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Impact of Climate Change on Indian Agriculture-A Study

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ABSTRACT : Climate change is perceptible through a rise in all India mean temperature and increased frequency of extreme rainfall events in the last three decades. This causes fluctuation in production of major crops in different years. Impact of climate change on Indian agriculture was studied under National Innovations in Climate Resilient Agriculture (NICRA). Rainfed rice yields in India are projected to reduce marginally (<2.5%) in 2050 and 2080 and irrigated rice yields by 7% in 2050 and 10% in 2080 scenarios. Further, wheat yield projected to reduce by 6-25% in 2100 and maize yields by 18-23%. Future climates are likely to benefit chickpea with increase in productivity (23-54%). Indian Council of Agricultural Research (ICAR) has initiated a network project NICRA during 2011 to address the impact of climate change on Indian agriculture. NICRA project is being reviewed by a High Level Monitoring Committee (HLMC) under the Chairmanship of Secretary, DARE & DG, ICAR with invited members representing different Ministries, Government of India. This committee recommends measures to be taken through NICRA for making Indian agriculture more resilient to changing climate. Besides an expert committee periodically review the project and advise on various aspects. Vulnerability assessment of Indian Agriculture to climate change is undertaken by Indian Council of Agricultural Research (ICAR). Such an assessment was for 573 rural districts of India (excluding the Union Territories of Andaman and Nicobar Islands, Lakshadweep). Based on the vulnerability analysis, 109 districts out of 573 rural districts (19% of total districts) are 'very high-risk' districts, while 201 districts are risk districts. Integrated simulation modelling studies indicated that under Representative Concentration Pathway 4.5, maximum temperature is expected to increase by 1 to 1.3°C in 256 districts, by 1.3 to 1.6 °C in 157 districts (2020-2049). The increase ranged from <1.3 °C in 199 districts to >1.6 °C in 89 districts. Cultivation of wheat in these districts is likely to be affected by heat stress. Under NICRA project, wheat germplasm comprising of advanced breeding lines and land races have been screened for heat/drought tolerance. ICAR-Indian Agricultural Research Institute (IARI) has released the high yielding varieties such as HD 2967 and HD 3086 which are being grown in large areas of North-west and North India. Zero till planting of wheat has advanced the wheat sowing in Punjab and Haryana. This information was given in a written reply by the Union Minister of Agriculture and Farmers Welfare Shri Narendra Singh Tomar in Lok Sabha today.

KEYWORDS: ICAR, climate change, Indian, agriculture, impact, heat stress, tolerance, ministries, high risk

I. INTRODUCTION

Large sections of the urban middle and upper classes take food security as a given. The weather events of 2021 and the possibility of similar experiences in 2021 pose a challenge to India's food security.[1,2]

The wheat crop was smaller due to higher than normal temperatures in March 2021. Then there was a shortfall in monsoon rains in Uttar Pradesh, Bihar, Jharkhand and West Bengal, affecting paddy production. This year has also started with higher temperatures, right from February. If the effect of El Nino turns out to be severe, there may be drought-like conditions in some parts of India, affecting kharif crops and bringing enormous hardship to farmers doing rain-fed cultivation. Last year, despite reports of a lower wheat crop, senior government functionaries were talking of feeding the world. This year, the prime minister has himself reviewed preparedness for sustaining agricultural production. The impact of climate change was visible in our neighbourhood last year, when unprecedented floods submerged one-third of Pakistan, causing death or injury to about 15,000 people and displacing 8 million. About 1.6 million hectares of agricultural land was destroyed or damaged. This climatic event has already caused food insecurity in Pakistan.[3,4]

In February 2021, the Intergovernmental Panel on Climate Change (IPCC) Working Group II released its report, Climate Change 2021: Impacts, Adaptation and Vulnerability, by 900 authors who reviewed 34,000 scientific papers. It pointed out that India is one of the most vulnerable nations for crop production. Droughts and heatwaves will affect crop productivity and farmers' incomes. It pointed out that maize production in India could



fall 25% if the temperature rises 1°C above the pre-industrial level. At 4°C higher, maize production could be 70% lower. IPCC modelling predicts higher rice and wheat prices that will severely impact economic growth. India must worry about the impact of hot February and March weather on the wheat crop, which give optimum yield in cool and moist weather. The optimum temperature for germination is 20-25°C. During the heading and flowering stages, elevated temperature can harm yield. During ripening, the optimum temperature is 14-15°C. If temperatures run above 25°C during this period, the grain has lower weight, because the plant wastes too much energy in transpiration. This is what happened to the wheat crop in 2021-22, and experts fear a repeat this year.[5,6]

