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AF-TAB
AGRI-FOOD TRENDS AND ANALYTICS BULLETIN

Climate-Proofing Agriculture

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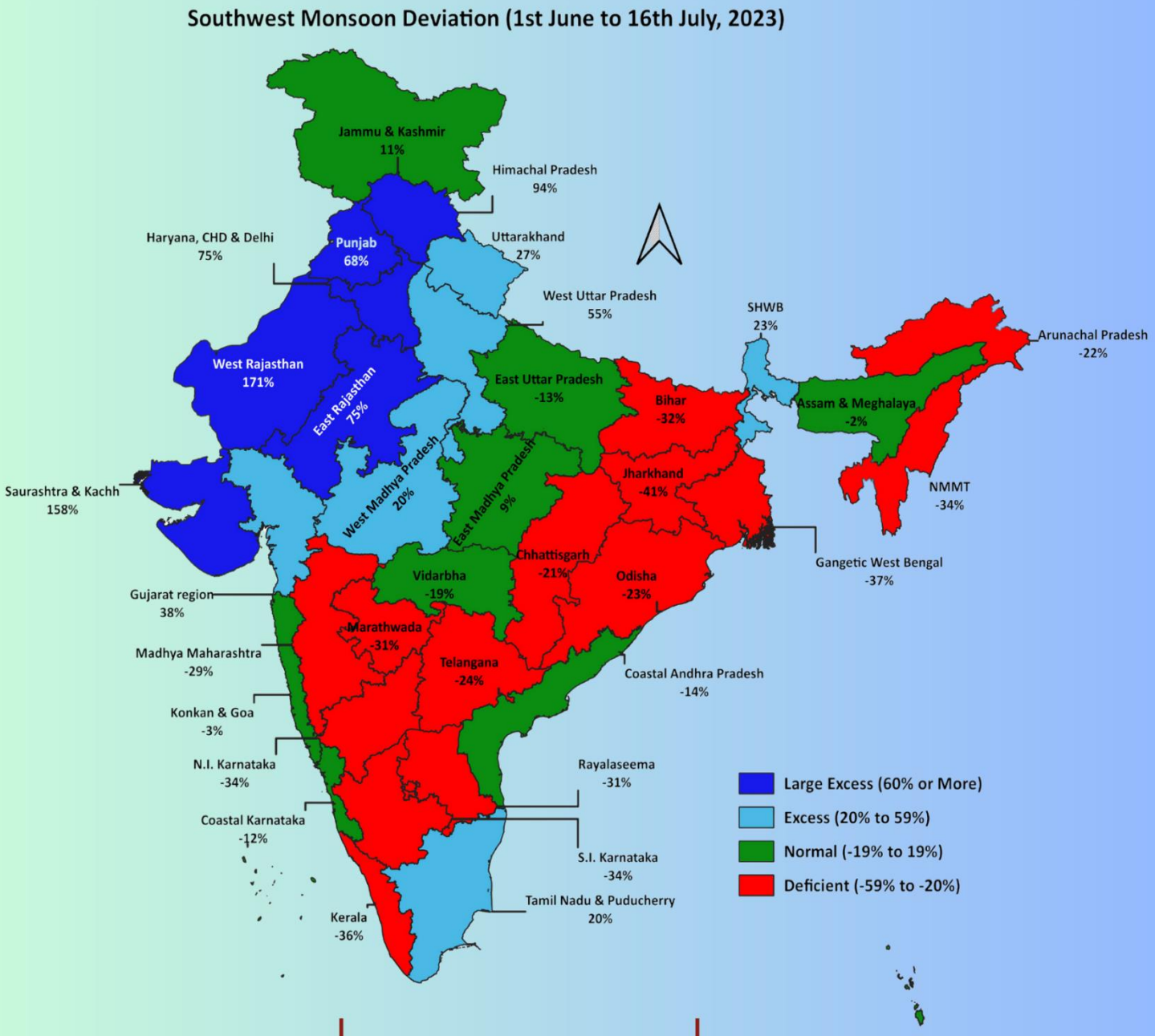

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INSIDE THE ISSUE

From the Director's Desk

Congratulations to ICRIER's Agricultural Policy, Sustainability, and Innovation (APSI) team on the second anniversary of the quarterly publication, the **Agri-Food Trends and Analytics Bulletin** (AF-TAB). With thousands of downloads, Volume II has received an overwhelming response from readers and has been quite a success. The team through this bulletin has provided valuable research insights and analysis to foster discussions in the policy circles dedicated to addressing the challenges in the Indian agriculture and food sector. It reflects the growing recognition and impact of ICRIER's research work in the agriculture and food space.

With almost one-half of India's agriculture still dependent on rains, the level and dispersion of monsoon continues to significantly impact food production and food price inflation in the country. This year, some areas are experiencing normal or above-normal rainfall, contributing to favourable agricultural conditions, while other regions are witnessing deficits or erratic rainfall patterns, posing challenges to crop cultivation and water availability. Climate change continues to exert its influence on global weather patterns, leading to extreme phenomena such as El Niño and erratic rainfall. These climatic anomalies have far-reaching consequences for agriculture, posing significant challenges to food production, supply chains, and ultimately, food prices. Understanding and addressing these challenges are vital for achieving resilience and sustainability in our agricultural sector.

In the face of El Niño and unpredictable rainfall, one of the major concerns is the subsequent effect on food inflation as witnessed in the case of tomatoes. When crops fail or yields are reduced due to inadequate or excess rainfall, the scarcity of produce can result in a surge in food inflation which stood at 4.5 percent in June 2023. This, in turn, affects the affordability and accessibility of food for vulnerable populations, exacerbating food insecurity.

This issue of the AF-TAB aims to explore the relationship between El Niño, erratic and unseasonal rainfall, and its impact on agricultural production as well as food inflation. By analysing the direct and indirect effects on agricultural productivity, supply chains, and market dynamics, we gain valuable insights into the mechanisms driving food price fluctuations.

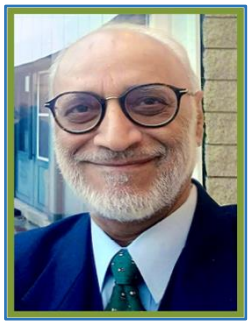
To tackle the challenges posed by El Niño and erratic rainfall, a climate-smart approach to agriculture is indispensable. This entails implementing innovative strategies that enhance the resilience of our farming systems while minimizing the adverse effects of climate change. Such strategies include improved water management practices, precision agriculture techniques, resilient crop varieties, efficient irrigation infrastructure, and the adoption of sustainable farming practices.

Furthermore, policymakers must prioritize measures to mitigate the impacts of climate change on agriculture. This involves developing robust early warning systems for extreme weather events, strengthening agricultural insurance mechanisms, promoting research and development in climate-resilient technologies, and fostering sustainable farming practices through targeted policy interventions.

By aligning our policies towards climate-smart agriculture, we can build resilience, ensure sustainable food production, and mitigate the impact of El Niño, erratic and unseasonal rainfall on food inflation. I hope this issue of AF-TAB provides valuable insights, inspires discussions, and guides stakeholders towards effective strategies for climate-smart agriculture.

Deepak Mishra
Director & Chief Executive
ICRIER

From the Chief Editor's Desk



The UN's World Meteorological Organization (WMO) has declared the onset of El Niño, which could lead to disruption in weather patterns worldwide. This comes at a time when the world is already grappling with the adverse effects of climate change, including extreme heat events in some parts and floods in other parts. These extreme weather conditions, coupled with the occurrence of El Nino, have a significant impact on rainfed agricultural production, resulting in higher food inflation.

In India, El Nino often leads to below-normal rainfall and occasional droughts. The India Meteorological Department (IMD) forecasted that El Nino may affect the monsoon in the latter half of the season (August to September). Currently, the cumulative southwest monsoon at all-India level depicts a 2 percent surplus above the long period average as of the second week of July 2023. However, there exist large variations across states, for instance, five states received large excess rainfall (60 percent plus over LPA) whereas 10 states received deficient rainfall (-59 percent to -20 percent of LPA) during the same period. Given India's reliance on rainfed agriculture, the occurrence of unseasonal rainfall and El Nino during *kharif* sowing period could further exacerbate inflationary pressures, which is a matter of great concern. The consumer food price index (CFPI) inflation has already accelerated between May and June 2023 from 2.96 percent to 4.49 percent, respectively.

In the light of these challenges, the current issue of AFTAB titled *Climate-Proofing Agriculture* focuses on the impact of climate change-induced extreme weather events, including El Nino and unseasonal rainfall, on India's agriculture and food inflation. The first piece in this issue, *El Nino, and Weather Vagaries: Deconstructing the Historical Trend*, explores the trend of El Nino and La Nina years over the past decades, highlighting the strong correlation between El Nino events and droughts in India, although drought onset is not solely determined by El Nino. The second piece, *Climate Smart Agriculture for Weather Vagaries*, emphasises the importance of adopting climate-smart agriculture (CSA) to mitigate the negative impact of climate change, extreme weather events and El Nino for ensuring food security. The policy measures suggested in these two articles range from prioritizing and scaling up CSA technologies and precision agriculture, particularly in the North-West Indo-Gangetic Plains of India, to adopting market-based measures like carbon finance to promote greenhouse gas mitigation and increase farmers' income. Furthermore, the authors have highlighted revamping distortionary agricultural support policies towards sustainability.

The third piece, *Weather Disturbances and Food Inflation in India*, explores how extreme weather events such as drought, extreme rainfall, and El Nino impact agriculture and destabilize food price inflation in India, particularly in cereal, pulses, and milk sectors. The fourth piece, *Unseasonal Rainfall and Price Rise in Horticulture Crops* delves into the impact of unseasonal weather vagaries on horticulture production in India. Both articles advocate the need for proactive government interventions, such as buffer-stocking policies and trade policies for non-perishable commodities in the short term, and investment in augmenting production, productivity, and processing capacity for perishable commodities.

