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kotak karma

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for Agriculture Policy, Sustainability and Innovations.

ICRIER is happy to announce setting up of a **Center of Excellence for Agriculture Policy, Sustainability, and Innovations (APSI)**. It is supported by **Kotak Mahindra Bank Limited (KMBL)**.

AF-TAB is a quarterly bulletin of APSI. We will be covering major activities of this Centre of Excellence including research output, events, policy interactions with stakeholders, field visits and policy outcomes on a quarterly basis, through this bulletin.

INSIDE THE ISSUE

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FROM THE DIRECTOR'S DESK

Climate change is knocking on our doors. Agriculture is likely to be impacted significantly due to extreme weather events like El Niño, cyclones, droughts, heat waves, etc. This can drastically bring down agricultural GDP growth, as it happened in 2023-24 (FY24) when it dropped to 1.4 percent from the highs of 4.7 percent in the previous year (FY23). This can be stressful for a large segment of our population as agriculture sector still engages 45.8 percent of the workforce in India, and feeds the world's most populous country with more than 1.4 billion people. Even worse, the unsustainable use of natural resources like land, water and biodiversity, and indiscriminate use of agrochemicals have compounded the farming challenges. Despite a noteworthy increase in per capita food production, the percentage of malnutrition (weight for age) in children below 5 years of age was 32.1 percent (NHFS 5, 2019-21). The entire agri-food value chain must rapidly adopt to the new era of agri-technologies and innovations, to meet increasing demand sustainably and enable India to meet net zero target by 2070.

In India, innovations in agriculture in the past came through transfer of foreign technology and its adaptation to Indian conditions through public research. The case in point is the ushering of green revolution. But later on, innovations in dairy, fishery, and fruits and vegetables have come from the cooperative, public and private sectors' efforts. Research and innovation by private industry have led to the yield increase and boom in cotton exports, generic pesticides, and agricultural machinery. Some studies confirm that every rupee invested in agriculture research returns more than ten rupees (Gulati et al. 2018; Kandpal et al. 2024). Yet, funding of agricultural research and development (R&D), both public and private, as a percentage of agricultural GDP has decreased over the years. In 2008-09, the agriculture research intensity (ARI) of the country was 0.75 percent, which is at 0.43 percent in 2020-21 and very much below the target of 1 percent recommended by the Government of India and the United Nations Food and Agriculture Organization (FAO).

Without significant increases in R&D investment, food and agriculture systems will fall short of the vision for a healthier, more sustainable and "*Viksit* India." This issue of ICRIER's quarterly publication, Agri-Food Trends and Analytics Bulletin (AF-TAB) is a call to action to reverse the decline in agri-R&D and extension with a focus on creating a climate-resilient and climate-smart agriculture. If this does not happen quickly and effectively, the cost of reversing the adverse damage from increased intensity and frequency of extreme weather events will become exorbitant.

Deepak Mishra
Director and Chief Executive
ICRIER

FROM THE CHIEF EDITOR'S DESK

Given the climate change, there is urgent need to promote climate resilient and climate-smart agriculture. The imperative to sustain agricultural productivity amidst climate change necessitates a paradigm shift towards technological innovations in India. The challenge is more as 86 percent of total operational holdings are marginal and small with less than 2 hectares of land.

In this context, the current AF-TAB issue on "Technology and Innovation for Sustainable Agriculture" focuses on the role of R&D expenditure and technological change for sustainable development of agriculture with a focus on India. The first article in this issue *India's Farming Future: Research and Resilience* emphasizes the need for R&D expenditure in green technologies to ensure food and nutritional security while adapting to climate change. This requires smart repurposing of existing policies, especially those related to input subsidies. The second article, *Reducing Post-Harvest Losses for Sustainable Food System* focuses on the crucial role of technology in reducing post-harvest losses for sustainable agriculture. The article underscores the need for technological advancements, especially mechanisation, across the entire agricultural value chain to reduce these losses.

The third article *Produce More from Less: Role of Precision Agricultural Technologies* presents a comprehensive examination of how precision agriculture can optimize resource use and enhancing productivity. The article explores how integrating advanced precision agricultural technologies, such as micro-irrigation, AI, and drones, can significantly enhance productivity and sustainability in India's farming sector. The fourth article *Seeding the innovation by private sector* emphasizes the pivotal role of private sector innovation in transforming India's seed industry. By examining trends in registered plant varieties, biotech developments, patents, and R&D expenditure, the article highlights the significant contributions of private companies in fostering new crop varieties and advancing agricultural productivity, positioning India as a key player in the global seed market.

In the light of these insights, the AF-TAB issue underscores the critical role of R&D and technological advancements in steering India towards agricultural sustainability.

Ashok Gulati
Distinguished Professor
ICRIER

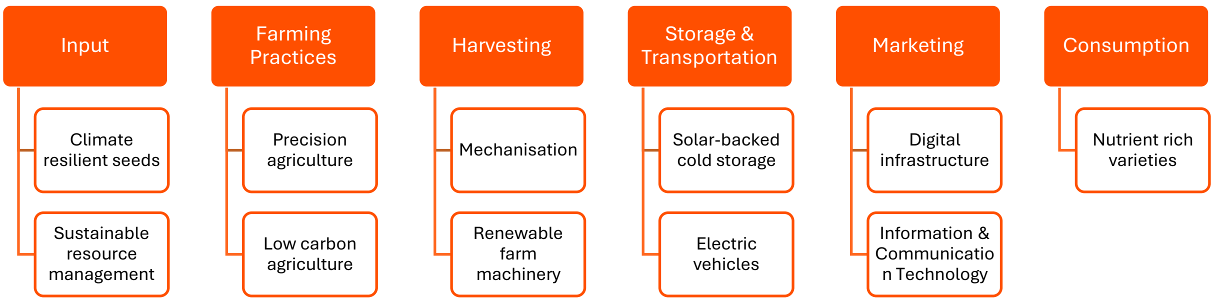
INDIA'S FARMING FUTURE: RESEARCH AND RESILIENCE

Purvi Thangaraj and Ashok Gulati

In the 174-year history of record-keeping, 2023 was the hottest year, with temperatures 1.45±0.12°C above the pre-industrial average (WMO, 2024). In India, average temperatures rose by 0.7°C from 1901 to 2018, leading to more extreme weather, increasing daily precipitation extremes (75 percent from 1950 to 2015), declining monsoon precipitation (6 percent from 1950 to 2018), sea-level rise (3.3 mm per year from 1993 to 2017), and more frequent droughts and cyclonic storms (MoES, 2020). This summer season saw over double the usual number of heatwave days in north-western and eastern India with temperatures exceeding 50°C, and eastern India experiencing its hottest April on record. The Intergovernmental Panel on Climate Change confirms that human activities, primarily greenhouse gas (GHG) emissions, have caused global warming. These extreme weather events significantly impact all sectors, including agriculture, which both drive climate change through emissions and suffer from it due to disrupted crop yields and farming viability.

Agriculture, employing 45.8 percent of the Indian workforce and contributing to 13.44 percent of the GHG emissions, is highly vulnerable to the impacts of climate change. These impacts are projected in terms of potential yield loss in rice (-14.4 percent), wheat (-17.1 to -31.8 percent), and chickpea (-12.5 to 16.6 percent) among others (MoEFCC, 2023). Agriculture vulnerability to climate change was identified as 'very high' risk in 109 districts and as 'high' risk in 201 districts of India (Rao et al., 2019). This can act as a blueprint for site-specific measures as investments and interventions can be planned to address high risks and vulnerabilities and improve any specific indicators where the district is unfavourably positioned. In this context, this article emphasizes the need for agricultural research and development (R&D) in the face of changing climate. India recognizes the critical need to enhance R&D in green technologies to ensure food and nutritional security for its growing population. Agricultural R&D can significantly boost productivity while aiding in climate adaptation and mitigation across the entire food system (**Figure 1**), from production to marketing. This integrated approach aims to create a sustainable and resilient agri-food system.

