La Nina with increasing intensity from fall (OND) to subsequent winter(JFM).
5. La Nina with decreasing intensity from fall (OND) and subsequent winter(JFM).

Area weighted rainfall on all Pakistan basis was computed for Winter season(JFM) and impact of La Nina was studied for above five segments.

Analysis of rainfall on all Pakistan basis during strong La Nina conditions in fall (OND) and subsequent winter (JFM).

These conditions were met during 1974 & 1989. During both years, rainfall received was below than long term average as indicated in graph.

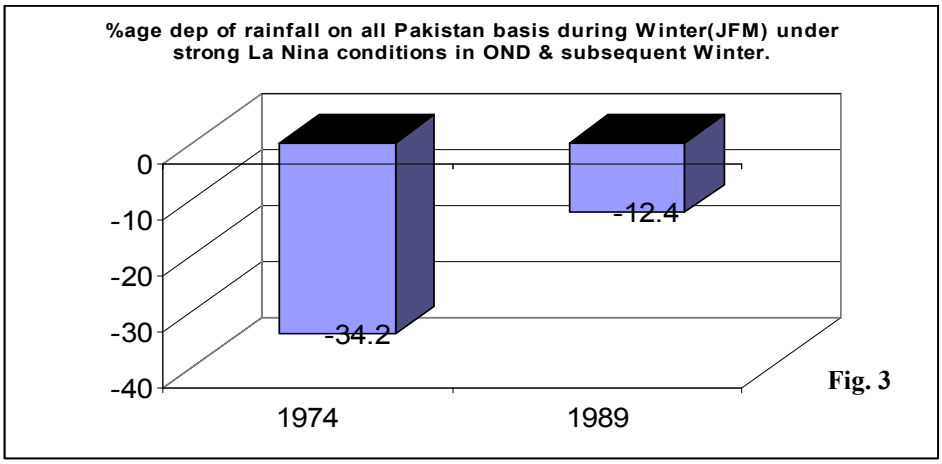


Fig. 3

In 1989, there was an abrupt change in global atmospheric pattern and SST warming was more rapid compared to 1974 situation. Accordingly in March, La Nina intensity became weak from strong in Jan. This warming resulted in increase of rainfall activity in March. As such decrease of seasonal rainfall was not as much as in 1974.

Analysis of rainfall on all Pakistan basis during moderate La Nina conditions in fall (OND) and subsequent winter (JFM).

These conditions were met during 1951, 1955, 1971 & 2000. During entire years, rainfall received was below than long term average as indicated in graph.

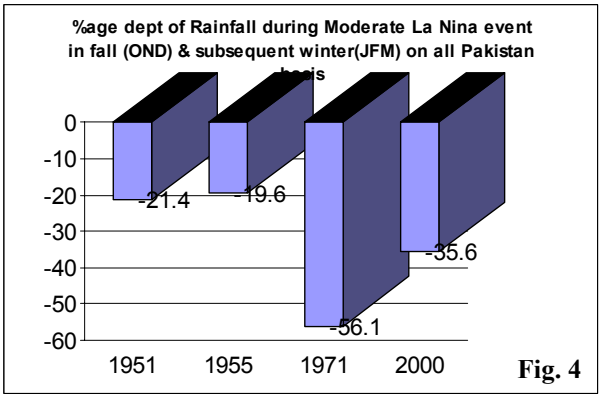


Fig. 4

Analysis shows a sharp decrease in rainfall during 1971 winter compared to other years. In fact abrupt changes in global atmosphere were noticed in November 1970. Rapid evolution of La Nina was recorded during fall season of 1970 compared to 1951, 1951 and 2000 when there

was slow evolution of La Nina episode. This might be one reason that largely below normal precipitation was recorded during subsequent winter of 1971.

Analysis of rainfall on all Pakistan basis during weak La Nina conditions in fall (OND) and subsequent winter (JFM).

These conditions were met during 1975, 1984, 1985, 1996 & 2001. 80% of the events received below than long term average as indicated in graph.