To climate-proof Indian agriculture, the current issue underscores a need for pre-emptive and medium to long-term policies which require investments in research and development (R&D) to foster climate-resilient farming practices, safeguard farmers' livelihoods, and ensure price stability.

Ashok Gulati
Distinguished Professor
ICRIER

El Niño and Weather Vagaries: Deconstructing Historical Trends

Ashok Gulati and Purvi Thangaraj

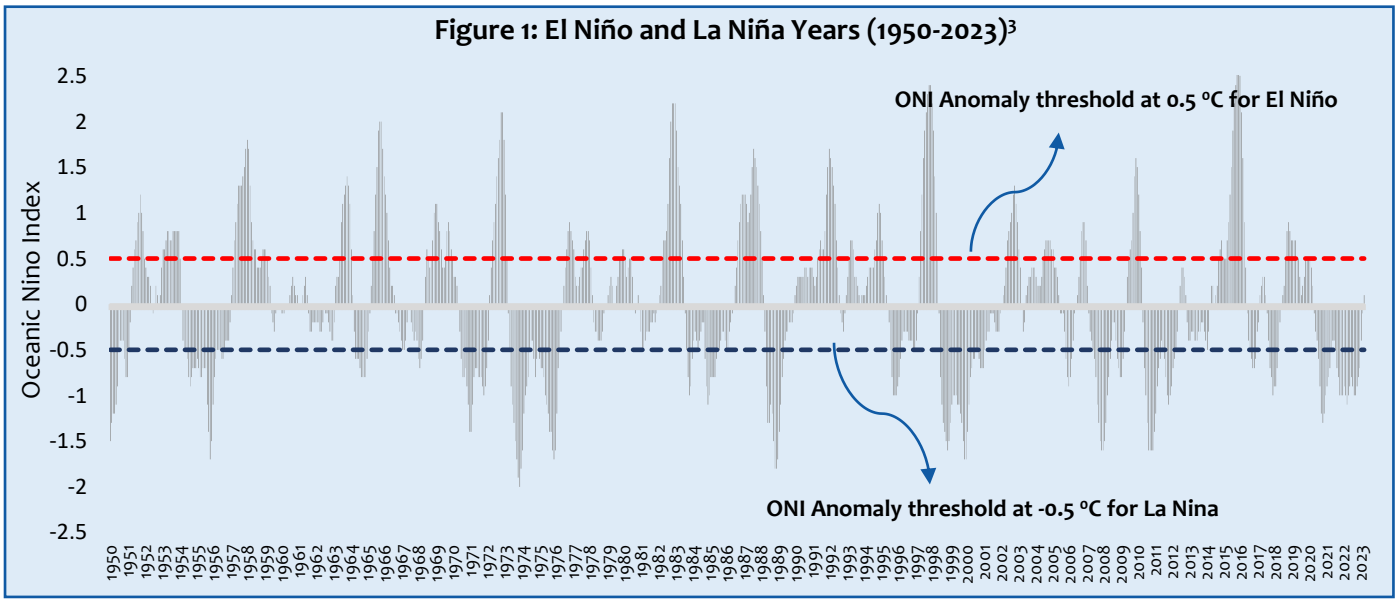
Weather patterns have fascinated humans for a long time due to their significant impacts on society, economies, and agriculture. One such occurrence that has piqued the interest of scientists and the general public lately is El Niño, a complex climatic phenomenon in the central and eastern tropical Pacific Ocean affecting global weather patterns. While declaring the 3rd and 4th of July as the hottest days on this planet, the World Meteorological Organisation also forecasts the second half of 2023 to be an El Niño year with 90 percent probability.

National Oceanic and Atmospheric Administration (NOAA) describes El Niño as a warming of the ocean surface, or above-average sea surface temperatures (SST) in the central and eastern tropical Pacific Ocean, while a below-average SST or cooling of the ocean surface is observed during La Niña. El Niño and La Niña are alternating warm and cool phases of the El Niño-Southern Oscillation (ENSO) in the tropical Pacific. This recurring pattern, shifting irregularly every two to seven years, affects ocean temperature, wind, and rainfall across the tropics (NOAA, 2023).

El Niño conditions are currently present and expected to gradually intensify during the winter of 2023-24 in the Northern Hemisphere, according to the latest NOAA advisory[1]. Notable sea surface temperature (SST) anomalies in the Pacific Ocean indicate a 2-3 °C rise compared to the average where this trend will continue and strengthen during the southern hemisphere's summer season. These conditions are likely to persist throughout winter with a 56 percent chance of intensifying into a strong event at its peak and an 84 percent likelihood of at least a moderate El Niño event occurring, projected to develop further and gain strength as we progress into 2024[2].

Analysing historical patterns, 26 El Niño and 25 La Niña events have been recorded since 1950, with the strongest El Niño occurring in 2015 (Figure 1 and 2). These events have significant implications for India, as they influence the wind circulation pattern and sea surface temperatures. The Mascarene High, a sub-tropical high-pressure zone is crucial for the intensity of the Indian monsoon (PJ, 2020). A stronger Mascarene High results in increased winds and abundant rainfall, while El Niño weakens it, leading to reduced rainfall in India. The Indian Ocean Dipole (IOD), another climate pattern, also affects the Indian monsoon through sea surface temperature anomalies (Kumar et al., 2020). The correlation between IOD and monsoon rainfall is still debated, but studies suggest that a positive IOD can trigger ENSO, as observed in the 2019 monsoon season (Ratna et al., 2021).

Figure 1: El Niño and La Niña Years (1950-2023)[3]

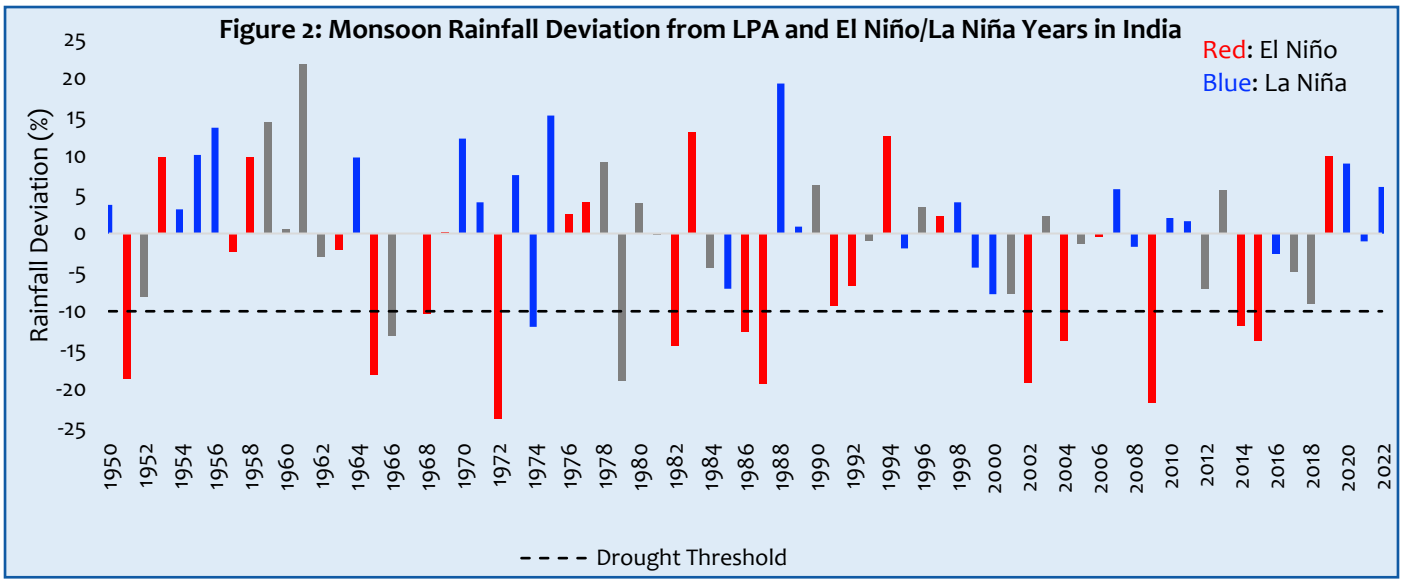


Source: NOAA

[1] These statements are updated once a month (2nd Thursday of each month) in association with the ENSO Diagnostics Discussion. Accessed from: https://www.cpc.ncep.noaa.gov/products/expert_assessment/ on 10th July 2023.

[2] https://www.climate.gov/news-features/blogs/june-2023-enso-update-el-niño-here

[3] To identify the years in which El Niño or La Niña occurred and were observed, we use the Oceanic Niño Index (ONI). If the SST anomaly persists or is expected to persist for five consecutives, overlapping three-month periods, with a threshold of +/- 0.50°C for the ONI it is considered as an El Niño (+0.50C) and La Niña (-0.50C) event.



Source: NOAA and IMD

To assess the influence of El Niño on Indian monsoons, we examine the deviation in monsoon rainfall (June to September) and its correlation with sea surface temperature (SST) anomalies. Since the 1950s, India has experienced a total of 15 droughts. In India, a negative deviation in monsoon rainfall exceeding 10 percent from its Long Period Average (LPA) is categorized as a drought. Our analysis and studies indicate that while not all El Niño years have resulted in droughts in India, most droughts have occurred during El Niño years (Saini and Gulati, 2014).

The major droughts in India have coincided with intense El Niño events, as depicted in Figure 2 and Table 1. However, it is interesting to observe during some El Niño years, India received near-normal or above-normal rainfall, for instance in 1983 (13 percent rainfall deviation), 1994 (12.5 percent), 1997 (2.2 percent) and 2006 (-0.4 percent). Surprisingly, even though 1994 and 2006 were El Niño years, India did not experience a drought. This can be attributed to the significantly positive phase of IOD during those years (DTE, n.d). This might lead us to believe that a strong positive phase of IOD can counteract the negative effects of El Niño and help mitigate drought conditions in India. Therefore, while there is a strong correlation between El Niño events and droughts in India, the occurrence of a drought is not solely dependent on El Niño.

