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El-Nino and the Indian Ocean Dipole: Implications for Indian Agriculture Production

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The significance of the monsoon for India's agriculture is unquestionable as it serves as a crucial water source for agricultural activities. The monsoon rains, which help refill water reservoirs, are necessary for about 50% of the nation's net sown land. The primary crop-growing season, Kharif, coincides with the summer monsoon season, which lasts from June to September and contributes 80% of the total annual rainfall. Rice, legumes, oilseeds, cotton, and sugarcane are among the principal crops that are produced during the monsoon season. Those states who have limited access to irrigation are more dependent on a normal monsoon. Despite contributing only around 18% of the nation's GVA, agriculture employs over half of all workers in India (Niti Aayog, 2022). Improved agricultural productivity can also help to reduce food inflationary pressures, particularly in grains and pulses. Therefore, a favourable monsoon is critical in supporting rural demand and keeping food prices in check.

Concepts of El Nino, La Nina and Indian Ocean Dipole (IOD)

Two climatic events, El Nino and La Nina, have a significant impact on monsoon patterns. El Nino is characterised by an abnormal warming of the Pacific waters around Ecuador and Peru, which affects temperatures globally and causes subnormal monsoons in India. The reverse effect is produced by La Nina. The south-west monsoon (SWM) in India is significantly influenced by El Nino or La Nina conditions. During El Nino, sea level pressure tends to be lower in the Eastern Pacific and higher in the Western Pacific. This implies warmer ocean waters in the east and colder ocean waters in the west. The opposite condition prevails during La Nina. The warming of ocean waters triggers a see-saw in atmospheric pressure between the eastern and western tropical Pacific, known as Southern Oscillation (SO). Since El Nino and SO are related, the two terms are often combined into a single term 'El Nino Southern Oscillation' or 'ENSO'. A warm ENSO phase signals El Nino and a cold ENSO phase is related to La Nina. El Nino is generally associated with deficient rainfall in India, whereas the development of La Nina tends to bring above normal monsoon.

In addition to these phenomena in the Pacific Ocean, the SWM also depends on the developments in the Indian Ocean, known as the Indian Ocean Dipole (IOD) conditions. The IOD can be in one of three phases namely, positive, negative, or neutral. When the western Indian Ocean basin of the ocean warms more than the tropical eastern basin, the IOD is positive. When the opposite occurs, an IOD is negative. Positive IOD events are linked to East Africa's above-average precipitation, particularly in nations like Somalia, Kenya, and Tanzania, which causes more floods. On the other side, drier weather is prevalent over sections of Australia and Indonesia, which could result in droughts and lower agricultural productivity there. On the other hand, adverse IOD occurrences may lead to increased rainfall in Australia and Indonesia and decreased rainfall in East Africa. Temperatures in the tropical Indian Ocean are similar to normal during the neutral period of the IOD, hence the Indian

SWM is unaffected. It may rather sometimes strengthen the monsoon winds leading to a higher rainfall.

India's Past Experience with El Nino

In India, there have been 15 drought occurrences and 21 El Nino years since 1950. It's interesting to note that El Nino occurrences led 10 of these 15 droughts. According to historical statistics, there is a nearly 70% chance of receiving inadequate rainfall during a severe or moderate El Nino event.

However, not every El Nino year has monsoons that are below average. According to earlier records, rainfall during the southwest monsoon was typical even in El Nino years because of helpful balancing factors. According to numerous studies, India saw normal or above-average rainfall in spite of the fact that 1994, 1997, and 2006 were El Nino years because the IOD was notably positive. India experienced average rainfall in 1969, 1976, and 1977, either as a result of El Nino's low severity or because it arrived at the end of India's monsoon season. In the previous El Nino year, which occurred in 2018–19, India saw a monsoon that was below average (90.3% of the LPA). Due to ongoing La Nina conditions that favor good monsoons, India has seen typical monsoons during the past four years.

According to statistics collected over the previous 50 years, an episode of a severe or moderate El Nino has, on average, resulted in inadequate or drought-like conditions in India, which have a negative impact on agricultural productivity and are correlated with slower GDP development.