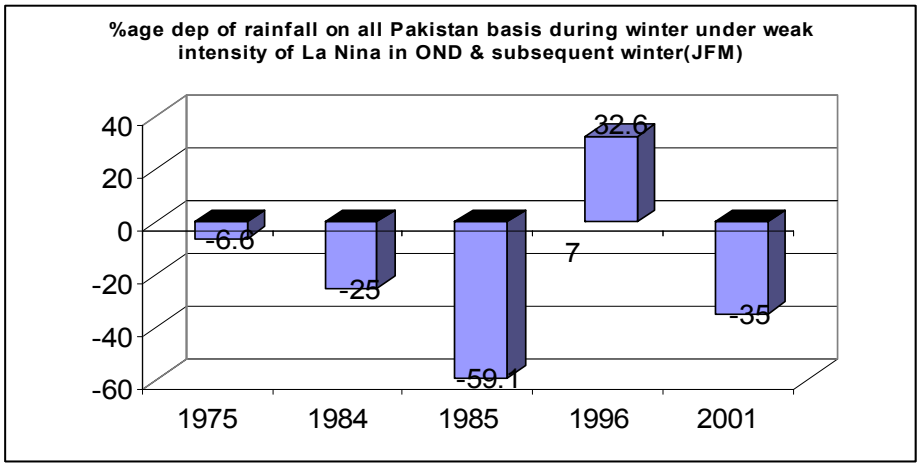


Fig. 5

In 1996, above than normal rainfall was received. Study of global parameters indicates that this episode of La Nina modestly evolved in October 1995 but ended in Feb 1996 and near normal weather conditions prevailed rest of the year. Accordingly heavy downpour was recorded during March in 1996 resulting above normal rainfall for the winter season.

Analysis of rainfall on all Pakistan basis with decreasing intensity of La Nina from fall (OND) to subsequent winter (JFM).

These conditions were met during 1956, 1957, 1965, 1972 & 1976. Precipitation activity over the country was enhanced in all cases and above than long term average rainfall amounts were recorded as indicated in graph.

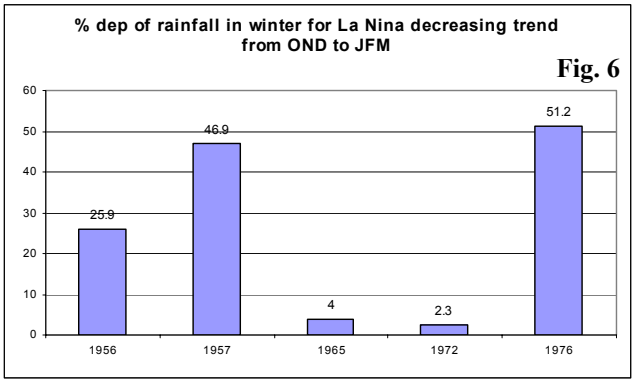


Fig. 6

On the other hand, rainfall was close to normal during monsoon period under same set of conditions in AMJ & JAS.

Analysis of rainfall on all Pakistan basis with increasing intensity of La Nina from fall (OND) to subsequent winter (JFM).

No such events has so far been reported as per data available for the past 52 years. Same criteria for AMJ and subsequent Monsoon period was met during 1954, 1964, 1973, 1975, 1988 and 1988. Analysis depicts that near-normal to above than normal precipitation was received in the country.

Conclusion

Problems in the evaluation and use of La Niña-related information arise because of the lack of consensus on a single, universally accepted description of what constitutes a La Niña event. Also, the way in which one defines La Niña in quantitative terms determines how many events have occurred. The more strict the definition, the fewer the events and the smaller the sample of La Niña cases to assess for its physical characteristics or for its environmental and societal impacts.

During cold ENSO episodes, cooler than normal ocean temperatures in the equatorial Central Pacific act to inhibit the formation of rain-producing clouds over that region. Mid-latitude low pressure systems tend to be weaker than normal. La Nina episodes feature large-scale changes in the atmospheric winds across the tropical Pacific, including increased easterly winds across the eastern Pacific in the lower atmosphere, and increased westerly winds over the eastern tropical Pacific in the upper atmosphere. These conditions reflect an enhanced strength of the equatorial Walker Circulation.

In this study, effort has been made to relate precipitation data of Pakistan during

cold episodes. As a whole, winter season rainfall activity over Pakistan is suppressed under same set of La Nina conditions during fall (OND) and subsequent winter as indicated in the graph.

However if La Nina episode is in decay process and its intensity become weak during winter compared to previous quarter (OND), i.e. SST start rising, then rainfall activity over Pakistan tends to be normal to above than normal (Fig-6).

However during monsoon period, rainfall pattern over the country is some what opposite. If intensity of La Nina increases from AMJ to JAS period, enhanced rainfall activity takes place. On the other hand, it become normal to below than normal if La Nina phenomena is in weakening process during monsoon (JAS) compared to AMJ. Results can be summarised in the following fig.