The impact of El Niño and droughts on India's agriculture has been significant as we can observe the effects of intense El Niño events and subsequent droughts on foodgrain production in the country. One of the most severe droughts in recent history occurred during 2002-03, resulting in a substantial decline of 38 million metric tons (MMT) in foodgrain production. This decrease accounted for a significant 17.86 percent decline compared to previous year. Subsequent droughts have not resulted in this intensity of decline in foodgrain production. In the most recent drought of 2014-15, the decline in grain production further decreased to 13 MMT, corresponding to a 4.9 percent decrease and the consecutive drought in 2015-16 had a minimal decrease of only 1 MMT. These improvements can be attributed to advancements in irrigation practices and water management techniques, as seen in the increasing irrigation cover of foodgrains from 18 percent in 1951 to 53 percent in 2015 (Table 1).

According to IMD's July 2nd bulletin[4], the Southwest Monsoon has now covered the entire country, surpassing the usual date of July 8th by six days (ahead of the normal schedule for complete countrywide coverage). Currently, the overall rainfall deviation from June 1st to July 11th stands at 2 percent surplus, with actual rainfall measuring 263.1 mm compared to the normal rainfall of 257.8 mm. However, regional disparities are evident, with Northwest India experiencing a departure from the Long Period Average (LPA) of 62 percent, Central India at 4 percent, East and Northeast India at -19 percent, and South Peninsular India at -23 percent[5]. Despite the IMD's prediction of normal rainfall, the occurrence of extreme weather events and these unpredictable weather patterns have already caused significant damage in North India, particularly in Punjab, Haryana, Uttar Pradesh, and Himachal Pradesh. While acknowledging the IMD's forecast, it is crucial to consider the potential impact on agriculture.

[4] https://mausam.imd.gov.in/Forecast/marquee_data/ext.pdf

[5] https://mausam.imd.gov.in/imd_latest/contents/weather_report.php

Table 1: Drought years, El Nino, Changes in Foodgrain Production, and Irrigation Cover since 1950

Drought years	Change in Production (MMT)	Change in Production (%)	Irrigation cover (%)	Monsoon Rainfall Deviation from LPA (%)	El Niño / La Niña
1951	1.2	2.3	18.1	-18.7	El Niño
1965	-17.0	-19.0	20.9	-18.2	El Niño
1966	1.9	2.6	22.2	-13.2	Neutral
1968	-1.0	-1.1	23.6	-10.3	Neutral
1972	-8.1	-7.7	25.4	-23.9	El Niño
1974	-4.8	-4.6	26.5	-12	La Niña
1979	-22.2	-16.8	30.4	-19	Neutral
1982	-3.8	-2.8	30.4	-14.5	El Niño
1986	-7.0	-4.7	32.6	-12.7	El Niño
1987	-3.1	-2.1	33.5	-19.4	El Niño
2002	-38.1	-17.9	43.4	-19.2	El Niño
2004	-14.8	-7.0	44.6	-13.8	El Niño
2009	-16.4	-7.0	47.8	-21.8	El Niño
2014	-13.0	-4.9	53.5	-11.9	El Niño
2015	-0.5	-0.2	53.0	-13.8	El Niño

Source: NOAA, IMD, Agriculture Statistics at a Glance

What are the pre-emptive policy measures to mitigate potential consequences of El Niño and weather vagaries?

The government has proactively taken steps to control food prices, such as banning wheat exports, imposing stocking limits, implementing export duty on rice and now effectively banning non-basmati white rice exports. Open market operations for wheat and rice have been conducted to address high cereal inflation. Aggressive wheat sales by the government helped reduce wholesale prices and resulted in a substantial wheat procurement of 26 MMTs. Vegetable prices, like tomatoes, ginger, and chillies, have surged, leading to frustration among households. The government's "Operation Green," which initially focused on Tomatoes, Onions, and Potatoes (TOP) and later expanded to include other vegetables, has not effectively controlled TOP prices. It requires a re-evaluation and could be transferred to an independent body specializing in vegetable value chains. This body should aim to stabilize prices, increase production, and ensure fair returns to producers, similar to the National Dairy Development Board's role in the milk sector. It should be headed by an expert in vegetable value chains (à la Verghese Kurien in case of NDDB for milk) with a clear mandate, resources, and accountability.

To control foodgrain prices, we recommend increasing market operations for rice at a price lower than what has been the current price for open market operations. This can continue until the arrival of the new crop. There are abundant rice stocks with the Food Corporation of India (FCI), exceeding buffer stock norms. However, the government should preserve its wheat reserves and utilize them strategically during November to March, when demand peaks and supplies are short. Reducing import duties on wheat from 40 percent to say around 10 percent would boost supplies, considering trade estimates of wheat production are significantly lower than the government's estimate of 112 million tonnes. Similarly, for pulses, particularly yellow peas, removing import restrictions is advised. In case of tur, there is a shortfall of at least a million tonnes even after the supply agreements from Mozambique, Malawi and Myanmar. India must look into MoUs with other nations for imports to meet domestic tur demand. These measures would help contain foodgrain prices in the short run.

Given the rising frequency of extreme weather events in the medium to long term, it is crucial to prioritize investment in agricultural research and development (agri-R&D). Specifically, the focus should be on

developing drought-resistant and heat-tolerant seeds for various crops, particularly rice and wheat. It is also essential to adapt farming practices to maximize output with minimal resources, especially water. For instance, promoting direct-seeded rice (DSR) and implementing drip irrigation techniques for sugarcane cultivation can save water. Additionally, adopting methods like fertigation and utilizing nano urea and nano DAP can help reduce the carbon footprint associated with fertilizer usage.

In conclusion, by implementing more efficient irrigation systems, adopting climate-resilient farming practices, farmers can minimize the adverse effects of water scarcity during drought periods. To mitigate the impacts of El Niño, it is crucial for India to implement contingency plans. This includes introducing crop varieties suitable for late-sowing, implementing water conservation and management strategies, and closely monitoring the monsoon while preserving natural water reservoirs. Promoting sustainable farming practices becomes paramount, as they prioritize environmentally-friendly techniques and can help reduce the adverse effects of El Niño on India's agricultural landscape and crop yields. It is essential for the government and policymakers to develop protocols and initiatives that reduce India's reliance on rainfall and minimize the negative impacts of El Niño, not just through policies but also by investing more in agriculture R&D and better farming practices. Along with this, buffer-stocking policies and trade policies must be in place to proactively address the challenges posed by El Niño (Gulati, 2023). Continued efforts to enhance drought resilience will be crucial for ensuring food security and mitigating the negative consequences of future El Niño events and droughts on India's agricultural sector.

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Agriculture is a biological production process where production and productivity are dependent on climatic conditions. Any disruption in climate changes like in temperature, precipitation, drought, solar radiation etc. affect the agriculture ecosystem including crop, livestock, and hydrology sector. Since the middle of the twentieth century, India has observed an increase in average temperature (risen by 0.7 degree during 1901-2018) and extreme rainfall events; a decrease in monsoon precipitation (declined by 6 percent from 1951 to 2015); alongside other changes in the monsoon system (MoES 2020). These human-induced climate changes are projected to persist and intensify throughout the twenty-first century. Projected temperature rise in near future (2040-2069) is 2.03°C under RCP 4.5[6] (medium emission scenario) and 2.70°C under RCP 8.5[7] (high emission scenario). While in far future (2070-2099), the projected temperature rise is 2.44°C under RCP 4.5 and 4.44°C under RCP 8.5 (MoES 2020). The frequency (>2 events per decade), intensity and area under drought conditions is also projected to increase in India.

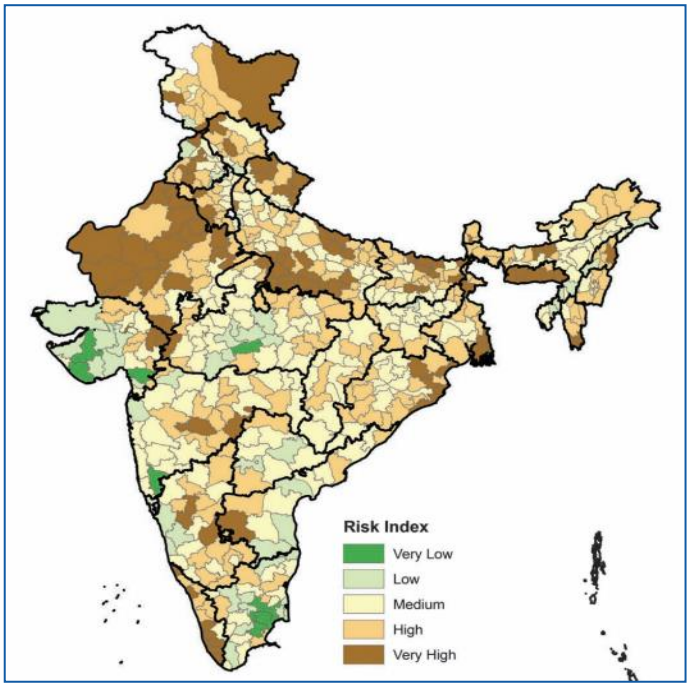
Impact of Climate Change on Indian Agriculture

Indian agriculture is highly vulnerable to the risks due to climate change; especially to drought, as approximately half of the agricultural land in India is rain-fed. Vulnerability assessment of Indian Agriculture to climate change is undertaken by Indian Council of Agricultural Research (ICAR)- Central Research Institute for Dryland Agriculture (CRIDA) which has classified 109 districts out of 573 rural districts (19 percent of total districts) as 'very high-risk' districts, while 201 rural districts as 'risk' districts (Figure 1).

