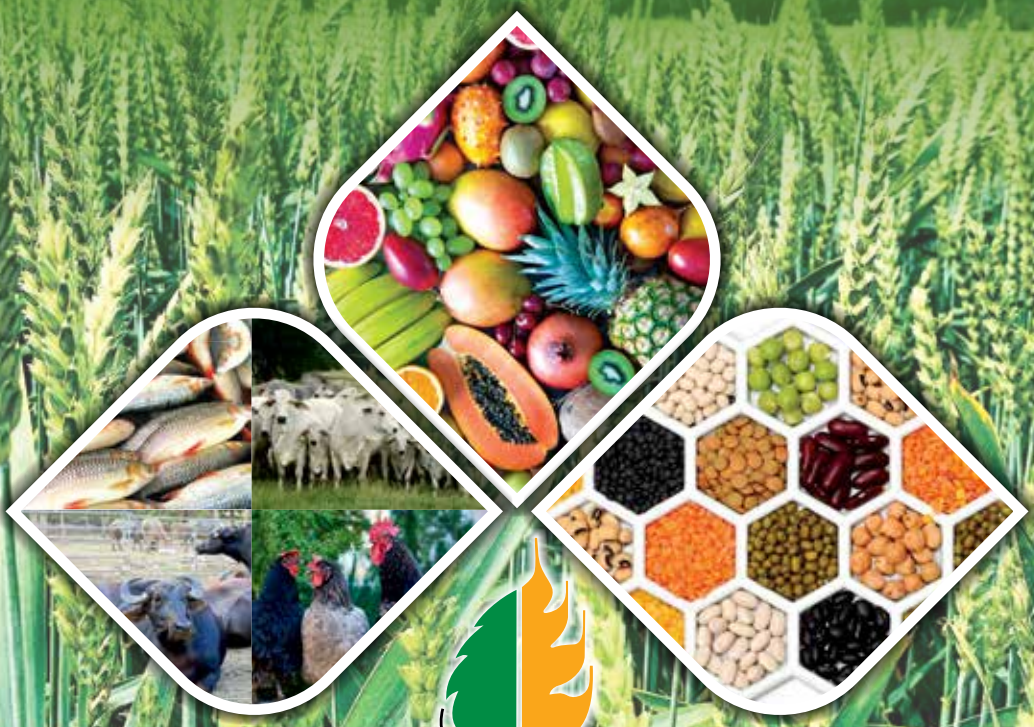
State of Indian Agriculture

Anjani Kumar and Himanshu Pathak



National Academy of Agricultural Sciences
New Delhi

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Citation:

Kumar A and Pathak H (2024). ***State of Indian Agriculture***. National Academy of Agricultural Sciences, New Delhi, p 95.

Published by:

National Academy of Agricultural Sciences
NASC Complex, Dev Prakash Shastri Marg
P.O. Pusa, New Delhi - 110 012, India
Email: naas-mail@naas.org.in

2024

ISBN: 978-81-931524-6-1

Printed at:

Malhotra Publishing House
B-6, DSIDC Complex, Kirti Nagar, New Delhi - 110020
Ph.: 011-41420246; Email: vinay.malhotra@gmail.com

About the Authors

Dr Anjani Kumar is Senior Research Fellow at International Food Policy Research Institute, South Asia Office, New Delhi. He received his PhD (1999) and Masters (1992) in Dairy Economics from National Dairy Research Institute, Karnal, India. Before joining IFPRI, he was Principal Scientist (Agricultural Economics) at the International Crops Research Institute for the Semi-Arid Tropics, Hyderabad. He has also served as Principal Scientist at the National Centre for Agricultural Economics and Policy Research, New Delhi and as Senior Agricultural Economist in the Asia Office of the International Livestock Research Institute, Nairobi. He has also worked as a Consultant for many national and international institutions including the FAO and the World Bank. He is the author of about 140 research papers published in national and international research journals on various agricultural development issues. He has also contributed more than 70 papers/chapters to important books and proceedings. He is a Fellow of the National Academy of Agricultural Sciences and the Indian Society of Agricultural Economics. He has won a number of awards from national and international organisations, including the prestigious Rafi Ahmed Kidwai Award (2017), Lal Bahadur Young Scientist Award (2005), and the NAAS Young Scientist Award (2003).