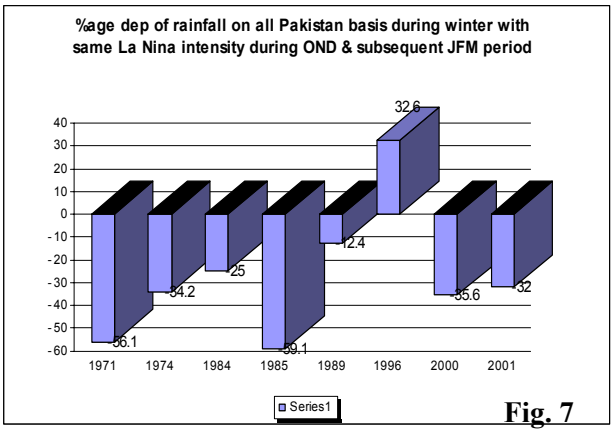


Fig. 7

Precipitation pattern during La Nina episode is different in winter & monsoon season because seasons of precipitation maximum are determined by seasonal changes in regional seasonal circulations, which govern the processes by which precipitation is produced. Winter rains in Pakistan are mainly produced by western disturbances with polar maritime air mass properties whereas monsoon rains are caused by monsoon waves with tropical maritime air mass properties. The feeding sources for disturbances in the two seasons are different & as such response to La Nina episode is also not uniform.

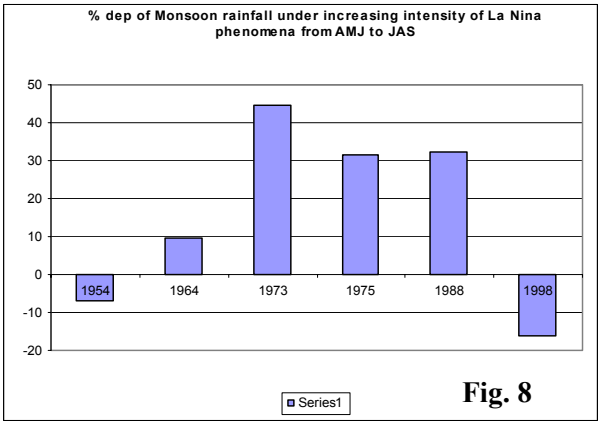


Fig. 8

Warm and cold ENSO episodes contribute to the pattern of variability of weather systems and to extremes of local and regional climate. Complex non-linear interactions between various components of climate system during ENSO events, results in seasonal shifts in the frequencies of occurrences and intensity of regional

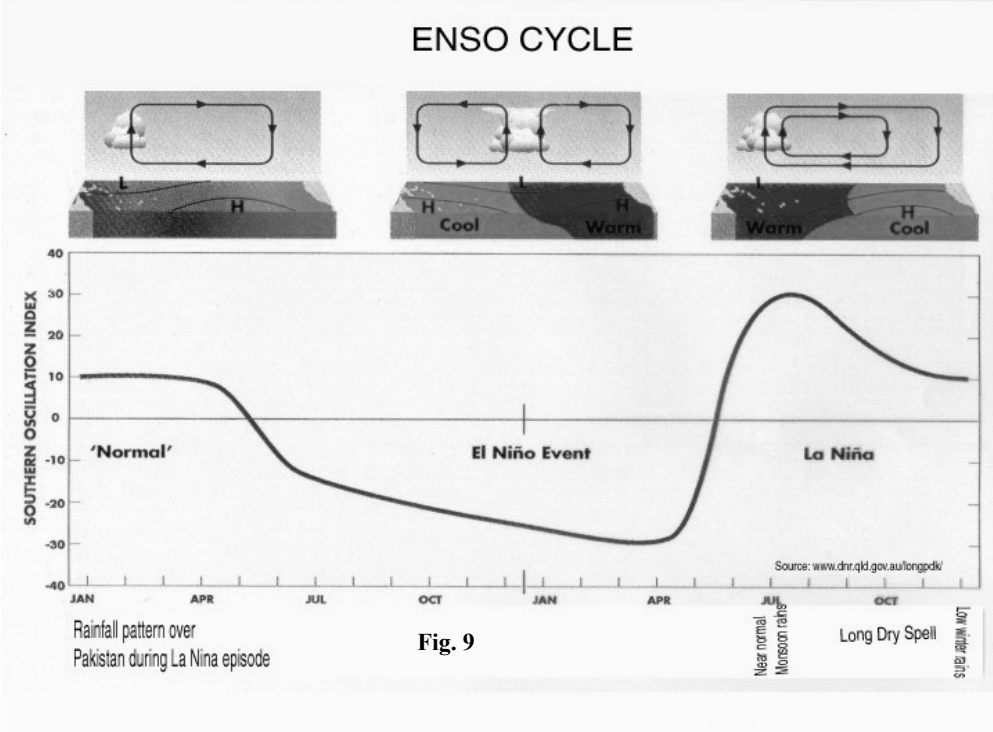


Fig. 9

weather systems.

ENSO is the part of recurring patterns of extreme weather events and persisting climate anomalies that have enormous societal impacts, especially in developing countries.

A concerted effort is required on the part of governmental and non-governmental organizations to develop appropriate policies to mitigate climate change and prepare their communities for periodic impacts of climate extreme.

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