Climate change provoke other inter-related problems such as land degradation, delayed response to added inputs, rising input costs, market volatility, etc. that hinder agricultural growth and the livelihood of those dependent on agriculture (ICAR 2019). In India, significant negative impacts have been implied with medium-term (2010-2039) climate change, which predicted reduced yields by 4.5 to 9 percent, depending on the magnitude and distribution of warming (NICRA 2023).

Study conducted by Indian Agricultural Research Institute (IARI 2008) showed that *rabi* crop will be affected enormously as every 1°c increase in temperature reduces wheat production by 4-5 million tons. Productivity of most cereals would decrease due to increase in temperature and decrease in water availability, especially in Indo-Gangetic plains. The loss in crop production is projected to be 10-40 percent by 2100, depending upon the modelling technique. The Economic Survey (2017-18) states that extreme temperature and rainfall shocks could result in yield loss of up to 14.7 percent and decline in farmers' income up to 14.3 percent. Indian agriculture employs 45.5 percent of the workforce and contributed to 18.8 percent of the country's Gross Value Added in 2021-22. In such a scenario, a 4.5 to 9 percent negative impact on production could cost roughly up to 1.5 percent of GDP per year due to climate change (NICRA 2019). Thus, climate change is a perceived threat for food security, agricultural sustainability, growth in agriculture gross domestic product (GDP) and farm revenues.

Figure 1: Risks due to Climate Change (2020-2049) in Agriculture



Source: ICAR-CRIDA 2019

[6] RCP 4.5 or Representative Concentration Pathway 4.5 is an intermediate stabilization pathway that results in a Radiative Forcing of 4.5 W/m2 in 2100 (MoES 2020)

[7] RCP 8.5 or Representative Concentration Pathway 8.5 is a high concentration pathway resulting in a Radiative Forcing of 8.5 W/m2 in 2100 (MoES 2020)

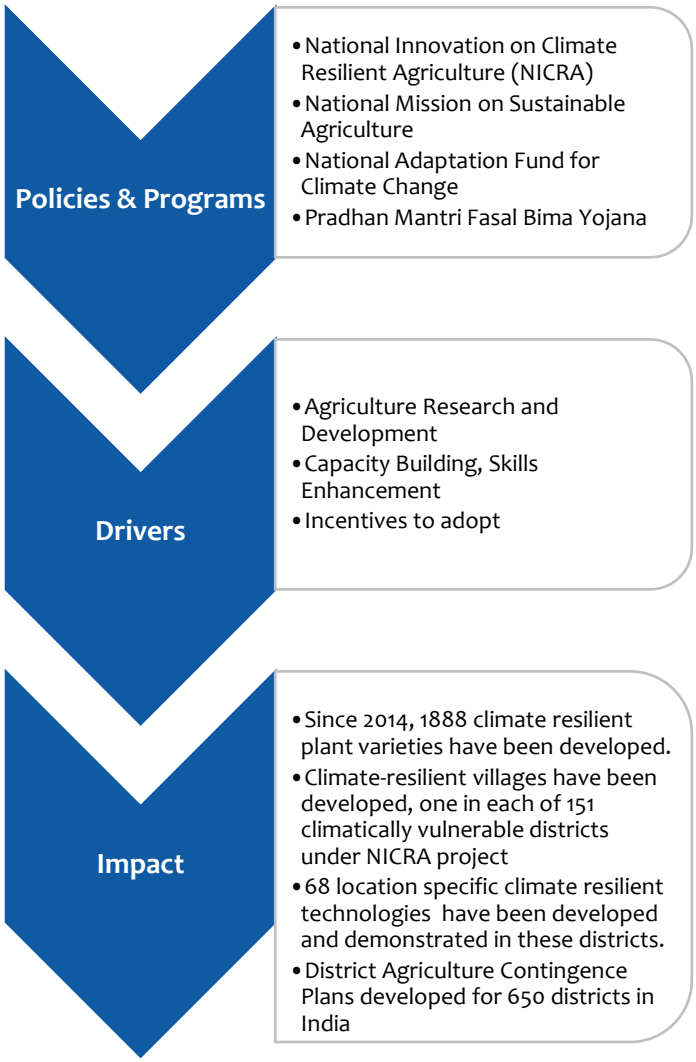
Climate Smart Agriculture policies and its impacts on Indian agriculture

As per FAO (2023), climate smart agriculture (CSA) is an approach to respond to climate change effectively and runs on 'triple objectives' of

(i) increasing productivity and incomes,
(ii) adapting to climate change
(iii) reducing green-house gas emissions, where possible

However, every CSA practice applied in every location may not produce 'triple wins.' While productivity and adaptation are linked and are related to private benefits of producers, mitigation is a public good offering public benefit (OECD 2023). The main drivers of CSA are research and development, along with incentives for producers for the adoption of CSA practices and technologies (Figure 2).

Figure 2: Impact of Climate Smart Agriculture policies and its drivers on Indian Agriculture



Source: Authors Compilation based on NICRA, PIB 2023

Although CSA technologies are available but there are challenges for its adoption (OECD 2023) at different levels:

1. **Farm Level**: cost of adoption, lack of financial benefit, access to credit, hidden costs, infrastructure and availability of inputs, uncertainty, risk management and competing pressures
2. **Sector Level:** Industry cooperation, effect of practices on production (perceived food security threat), information and awareness
3. **Policy Level**: Limited extent of climate policy, reporting and administrative costs, leakage, and non-climate related agriculture policies (input and output subsidies, subsidized insurance)

What is the way forward to resolve these challenges of CSA adoption?

Prioritizing CSA in North-West Indo-Gangetic Plains of India

Puddled transplanted rice followed by intensively tilled wheat is the most predominant cropping system and the lifeline for millions of people in North-West Indo-Gangetic Plains of India. The cultivation of rice requires high amounts of water, nutrients, and energy, resulting in increased emissions of greenhouse gases (Singh & Gulati 2023a). This region is also vulnerable to climate change and heat stress (IPCC 2022). Diversifying at least 5 percent of the paddy cultivation area in this region to alternate crops such as maize, oilseeds or high-value crops is highly recommended.

Scaling up of the CSA technologies like Direct Seeded Rice (DSR), Alternate Wetting and Drying (AWD), System of Rice Intensification (SRI), zero-tillage, neem-coated urea, nano-fertilizers, precision agriculture, drip irrigation etc. is also crucial for region.

CSA as a tool for increasing Farmer's Income

As the world moves to implement a new branch of environmental finance, carbon finance - market-based measures to promote GHG mitigation, markets can offer an additional incentive (carbon credit) for small-holder farmers to adopt climate smart practices. Carbon is a tradable good in this credit system where one carbon credit unit is equivalent to one tonne of carbon dioxide emissions. The buyer are companies and nations that can purchase carbon credits to offset their own emissions in permissible limits, whereas the seller—the farmer who reduces emissions or sequesters carbon in their farms are entitled to receive

payments in return. Carbon credits can thus allow them to earn an income for every unit of greenhouse gas reduce or sequester from the atmosphere. Software and digitization of farm data can enable credible and verifiable data for carbon credit which in turn can facilitate the flow of funds to farmers. The value of one carbon credit depends upon the carbon market price. Farmers are generally paid $15 to $20 per ton of carbon saved/sequestered under agriculture companies' programs (Indigo 2023). India, with the world's largest area of cropland, has significant room for environmental improvement and to become the leading market for carbon farming credits.

Focus on CSA research and innovation

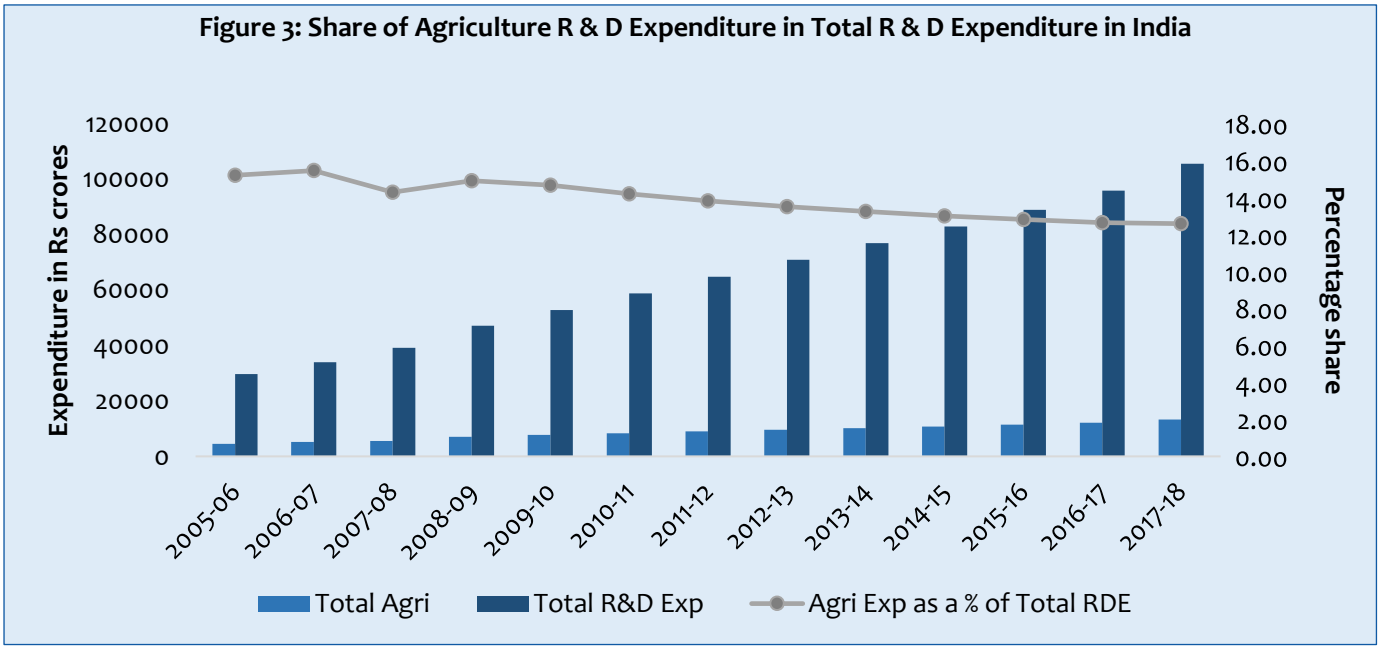
Share of the agriculture sector in R&D has slightly declined from 15.47 percent (2006-2007) to 12.6 percent in 2017-18 (Figure 3). Increasing agricultural research is critical for maintaining agricultural productivity and increasing climate resilience and decarbonizing agriculture as climate change induced weather patterns are becoming more extreme and unpredictable.