Role of Indian Ocean Dipole (IOD) in Indian Monsoon

It is defined by the difference in sea surface temperature between two regions (or poles, therefore a dipole) - a western pole in the Arabian Sea (western Indian Ocean) and an eastern pole in the eastern Indian Ocean south of Indonesia. This is often referred to as "Indian Nino" because to apparent changes in the thermal and atmospheric conditions of the Tropical Indian Ocean.

Positive and negative IODs are the two varieties. It impacts the monsoon rains in the Indian summer. A positive IOD happens when the Arabian Sea's sea surface temperature is higher than average and the tropical eastern Indian Ocean's sea surface temperature is lower than average. When the situation is the opposite, it is claimed that a negative IOD has developed.

Impact of IOD on Southwest Monsoon

According to several studies, a good IOD year results in above-average rainfall in the central region of India. Positive IOD indexes were demonstrated to commonly be associated with the effects of El Nino Southern Oscillation (ENSO), which led to increased monsoon rainfall in several ENSO years. A negative IOD, on the other hand, encourages El Nino, which results in a severe drought. The Arabian Sea is experiencing more cyclones concurrently, which is typically brought on by a positive IOD. A negative IOD causes cyclogenesis (the creation of tropical cyclones) to be more intense than typical in the Bay of Bengal. The Arabian Sea experiences less cyclogenesis during this time.

Impact of Indian Ocean Dipole on El Nino

Sea surface temperature anomalies and changes may be indirectly impacted by oceanic dipoles during the Indian El Nino. Sea surface temperature is higher in the extreme east of the Pacific as a result of the Indian Ocean dipole, which can cause and aggravate a variety of El Nino-like oscillations and irregularities. El Nino and La Nina-style phenomena are typical elements of the global climate system. These phenomena occur when the Pacific Ocean and the atmosphere that surrounds it diverge from their balanced state over multiple seasons. El Nino events are associated with the heating up of the central tropical Pacific and Eastern

tropical Pacific regions, whereas La Nina occurrences are the opposite, with a continuous cooling of these same regions.

Impact on Indian agriculture

The monsoon rains are significantly impacted by the El Nino phenomena. Since rains are essential for agricultural activity, El Nino is also likely to raise concerns in India. India's economy is dependent on agriculture, thus the monsoon's success is crucial for the country's harvests since the majority of its agricultural area is still rain-fed. Reduced rainfall brought on by El Nio may cause crop failure, water shortages, a rise in food prices, and decreased yields, which will affect farmer income and have an effect on millions of people. During the wheat harvest, a big obstacle to India's food security presents itself. Although the rabi seeding was encouraging, if early rain occurs before harvest as predicted by El Nio experts, it could drive up the price of wheat. If there is another 20 percent reduction in production, it would lead to food inflation and malnutrition.

A significant buffer supply of staple foods like wheat, rice, and legumes should be established by the government first. In this regard, it's crucial to maintain a close check on the purchase of wheat and to leave the door open to imports in case of a shortage. The quantity and distribution of rainfall have a significant impact on the main Kharif crop, rice. The government restricted rice exports last year due to production worries brought on by below-average monsoon rains in important growing areas. These export limits should be extended if rice output is below average this year as well, in order to assure enough domestic supplies. Conditions of drought are linked to crop failures, decreased yields, and higher input costs, which raise prices for consumers and cause financial losses for farmers. Different parts of India experience the negative effects of El Nino to varying degrees and in different geographic locations. El Nino also worsens infrastructure damage, lowers water quality, increases pest and disease risk, increases risk of wildfires, and increases soil salinity. El Nino has historically had a negative impact on the production of various crops, including rice, wheat, pulses, and oilseeds. The damaging effects of El Nino episodes on the economy have been quantified in several research. For instance, Saini and Gulati (2014) pointed out that the SWM decreased by more than 19% from its peak in the catastrophic drought episode of 2002, which was caused by El Nino. For example, Saini and Gulati (2014) noted that in the major drought event of 2002, which was driven by El Nino, the SWM fell by more than 19% from its LPA. Food grain production contracted by nearly (-)18% (38 million tons) and agricultural output contracted by (-)7% (approximately a loss of US$8 billion).