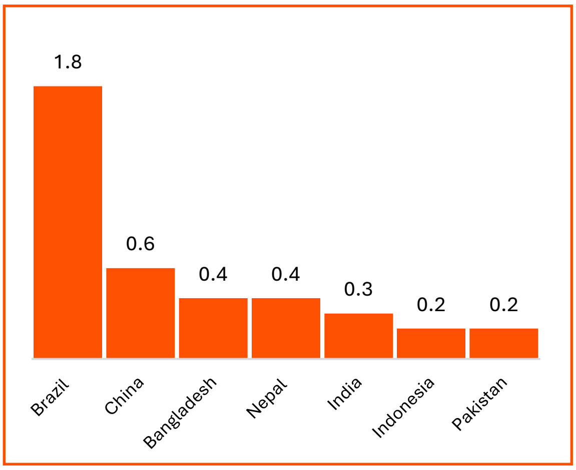
Figure 1. Agri-R&D in a Sustainable Food System



Source: Authors' creation

Studies estimate that marginal returns on agriculture research are more than 10 times, making a compelling argument for increasing Agriculture Research and Development expenditure (ARDE) for climate resilience. Our analysis shows that ARDE reached Rs. 160 billion (USD 2.16 billion) in 2020-21 (DST, 2023), with 89 percent coming from the public[1] sector and 11 percent from the private[2] sector. Public sector expenditure rose from Rs. 41.09 billion (USD 0.93 billion) to Rs. 141.92 billion (USD 1.92 billion) between 2005-06 and 2020-21. Similarly, private ARDE increased from Rs.4.14 billion (USD 0.24 billion) to INR 18.13 billion (USD 0.09 billion). While these numbers give an idea of the scale, it is important to consider the percentage relative to agriculture's Gross Domestic Product (AgGDP), estimated as Agriculture Research Intensity (ARI), a crucial indicator of research commitment relative to the agricultural sector's size. The ARI peaked at 0.75 percent in 2008-09 and stands at 0.43 percent in 2020-21. However, while comparing India's ARI[3] with other developing countries, there is a need to catch up with Brazil and China (ASTI, 2024; **Figure 2**).

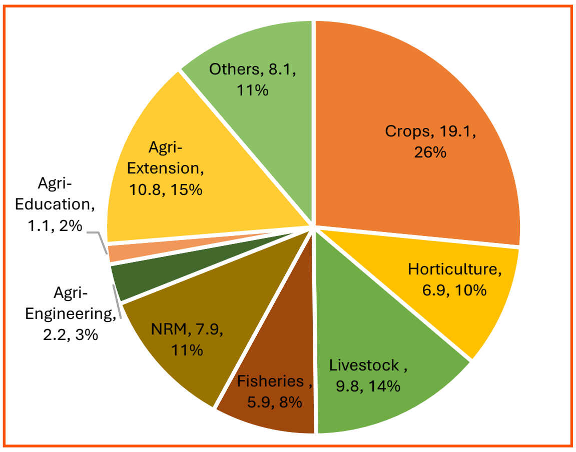
Figure 2: ARI in selected countries



Source: ASTI 2024

India's apex institute for agriculture research, the Indian Council of Agricultural Research (ICAR), under the Department of Agricultural Research and Education (DARE), reported an expenditure of Rs. 71.9 billion (USD 0.97 billion) in 2020-21 (ICAR, 2023) spread across its eight functional divisions (**Figure 3**).

Figure 3: ARDE of ICAR Divisions, 2020-21 (INR Billion)



Source: ICAR, 2023. NRM stands for Natural Resource Management.

Research and extension investments have been predominantly concentrated on crops (including horticulture), however, the returns on research investments are significantly higher in the livestock sector, yielding Rs 20.81 per unit of investment compared to Rs 11.69 in the crop sector (Kandpal et al., 2024), resulting in a skewed pattern of ARDE. It must be highlighted that, despite spending in natural resource management, accurately estimating the exact expenditure dedicated to climate resilience remains challenging as it is not bound by a single division within ICAR. However, the increasing negative externalities of input-intensive agriculture on natural resources and the growing threat of climate change underscore the need for greater allocation of resources toward research on

[1] Public Sector includes Central Government Ministries/Department, Public Sector/Joint sector industries, State Government and Higher Education.

[2] Private sector R&D reporting by DST is survey-based, which includes Private sector and Scientific & Industrial Research Organisations (SIRO).

[3] The difference between India's ARI presented earlier and by ASTI are mainly because ASTI's definition of agri-R&D excludes education and extension related expenditure.

natural resource conservation, climate adaptation and mitigation (ibid).

Recognizing the established importance of R&D, the Government of India has implemented various policies and programs to enhance climate resilience. Below is an overview of its major initiatives:

- National Action Plan on Climate Change (NAPCC): Launched in 2008, NAPCC outlines a strategy for adapting to climate change while enhancing the ecological sustainability of India's development. The NAPCC works through various missions (solar, enhanced energy efficiency, sustainable habitat, water, sustaining the Himalayan eco-system, green India, sustainable agriculture, strategic knowledge for climate change, coastal system, human health, and sustainable transport), focusing on climate change understanding, adaptation and mitigation, energy efficiency, and natural resource conservation.

- National Innovations in Climate Resilient Agriculture (NICRA): Launched in 2011, this project focuses on strategic research for adaptation and mitigation, demonstrating technologies in farmers' fields, and raising awareness among farmers and other stakeholders to minimize the impacts of climate change on agriculture. The key areas of strategic research include: (i) identifying the most vulnerable districts and regions, (ii) developing crop varieties and management practices for adaptation and mitigation (Box 1), and (iii) assessing the impacts of climate change on livestock, fisheries, and poultry, and formulating adaptation strategies.

  Pradhan Mantri Krishi Sinchayee Yojana (PMKSY): Launched in 2015-16, this initiative aims to improve physical access to water on farms, expand cultivable areas under assured irrigation, enhance on-farm water use efficiency, and promote sustainable water conservation practices. Administered by the Ministry of Jal Shakti, PMKSY is an umbrella scheme comprising two major components: the Accelerated Irrigation Benefit Programme and Har Khet Ko Pani, which includes command area development & water management; surface minor irrigation; repair, renovation, and restoration of water bodies; and groundwater development. The scheme also features the Per Drop More Crop component, supporting micro-level water storage and conservation activities.

- Agrometeorological Advisory Services (AAS) - Gramin Krishi Mausam Sewa (GKMS): The main objective is to collect and organize climate/weather, soil, and crop information, and to amalgamate them with weather forecasts to assist farmers in making decisions on day-to-day farm operations, which can further optimize the application of input resources at farm level during deficient rainfall situation and extreme weather events to reduce monetary loss and to maximize crop yield.

Box 1. Initiatives For Promoting Climate-Resilient Crops

Since 2014, the National Agricultural Research System under the aegis of the ICAR released 2,380 varieties of various field crops. Among these, 1,971 are climate-resilient varieties, including cereals (913), oilseeds (335), pulses (364), forage crops (106), fibre crops (189), sugarcane (54), and potential (underutilized) crops (10). These varieties exhibit tolerance to one or more biotic and/or abiotic stresses. Specifically, 429 field crop varieties demonstrate high tolerance to extreme abiotic stresses such as drought/moisture stress (240), waterlogging/submergence (72), salinity/alkalinity/sodic soils (58), heat stress (42), and cold/frost (17). Additionally, 487 varieties of horticultural crops have been released, including 22 climate-resilient varieties that are tolerant to high temperatures (6 varieties: 2 each of potato and tomato, 1 each of spinach and radish), drought (12 varieties: 4 of cassava, 3 of coconut, 2 of taro, and 1 each of greater yam, white yam, and sweet potato), water use efficiency (3 potato varieties), and salinity (1 cassava variety).

Table 1. Agri-R&D Expenditures for Promotion of Climate-Resilient Crops

Program/Scheme	Purpose	Expenditure	Duration
ICAR institutes (57)	To develop climate-resilient crop varieties and technologies to enhance the adaptive capacity of crops in response to global warming	INR 3,456.11 crores	2020-21 to 2023-24
NICRA	To develop climate-resilient varieties and technologies for various abiotic stresses	INR 219.98 crores	2019-20 to 2023-24
ICAR-Indian Agricultural Research Institutes National Phenomics Facility	To precisely screen materials for drought and heat tolerance for further use in breeding climate-resilient varieties	INR 43.83 crores	NA
ICAR	For genome editing research in rice	INR 6.71 crores	2018-22
ICAR-CRISPR Crop Network	For targeted improvement of stress tolerance, nutritional quality, and yield of crops using genome editing	INR 7.4 crores	2022-25
ICAR	For enhancing climate resilience and ensuring food security with Genome Editing tools for major field and horticultural crops	INR 500 crores	2023-26

Source: MoAFW, 2023

If so many varieties have been released that are climate resilient, the moot question that arises is: how come the El Nino in 2023 brought down agri-GDP growth to 1.4% in FY24 compared to 4.7% in FY23. We need some satisfactory answers to this. One plausible answer is that whatever has been done so far is not enough to protect Indian agriculture from extreme weather events or there is a serious lack of extension-related activities that might have otherwise aided in research moving from lab to land.