Project on Soil Health, and Fertility, Paramparagat Krishi Vikas Yojana etc. It is also noteworthy that agriculture sector gets support from other ministries and state governments through food subsidy, fertilizer subsidy, irrigation, and power subsidies. If we include all these expenditures then the country's share for green agriculture will be well below 13-15 percent. Importantly, government-funded research into CSA practices should be increased.

Improve policy coherence

CSA is a part of UN's Sustainable Development Goals (SDGs). Policymakers should help to improve policy coherence, making sure that policy instruments are working in the same direction. With CoP26 commitment of 'Carbon neutrality by 2070' and mass movement for 'LiFE'– 'Lifestyle for Environment' as a key to combating climate change and with revised nationally determined contribution (NDC), India is undertaking several measures, both regulatory and fiscal, to be compliant with a 2°C pathway.

Figure 3: Share of Agriculture R & D Expenditure in Total R & D Expenditure in India



Source: Research and Development Statistics 2019-20. Department of Science & Technology, MoS&T, GoI

Although, climate smart agriculture is not the explicit goal of Indian agriculture policies and programs, the Ministry of Agriculture and Farmers' Welfare, Government of India has spent 13-15 percent of its total expenditure towards green agriculture in the last three years (Singh and Gulati 2023b). This expenditure has been made through crop insurance, promotion of agricultural mechanization for in-situ crop residue management, national mission on natural farming, Pradhan Mantri Krishi Sinchai Yojana-Per Drop more Crop, National Project on Organic Farming, National

Agriculture policies should ideally reinforce interventions to reduce environmental harm and GHG emissions while achieving other development objectives of the sector. Business as usual input and output support policies of free or subsidized groundwater extraction, minimum support price for water-guzzling crops, and subsidized urea for ground-water pollution and GHG emissions are not sustainable. Agriculture support (Input and output subsidies) and public funding needs to be re-purposed towards

climate compatible, people and planet positive sustainable agriculture.

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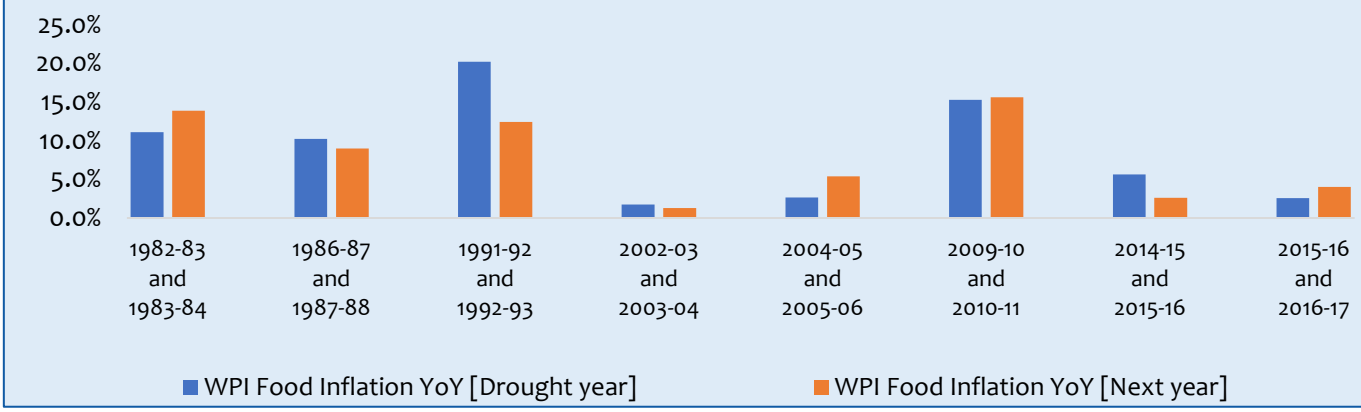
Climate change and subsequent weather disruptions are already affecting agriculture systems around the world and this problem is only expected to intensify in the future. The latest forecast from the World Meteorological Organization (WMO) (July 2023) confirms a 90 percent probability of the El Niño event continuing during the second half of 2023. El Nino, with its impact on southwest monsoon which accounts for most of India's rainfall, is feared to affect *kharif* crops such as paddy, moong, tur, soybean, groundnut, maize, and sugarcane. El-Nino is not only going to affect *kharif* crops but the next *rabi* crops as well by affecting soil moisture and water availability in the reservoirs.

Since 1980, there have been eight such drought years in India when the rainfall deviation was below minus 10 percent.[8] All those drought years were El Nino induced. Five out of eight events resulted in high food inflation at the wholesale level. However, there also have been drought years when the food inflation did not go out of control such as the years 2002-03, 2004-05, 2014-15 and 2015-16 which saw moderate inflation (Figure 1).

Moreover, the recent erratic behaviour of monsoon rains (Table 1) with large excess in some regions like Punjab, Haryana, Rajasthan, and deficiency in other regions like Southern and Eastern states can have serious ramification on overall agriculture production which may further spur food prices up. But before we get into how El Nino and weather disturbances are going to affect CPI inflation and what should be the policies taken to contain inflation, let us understand the current inflation scenario in India.

Given the efforts of the Central Bank and the Centre to tame inflation, the overall inflation and food inflation has moderated in the financial year (FY) 2023. The inflation in consumer price index (CPI) as well as consumer food price index (CFPI) has come below the Reserve Bank of India (RBI)'s upper tolerance level of 6 percent in June 2023, and stood at 4.81 percent and 4.49 percent, respectively which is slightly higher than that of May 2023. In May 2023, the CPI and CFPI was at 4.25 percent and 2.91 percent, respectively.

Figure 1: WPI food inflation during drought years (1980 onwards)



Note: Based on WPI food articles since WPI food index is available from 2012 onwards. The base year is 2011-12.
Source: Office of the Economic Advisor

Since the onset of El Nino can be predicted with better confidence now and its severe effects are known and have been observed in the past, it calls for pre-emptive actions and government interventions to control food inflation.

Cereals

In the case of staples such as rice or wheat, which tend to have relatively inelastic demand, fear of likely shortage caused by El Nino could drive prices up. The prediction of El Nino has come at a time when India is already battling with high inflation, growth slowdown concerns and weather fluctuations (heatwaves and unseasonal rains). This is a cause of serious worry for policy makers as cereal inflation is already in double digits at 12.71 percent in June 2023. Wheat inflation is at

[8] Rainfall deviation from its LPA below minus 10 percent is considered a drought year. The year 1991 was also a drought year where the deviation was minus 9.3 percent

12.37 percent while the inflation on rice is at 11.78 percent in June 2023. It is worth noting that price of rice is already at elevated levels. A bad monsoon could impact the production of rice putting upward pressure on food inflation. Notably, the rice crop sown area is 24 percent below than the last year. As of 12th July 2023, many rice producing regions like Telangana (-31 percent), Odisha (-26 percent), Jharkhand (-43 percent) as well as some regions of West Bengal have received deficient rainfall. In contrast, Punjab, Haryana and Western UP have received excess rainfall during the same period. This can affect the production of rice even more. Poor rainfall could also deplete reservoir levels which could have a bearing on *Rabi* crops (such as wheat) as well.

Table 1: State wise rainfall deviation (Period:01-06-2023 To 12-07-2023)

SNO	State	% DEP.	CATEGORY	MAJOR CROPS
1	RAJASTHAN	145%	LE	Wheat, Bajra, Maize, Gram, Moong, Oilseeds, Onion
2	GUJARAT	110 %	LE	Bajra, Gram, Oilseeds, Cotton
3	HIMACHAL PRADESH	105 %	LE	Wheat, Maize, Rice, Barley
4	PUNJAB	96 %	LE	Rice, Wheat
5	HARYANA	91 %	LE	Wheat, Bajra
6	TAMIL NADU	23 %	E	Rice, Maize
7	UTTARAKHAND	22 %	E	Wheat, Rice
8	MADHYA PRADESH	15 %	N	Wheat, Maize, Gram, Masur, Moong, Oilseeds, Tomato
9	UTTAR PRADESH	12 %	N	Wheat, Rice, Bajra, Sugarcane
10	ASSAM AND MEGHALAYA	0 %	N	Rice
11	WEST BENGAL	-14 %	N	Rice, Maize
12	ANDHRA PRADESH	-17 %	N	Rice, Tomato
13	CHHATTISGARH	-17 %	N	Rice
14	MAHARASHTRA	-23 %	D	Gram, Tur, Oilseeds, Cotton, Sugarcane, Maize, Onion
15	ODISHA	-26 %	D	Rice, Lentils
16	KARNATAKA	-27 %	D	Maize, Tur, Moong, Tomato
17	TELANGANA	-31 %	D	Rice, Tur, Cotton
18	KERALA	-32 %	D	Rice, Spices
19	BIHAR	-33 %	D	Wheat, Rice, Maize
20	N M M T	-33 %	D	Rice
21	JHARKHAND	-43 %	D	Rice

Source: IMD
*Note: * NMMT- Nagaland, Manipur, Mizoram, Tripura; LE- Large Excess, E- Excess; N- Neutral, D- Deficient*

Pulses

Pulse and pulse product registered a YoY inflation of 10.53 percent in June 2023, higher from YoY inflation of 6.56 percent in May 2023. Within pulses, tur registered double digit high inflation of 27.50 percent due to lower acreage (from 4.8 in 2021-22 to 4.6 million ha in 2022-23) and subsequent lower production (4.22 to 3.43 million tonnes (MMT) from 2021-22 to 2022-23 as per 3rd advanced estimate, DES). At the same time, moong and urad registered an inflation of 7.51 percent and 6.70 percent respectively in June 2023 which is higher from May 2023. Major producing states for pulses such as Madhya Pradesh, Rajasthan and Maharashtra are dependent on rain for their production. A bad monsoon caused by El Nino and other weather disturbances can further affect the production of pulses causing a rise in its price level.