Dr Himanshu Pathak is Secretary of the Department of Agricultural Research and Education, Government of India and Director General of the Indian Council of Agricultural Research, New Delhi. He provides leadership to one of the largest agricultural research and development organisations in the world. Earlier, he served as Director of ICAR-National Rice Research Institute, Odisha, and as Director of ICAR-National Institute of Abiotic Stress Management, Maharashtra, India. He has over three decades of experience in the areas of agricultural research, education, and extension. He has published about 250 research papers with an h-index of 79, i10-index of 249, and more than 24,200 citations. He is a fellow of the Indian National Science Academy; the National Academy of Sciences, India; and the Humboldt Foundation. He is a recipient of the Rafi Ahmed Kidwai Award of the Indian Council of Agricultural Research and is a fellow and President of the National Academy of Agricultural Sciences.

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Preface

India's agricultural sector demonstrated robust resilience during the COVID 19 pandemic, registering positive growth during that period and the majority of the country's population remains directly or indirectly dependent on the sector. Ample evidence suggests that sustainable and inclusive agricultural growth is best supported by investment in research and that research managers and policymakers should have a clear and sustained overview of the sector in order to optimally design and adjust interventions. With this in mind, during a meeting with distinguished fellows of the Academy, we recognised the need for an annual report on the "State of Indian Agriculture". Duly encouraged by the fellows and executive members of the National Academy of Agricultural Sciences, we embarked on this journey.

This document intends to highlight the impediments and challenges within the sector with the aim of finding the most effective path toward inclusive agricultural growth. We, acknowledge the need for more in-depth studies and analysis, however we feel that the issues and recommendations emerging from this publication can foster a better understanding of the complexities inherent in Indian agriculture. We feel that this improved understanding can contribute to alignment within the policy and research framework and milieu. We believe that this will, in turn, improve efficiency, help ensure equity and sustainability, and address India's concerns regarding food and livelihood security at the national, regional, and household levels.

We thank all the resource persons, reviewers, and fellows of the National Academy of Agricultural Sciences (NAAS) who helped us decide on the structure and contents of the paper and commenting on a draft version of it. We received significant input from Dr Seema Bathla, Dr Raka Saxena, Dr Sendhil R, and Dr P Shinoj. We are grateful to all of them. We would like to particularly express our sincere thanks to Kriti Sharma, Manpreet

Kaur, Sonali Katoch, and Soumya Subhashree Mohapatra for assisting us in the analysis and drafting of the document. We place on record our great appreciation for their unflinching support.

We would also like to convey our gratitude to the NAAS for pursuing and bringing out this publication. We believe that this would help the ICAR, the Government of India, and other stakeholders enhance the performance of Indian agriculture and thereby improve the standard of living of Indian farmers.

Authors

Abbreviations

APMC	Agricultural Produce Market Committee
AWiFS	Advanced Wide Field Sensor
CAGR	Compound Annual Growth Rate
CIPHET	Central Institute of Post Harvest Engineering & Technology
CPI	Consumer Price Index
CPIAL	Consumer Price Index for Agricultural Labour
CSSRI	Central Soil Salinity Research Institute
DAH&D	Department of Animal Husbandry & Dairying
DARE	Department of Agricultural Research and Education
DES	Directorate of Economics & Statistics
DoA&FW	Department of Agriculture & Farmers Welfare
e-NAM	Electronic National Agriculture Market
ESCAP	Economic and Social Commission for Asia and the Pacific
FCI	Food Corporation of India
FPI	Food Processing Industry
GoI	Government of India
GSDP	Gross State Domestic Product
GVA	Gross Value Added
ICAR	Indian Council of Agricultural Research
ICFA	Indian Council of Food & Agriculture