Way Forward

Despite numerous initiatives and increased expenditures on agricultural R&D, there is a pressing need to scale up these efforts for broader impacts, necessitating larger allocations of funds. Achieving this would require nearly doubling the current budgetary allocations for ARDE from the current Rs. 9,941 crores allocated to DARE within the next 2-3 years. The Committee on Agriculture (2014) has recommended a significant increase in research funding to "1 percent of the AgGDP" to improve the effectiveness and efficiency of agricultural research in India. To aid this increase in budgetary allocations, Gulati, Ferroni, and Zhou (2018) highlight that each rupee invested in ARDE yields a much higher return (11.2) compared to investments in fertilizer subsidies (0.88), power subsidies (0.79), education (0.97), or roads (1.10). Therefore, reallocating funds from fertilizer and power subsidies to agricultural R&D could significantly enhance food and nutritional security amidst climate change challenges. This requires smart re-purposing of existing policies, especially those related to input subsidies. Agricultural R&D has largely focused on research, but the benefits of this research may be limited without an effective extension system to deliver its outcomes, therefore, it becomes crucial to pair investments made in agriculture R&D with a focus on extension services.

References

- Ankita Kandpal, Pratap S Birthal, Shruti Mishra. (2024). From Research to Impact: Payoffs to Investment in Agricultural Research and Extension in India. ICAR-National Institute of Agricultural Economics and Policy Research, New Delhi.
- ASTI. (2024). ASTI (Agricultural Science and Technology Indicators) database. International Food Policy Research Institute (IFPRI). ASTI (cgiar.org)
- Committee on Agriculture. (2014). National Agricultural Research System: An Evaluation, 58th Report, 15th Lok Sabha, New Delhi: Lok Sabha Secretariat, The Parliament of the Republic of India. p.111.
- DST. (2023). Research & Development Statistics at a Glance. Department of Science & Technology. Government of India.
- Gulati, A., Ferroni, M. and Zhou, Y. (2018). Supporting Indian Farms, the Smart Way. Academic Foundation.
- ICAR. (2023). Indian Council for Agricultural Research. Budget Book. Ministry of Agriculture and Farmers Welfare.
- MoAFW. (2023). Rajya Sabha Unstarred Q. No. 1441: Initiative for Promotion of Climate Resilient Crops. Ministry of Agriculture and Farmers Welfare.
- MoEF&CC (2023). India's Third National Communication and Initial Adaptation Communication. Submitted to The United Nations Framework Convention on Climate Change (UNFCCC).
- MoES. (2020). Assessment of Climate Change over the Indian Region. https://doi.org/10.1007/978-981-15-4327-2.
- Rama Rao, C.A., Raju, B.M.K., Islam, A., Subba Rao, A.V.M., Rao, K.V., Ravindra Chary, G., Nagarjuna Kumar, R., Prabhakar, M., Sammi Reddy, K., Bhaskar, S. and Chaudhari, S.K. (2019). Risk and Vulnerability Assessment of Indian Agriculture to Climate Change, ICAR-CRIDA, Hyderabad.
- WMO. (2024). World Meteorological Organisation. State of Global Climate 2023.

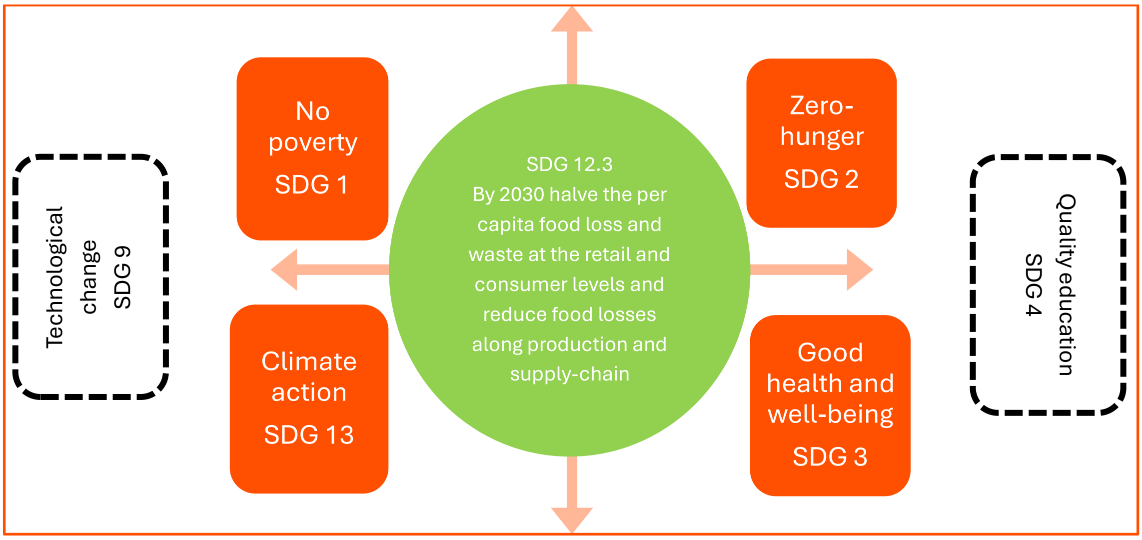
REDUCING POST-HARVEST LOSSES FOR SUSTAINABLE FOOD SYSTEM

Raya Das and Ashok Gulati

The global population is projected to reach 9.7 billion by 2050, further adding to global food security concerns (World Population Prospect, UN, 2022). This increase translates into 22.5 percent more human mouths to feed, alongside more equitable access to food. Hence, enhancing the efficiency of our food systems is imperative, and a critical strategy to achieve this is by minimizing post-harvest losses. Post-harvest loss is defined as loss of quantity and quality of food from harvest to consumption. Post-harvest losses have two components, the reduction of quantity and quality at earlier stages of production such as harvest, storage and transportation up to retail level is referred to as food loss. The food waste occurs at latter half of the supply chain at consumers, distributors, retailers end. According to FAO 2021, 13.2 percent of the world's food is lost from harvest to the retail stage. United Nations Environment Programme (UNEP) 2021 estimates 17 percent of food waste at the retail and consumer levels. Together, globally 30 percent of the food produced never reaches to human stomach (FAO, 2021). When food is lost or wasted, all the resources that were used to produce this food - including water, land, energy, labour, and capital - go to waste. Post-harvest loss is also estimated to account for 38 percent of total energy usage in the global food system (FAO, 2021).

Hence, United Nations Sustainable Development Goal (SDG) 12.3 aims to halve per capita global food waste and reduce food losses substantially by 2030. This goal impacts other food and nutrition sustainable development goals and climate action. To achieve reduction of food loss and waste it is required to achieve SDG 9 of technological and infrastructural development and SDG 4 of providing quality education (Figure 1). In this context, the present article focuses on the role of technology to reduce post-harvest losses for sustainable agriculture.

Figure 1. Reducing post-harvest loss and waste (FLW) for Sustainable Food System



Source: Compiled by authors

Extent of Post-harvest Losses in India and the Need for Technological Change

Developing countries face substantial food loss in the supply chain, while developed nations have significant food waste at the consumer end. In this context, the article delves into the challenges of food losses in India and the role of technological development to reduce post-harvest losses. In India due to limited farm mechanisation and weak logistics from storage to transportation to retail outlets, reducing post-harvest losses is a major challenge. Notably, it has been estimated by the latest all India post-harvest loss survey in India that approximately 12.5 MMT of cereals, 2.11 MMT of oilseeds, 1.37 MMT of pulses, 49.9 MMT of horticulture crops are lost in value-chain after harvesting and does not reach consumers (NABCONS, 2022). In economic value term, India still suffers a staggering loss of Rs. 1.53 trillion (USD 18.5 billion) annually during 2020 to 2022 due to post-harvest loss of crops and agri-allied produce.

While the available secondary source provides the quantity loss data, it is imperative to assess the quality losses of agriculture produce in value-chain and transform it in terms of quantity losses to get the right magnitude of losses. In this regard, our sample survey conducted in 2022 included both quality and quantity losses based on the survey of 1200 farmers in Punjab, Bihar and Madhya Pradesh for paddy, wheat, maize, and soybean (ICRIER-ADMI,2024[4]). Table 1 shows post-harvest losses in terms of both quantity and quality at farmer level and market level. At aggregate level, there is a significant variation of losses across different crops and states in case of paddy. Soybean exhibiting the highest loss percentage at 15.34 percent, followed by wheat at 7.87 percent, paddy at 6.37 percent, and maize at 5.95 percent.