Milk

Inflationary concerns remain high in case of milk and milk products, where inflation is still roaring at 8.56 percent in June 2023. Milk and milk products have the highest weight in CPI and so, contributes the most to CPI inflation. It may be worth noting that the milk production in the country, which normally has been growing at 5 to 6 percent per year over the last few years, suddenly came to almost a halt in FY 2023 with overall production at 222 MMTs against 221 MMTs achieved in FY22. The procurement price of raw milk has gone up due to higher input costs. High feed cost particularly fodder has been one of the major reasons

for rising milk prices. El Nino with its effect on feed and fodder crops will further harden the prices of dairy products which is already on the higher side.

What policy measures can be taken to contain food inflation?

Given inflationary pressure is already felt in cereal, pulses and milk which may further spike up with unseasonal weather events, it is crucial to take urgent policy actions to contain inflation.

Currently, there are no immediate alarms on depletion of food grain stocks but the government needs to be cautious on the wheat front. The stock of wheat as on July 01 is 30.1 MMTs as against the buffer stock norm of 27.6 MMTs. But if it is used now then during November-December and January when the demand will be high there will not be enough stock. Moreover, fearing high wheat inflation, the Government of India has imposed stocking limits of 3000 tonnes for traders or wholesalers, 10 tonnes for retailers for each outlet and 3000 tonnes for retailers. A sensible decision would have been to bring down the import duty on wheat from 40 to 10 percent which can tame inflationary expectation. For rice, the government has banned the export of non-basmati white rice which constitute 25 percent of all rice exports from India. Also, the FCI stock position is comfortable at 40.8 MMTs, more than three times of the stocking norms of 13.54 MMTs as of 1st July (FCI, 2022a). So, there is no need to panic on that front.

In case of pulses, as on 14th July, the total area sown in the current kharif season has reduced by 13 percent from 77.17 lakh hectares (Lha) in 2022-23 to 66.93 Lha in 2023-24. Within pulses, area sown under tur has decreased by 38 percent during the same period. On top of that, major tur producing places like Maharashtra and Karnataka have witnessed rainfall deficiency of 23 percent and 27 percent, respectively. This will affect tur production further and increase prices. To regulate domestic supplies of pulses, the centre can build adequate buffer stock, especially of tur through imports from Malawi, Tanzania, Myanmar, with whom India has import agreements, to contain inflation in the short term. Importantly, restrictions on yellow pea imports through a Minimum Import Price (MIP) of Rs 200 needs to be abolished.

Another important policy action likely to gauge food inflation in India is to liberalise the future markets of large number of agriculture commodities. The current marketing policy environment is not too conducive to the development of future markets of agri-commodities in India.

In case of milk, which has the largest weight in CPI, Government needs to bring down import duties on SMP and buffer to say 10 percent. The current duty on SMP is 60 percent and on butter 40 percent, which are too high and basically reflect high protection to dairy sector. This high protection will only lead to inefficiency and high-cost development of this sector, not the best way to create a globally competitive dairy sector. In the medium to long run, the GoI should have a plan to augment good quality fodder supplies and raise productivity of milch animals.

If we have to tame food inflation, we will have to invest more in climate-smart agriculture, in precision farming, with high productivity and less damage to natural resources. There should be more investment to improve the irrigation facilities.

To sum-up, food inflation can be contained even below 5 percent in FY 2024 even with extreme weather events provided India uses trade policy and buffer stocking policy wisely and well in time.

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Unseasonal Rainfall and Price Rise in Horticulture Crops

Raya Das and Ranjana Roy

The country has been witnessing price pressure in horticulture commodities in recent months. The tomatoes inflation is attracting attention from the policy makers as its price in July 2023 is hovering around Rs. 140 per kg in Kolkata and Rs. 120 in Mumbai markets respectively with a momentum of more than 400 to 500 percent over its previous month prices. Green chillies are also raging at Rs. 150 per kg with year on year (YoY) inflation rate of 3.84 percent in June 2023. Ginger and cumin inflation are getting out of hand at 148.2 percent and 74.1 percent YoY, respectively.

Why this surge in prices of horticulture crops?

To this, our research shows that inflation pressure on these commodities is linked to the unseasonal rainfall led damage to the growing crops in major horticulture producing states in pre-monsoon season of March-April-May (MAM) putting positive momentum of price in these commodities in recent months. In the current year, the country received 146.6 mm rainfall during MAM with 12 percent departure from long periodic average (LPA). However, excess rainfall has spatial variation across regions. For example: the departure is large excess in central India (136 percent) in this year during MAM, followed by South Peninsula (37 percent), and North-west India (33 percent). This excess rainfall has impacted the *rabi* and *zaid* harvest in different major producing centres leading to price pressure in the produce. The adverse weather condition during MAM particularly in horticulture belt led to loss in horticulture production in the country particularly vegetables and spices, spiralling price pressure at consumers' end for consecutive months.

Table 1 shows the level of departure of rainfall during MAM in major producing states of tomato, green chillies, cumin. For instance, Central India comprises 39.3 percent of tomato production in India followed by 32.2 percent in South Peninsula (NHB, 2022). The regions received large excess and excess rainfall, respectively during these months.

Table 1: Unseasonal rainfall in major horticulture producing states during MAM 2023

Producing states	Production in MMT#	Positive rainfall departure from LPA%
Tomato		
Madhya Pradesh	2.7 (14.8)	337%
Andhra Pradesh	2.3 (12.8)	96%
Karnataka*	1.74(9.6)	7%
Gujarat	1.48(8.2)	830%
Odisha	1.43(7.9)	38%
Maharashtra	1.18(6.6)	144%
All India	20.7	12%
Green Chillies		
Andhra Pradesh	0.70 (37.35)	96%
Telangana	0.43 (23.11)	149%
Madhya Pradesh	0.30 (15.83)	337%
All India	1.9	12%
Cumin		
Gujarat	0.32 (58.2)	830%
Rajasthan	0.23 (41.8)	312%
All India	0.55	12%
Ginger		
Madhya Pradesh	0.52 (20.8)	337%
All India	2.5	12%

Source: NHB, Spice Board, IMD, GOI

*Notes: Values in parentheses indicate share in total production. *In major producing belt of Southern Karnataka (Kolar) rainfall witnessed excess rainfall of 35.7 percent from LPA in May 2023.# Production figures are for 2021-22.*