ICAR's Indian Institute of Wheat and Barley Research, Karnal, is the leading scientific institution for wheat. It has been issuing weekly advisories to farmers to mitigate the impact of hot weather. They have been advised to irrigate wheat crops lightly, and to spray 0.2% muriate of potash. In Punjab, Haryana and western UP, farmers are progressive and follow scientific advice, so yield loss will not be very high in the region.

Unlike last year, there is much higher media coverage and awareness about the adverse impact of hot weather on the wheat crop. Last year, wheat exports were banned only on May 17. By that time, many export contracts were signed and traders and corporates had bought wheat to export. Global prices were touching \$500 a tonne due to the Russian invasion of Ukraine and stoppage of exports from Black Sea ports. This year, the export of wheat is already banned. The private trade would also be expecting promulgation of stock limits under the Essential Commodities Act. So, they may not be buying large quantities of wheat.

II.DISCUSSION

India is already impacted by climate change. In February 2011, the government had set up National Innovations on Climate Resilient Agriculture (NICRA) in the Indian Council of Agricultural Research, but it is under-funded. There is a need to provide adequate resources to face the challenge posed by climate change.[7,8]

Siraj Hussain is former Union Agriculture Secretary and a Trustee of the World Food Programme Trust for India.

- After the drop in wheat production due to heat waves, extreme weather events have now cast a shadow on rice production, which is likely to drop beyond centre's initial 6% loss estimate.
- In six years (2015-21), the country lost 33.9 million hectares of the cropped area due to floods and excess rains and 35 million hectares due to drought, which are likely to intensify as various studies predict.
- Centre recently assured of developing climate-resilient varieties and district-level contingency plans to deal with the emerging climate crisis. Experts say a lot more needs to be done.

After a difficult two years of the COVID-19 pandemic, Manjeet Singh was hopeful that 2021 would bring some cheer. A farmer from Harigarh village in Punjab's Barnala district, Singh owns 4.04 hectares of farmland, his only source of his livelihood. But a series of extreme weather events this year led to financial losses, dampening the optimistic note he started the year with. There was a sudden unexpected increase in temperature in March this year. This coincided with the time the wheat crop was at a maturing stage, he shares. As a result, there was a drop in production. Wheat production from Singh's farm, in previous years, has been about 48-50 quintals per hectare. This year, his farm produced only 38 quintals per hectare – a drop of about 10 quintals per hectare. This, in turn, brought down his income by Rs. 20,000 per hectare. Singh gets Rs. 2,015 per quintal as the minimum support price (MSP) set by the government.[9,10]

"If this was not enough, my paddy crop, too, suffered losses due to recent rainfalls," added Manjeet Singh. He explains, "When the crop was almost ready to harvest, there was heavy rainfall in the last week of September, followed by another two-day rain spell between October 7 and 8." The unexpected heavy rains, he said, prolonged harvesting and increased his input cost on anti-pesticide sprays. It also reduced crop production by 7-8 quintals per hectare and with that, there was further loss of income.



The variations in weather are increasingly challenging for the agriculture sector. As per Indian Meteorological Department (IMD), September rainfall was in excess of 82% in Haryana, a record after 1945. Similarly, Punjab also received 30% more rain, the first time since 1988.[11,12]