Table 1: Aggregate post-harvest losses of the selected crops (in percent)

Stakeholders	Operations	Madhya Pradesh				Punjab	Bihar
		Wheat	Paddy	Maize	Soybean	Paddy	Paddy
Farmer level	Harvesting	3.93	2.61	1.73	5.97	2.81	1.88
	Threshing#	0.01	0.42	1.16	3.48	0.07	1.60
	Cleaning	0.30	0.25	0.46	0.59	0.21	0.36
	Drying	0.00	0.04	0.21	0.19	0.00	0.34
	Storage	0.39	0.43	0.50	0.66	0.00	0.96
	Transportation to mandi*	0.54	0.56	0.14	0.33	0.23	0.64
	Total loss (FL)	5.17	4.31	4.20	11.22	3.32	5.78
Market level	Storage	0.09	0.11	0.12	0.20	0.15	0.33
	Transportation	0.02	0.13	0.10	0.15	0.08	0.13
	Processing	0.00	0.46	0.12	0.19	0.51	0.40
	Wholesaler	0.24	0.27	0.22	0.24	0.20	0.22
	Retailer	0.21	0.13	0.18	0.19	0.08	0.09
	Total loss (ML)	0.43	1.10	0.74	0.97	1.02	1.17
Total quantity loss		**5.60**	**5.41**	**4.94**	**12.19**	**4.34**	**6.95**
Quality loss (in percent quantity)		**2.27**	**1.11**	**1.01**	**3.15**	**0.66**	**1.55**
Overall loss		**7.87**	**6.52**	**5.95**	**15.34**	**5**	**8.50**

Source: Gulati et al., 2024 ICRIER-ADMI Report

[4] The sample includes 600 paddy farmers, 200 each of wheat, maize, and soybean farmers, as well as 60 paddy, 20 each of maize and soybean, and 16 wheat market-level stakeholders, conducted in 2021-22. The ICRIER-ADMI survey encompasses 12 crop districts selected to capture diverse agricultural landscapes. In Punjab, Amritsar and Bhatinda are selected, each representing different agro-climatic zone. Similarly, in Bihar, Rohtas and Muzaffarpur are selected from different agro-ecological regions for paddy crop. In Madhya Pradesh, Raisen and Gwalior are surveyed for paddy and wheat, respectively, from varied agro-climatic conditions. Similarly, Ujjain, Bhopal, and Rajgarh are included for soybean, while Chhindwara and Rajgarh are surveyed for maize, representing different agro-ecological regions (Gulati et al., 2024).

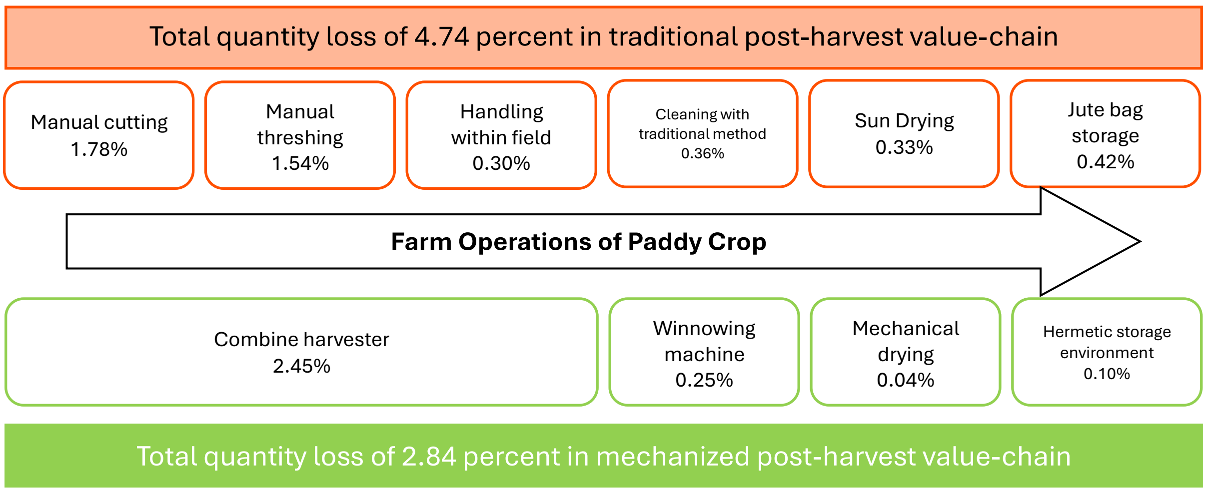
Farm Mechanisation and Post-harvest Losses in India

Significant drivers of post-harvest losses in India include poor handling mechanisms of farm produce between harvesting, storage, and distribution and lack of technological development. Due to large section of marginal and small farmers (less than 2 hectares of land) comprising 86 percent of total operational holdings, farm mechanisation is a major challenge in India. There has been an increase in tractor selling and mechanisation in India leading to higher productivity and cropping intensity. Net sown area per tractor declined from 487 ha. /tractor in 1975-76 to 18 ha. / tractor in 2019-20 as the usage of tractor drastically increased. However, there is regional variation in farm power availability, ranging from 6 kW per hectare in Punjab to 0.7 kW per hectare in Mizoram. The national average stands at 2.8 kW per hectare as of the 2020-21 level, while the Government of India had set a target of achieving 4 kW per hectare by 2022 (Bhandari et al., 2023).

Lack of farm mechanisation of agriculture leads to high post-harvest losses. At all India level, the level of agriculture mechanisation remains relatively low at 47 percent which is lower than China at 59.5 percent, Brazil at 75 percent, and United States at 95 percent (Standing Committee Report, August, 2022). If we assess the food losses in supply chain, harvesting and threshing comprise a distinct share of total food losses. For instance, according to NABCONS 2022, 87 percent of total 4.77 percent of food loss in paddy happens in the supply chain at farm level, within that 67 percent is harvesting and threshing losses. Addressing the specific challenges faced by farmers during initial stages of supply-chain is essential through mechanization for improving overall agricultural productivity and reducing post-harvest losses. For harvesting and threshing the mechanisation level for paddy crop is at 60 percent, wheat at 75 percent, maize and oilseeds at 30 percent at all India level (Standing Committee Report, 2022).

If we take the case of paddy, based on our survey, we estimated losses across traditional post-harvest value-chain vis-à-vis mechanized value chain (Figure 3). Total quantity loss is 4.74 percent in traditional value-chain at farmer level, while the post-harvest loss in paddy could be 2.84 percent if mechanized post-harvest value-chain has been followed.

Figure 3: Estimation of post-harvest losses at farm level and role of technological change



Source: ICRIER-ADMI survey on post-harvest losses, 2022

The survey of paddy farmers also show that 62.4 percent of paddy farmers used combine harvesters and the share is 97 percent in Punjab, vis-à-vis 10 percent in Bihar. Threshing is the process of removing paddy kernels or grains from panicles. Manual threshing after drying paddy by paddles result in significant losses.

In the agricultural development discourse in India, farm mechanization has predominantly centered on 'tractor-isation' (ICFA, 2017). However, to minimize losses, technological advancements are necessary across all farm operations. After threshing by traditional machinery or combine harvester, threshed paddy is separated from straws, husk, and chaff by winnowing or cleaning. In Punjab, 100 percent of agricultural households use mechanical winnowing, whereas in Bihar, only about 30 percent of agricultural households do so. Using winnowing machines results in lower winnowing losses, with an average loss of 0.21 percent in Punjab compared to 0.36 percent in Bihar. For drying, sun drying is the predominant method for paddy. The average post-harvest loss for sun-dried paddy in the selected study areas is 0.33 percent, while mechanical drying processes result in a minimal loss of 0.04 percent. Therefore, technological advancements throughout the value chain are essential to reducing post-harvest losses in India.

Policy Suggestions

1. **Increase usage of combine harvesters to reduce post-harvest losses**

To increase access to mechanization, the Government of India (GoI) has been providing incentives to marginal and small farmers under the centrally sponsored Sub Mission on Agricultural Mechanization (SMAM) since 2014. The budget allocation for SMAM was Rs. 1050 crores, with a revised allocation of Rs. 850 crores. Since the 2022-23 budget, the scheme has been merged with the Rashtriya Krishi Vikas Yojana (RKVY). Under the SMAM scheme, small and marginal farmers receive subsidies for purchasing agricultural machinery, including tractors, power tillers, combine harvesters, rice transplanters, and rotavators. Despite these efforts, the latest All India Debt and Investment Survey (AIDIS) 2019 reveals a lack of ownership of tractors and combine harvesters among small farmers. Only 4.4 percent of cultivator household own tractor and 5.3 percent own either power tiller, combine harvesters, laser land-levellers or threshers. The ‘Uberisation Model’ can increase the access to tractor without ownership among marginal and small farmers.

2. **Role of FPOs and Custom Hiring Centres**

In this context, Farmer Producer Organisations (FPOs) can play a key role in promoting group leasing arrangements for agricultural machinery including combine harvesters, mechanical and solar dryers through Custom Hiring Centres (CHCs) to reduce post-harvest losses. As of 2022, total 37,097 custom hiring centres have been established under SMAM, which means about 3395 small and marginal farmers per custom hiring centre, which needs to be scaled up to increase access to mechanisation.

3. **Promoting use of mechanical dryers**

Mechanical drying reduces the risk of mycotoxin contamination during storage and minimizes the presence of foreign matters compared to traditional sun drying. For example, studies in Bangladesh show that BAU-STR dryer use as a small-scale LPG or charcoal-fuelled dryer technology can reduce postharvest drying loss by 2.5-4 percent compared to traditional sun drying methods. Solar bubble dryers also showed effective results for smallholders in some contexts. A cost-benefit analysis by the International Rice

Research Institute found that Southeast Asian countries can reach a breakeven point if individual farmers use the dryer with two hectares of rice fields and two crops yearly.