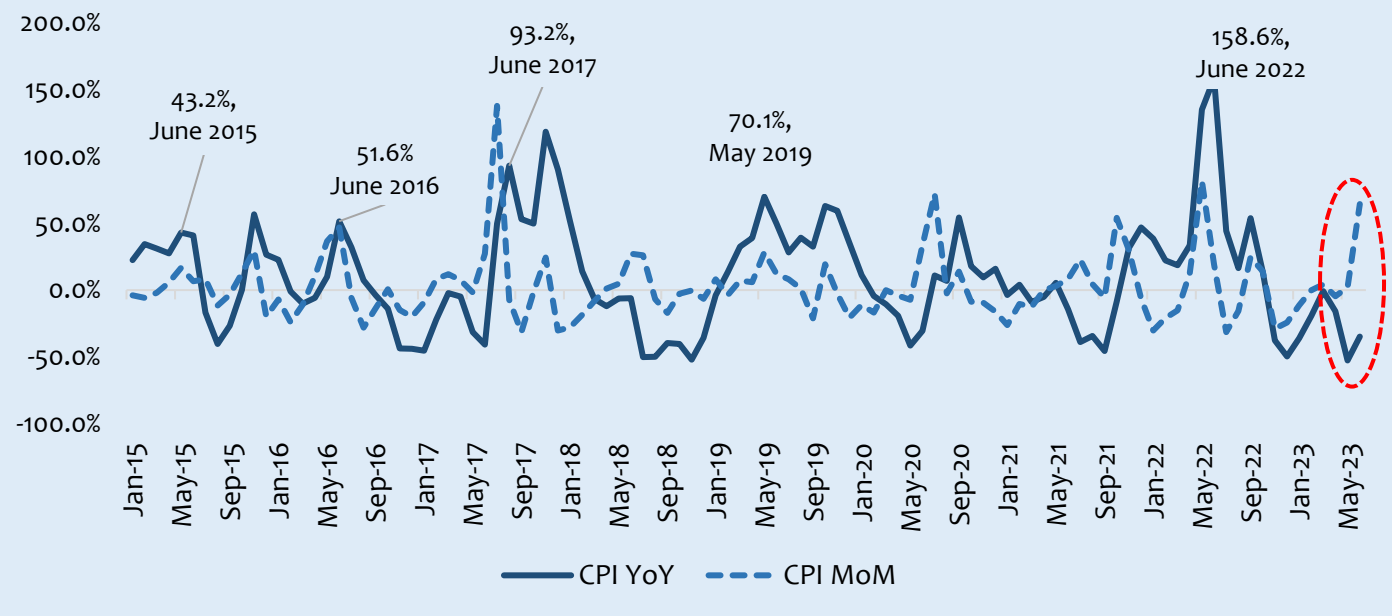
Red hot tomato prices

Tomato is a perishable commodity with a short duration crop cycle where harvest arrives in the market every two months and the supply is spread across the country. Any supply shock in any of the states distorts the overall supply-chain and destabilises its price. The tomatoes that were sown in January-February are ready for harvest from March-June. Currently, the harvest is coming from Karnataka followed by scattered arrival from Andhra Pradesh, Maharashtra, and Himachal Pradesh. But there has been a dip in this year's supply due to pest attacks in Karnataka resulting from unseasonal rainfall and heatwaves. The market arrival in Karnataka has dropped from 9.5 lakh quintals in June 2022 to 6.5 lakh quintals in June 2023. As per the government report during vegetative to fruiting period (March-May), crop got affected by Thrips, White flies, and Early blights approximately affecting 50 percent of the produce. Moreover, Kolar region is also seeing a higher demand from North India due to harvest loss in the major supplying belts of Nashik (Maharashtra), Chindwada (Madhya Pradesh) during MAM. Rainfall departure was in large excess in Madhya Pradesh (337 percent), Maharashtra (144 percent) during MAM 2023. Extreme rainfall during these months affected the growing crops and resulted in fungal diseases. Kolar and Chikkballapura districts witnessed area loss of 6324 hectares and 4397 hectares due to leaf curl virus leading yield loss of 50-70 percent. Kolar region being the major supplier during this period, shortage in production led to soaring tomato prices in the country.

Adding to that, the deflation in tomato in MAM period this year which were at -0.75 percent, -15.96 percent, -52.84 percent YoY, respectively disincentivized farmers to sow the crop for the next growing cycle. As per the market intel, overall, the sown area during May and June has been about 15 percent less compared to last year. Even though tomato commodity has negative Y-o-Y inflation -34.73 percent in June 2023 due to high base effect of 158.6 percent YoY in June 2022, the price pressure is very high with momentum of 64.5 percent over the May 2023 (Figure 1). Adding to the woes, supply from Himachal Pradesh is also disrupted due to the recent flash flood in the state, resulting in increasing inflationary pressures in northern India. However, the tomato price is likely to cool down once the new harvest starts coming in August.

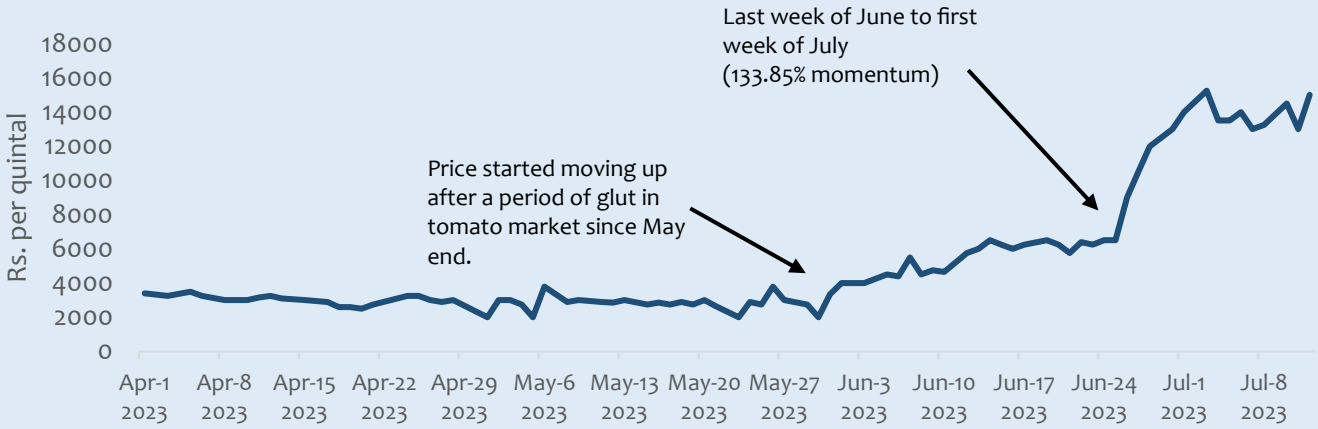
Let us see the retail price movement of tomato this year since April (Figure 2). Tomatoes are harvested on an average 15 times during the growing season. However, due to damage in crop during MAM period, the frequency of harvest reduced to 3-5 rounds resulting in supply shortages and price pressure since end of June. However, the prices in the major metropolitan cities started shooting up from May end and the sharp kink in price trend is visible in the last week of June. For instance, retail price in Bengaluru, the nearest consumption centre of Kolar belt, increased from Rs. 15 per kg in April to Rs. 35 per kg in the first week of June, then again went up to Rs. 100 per kg in June end. Whereas in other urban centres the average retail price reached as high as Rs. 160 -190 for a kilo of tomato.

Figure 1: Episodes of tomato price surge after pre-monsoon season during 2015-2022



Source: MoSPI

Figure 2: Daily retail price movement of tomato



Source: NHB, 2023

Not just tomatoes prices

Coming to the next commodity groups - spices are also witnessing high inflation, which is also attributed to unseasonal rainfall this year. India is the largest producer, exporter, and consumer of spices. Gujarat (55.8 percent), and Rajasthan (43.9 percent) are the major producers of cumin, which are primarily harvested during March-April. Rainfall has been in excess in the major cumin growing belts during MAM; the north Gujarat received large excess rainfall at 830 percent departure from LPA and Rajasthan at 312 percent during MAM leading to significant damage to crops, which in turn led to inflation of 58.55 percent YoY in May 2023 and 74.11 percent YoY in June 2023 (Table 1). Followed by heatwaves in March, cumin crop became more vulnerable to excess rainfall. Price of cumin is hovering around Rs. 422 per kg in May 2023 in the largest cumin market—Unjha, Gujarat which was around Rs. 252 per kg in December 2022. As per CRISIL report, cumin pods were at fruiting stage this year and unseasonal rain has caused 10-15 percent yield drop as well in Rajasthan (CRISIL,2023).

The ginger production is also hampered by unseasonal rainfall during MAM in the largest producing state--Madhya Pradesh, skyrocketing the inflation to as high as 100 percent in May 2023 and 148.2 percent in June 2023. Further, in the second largest producing state, Karnataka, the production declined from 5.6 lakh tonnes in 2021-22 to 5 lakh tonnes in 2022-23 due to reduction in area under the crop (Spice Board of India, 2023). Green chillies price has also surged due to shortage in supply from Andhra Pradesh and Karnataka with 3.84percent inflation YoY in June 2023. The cause of supply shortage in chillies is due to large excess rainfall in major producing states such as Andhra Pradesh and Telangana. Due to lower supply from these states, wholesale prices hovered around Rs.58.4 per kg in Kolkata and Rs.52.2 per kg in in Mumbai which is being reflected in major urban centres as well. The retail prices are at Rs. 220 per kg. and Rs. 150 per kg as on 10th of July, 2023 in these two states.

Policy suggestions to tame inflation in horticulture crops

The country's horticulture production has increased significantly. The production rose from 166.9 MMT to 341.63 MMT from 2004-05 to 2021-22. However, the cobweb pattern in prices of vegetables especially in TOP has become a cyclical phenomenon. Moreover, the current surge in prices among perishables particularly tomatoes due to unseasonal rains led supply shortages is worrying the policymakers. Now, the question remains how to control the prices of tomatoes. In this regard, 'Operation Greens' schemes were launched as a new vertical of Pradhan Mantri Kisan SAMPADA Yojana by Late Arun Jaitley in the Union Budget 2018-19 to improve the efficiency of TOP value-chain with an outlay of Rs. 500 crores. In 2021-22, the scheme also included other 22 perishable commodities. To curb the spike in price in short-run, Rs. 50 crores were allotted under the scheme, where the support includes providing subsidies on transportation and investment in storage facilities for TOP crops. In long-run, the scheme intended to spend Rs. 450 crores to increase in food processing capacities and development of agri-logistics. In 2023-24 budget, allocation towards the Operation Green scheme was 213.59 crores. However, unlike the success of dairy value-chain by NDDB, the inefficiency of supply chain of vegetable commodities, particularly TOP continues to persist due to lack of proper implementation of the scheme. To curb tomato

prices, processing in periods of glut in the market needs to be enhanced. At least 10 percent of the fresh tomatoes need to be processed into paste/puree which can be used when there is shortage of fresh produce in the market. This is also applicable for commodities like ginger and garlic to bridge the supply-demand gap during supply crunch.

Further to ensure supply in adverse weather condition, there is a need to promote polyhouses cultivation for tomatoes and perishable vegetables. To help FPOs and farmers to adapt theses technological change, government can provide support to increase the usage. Hence, improving efficiency in supply chain and investment in the processing sectors are the need of the hour to boost the horticulture sector and to control retail inflation amidst aberration of climate.

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RBI-ICRIER ROUNDTABLE
Understanding Price Dynamics of Major Agricultural Commodities and Identifying Ways to Improve Value-chains

ICRIER along with the Reserve Bank of India (RBI) organised a roundtable seminar on "Understanding Price Dynamics of Major Agricultural Commodities and Identifying Ways to Improve Value-chains" at the RBI Central Office, Mumbai on May 12, 2023. The seminar was graced by Shri Shaktikanta Das, Governor of the RBI, Dr. Michael Debabrata Patra, Deputy Governor of the RBI, various other senior officials of RBI, along with team members from ICRIER.