There is significant crop loss associated with these weather events. In Punjab, as Gurbinder Singh, director of the state's agriculture department, told Mongabay-India, rainfall in September damaged 1.39 lakh (139,000) hectares of paddy area. This is nearly 5% of the total crop area of three million hectares in the state. Similarly, unseasonal heavy rain damaged nearly 20% of the 1.3-million-hectare crop area under paddy in Haryana, informed Hardeep Kadian, director of the agriculture department in the state. Singh, the Punjab agriculture director estimates a production loss of 2% to 5% in the state, while Kadian says production damage may touch 10% in Haryana. Besides Punjab and Haryana, Uttar Pradesh (U.P.), the second-largest rice-producing state, received unseasonal heavy rainfall in October when farmers were getting ready for harvest. IMD's latest data revealed that 65 out of 75 districts in U.P. received large excess rainfall. Rajesh Kumar Gupta, the in-charge, U.P. agriculture department's statistic wing, told Mongabay-India that the total paddy area in U.P. this year is 5.9 million hectares. At the beginning of the season, deficient rainfall had affected almost 1.5 million hectares of sowing. "We made a handsome recovery with sufficient rainfall in August and September. But just before the harvesting, extreme rainfall in the first ten days of October damaged paddy area up to 2.5 lakh (250,000) hectares," informed Gupta. He said, "This, we fear, will bring our paddy production down from 16 million tonnes in 2021 to 14.5 to 15 million tonnes this year, a production loss of approximately 10%." [13,14]

This certainly is not good news for India's rice production, which already fell by 6% in the Union agriculture ministry's first advance estimates released on September 21 this year. The paddy season was already affected by deficient rainfall and subsequent fall in paddy areas in Bihar, Jharkhand, West Bengal and Madhya Pradesh (M.P.). Then, after the rain-deficient sowing period, the excess rainfall just before harvesting, in important rice-producing states, cast a further shadow, with losses in overall crop production this year. G. V. Ramanjaneyulu, executive director at Centre for Sustainable Agriculture in Hyderabad, told Mongabay-India that overall, the loss to rice production this year could touch 10% due to recent weather events.

Government policies reflect situation of food grain

While union agriculture minister Narendra Singh Tomar recently stated in parliament that there was no food grain crisis in the country, the impact of extreme weather on agriculture is being recognised in government policies. The centre, on September 9, roughly two weeks before releasing the first crop estimate, banned the export of broken rice in the wake of production concerns and domestic demand. Similarly, earlier this year in May, the country banned wheat export after unseasonal high temperatures in March affected the crop production. As per IMD, March was the warmest since 1901, when temperature record-keeping began in the country. Pavneet Kaur Kingra, head of the Department of Climate Change and Agricultural Meteorology at Punjab Agricultural University, told Mongabay-India that the temperature rise limited the development of the grain, leading to shrivelling of wheat grains. While the average temperature hike may be 4%, there were days when the temperature had hiked by 7-8%, Kingra added. On how one should interpret the increase in temperature, she said that it is a clear sign of climate variability, which is influenced by climate change and global warming. [15,16]

69 million hectares of crop area lost in six years

Hydro-meteorological calamities, including heavy rainfall and floods, have damaged 33.9 million hectares of India's cropped area between 2015-16 and 2021-22, as per the ministry of agriculture data tabled in the recent monsoon session of parliament.

The drought – an event arising out of scanty and deficient rainfall – was equally destructive. About 35 million hectares of cropped area (where crop loss was 33% and above) was damaged between 2016-17 to 2021-22, according to data obtained by this journalist in the last week of October, under the Right to Information (RTI) Act, provided by the drought management cell of the Union Ministry of Agriculture and Farmer Welfare. A close look at both these data sets revealed that Rajasthan, Karnataka, Madhya Pradesh, and Maharashtra were among the most affected states, which faced crop losses from drought and excess rainfall. Other states where floods and heavy rains were predominant factors for crop loss were Bihar, West Bengal, Uttar Pradesh, Assam, Gujarat, and Odisha. The fact that most of these affected



states are not geographically connected indicates that the issue of climate variability and its impact on agriculture is widening. These states were also found vulnerable in IMD's 2021 report, which studied monsoon rainfall variability over 30 years (1989- 2018). The IMD report revealed that seven states witnessed decreasing rainfall trends during these years, while 12 states witnessed increasing rainfall trends during the same period. IMD analysis of this year's monsoon presents a similar trend. It revealed that only 40% out of 703 districts in India had average rainfall. [17,18]