4. The Road to increase storage capacity at grass-root level through Primary Agriculture Cooperatives (PACs)

In 2020, the GoI introduced the Agriculture Investment Fund to bolster post-harvest technological advancements. This initiative supports FPOs by offering a 3 percent interest subvention for infrastructure investments. On May 31, 2023, the Union Cabinet approved the construction of warehouses for agricultural produce through PACS. These warehouses will also function as CHCs, processing units, and Fair Price Shops (FPS).

In February 2024, the Prime Minister of India launched what is being hailed as the 'World's largest grain storage plan in the cooperative sector.' This initiative is a key component of a larger strategy to modernize India's agricultural system, an essential step toward achieving *Viksit Bharat*. The plan aims to expand storage capacity by 70 MMT and requires an estimated investment of Rs. 1.25 trillion (approximately USD 15.09 billion) over the next five years. This initiative has the potential to significantly reduce post-harvest storage losses at the grassroots level.

References

- AIDIS (2019). All India Debt and Investment Survey. NSS 77th Round. MoSPI. GoI
- Bhandari et al. (2023). Making India a Global Power House in the Farm Machinery Industry. NCAER Policy Brief, No.1.
- FAO (2021). Food Loss and Waste Database. Retrieved from Food Loss and Waste Database | Technical Platform on the Measurement and Reduction of Food Loss and Waste | Food and Agriculture Organization of the United Nations (fao.org)
- Gulati, A., Das, R., Winter-Nelson, A (2024). Reducing Post-Harvest Losses in India: Farmer Level Interventions and Grain Management Strategies. ICRIER-ADMI Report. (Edited)
  - Jena, P.C., Das, R., Gulati, A, Winter-Nelson, A (2024). Estimating Harvest and Post-harvest Losses of Wheat, Paddy, Maize, and Soybean in India: A study based on survey in Madhya Pradesh, Punjab, and Bihar (Part-1).
  - Das, R., Gupta, S., Gulati, A., Winter-Nelson, A (2024). Assessment of Post-Harvest Grain Management System of FCI and Effectiveness of Private Warehouses to Reduce Food Loss in India (Part-2).
- Indian Council of Food and Agriculture (ICFA) (2017). *Farm Mechanisation*. National Round Table Conference Report.
- NABCONS (2022). Study to determine post-harvest losses of agri-produces in India. MOFPI. GOI. Study_report_of_post_harvest_losses.pdf (mofpi.gov.in)
- Standing Committee Report (2023). Research and Development in Farm Machinery for Small and Marginal Farmers in the Country, 58th Report, Lok Sabha Secretariat, New Delhi.
- United Nations, Department of Economic and Social Affairs. (2022). World Population Prospects 2022: Highlights. New York: United Nations.
- United Nations Environment Programme. (2021). Food Waste Index Report- 2021. Nairobi: UNEP. Retrieved from https://www.unep.org/resources/report/unep-food-waste-index-report-2021

PRODUCE MORE FROM LESS: ROLE OF PRECISION AGRICULTURAL TECHNOLOGIES

Ritika Juneja and Ashok Gulati

Introduction

With India's population projected to reach 1.67 billion by 2050 (United Nations, 2022), the agricultural sector faces the formidable challenge of feeding a burgeoning population given the limited resources, climate change and environmental degradation. The OECD/FAO Agricultural Outlook predicts a 5 percent annual rise in per-capita incomes in India over the decade 2023-2032, driving up demand for high-value agricultural commodities such as meat, fish, dairy, fruits, and vegetables. This dual pressure of population growth and rising demand underscores the urgency for agricultural innovation, focusing on sustainable practices that enhance productivity while conserving resources. Future of agriculture in India necessitates integrating traditional farming methods with advanced technologies like micro irrigation (MI), sensors, drones, internet of things (IoTs), and artificial intelligence (AI) for precision farming. This transformation, already advancing in the USA, China, and Europe, epitomizes what Howard Graham Buffett terms the "Brown Revolution."

This article offers insights into the recent developments in various precision agricultural technologies in India. It specifically highlights micro irrigation as a crucial strategy to produce more from less. The discussion delves into how these technologies not only boost crop productivity but also aid in conserving resources and reducing environmental impact.

Precision Agricultural Technologies

1. **Micro irrigation**, characterized by its efficient water use and targeted nutrient delivery, is highlighted as a key component precision farming

practices aimed at maximizing yield per unit of resources employed. Under the "Per Drop More Crop" (PDMC) component of the *Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)*, government provides financial assistance[5] to small and marginal farmers up to 55 percent, and to other farmers' up to 45 percent for the installation of micro irrigation system. The funding is shared between the Central and the State Governments in the ratio of 60:40. However, for North Eastern and Himalayan states sharing ratio is 90:10, and for Union Territories full funding is from the Central Government. In the Financial Year 2022-23, a budget of Rs 4043.38 crore has been earmarked for the MI Scheme.

MI in India covers 16.6 million hectares as on June 2022 (MoA&FW, 2021; Soman, 2023), where drip irrigation accounts for 48 percent of the area and sprinkler accounts for the remaining 52 percent area. However, as a percentage of the net irrigated area, penetration of MI is only 21.3 percent, which is lower than the global average of 28.4 percent, and much lower than countries such as Israel (99.6 per cent), Brazil (77.3 percent), South Africa (77 percent), the USA (68.6 percent), France (57 percent) and Russia (56.6 percent) (ICID. CIID, 2021).

[5] The subsidy payable to the beneficiary will be limited to an overall ceiling of 5 hectare per beneficiary.

Benefit-cost analysis of micro-irrigation: The benefits of micro-irrigation pertain to improving water use efficiency to 80-95 percent, much above that achieved by flood irrigation (30-50 percent). Further, an evaluation study of the adoption of MI technology by sample farmers across states reports that owing to a reduction (saving) in the quantity of irrigation water applied, there is resultant saving in energy (electricity/diesel/solar) needed to pump irrigation water of about 38 percent. In addition to this, due to an improvement in the efficiency of water and fertiliser use, a significant yield improvement has also been recorded in most crops under micro-irrigation.

Benefits from the adoption of micro-irrigation technology as estimated in an impact evaluation study on NMMI (June, 2014)

Benefits	% saving (reduction) or enhancement, as applicable
Power saving	38
Fertilizer saving	28
Yield enhancement	42.34 (Fruits); 52.8 (Vegetables)
Irrigation cost reduction	32.3
Increase in irrigated area	8.41
Increase in Farmers' Income	48.5

The micro-irrigation systems showed a favourable benefit-cost (BC) ratio exceeding 1 across various crops and states in the NMMI evaluation study, both with and without subsidy. In Maharashtra, an ICRIER study by Gulati & Mohan (2018) found that the BC ratio for drip technology in sugarcane was consistently above one with and even without subsidy, except in cases where initial costs were nearly double the prescribed government installation costs (DoAC&FW, 2017), and farmers relied on unsubsidized loans. The study also revealed a payback period of less than three and a half years in all cases where the BC ratio exceeded 1, underscoring the economic viability and income-enhancing potential of adopting micro-irrigation systems. Shroff and Miglani (2024) estimated that drip investment is economically viable for farmers (i.e., BC ratio >1) growing commercial crops such as Banana, Sugarcane and Cotton in Maharashtra with and without subsidy. Furthermore, annual NPW estimation indicates that sugarcane and banana farmers can fully offset the capital cost of drip system in the first year, even without subsidy. Whereas, cotton farmers would require three years to recover the capital cost without any subsidy.

BC Ratio	Sugarcane	Banana	Cotton
With Subsidy	2.44	2.17	1.31
Without Subsidy	2.26	2.07	1.15

Source: Shroff, S. and Miglani, V. (2024)

Narayanamoorthy at. Al., (2018) estimated that BC ratio of drip irrigation in vegetable crops (brinjal in this case) in Tamil Nadu is quite attractive (4.36 to 4.64 without subsidy, and marginally higher 4.7 to 4.85 with subsidy),

making it a viable option for sustainable management of irrigation water.

Jain Irrigation Systems Ltd. also demonstrates drip irrigation pilots for paddy in Karnal (Haryana) and Tamil Nadu, and for sugarcane in Maharashtra, Karnataka, and Andhra Pradesh (Gulati and Mohan, 2018). Results reveal that while flood irrigation requires 3,065 litres of water to produce 1 kg of paddy (at a yield of 7.75 t/ha), drip irrigation reduces this to just 842 litres[6]. Moreover, drip paddy consumed only 565 units/ha of power against 1167.5 units/ha consumed in the flood-irrigated paddy. Overall, adopting micro irrigation can result in a significant 30 – 40 percent increase in crop yields, while conserving up to 40 percent of water and saving energy across various crops (Soman, 2023) and (IAI, 2023).