The seminar began with a presentation by Dr. Ashok Gulati, Distinguished Professor at ICRIER, to the RBI Governor, and Deputy Governor and esteemed panel where he provided inputs on how to tame inflation and increase farmers share in the retail prices in major agricultural commodities studied in the project. The presentation concluded with policy suggestions encompassing a gamut of short term and long-term policy measures including trade policies, buffer stocking policies as well as pre-emptive policy measures to curb inflation and improve efficacy of the agricultural value chains.

The discussion was then followed by detailed presentations on the results of the four commodity papers by ICRIER Team which are as follows: (i) Understanding and Forecasting Pulses Inflation in India: A study of gram, tur and moong; (ii) Understanding the Drivers of Vegetable Inflation in India: A Study of Tomato, Onion, and Potato; (iii) Understanding Price Dynamics and Value Chain of Fruits in India: A study of Grapes, Banana, and Mangoes and 4) Understanding and Forecasting Livestock Inflation in India: A Study of Milk, Poultry Meat and Egg. The presentations were made by Dr. Shyma Jose (Fellow, ICRIER), Dr. Ranjana Roy (Fellow ICRIER), Ms. Raya Das (Fellow, ICRIER), and Ms. Sabarni Chowdhury (Research Associate, ICRIER).

The key objectives of the papers are to identify important factors determining prices of the 12 agricultural commodities under the study and provide insights on the changing market dynamics and the role of supply management measures to control inflation. The studies have built monthly balance sheet for each of these 12 commodities that explains supply and demand situation of a commodity on a real-time basis at the monthly level and to evaluate and document patterns of market responses, in particular patterns about the behaviour of farmers, traders, importers, and consumers. The presentations were followed by an interactive session with the RBI team members. Finally, the session ended with concluding remarks from Dr. Sitikantha Pattanaik, Executive Director, DEPR, RBI.

ICRIER Brainstorming Session on Nanofertilizers: A Disruptive Innovation

The APSI vertical at ICRIER organized a brainstorming session on "Nanofertilizers: A Disruptive Innovation," on May 17th, 2023 at ICRIER Conference Room, India Habitat Center. A total of 15 people participated in the session including the esteemed audience of industry experts, fertiliser specialists, economists, and scientists. The agenda of the brainstorming session was to stimulate discussion on identifying innovative policies and strategies to promote the adoption of sustainable agricultural practices, including the use of the innovative fertiliser alternatives, among farmers, addressing concerns related to cost-effectiveness, productivity, and long-term benefits, with the aim of encouraging widespread adoption.

Dr. Deepak Mishra, Director and Chief Executive of ICRIER, delivered the welcome address, followed by Dr. Ashok Gulati, Distinguished Professor at ICRIER, providing introductory remarks about the session. Dr. Gulati emphasized the significance of preserving soil, water, and air, particularly highlighting that in India, 90 percent of subsidies are allocated to granular urea, which is considered problematic and harmful. He underlined the need to explore innovative policies to tackle these concerns and expressed a strong interest in discovering effective strategies to convince farmers to embrace these policies.

During the presentations, Dr. Tarunendu Singh from IFFCO discussed Nano urea and presented field studies on its effectiveness. Prof. Nandula Raghuram, from the Centre of Sustainable Nitrogen and Nutrient Management, highlighted the significance of Nitrogen Use Efficiency (NUE) and emphasized the need for optimizing nitrogen input response. Dr. Anand Gole from Coromandel shared insights on phosphorous and introduced a new product, a Nano P formulation designed for foliar spray. Dr. Alok Adholeya, along with Dr. Rita Choudhary from ICRIER, presented on the economic potential of nanofertilizers. They showcased ICRIER's methodology and shared two scenarios demonstrating the replacement of conventional urea with IFFCO's nano urea in paddy fields in Punjab, using the reference year of 2019-2020.

The presentations were followed by the remarks from the discussants where Dr. S. Nand, Additional Director General, Fertiliser Association of India, highlighted the pricing policy as the main obstacle in the fertiliser industry. He emphasized that while modified urea products with high use efficiency exist, the provision of free or heavily subsidized granular urea (90 percent subsidy) discourages farmers from adopting these improved alternatives. The lack of innovation in incentivizing the adoption of new products was identified as a significant issue. Dr. R.K. Tewatia, Former Director (Agriculture Sciences), The Fertiliser Association of India, shared IFFCO's projections for nano urea production, expressing the company's expectation to achieve a surplus in producing bottles of nano urea by 2025. However, despite the significant

sales of nano urea bottles in the 2022-23 period, farmers remain sceptical about its effectiveness in replacing conventional urea. To promote the adoption of nano urea, it is essential to address farmers' concerns and rationalize production capacity. Dr. Ashok Patra, Former Director, ICAR-Indian Institute of Soil Science, Bhopal, raised concerns about the mass balancing of nitrogen when using nano urea and its ability to fulfil the nitrogen requirements for crop production, especially in nitrogen-deficient soils. He emphasized the importance of considering the residual effects of previous fertiliser applications and understanding the impact of nano urea on soil microorganisms and nitrogen fixation processes. Dr. P.S. Vijaykumar, Scientist-E, Institute of Nano Science & Technology, Mohali, Punjab, emphasized the importance of addressing acute and chronic toxicity issues associated with nanomaterials when workers or farmers are exposed to them.

In the closing remarks, Dr. Alok Adholeya, Visiting Professor, ICRIER, emphasized the significance of policy changes to reduce granular urea usage and subsidy through the adoption of nano urea. The APSI team aims to utilize data from IFFCO trials across India to recommend or develop policies for government organizations. Dr. Ashok Gulati stressed the importance of analysing financial numbers and economic incentives to influence government behaviour and encourage the adoption of policies aligned with desired outcomes and beneficial for farmers.

APSI IN THE FIELD
Field visit to Punjab

APSI Team with VC, PAU

APSI Team interacting with Farmers

As a part of the project focused on Re-aligning Agriculture policies for Sustainable Agriculture, the APSI team, comprising Dr. Ashok Gulati, Dr. Reena Singh, Ms. Raya Das, and Ms. Purvi Thangaraj, embarked on a field visit to Punjab. During their time there, the team engaged in visits and discussions at prominent agriculture research institutes, grain markets, and silage plants, and interacted with farmers. The objective was to gain insights into Punjab's current and forthcoming endeavours in the realm of people and planet-positive sustainable agriculture (PPPSA).

Discussions at leading research institutes – Punjab Agriculture University (PAU), Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), and Borlaug Institute for South Asia (BISA) – revealed the urgency and need for efficient natural resource management to tackle climate change and depleting natural resources of the state.

Initiatives to promote environmentally friendly and resource-efficient agricultural practices while enhancing productivity and sustainability in agriculture, PAU discussed a range of practices encompassing various areas such as water-saving technologies, short-duration varieties, genomic-assisted breeding, crop residue management techniques, integrated nutrient management, biofertilizers, integrated pest management strategies, special varieties, and advanced technologies.

During the visit to BISA, various innovative farming practices and research trials were showcased. These included techniques such as Direct Seeded Rice, Raised-Bed farming, and Zero-Tilled Mulched fields. These practices have demonstrated several benefits, such as reduced lodging of crops, water conservation, improved decomposition of crop residues, increased organic carbon content in the soil, and a micro-climate that is less than 1 degree Celsius.

Interacting with farmers, including a progressive farmer, yielded to be fruitful in trying to understand if there were synergies between the different stakeholders we met. Farmers seemed to be aware of the troubling and depleting groundwater in Punjab where 78 percent of the assessment blocks are over-exploited. However, their concerns might not translate into practice due to the existing policy regime of subsidies and procurement practices of the state.

Lessons from the field visit aided the team's knowledge of the widespread difficulties in natural resource management in Punjab, as well as the exchange of ideas with all stakeholders on how to address them.

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Conferences / Seminars:

Gulati, Ashok (April 27, 2023): Speaker at the "**Chintan Shivir**" organised by the Department of Food and Public Distribution, Government of India, Suraj Kund, Haryana and delivered a presentation on "**Leveraging PDS for more Nutritious and Environmentally Sustainable Food Systems**".

Gulati, Ashok (April, 2023): Discussant at the event organised by the NCAER in collaboration with the IMF for the presentation of an Analytical Chapter titled, "**Inflation and Disinflation: What Role for Fiscal Policy," from the latest IMF Fiscal Monitor**.

Gulati, Ashok and APSI Sustainability team (April, 2023): "Meeting with Dr. Satbir Singh Gosal, Vice Chancellor, Punjab Agricultural University, and other officials to discuss **climate-resilient agriculture initiatives**.

Gulati, Ashok (June 27-30, 2023): Participated as an Expert at the "***Smallholder Farming Expert Roundtable***" organised by the Bayer Group, St. Louis, USA.

Op-eds:

- Gulati, Ashok (June 26, 2023): "Old friends in a changing World", The Indian Express also published in the Financial Express under the title "Sowing deeper cooperation".

- Gulati, Ashok and Purvi Thangaraj (June 12, 2023): "A nine-year report card", The Indian Express also published in the Financial Express under the title "How NDA II has fared".

- Gulati, Ashok and Purvi Thangaraj (May 29, 2023): "Nutrition in a warmer world", The Indian Express also published in the Financial Express under the title "Sowing climate resilience".

- Gulati, Ashok (May 15, 2023): "Weather-proofing food security", The Indian Express also published in the Financial Express under the title "Reining in Food Inflation".

- Gulati, Ashok (May 01, 2023): "Reimagining ration shops", The Indian Express also published in the Financial Express under the title "PDS and climate-smart agriculture".

- Gulati, Ashok (April 17, 2023): "Living with El Nino", The Indian Express also published in the Financial Express under the title "Beating Food Inflation".

- Gulati, Ashok and Raya Das (April 3, 2023): "Weather vagaries, wheat woes", The Indian Express also published in the Financial Express under the title "Wheat may not come a cropper".

APSI TEAM

Cover Page Image Courtesy: Map created by Rahul Arora on QGIS Software using the data from India Meteorological Department

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