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ICT	Information and Communication Technologies
IPM	Integrated Pest Management
ISRO	Indian Space Research Organisation
KCC	Kisan Credit Card
MAS	Marker-Assisted Selection
mHa	Million Hectares
Mmt	Million Metric Tons
mtons	Million Tons
MoSPI	Ministry of Statistics and Programme Implementation
MSP	Minimum Support Price
NAAS	National Academy of Agricultural Sciences
NABARD	National Bank for Agriculture and Rural Development
NBSS&LUP	National Bureau of Soil Survey and Land Use Planning
NCAER	National Council of Applied Economic Research
NFSM	National Food Security Mission
NTM	Non-Tariff Measure
PM-KISAN	Pradhan Mantri Kisan Samman Nidhi
PMFBY	Pradhan Mantri Fasal Bima Yojana
PMKSY	Pradhan Mantri Krishi Sinchayee Yojana
RKVY	Rastriya Krishi Vikas Yojana
RWBCIS	Restructured Weather Based Insurance Scheme
SMSP	Sub-Mission on Seeds and Planting Materials
TE	Triennium Ending
UT	Union Territory
WPI	Wholesale Price Index

Introduction

In 2022, India celebrated 75 years of independence from the British Raj. This marked a watershed moment in the country's history, the beginning of its *Amrit Kaal* or 'golden era', the quarter century during which it resolves to transform itself into a developed nation. In November of 2023, India concluded its one-year term as president of the G20, a year that was imbued with the spirit of *Vasudhaiva Kutumbakam* (One Earth, One Family, One Future) and during which green, inclusive, and resilient growth was endorsed as a priority. Tremendous geopolitical turmoil and natural calamities in recent years have led to supply shocks, slowdown in growth, and high inflation in several countries. India, during this period, demonstrated remarkable resilience toward these uncertainties. The country's growth story has assumed a structurally more robust trajectory. It has geared up to turn domestic and international challenges into opportunities, preparing a blueprint to steer the economy toward a golden era.

India has regained its position as the fastest growing large economy in the world. In fiscal year (FY) 2023, the gross domestic product (GDP) grew by 7.2 percent in real terms. A favourable policy environment and greater focus on capital expenditure together have resulted in a robust growth of 11.4 percent in the investment-to-GDP ratio. The share of capital expenditure in GDP (synonymous with capital formation) is high at 34 percent. Increased investments in the infrastructure, technology, manufacturing, and agricultural sectors have created the much-needed momentum for faster and sustainable growth. The increase in capital expenditure by 37.4 percent over FY2022,envisioned in the Union Budget FY2023 will further boost investment and ensure long-term economic growth. These and many more initiatives have laid the groundwork for faster and more inclusive growth, better institutions, and governance, and enhanced social welfare.

It goes without saying that the agricultural sector contributes significantly to India's socioeconomic growth and development (Pathak *et al*. 2022).

Being a principal source of income and livelihood for half the country's population, agriculture can help India achieve a developed nation status. Significant transformations are taking place within the food system; these range from shifts of traditional farming methods to modern capital-intensive systems enabled by digital farm services, to the use of artificial intelligence and drone technology. Efforts have also been made to link farmers directly with markets in order to help them better assess changing consumer food preferences. While moving to a higher growth trajectory, agriculture faces numerous domestic and international challenges; these include increasingly erratic rainfall, heat waves, the need to reduce greenhouse gas (GHG) emissions, degradation of water and soil, high volatility in yield and commodity prices, a surge in imports, global slowdowns, and increased international conflicts such as that between Russia and Ukraine and in Palestine.