2. **Artificial Intelligence (AI)**, combined with sensor technology and IoT, holds tremendous potential to advance precision agriculture in India. The Central Government is actively promoting AI through partnerships such as IBM's Watson Decision Platform, initiating AI-driven crop yield prediction models across 10 districts in Assam, Bihar, Jharkhand, Madhya Pradesh, Maharashtra, Rajasthan, and Uttar Pradesh. Additionally, in collaboration with Microsoft, the government aims to empower small-holder farmers with AI sensors to enhance crop yields and helping them to make informed decisions (INDIAai, 2024). The World Economic Forum's AI for Agriculture Innovation (AI4AI) initiative is also playing a significant role in India's agricultural transformation. Through initiatives like the *'Saagu Baagu'* pilot in Telangana's Khammam district, over 7,000 chilli farmers have reported notable improvements: a 21 percent increase in yields per acre, 9 percent reduction in pesticide use, 5 percent decrease in fertilizer use, and an 8 percent increase in unit prices due to enhanced quality. Consequently, farmers have seen their incomes rise by more than Rs 66,000 per acre per crop cycle. In October 2023, recognizing its success, the Telangana government expanded the *Saagu Baagu* project to encompass 500,000 farmers across ten districts, focusing on five key crops (World Economic Forum, 2024).

3. **Unmanned aerial vehicles (UAVs) or drones**, equipped with geographic information systems (GIS), sensors, and AI, traditionally used in security, warfare, and disaster management, are now rapidly gaining prominence in Indian agriculture. According to PwC (2022) agricultural drone usage in India is projected to grow at a compound annual growth rate (CAGR) of 38.5 percent, reaching a market value of USD 121.43 million by 2030. In Thettelapadu village, Khammam district, Telangana, a forward-thinking farmer reported significant savings by using drones to spray fertilizer and pesticides worth Rs 3 lakhs on a 10-acre chili farm—saving up to Rs 1 lakh on labour costs and Rs 9,000 on pesticides annually (Sudhir, 2024). Recognizing drones as pivotal for the future of Indian agriculture, initiatives like Kisan drones and Public-Private Partnerships (PPPs) for advanced farming services have been promoted. Farmer Producer Organizations (FPOs), farmer cooperatives, and state institutions can receive grants covering up to 75 percent of the costs for drone demonstrations in agricultural fields. Additionally, implementing agencies have allocated a contingency expenditure of Rs

[6] Data obtained from the field visit to Karnal, Haryana. Also, reported by Gulati & Juneja (2021)

6,000 per hectare for drone hiring. In November 2023, the Prime Minister launched the *'Namo Drone Didi'* Scheme under the *'Sashakt Nari-Viksit Bharat'* program. This initiative aims to provide drones to 15,000 selected Women Self-Help Groups (SHGs) between 2023-24 and 2025-26, offering rental services to farmers for agricultural purposes. The scheme has budgeted Rs 500 crores for FY 2024-25 (Ministry of Finance, 2024).

As formal data on the benefits and costs of AI and Drones is lacking, this article concentrates solely on describing the precision technologies and outlining government financial support. Conducting BC analysis remains an area for future research.

Way Forward

Looking ahead, precision agriculture technologies hold the potential to revolutionize the agriculture sector provided they are economically viable even without government subsidy. However, their adoption among farmers remains sluggish. Studies cite reasons such as high initial investment costs, delays in subsidy disbursement due to fund shortages in some states, and small and scattered agricultural landholdings, etc. There is a critical need for a comprehensive review of implementation processes and strategies. Additionally, both central and state governments should adopt rational pricing strategies for inputs like water, reflecting its long-term scarcity. Moving away from free or heavily subsidized provisions, governments could consider cash transfers based on per-hectare usage, deemed more sustainable financially and environmentally. Furthermore, the development of trained personnel is crucial to fully harness the potential of these technologies. Farmers and technology operators play essential roles in driving this transformative change. It remains intriguing to observe future developments and assess the long-term effectiveness of precision technology applications in agriculture.

References

- DoAC&FW. (2017). National Mission on Sustainable Agriculture - Operational Guidelines. New Delhi: Department of Agriculture Cooperation & Farmers Welfare (DoAC&FW), Ministry of Agriculture, Government of India.
- Gulati, A., & Juneja, R. (2021, March 29). Make every drop of water count for sustainable agriculture. The Indian Express.
- Gulati, A., & Mohan, G. (2018). Towards sustainable, productive, and profitable agriculture: Case of Rice and Sugarcane. New Delhi: Indian Council for Research on International Economic Relations (ICRIER) Working Paper No. 358.
- ICID. CIID (2021) Database. Accessed from International Commission on Irrigation & Drainage. Commission Interationale des Irrigation et du Drainage
- INDIAai. (2024). AI among 5 MoUs signed by Agriculture Ministry to modernize agriculture. INDIAai.
- Irrigation Association of India (IAI). 2023.
- MOA&FW. 2021. Ministry of Agriculture and Farmers Welfare. Report June 2021. Government of India.
- Ministry of Finance. (2024). Union Budget. Government of India.
- Narayanamoorthy, A., Bhattaraib, M., Jothi P. (2018). An assessment of the economic impact of drip irrigation in vegetable production in India. Agricultural Economics Research Review 2018, 31 (1), 105-112. DOI: 10.5958/0974-0279.2018.00010.1
- NHB. (2024, June 12). Development of Commercial Horticulture through Production and Post-Harvest Management.

Retrieved from nhb.gov.in: https://nhb.gov.in/schemes/subsidy-claim-guidelines.html

- NMMI. (2014). Impact Evaluation Study Report on National Mission on Micro Irrigation (NMMI). Report submitted by Global Agri System to Ministry of Agriculture. Government of India
- OECD/FAO. (2023). OECD-FAO Agricultural Outlook 2023-2032. OECD Publishing, Paris, https://doi.org/10.1787/08801ab7-en.
- PwC. (2022). Redefining agriculture through artificial intelligence: Predicting the unpredictable. PwC.
- Shroff, S. and Miglani, V. (2024). Water-saving and Economic Gains of Micro Irrigation Adoption Scheme "Per Drop More Crop": A Case of Sugarcane, Banana and Cotton Cultivation in Maharashtra. Econ. Aff., 69(01): 487-502
- Soman, P. (2023, April). Role of Micro irrigation in producing more with less. International Journal of Irrigation and Water Management, 10(4), 001-022. Retrieved June 24, 2024, from www.internationalscholarsjournals.org
- Sudhir, S. (2024, February 25). New horizons: Drones take flight over Indian farms. The Deccan Herald.
- United Nations. (2022). UN World Population Prospects 2022. Probabilistic Population Projections based on the World Population Prospects 2022. Retrieved from http://population.un.org/wpp/
- World Economic Forum. (2024, April 29). AI for agriculture: How Indian farmers are harvesting innovation. Impact.

SEEDING THE INNOVATION BY PRIVATE SECTOR

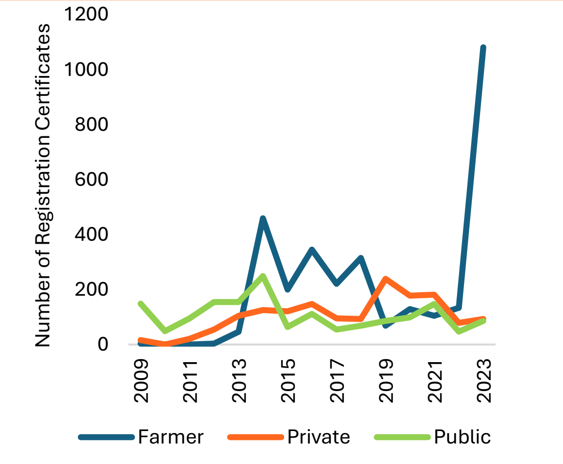
Reena Singh and Ashok Gulati

Seeds play a foundational role in improving food security and nutrition, supporting the livelihoods of farmers and rural communities, and contributing to sustainable resource use and climate change adaptation and mitigation. Initially, the Indian seed sector was dominated by the public institutions that include National and State Seed Corporations, Public Sector Undertakings, National Agricultural Research Education and Extension System including ICAR-Research Institutes and Central and State Agricultural Universities (SAUs). After the introduction of 'New Policy on Seed Development, 1988, the private seed sector growth got accelerated, involving both national and multinational seed companies. In 2020, the Indian seed industry was valued at USD 3.6 billion (TAAS-ISST 2020) and has emerged as the fifth largest seed market across the globe. Private seed sector companies adopt innovation and uniqueness to capture or protect market shares and makes substantial investment in R&D at their end. This article analyses the sources of innovation by private players in seeds. To measure innovation, we used four primary sources: (1) Registration of plant variety protection certificates; (2) Biotech (Bt)-genes and transgenic cotton hybrids; (3) Patent landscaping of crop biotechnology; and (4) expenditure data.