Indian Disaster Management Act and El Nino/IOD events

The Indian government has launched many efforts to support climate-resilient agriculture in an effort to combat the problems caused by El Nino. In order to ensure that farmers have access to water even during droughts, one of the major tactics is to encourage rainwater gathering and groundwater recharging. To support these activities, the government has introduced a number of programs, including the Pradhan Mantri Krishi Sinchai Yojana (PMKSY), Pradhan Mantri Gram Sinchai Yojana (PMGSY), and the National Groundwater Management Improvement Scheme (NGMIS).Encouragement of the use of crop varieties resistant to drought is another successful strategy for reducing El Nino's effects. Crops including rice, maize, and sorghum have high yielding, drought-tolerant cultivars developed by the ICAR that can tolerate the water stress brought on by El Nino. These crops are a perfect option for farmers in areas prone to drought because they require less water and may flourish in low rainfall environments.

State governments also take an active interest in this. For instance, to encourage farmers to switch to the Direct Seeding of Rice (DSR) method during the Kharif sowing seasons, the Punjab government has organized training workshops and produced brief videos.

Together, Maharashtra and Karnataka, which account for 27% of the land in India planted with sugarcane, have27 percent of the area under sugarcane in India, have enforced rules making drip method of irrigation mandatory for the cultivation of sugarcane in the states.

Drought relief initiatives must be coordinated, according to the Department of Agriculture and Cooperation's duty. The Ministry of Agriculture's National Disaster Management Cell keeps an eye on the resource situation and the extent of the drought in various states. Every year, before to the start of the Kharif Season, the Department of Agriculture also evaluates and modifies the Crisis Management Plan (CMP) for drought. The Plan outlines the duties and roles of numerous entities involved in drought crisis management.

The State Disaster Response Fund (SDRF) is used by the state governments to start the essential humanitarian efforts after natural disasters. The ratio of central to state government contributions to the SDRF is 3:1 for the 18 general category states15 and 9:1 for the 10 special category states.GOI provides additional financial assistance from the National Disaster Response Fund (NDRF), over and above SDRF, for natural calamities of severe nature as per established procedure and extant norms. Allocation under SDRF is made on the basis of recommendations of the Finance Commission.

Until a few years ago, the approach to drought management in India was largely reactive and relief centric. The focus is now on prevention, mitigation, and readiness instead of only providing assistance, which has reduced the number of people who lose their lives and their means of subsistence as a result of drought. Drought management is governed by the National Guidelines for the Management of Drought as per the NDMA, which include three essential elements: (1) monitoring and assessing the intensity of the drought; (2) declaring a drought; and (3) developing and implementing drought management strategies. At the national and state levels, a number of institutional frameworks have been established for the early detection and monitoring of droughts in India. At the federal level, the National Agricultural Drought Assessment and Monitoring System (NADAMS) project, created by the National Remote Sensing Center, is carried out by the Mahalanobis National Crop Forecast Centre (MNCFC), a division of the Department of Agriculture, to assess the drought in 17 states across the nation using the guidelines in the Drought Manual. Additionally, a Crop Weather Watch Group (CWWG) has been in operation since 1979 and publishes weekly data on rainfall, agricultural operations, market prices, employment, and other activities throughout the drought. A crucial role is also played at the state level by organizations like State Remote Sensing Application Centers (SRSACs) and State Drought Monitoring Centers. The Central Research Institute for Dryland Agriculture (CRIDA) has developed District Agriculture Contingency Plans (DACPs) for more than 600 agriculturally significant districts across the nation so far to help farmers prepare for major weather-related aberrations like delayed SWM onset, dry spells, etc. In collaboration with state agricultural institutions and state government ministries, CRIDA created these comprehensive district plans that span the agriculture, horticulture, livestock, poultry, and fisheries industries. Additionally, the state governments are required to have established contingency plans for managing the drought at the sub-district (tehsil/block/mandal/taluka) level.

Conclusion

Despite the risks that El Nino brings to the economy and inflation, the adverse consequences could be reduced by thoughtful policy responses and dependable aid measures. The government must exercise caution and put strategies in place to mitigate the effects of such weather-related shocks.