III.RESULTS

In 2016, the Ministry of Science and Technology released a report which said that agriculture in the country was highly prone to climate change. The uncertain weather, especially drought, may affect production loss and the quality of fruits as large area of agriculture was still rainfed, the report said. As per the ministry of agriculture data, 67.79 million hectares out of 180 million hectares of total agricultural land in India is still unirrigated. This makes 40% of the agriculture in the country dependent on rain, which is now constantly experiencing variations. These vulnerabilities will have a direct impact on people. The International Food Policy Research Institute's (IFPRI) Global Food Policy 2021 report has warned that climate change may push 90 million Indians towards hunger by 2030. It has listed a decline in agricultural production and disruption in the food supply chain, reason for future crisis. [19,20]

Centre says finding solutions, experts say not enough

As per the agriculture ministry's statement in parliament, the government is finding ways and initiating steps to tackle the increasing temperature and heavy rainfalls. It claimed to have conducted field-trials of 177 varieties developed by the Indian Council of Agriculture Research (ICAR) and different state agriculture universities for climate extremes like floods, droughts, heat waves etc. The ministry also claimed to have formulated District Agriculture Contingency Plan (DACP) for 650 districts to mitigate the impact of weather-related challenges. But according to experts, government action is inadequate since the challenges are bigger. Director at Bengaluru-based Foundation for Agrarian Studies, Sandipan Baksi told Mongabay-India that the vulnerability in agriculture due to extreme climate-related events is a reality. "But the problem is that a scientific intervention needed to absorb the climate shock is missing," he added. [21,22]

Baksi said that the country needs to increase public spending on irrigation to deal with rising vulnerabilities. It needs improvement in rural infrastructure, more expenditure on extension services, sustainable farming, crop diversification, etc. "Our last year's research report on trends of public spending in India between 2010 and 2020 found that the overall public expenditure on agriculture has decreased (from 11 per cent to 9.5 per cent between 2010-11 and 2019-20). In that situation, there is no way we can meet the future challenges," he added.

Where is the safety net for farmers

Marginal and small farmers, as per the 2015-16 agriculture census, account for 86% of total farmers in India and are the most vulnerable to extreme weather events. Experts advocate protective measures for these vulnerable farmers. A senior leader of Sanyukt Kisan Morcha (SKM), Darshan Pal says that climate vulnerability is the new distressed factor, especially among marginal and small farmers because their shock absorbing capacity is far less than big farmers. The SKM was part of the farmers' movement last year, leading to a policy-level change in India. "Ideally, there should be safety nets to protect all categories of farmers against extreme climate events. Crop insurance can be one among other concrete solutions. But right now, the existing crop insurance model is faulty and hardly benefitting the farmers," he added. According to him, the farmers want an effective crop insurance system. The model should be such that it ensures that a farmer should get compensation for loss of crop on even one-acre land. [23,24]

National Bank for Agriculture and Rural Development (NABARD) has also underlined the poor performance of crop insurance. In a book published recently, NABARD has argued that crop insurance is no longer a "perfect medication" for farmers hit by natural calamities. Economist R.S. Deshpande who has written the book by NABARD, called for a complete revamping of crop insurance. Otherwise, a crisis is set to mount on farmers. Deshpande is currently associated with Institute for Social and Economic Change, Bengaluru. In a word of caution, Sandipan Baksi says that agriculture in India still suffers from very low yields and production. "Attributing each and every event to climate



change without proper research may prevent some of the essential measures to expand production, leaving the marginalised sections in a state of continued vulnerability,” he added.[25,26]

IV. CONCLUSIONS

The Intergovernmental Panel on Climate Change’s (IPCC’s) Sixth Assessment Report (AR6) on climate change impacts, adaptation and vulnerability, released over the month ago, delivered a wake up-call to narrow the widening “adaptation gap” and build resilience against “unfamiliar” climates.[27]

The second tranche of the set of three reports being published every 6-7 years by the IPCC, for the first time, made regional and sectoral level assessment of climate change impacts on ecosystems, biodiversity, and human communities. The report observes with confidence the adverse impact of these climatic changes on availability and prices of food, exacerbating undernourishment in the South Asian region. The latest IPCC report on climate change mitigation, released on April 4, further draws attention to the close linkages between climate change mitigation, adaptation and development pathways and the associated trade-offs.