1. Trends of Registered Varieties/Hybrids

India as a member of World Trade Organisation (WTO) and signatory to the Trade- Related Aspects of Intellectual Property Rights (TRIPS) enacted the 'Protection of Plant Varieties and Farmers' (PPV&FR) Rights Act, 2001'. PPV&FR Authority facilitate registration of New Varieties, Essentially Derived Varieties[7] (EDV), Extant Varieties[8] notified under the Seeds Act, 1966, Extant variety about which there is common knowledge (VCK) and Farmers' varieties[9]. Analysis of the data from 2009-2023 indicates that a total of 6272 registration certificates were issued for varieties of notified crop species. Of these, 1616 registration certificates (comprising share of 26 percent) were issued to public research organizations/SAUs, 1548 (comprising share of 25 percent) to private seed companies and 3108 (comprising share of 49 percent) to individual farmer/farming community (**Table 1**). The number of CoRs issued to private sector were highest during 2019-2021 (during covid period) (**Figure 1**).

Figure 1: Year-wise CoRs Issued to Private and Public Sector: 2009-2021



Source: Authors compilation from PPVFRA, MoAFW

[7] Essentially Derived Variety (EDV) is a variety which is predominantly derived from another variety (protected or otherwise) and conforms to the initial variety in all aspects except for the differences which result from the act of derivation, and is distinguishable from initial variety

[8] Extant variety means a variety which is notified under section 5 of the Seeds Act, 1966 (54 of 1966); or a farmers' variety; or a variety about which there is common knowledge; or any other variety which is in the public domain.

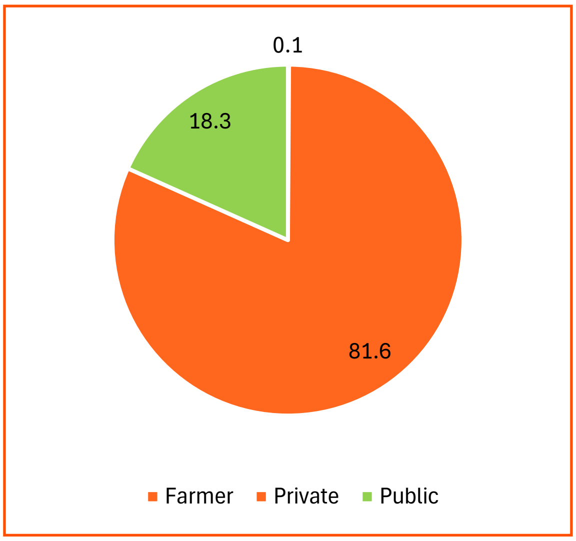
[9] Farmers' Variety means a variety which has been traditionally cultivated and evolved by the farmers in their fields; or is a wild relative or land race of a variety about which the farmers possess the common knowledge;

Table 1: Certificate of Registrations (CoR) Issued by PPV&FR Authority (2009-2023)

Category	Type of Variety	Grand-Total
Farmer	Farmer	3108
	New	1
	Sub-Total Farmer	3108
Private	EDV	14
	Extant (Notified)	99
	Extant (VCK)	639
	New	796
	Sub-Total Private	1548
Public	Extant (Notified)	1369
	Extant (VCK)	68
	New	179
	Sub-Total Public	1616
Grand-Total	Farmer+Private+Public	6272

Source: PPVFRA, MoAFW

Figure 2: Percent Share of private and public sector among new varieties issued CoR during 2009-2023



Source: Authors compilation from PPVFRA, MoAFW

It was very interesting to note that though the private sector contributed to 25 percent of the total varieties issued CoR, its share in new varieties was 81.6 percent (Figure 2). It reflected the general trend in the growth of the Indian seed sector wherein private seed companies have been bringing more innovations in the form of new varieties, hybrids, and proprietary technologies in the last two decades.

Analysis of latest five years' data of 2019-2023 indicate that the major growth drivers of seed industry in India are the maize hybrids, Bt cotton hybrids, hybrid pearl millet, hybrid rice and hybrid vegetables (cauliflower, brinjal, okra, tomato) developed by the private sector (PPVFRA).

2. Trends of Biotech genes and transgenic cotton hybrids

In India all Genetically Modified Organisms (GMOs) including Genetically Engineered (GM) plants are regulated under the Environment (Protection) Act,1986. Bt[10] cotton is the only commercially approved GM Crop in India. Transgenic cotton hybrids and new genes are required to be registered with the biosafety authority. In 2002 the first Bt gene cry 1 Ac (MON 531Event) and three hybrids were approved for commercialization and marketed through Mahyco (in joint venture with

[10] Bt stands for *Bacillus thuringiensis*, the bacteria that produces crystal shaped protein (Cry toxin) that specifically kills certain insects when ingested but is not toxic to humans or other mammals

Monsanto). In 2006, new Bt genes began appearing. The total area under Bt cotton has increased from 0.05 million hectares in 2002 to 11.4 million hectares in 2017. Bt cotton is cultivated in more than 90 percent of the area under cotton cultivation in India (MoEFCC-BCIL 2019). Several private sector institutions are involved in the research and development of GM crops in India.

3. Trends of Patents

Indian Intellectual Property (IP) laws make it clear that seeds and plants or parts thereof cannot be patented. Patent-landscaping trends of crop biotechnologies has the potential implications for Indian seed industry. Multi-National Companies (MNCs) dominate patent landscaping in crop biotechnology sector. The crop traits for patents included abiotic stress tolerance, yield-related, nutritional enhancement, plant growth characteristics, biotic stress/disease tolerance, herbicide tolerance, insect/pest resistance, altered oil content, altered composition, plant architecture, nitrogen use efficiency, plant biomass, agronomic characteristics, water use efficiency, RNA interference, seed-related characteristics, drought tolerance, salinity tolerance, male sterility, expression of enzymes, products of pharma/ agro/ therapeutic/ commercial attributes, plant breeding techniques, various molecules (Menon et al. 2015). It is, however, important to note that the patents by MNCs mainly reflect research undertaken outside of India and brought in through local subsidiaries and partners.

4. Private Sector R&D Expenditure

The seed industry has Government of India (DSIR) recognized research and development (R&D) departments which encourages in-house R&D and has resulted in a large number of private research varieties and hybrids. Globally, the average spent by private sector seed companies on R&D ranged between 10-12 percent of revenue, whereas in India it amounted to approximately 3 percent (FSII 2022).

R&D Expenditure in Nirmal Seeds (Case Study)

Nirmal Seeds Pvt. Ltd. (NSPL) was established in 1988 at Maharashtra, India. The company has registered/released 88 new varieties/hybrids, has 49 CoRs and two patents on its credit. In last three years, it has employed 67 R&D personnel. The data on R&D expenditure for three years (2019-2022) indicates that the company spend approximately 2 percent of its revenue on R&D.

Financial Year	R&D Expenditure (in INR Lakhs)	Turn-Over (in INR Lakhs)	% of R&D Expenditure
2019-20	483.43	24,486.59	1.97
2020-21	440.43	25,916.64	1.70
2021-22	517.03	25,220.13	2.05

Source: Nirmal Seeds Private Limited

5. Conclusions

Crop improvement research is driven in some crop by public research but the role of private sector in seed research has grown multifold in the last two decades. The seed industry can become globally competitive, self-reliant and export-oriented, particularly for several Asian and African countries, which share similar agro-climatic conditions like India. The recent year's export data (International Seed Federation) reveals that India's export share has increased slowly from 0.64 percent in 2014 to 1.22 percent in 2019, and then small decline to 1.14 in 2020. In order to boost the export of seeds, export incentives can be considered for seed industry in order to compete with other major exporters. Performance linked incentives (PLI) for R&D can also be considered for private sector to encourage them to increase research investments from current 3 percent.

References

- FSII (2022). Federation of Seed Industry of India (FSII) recommendations for policy support - NAAS workshop Dec 2022
- GEAC. Genetic Engineering Appraisal Committee, Ministry of Environment, Forest, and Climate Change (MoEFCC), Government of India. http://www.geacindia.gov.in/index.aspx (accessed on 17th June 2024).
- Menon S, Jha SK, and Jain K (2015). Patent landscape analysis for crop biotechnology in India. Int. J. Intellectual Property Management, Vol. 8, Nos. 3/4, 2015.
- MoEFCC-BCIL (2019). Handbook for Seed Inspectors: Genetically modified Seeds and Regulations. Prepared by Ministry of Environment Forests and Climate Change (MoEFCC) in association with Biotech Consortium India Limited (BCIL).
- PPVFRA. Protection of Plant Varieties and Farmers Rights Authority (PPVFRA), Department of Agriculture & Farmers Welfare, Ministry of Agriculture & Farmers Welfare (MoAFW), Government of India. https://plantauthority.gov.in/ (accessed on 18th June 2024).
- TAAS-ISST (2020). Stakeholders Dialogue on Way Forward for the Indian Seed Sector- A Road Map. Published by Trust for Advancement of Agricultural Sciences (TAAS) and The Indian Society of Seed Technology (ISST).

