

Impact of El-Nino and La-Nina episodes on rainfall variability and crop yield

ABSTRACT

El Nino and La Nina events have an impact on the Indian monsoon in terms of less rainfall than average and more rainfall in La Nina years. El-Nino events are more likely to see rainfall variability during the monsoon and depressions over the Bay of Bengal (July-August). ENSO is a disruption in ocean surface temperatures and atmospheric circulation over the Pacific Ocean leading to wide spread changes in rainfall/precipitation regimes around the world. El Nino years' effects on crop production in India as a result of lower rainfall during the south-west monsoon. In the kharif season (June to September), crops suffer from moisture and have lower yields in El-Nino years, but the opposite in La-Nina years. The El Nino is associate with the possibility of drought like situation at many occasions and La Nina is the opposite of El-Nino events.

Key words: Rainfall, El-Nino, La-Nina, Production, Monsoon

INTRODUCTION

The large-scale ocean-atmosphere climate phenomena known as El Nino is associated with a cyclical rise in sea surface temperatures in the central and east-central equatorial Pacific (about between the date line and 120° W). El Nino, also known as a Pacific warm episode, is the warm phase of the El Nino/Southern Oscillation (ENSO) cycle. Originally, the term "El Nino" referred to a yearly increase in sea surface temperatures off the west coast of tropical South America. Everywhere in the world, the El Nino Southern Oscillation (ENSO) occurrences have an impact on the weather, temperature, marine, and terrestrial ecosystems. To forecast the monsoon rainfall over South Asia, climatologists have attempted to understand the coupling of the Indian Monsoon with the Southern Oscillation. When ocean surface temperatures and atmospheric circulation are disrupted across the Pacific Ocean, widespread changes in global precipitation patterns result. This is how ENSO is generally described. Warm ENSO periods are occurring more frequently, which affects the tropical and subtropical regions' precipitation patterns (Houghton et al. 2001). Several earlier studies (Sikka and Gadgil 1980; Rasmusson and Carpenter 1982; Shukla and Paolino 1983; Ropelwski and Halpert 1989; Thapliyal et al 1998) have looked into the connection between

the warm phase of ENSO and below average summer monsoon precipitation over the Indian subcontinent. The Pacific Decadal Oscillation (PDO), which modifies the effects of ENSO, has had relatively little effect on Myanmar (previously known as Burma), India's close neighbour and an important agricultural nation that occupies a large landmass in Southeast Asia's tropical belt. It has been suggested, more precisely, that the warm phase of PDO increases the warm phase of ENSO's impact on precipitation patterns.

METHODOLOGY

Data analysis

Historical Research data on available climatic parameters was collected from various sources google scholar and other journal of Agro meteorology.

The relationship of *El Nino*, and *La Nina* years was analysis through various research which has been analysed on the basis of excess or deficit rainfall, the productivity of different crops through out the world and assessed on the basis of *El Nino*, *La Nina* year.

El Nino and La Nina episodes: Li (1990) studied that very cold winters across eastern China frequently came one year before El Nino episodes. The flow from the anomalous East Asian anticyclone may loop onto the original SSTA, increasing cold air advection across the Kuroshio Current region and further reducing the SSTs (as in cold WNP situations). This possibility hasn't been investigated here, although it is theoretically possible. Similar to how a cyclonic anomaly may cause warm air to advect towards East Asian coastal seas, warming the SSTs (in warm WNP situations).

In Nials *et al.* (1979) investigation of “the emergence and fall of early irrigation systems in the Moche Valley on the north coast of Peru, they found an El Nino catastrophe of enormous proportions. They referred to this historic catastrophe as the "Chimu flood." A century before the year 1100 A.D., they discovered evidence indicating this flood of extraordinarily huge proportions happened early in the Chimu dynasty. A very cautious assessment, in their opinion, would show that flood waters at least 2-4 times the size of the extraordinary floods in 1925 happened then. They added that there seems to be evidence of a different significant flood that happened around 500 B.C. in the Moche Valley. Their worry about the escalating coastal population growth”,

According to Mooley and Paolino (1989), the Indian monsoon's response to changes in sea surface temperature across the eastern south equatorial Pacific was related. El-Nino may have also had an impact on the amount of rainfall that fell over India, according to Mooley (1997). Additionally, Walker and Bliss (1932) discovered that S.O. tends to coincide with drought in India.