Among worst affected

According to the Global Climate Risk Index 2021, India is among the top ten countries most affected by climate change. At a broader level, the country may keep pace with the food requirements of a growing population, courtesy the technological and institutional innovations. However, several studies suggest that climate change already has evident effects on crop production, with associated consequences for local food supply disruptions and negative impacts on rural incomes and poverty. A Report by the Parliamentary Standing Committee on Agriculture, 2017 estimated that climate change related losses are about 4-9 per cent of the agricultural economy each year, which is an overall GDP loss of 1.5 per cent.[28]

India has begun to pay more attention to the ways in which climate change impacts agriculture in varying contexts. Climate change policy in Indian agriculture has an explicit focus on adaptation and developing adaptive capacity of farmers is of prime concern. Rightly so, as nearly 86 per cent of Indian agriculture is small-holder agriculture and a significant part of it, particularly in dryland areas, is subsistence agriculture where adaptation is an issue of survival.

The National Mission on Sustainable Agriculture (NMSA), formulated in 2010 under the aegis of National Action Plan on Climate Change (NAPCC), through a series of adaptation measures, aims at promoting location specific improved agronomic practices that focusses on integrated farming, water use efficiency, soil health management and synergising resource conservation, especially in rain-fed areas.[29]

Development plans in the agriculture sector focussing on soil and water management, crop diversification, cropping system optimisation, risk sharing (co-investment, community engagement), risk transfer (crop/livestock insurance), and improved localised forecasting and agro-advisory, while improving adaptation outcomes in most cases also optimise mitigation co-benefits.

Prioritise activities

In the domain of planning and practice, it would be important to prioritise activities having both adaptation and mitigation benefits, since several of the response strategies and initiatives either focusses on ensuring stable food supply or has the mandate of protecting and conserving natural resources and ecosystems. As fragmented and small land size reduces farmers’ adaptive capacity to climate change, it is essential to design policies and strategies especially focussing on small and marginal landholders.

Agriculture being a State subject under the Indian Constitution, planning and policy implementation falls substantially within the purview of respective States and local institutions, with the Central government providing the broad policy framework and guidelines. The development of State Action Plan on Climate Change (SAPCC) need to be considered as a dynamic document; many States and UTs have either revised or are in the process of revising SAPCCs in synergy with the post 2020 NDC goals and the SDGs.



It is important to periodically review, update and integrate the agriculture, forestry and land use component in the SAPCCs. Given the localised nature of climate impacts and the adaptation needs, it is essential to further downscale it to the district or village level based on scientific evidence generated through collaborative research. Certain States such as Himachal Pradesh in recent years has undertaken a more robust adaptation planning approach based on assessment of climate vulnerability at the village level.

The financial needs of adaptation in India (2015–2030) in key climate sensitive sectors such as agriculture, forestry, fisheries, and water resources is estimated at \$206 billion (at 2014–2015 prices). A pro-active adaptation approach in agriculture is needed, streamlining efforts and resources on climate and disaster resilience to reduce risk exposure, limiting impacts, and preparedness in coping with disasters.

Natural disasters

India has well developed institutional arrangements for disaster management at the national, State and district level. Adaptation measures pertaining to impact of natural disasters in agriculture and allied sectors (as per Food and Agriculture Organization, the sector accounts for nearly a quarter of damages caused by natural hazards in the developing world) need to be embedded in the disaster management plans prepared by the departments at the district level.[30]

In addition to adaptation measures such as the development of adaptive crop varieties, it is important to provide the supporting infrastructure including water supply, power and physical connectivity on which agricultural value chain depends. Areas affected by floods, hailstorms and drought need to be rebuilt better based on disaster management assessment. The Sendai Framework for Disaster Risk Reduction 2015-2030 (Sendai Framework), to which India is also a signatory, provides critical opportunity to build agriculture related infrastructure on which food production depends.

The scale and scope of potential climate impacts in the agriculture sector warrant a shift from the current practice of individual sector-specific programmes and schemes. Mainstreaming of climate considerations both across the development programmes in agriculture, forestry, land use, water and health as well as in the process of spatial planning considering natural, socioeconomic and demographic conditions are required.

Most importantly, adaptation to climate change in the sector would require not only large and continued financial investment, but also in terms of knowledge and human capacity.

Anand is Senior Fellow, and Kumar is Distinguished Fellow and Lead, Food and Land Use Coalition (India), at The Energy and Resources Institute, New Delhi[30]

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