APSI IN THE FIELD

1. Field Visit to Punjab & Haryana (May 2024)

Farmers Agri Mart, Punjab

Focus Group Discussion at Guava

Agro-forestry Farmer, Punjab

Greenhouse cultivation of Cucumber,

By engaging with diverse stakeholders, we sought to align efforts and foster collaboration to promote sustainable agricultural practices that address the pressing issues of climate change and environmental impact in the region.

Field visits were conducted with high-value horticulture farmers to gain insights into their practices and challenges. In addition, stakeholder consultations were held to build consensus among key entities, including the Punjab Development Commission, Punjab Agriculture University, and the Departments of Agriculture of both Punjab and Haryana. These interactions aimed to thoroughly understand the current and future agricultural initiatives in these states, with a particular focus on environmental sustainability and climate change adaptation strategies.

Tour Team: Dr. Ashok Gulati, Dr. Reena Singh, Ms. Ritika Juneja, and Ms. Purvi Thangaraj

2. Field Visit to Mahyco Pvt. Ltd., Maharashtra (June 2024)

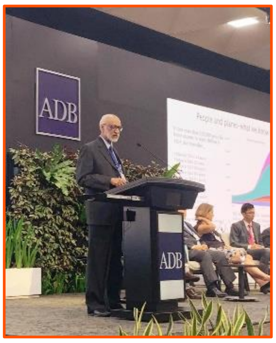
Technology Lab Visits at Mahyco Pvt. Ltd. And Groww Indigo Pvt. Ltd.

Focus group discussion with Farmers in Jalna District, Aurangabad, Maharashtra

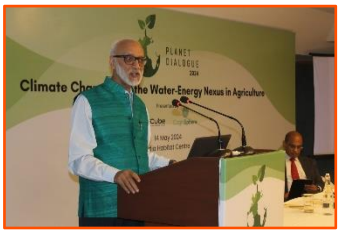
We observed the field trials, technology labs, and farming practices firsthand. The purpose of this visit was to gain a comprehensive understanding of the role of agriculture research and development, and the importance of innovations in critical agricultural inputs in promoting environmental sustainability. This visit provided valuable insights into the innovative approaches and best practices employed by Mahyco, contributing to the broader goal of developing sustainable and climate-resilient agricultural systems.

Tour Team: Dr. Ashok Gulati, Dr. Reena Singh, and Ms. Purvi Thangaraj

Conference / Workshop



- Speaker at the Session "Public and Private Partnerships in Agri-Food Systems Transformation" and the "Deep Dive Session on Asia's Rice Market, Food Security Challenges and Policy Responses" at the Asia and the Pacific Food Security Forum 2024, 9-12th April, 2024, organised by Asian Development Bank (ADB), Manila, Philippines.
- Delivered a Lecture at the 78th Business Plan Meet organised by the NABARD, Kovalam, Thiruvananthapuram, Kerala, 23rd April, 2024.



- Keynote Speaker at the Planet Dialogue 2024 on "Climate Change and Water-Energy Nexus in Agriculture", organised by Cognisphere at India Habitat Centre, 14th May, 2024.

- Singh, Reena invited as Speaker at the virtual Webinar "No Farm, No Food: The Interconnections between Agriculture and Climate" organised by AgFoodTech Connect, 5th June, 2024.

- Roundtable on Taming Wheat and Rice Inflation, organised by ICRIER, on June 5, 2024, New Delhi
- Participated in the Pre-Budget Consultation Meeting for the Union Budget 2024-25 under the Chairmanship of Hon'ble Finance Minister, Smt. Nirmala Sitharaman, 21st June, 2024, New Delhi
- Keynote Speaker at the National Workshop on Unleashing India's Agribusiness Potential through Innovative Agri Value Chain Financing organised by the Ministry of Agriculture and Farmers' Welfare, Government of India, New Delhi, 27th June, 2024.

Publications

Book Review / Report:

- Singh, Reena (April 24, 2024): **Them and Us**, book review published in the Financial Express
- Gulati, Ashok, Raya Das, and Alex Winter – Nelson: "**Reducing Post-Harvest Losses in India: Farmer-Level Interventions and Grain Management Strategies**", ICRIER and ADMI, published in May, 2024.

Journal Article / Policy Brief:

- Gulati, Ashok, Ranjana Roy, Ritika Juneja and Manish Kr. Prasad: "**A New Deal for Agriculture Towards Viksit Bharat @2047**", Economic and Political Weekly, Vol. 59, Issue 15, published on 12th April, 2024.
- Gulati, Ashok, Raya Das, and Alex Winter – Nelson: "**Reducing Post-Harvest Losses in Indian Agriculture- A Case Study of Selected Crops**" Policy Brief No. 20, ICRIER and ADMI, published in April, 2024.
- Jose, Shyma and Ashok Gulati: "**Prospects of India's Demand and Supply for Agricultural commodities towards 2030**" article published in the Research Chronicle by NABARD, published in April, 2024.

Op-Eds

- Gulati, Ashok (April 01, 2024): "**Viksit must be inclusive**", The Indian Express, also published in the Financial Express under the title "**Agriculture in Viksit Bharat**".
- Das, Raya and Ranjana Roy (April 02, 2024): "**A quandary called the MSP**" The Telegraph Online.
- Gulati, Ashok, Ritika Juneja and Purvi Thangaraj (April 15, 2024): "**Food for Reform**" The Indian Express, also published in the Financial Express under the title "**Food Systems under Modi 3.0**".
- Gulati, Ashok (April 29, 2024): "**Healing the Soil**", The Indian Express, also published in the Financial Express under the title "**India and the Earth Day**".
- Gulati, Ashok, and Ritika Juneja (May 13, 2024): "**Make it Farmer Friendly**" The Indian Express, also published in the Financial Express under the title "**sluggish agri exports**".
- Singh, Reena (May 20, 2024): "**Feeding India amid climate fight**", The Financial Express.
- Gulati, Ashok, and Ritika Juneja (May 27, 2024): "**A to-do list for inflation**" The Indian Express, also published in the Financial Express under the title "**Taming Food Inflation**".
- Mehra, Puja (May 27, 2024): "**Questions on the economy that BJP and Congress must answer**, Live Mint
- Gulati, Ashok (June 10, 2024): "**The message from rural India**", The Indian Express, also published in the Financial Express under the title "**A message from rural voters**".
- Singh, Reena (June 14, 2024): "**It would be difficult to feed India if our Climate Goals are not met**", The Wire.
- Gulati, Ashok (June 24, 2024): "**Filling the void in farms**", The Indian Express, also published in the Financial Express under the title "**Rebooting Agriculture**".

Media Interviews / Podcasts

- Gulati, Ashok (May 12, 2024): Agri Round-up with Ashok Gulati: **Performance over the past ten years and manifesto promises for the future**, ICRIER
- Gulati, Ashok (June 8, 2024): Agri Round-up with Ashok Gulati: **The rural distress and how to end it**, ICRIER
- Gulati, Ashok (June 25, 2024): Interview on the topic "**Challenge is maintaining good prices for farmers**" with Business Standard.

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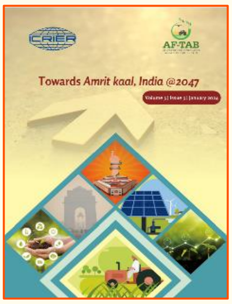

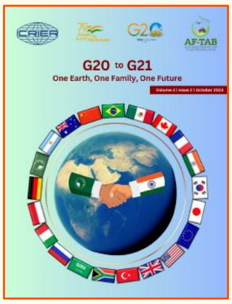

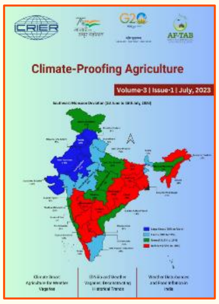

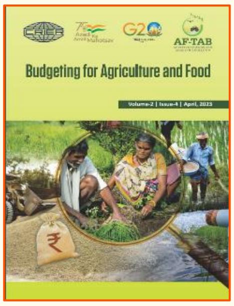

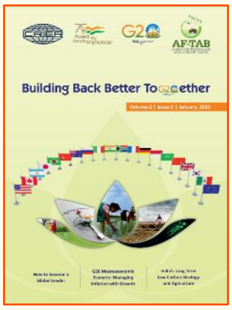

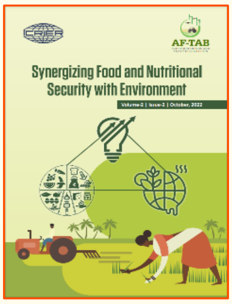

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