A strong (weak) monsoon reduces (enhances) the amplitude of an ongoing warm event or increases (decreases) the amplitude of an ongoing cold event, according to Kirtman and Shukla (2000). They also discovered that a changeable monsoon acts as an ENSO trigger. Clarifying the effects of monsoon variability on the Pacific circulation and the related SST anomalies is therefore crucial to improve our comprehension of ENSO variability and predictability.

The single most significant mode of the earth's yearly climate fluctuation is currently acknowledged to be ENSO. Evidence for the connection between Indian monsoon rainfall and ENSO, initially proposed by Sir Gilbert Walker more than 70 years ago (Krishna Kumar et al. 1995), has accumulated during the past ten years. The "typical" global and large-scale regional precipitation patterns connected to the ENSO were examined by Ropelewski and Halpert in 1987.

For the purpose of forecasting ENSO, Knaff and Landsea (1997) used the Climatology and Persistence (CLIPER) forecasting scheme. This statistical approach is wholly based on an optimal combination of persistence, month-to-month trend of initial condition, and climatology using 14 potential predictors for the equatorial and central Pacific at lead times ranging from zero seasons (0-2 months) through seven seasons (21-23 months), including SOI, Nio 1+2, Nio 3, Nio 4, and Nio 3.4 SST indices.

Barrett (1998) stressed that forecasts only have value if they change the subjective probability distributions of decision makers over stochastic factors that influence choice when evaluating the utility of inaccurate ENSO forecasts. El Nino was considered to be greatly overhyped in this context because forecasting skill with regard to ENSO phase is different from the capacity to predict ENSO's effects on variables of direct concern to decision-makers.

Impact of ENSO and Rainfall Variability

Webster and Yang (1992) have reviewed the Monsoon and ENSO coupling's historical context. Season to season changes affect how the Indian Ocean responds to the El Nino Southern Oscillation (ENSO). Monsoon depressions over the Bay of Bengal in July and August are more likely to occur during El Nino years. According to Singh et al. (2000), El Nino and La Nina conditions frequently suppress the summer monsoon and winter precipitation, respectively (Rasul 2012). It was evident that rainfall, hydrology, and rice productivity in the Cauvery river basin are all associated with El Nino occurrences. According to the investigation, El Nino years had higher interannual rainfall variability (809.3mm to 2366 mm) than La Nina and normal years.

La Nina, which is the opposite of an El Nino event, is brought on by a change in the Pacific Ocean's Sea Surface Temperature (SST). The La Nina cycle is a result of intricate interactions between oceanic and atmospheric systems. The trade winds during a La Nina cycle force warm water towards the west, where it builds up in the western Pacific. The atmospheric conditions are managed by the Walker circulation. As the north-south Hadley circulation diminishes, the subtropical high-pressure system decreases as well, implying a feeble vortex transport from the tropics to the subtropics. Meehl (1994) reported on the dynamically interlined climatic system variability across several geographical regions. According to Ranade *et al.* (2010), the La Nina phenomena offers crucial information for operations involving heavy rainfall across the Indian subcontinent. When compared to La Nina years, the rainfall circumstances during El Nino years are significantly more detrimental to nearly all hydro-ecosystems worldwide.

The study of the relationships between the monsoons and the ENSO phenomena has definitely been the most fascinating on the interannual scale in the tropics (Glantz *et al.* 1991; Webster and Yang 1992).

Progress has been made in recent decades in foretelling how the ENSO phenomenon in the Pacific Ocean would develop (Goddard *et al.* 2001). 5 months in advance, forecast centres provide passably accurate estimates of the seasonal evolution of tropical sea surface temperatures (SST) (see, for instance, Goddard *et al.* 2001). As a result, seasonal rainfall can be predicted using the link between rainfall and ENSO. Such statistical forecasts based on surface temperature teleconnections offer a different basis for seasonal climate prediction that complements and frequently outperforms those based on global climate models (Barnston *et al.* 2005). According to Soman and Slingo (1997), "SST-based indices for ENSO are better to SOI because they are explicitly predicted, have less high-frequency noise, and more accurately depict the ENSO influence over the Asian monsoon region".

According to Sikka (1980), "El Nino and monsoon failures over India are linked year to year, with the monsoon failing in the majority of El Nino cases". Based on more accurate El Nino indices, Rasmusson and Carpenter's (1983) thorough investigation revealed that the correlation between El Nino and monsoon failures is even larger than what Sikka's study suggested. In Krishna Kumar *et al.* (1995), an overview of the research on the role of ENSO in monsoon variability is provided. In conclusion, the majority of occurrences during the ENSO warm (cold) extremes cause below-normal (above-normal) rainfall. So, in addition to the internal epochal variability, external forces like El Nino and La Nina can cause drought and flood conditions.

In South East Asian regions, rainfall during the monsoon season is the main water source. Many people who depend on the monsoon for agricultural activities have their livelihoods negatively impacted by its success or failure. The monsoon is a thermally driven circulation system, thus as the world warms, more rain should fall over India. On the other hand, during ENSO years, India has seen a drop in monsoon rainfall, especially over the Indo-Gangetic plains and central India. (Sen Roy *et al* 2003), it was found that “regression coefficients showing the relationship between July–August precipitation in India and ENSO were negative for northeast India, which is contiguous with Myanmar. In the case of Myanmar, under similar ENSO conditions, the relationship is negative as with northeast India. Similar results maybe noted with warm PDO and El Nino years. This appears to indicate that the descending leg of the Walker circulation cell perhaps affects Myanmar and the adjacent areas of India similarly during these conditions”.

Impact assessment of ENSO of crop production

“Changes in South west monsoon rainfall behaviour raise concern about the food security. Numerous studies have demonstrated that the kharif harvest was lower when total June –September rainfall was lower” (Webster *et al* 1998, Kumar 2004). The El Nino is associate with the possibility of drought like situation at many occasions and La Nina is the reverse of that and thus a drought during the 2009 was on of the most severe in decade with rice harvesting declining by 14 per cent (Commission for Agriculture and Cost Prices 2010).

According to Bhuvanewari *et al.* (2013), the Cauvery basin's rainfall hydrology and rice productivity are tied to El Nino episodes. The SWAT model's capacity to predict stream flow and rice productivity with accuracy was demonstrated through its validation. They further looked at the fact that the amount of rainfall was higher in El Nino years with significant interannual variation (809.3 mm to 2366 mm). According to a study published in the journal Nature Communications, an investigation of wheat productivity revealed that global yields for the most extensively cultivated grain were, on average, 1.4 percent lower than normal in El Nino years. According to the study, around 22% of the wheat harvested globally in 2000 saw "significant" unfavourable effects from El Nino, notably in portions of China, Mexico, south and east Australia, and the northwest United States. About 6 percent of wheat benefited significantly, including in parts of Russia, Argentina and northern China, the researchers found. Global wheat yields were 4 percent lower than normal in La Nina years, the researchers found (www.bloomberg.com/news/article/2014-15).

Jones (2000) examined data from official statistics and demonstrated that El Nino significantly affects yield at the national level in his research Comparative Assessment of

Agricultural Uses of ENSO-Based Climate Forecasts in Argentina, Costa Rica, and Mexico. While maize output was equal to or up to 36% greater in 15 of 20 El Nino occurrences (75%) than the mean historical value, it was up to 56% lower in 17 of 23 La Nia episodes (74%) than the mean. La Nia had an even higher effect on soybeans, resulting in yield losses in 71% of instances. In 58% and 62% of cases, respectively, yield residuals were positive in El Nino and neutral years. With only one trend, sunflowers showed less correlation between yield and ENSO phases, with a 59% chance of producing more during La Nia years. The least responsive crop was wheat, which only saw lower yields in 57% of La Nia years. Wheat and sunflowers did not exhibit predictable tendencies during El Nino years. An examination at the county level revealed that these national tendencies were broadly reproduced, but it also identified a number of regions where ENSO effects on agricultural production repeatedly deviated from the average.

According to research by Rao et al. (2011), the state of Andhra Pradesh's total food grain output fluctuated between 9.5 and 15.0 million tonnes during normal years, but only between 9 million and 12 million tonnes during El Nino years. Therefore, despite the state's total food grain output growth tendency up to the year 2002, there is an evident signal that it will decline by at least 0.5 million tonnes to 3 million tonnes during the years with El Nino. Only the most recent two El Nino years, 2004 and 2006, saw above-average overall food grain production. The idea that it may be challenging to achieve improved growth rates in food grain production during El Nino years is confirmed by the fact that the overall food production in the years 2004 and 2006 decreased relative to the corresponding preceding year.

CONCLUSION

Events such as El Nino and La Nina affect the Indian monsoon by causing rainfall to be higher during La Nina years and lower than average during El Nino years. In El-Nino year's crops suffer moisture stress in kharif season result decreases the yield and completely reverse in La-Nina years in which received higher rainfall and higher production also.

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