It is against this backdrop that the National Academy of Agricultural Sciences (NAAS) offers this report, which intends to delve into the state of Indian agriculture. Its broad aim is to consider institutional, technological, and digital interventions in terms of the efficacy with which they augment farmers' productivity and income. NAAS has entered its 33rd year as a leading and successful science academy that is dedicated to the service of Indian agriculture through scientific and policy-oriented interventions. Taking stock of the progress that has been made on various fronts in agriculture will be helpful to the Academy in suggesting appropriate policies for a faster and more sustainable transformation of agriculture. The following is the structure of the report. Sections 1 and 2 discuss the achievements of the agricultural sector in terms of output growth at the all-India level and across the states, input use patterns, farmers' income, and agricultural trade. It also analyses changes in the structure and composition of agricultural output and the implications of those changes for the future of Indian agriculture. Sections 3 and 4 highlight farmers' access to institutional finance, agri-markets and key research; the two chapters also discuss new developments in the agricultural sector. Section 5 brings forth pertinent issues relating to climate change, and the final section suggests a way forward for agriculture during the *Amrit Kaal*.

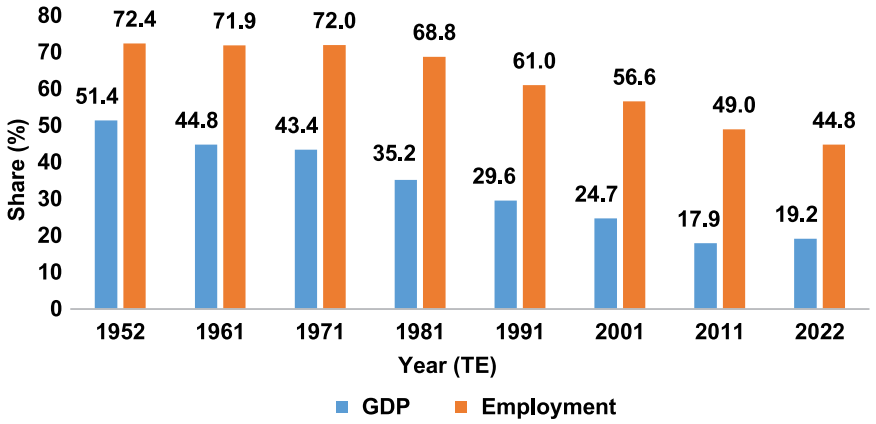
1 Performance of Indian Agriculture

1.1. Contribution of Agriculture to GDP and Employment

According to the theory of economic development, as an economy progresses the contribution of agriculture to GDP and employment declines and that of the industrial and tertiary (service) sectors increases. In 1950/1951, 69 percent of India's total workforce was engaged in agriculture, contributing 53 percent to the national income. Over the years, while the share of agriculture has declined in terms of both national income and employment, the reduction in employment share has not kept pace with the decline in its share of total income. At the all-India level in 2022/2023, for instance, the share of agriculture in total employment was 44.8 percent while its share of GDP stood at 19.2 percent. As of FY 2023, India's INR 297 trillion (about US $ 3.7 trillion) economy included 19 percent contributed by the agricultural and allied sectors, 31 percent by industry, and 54 percent by the service sector. Over the long term, the share of industrial GDP in total GDP has hovered around 25-30 percent, despite a favourable policy and incentive structure. The current 19 percent contribution by agriculture to total GDP reflects its sizeable decline in response to growth in the share contributed by the services sector.

However, it seems that neither the industry nor the service sector has been able to pull people out of agriculture as 45 percent of India's 520-million-person labour force continues to be employed in agriculture. Though agricultural income is estimated to be INR 46 trillion (about US $0.6 trillion) and is growing, low levels of labour productivity result from the large numbers of people dependent on it (Figure 1). This mismatch in income and employment shares may also indicate a neglect of agriculture in the existing economic development model, which in turn has caused large disparities in income between the agricultural and non-agricultural sectors. This suggests an urgent need to recognise the importance of

Figure 1. *Share of agriculture in GDP and employment in India*

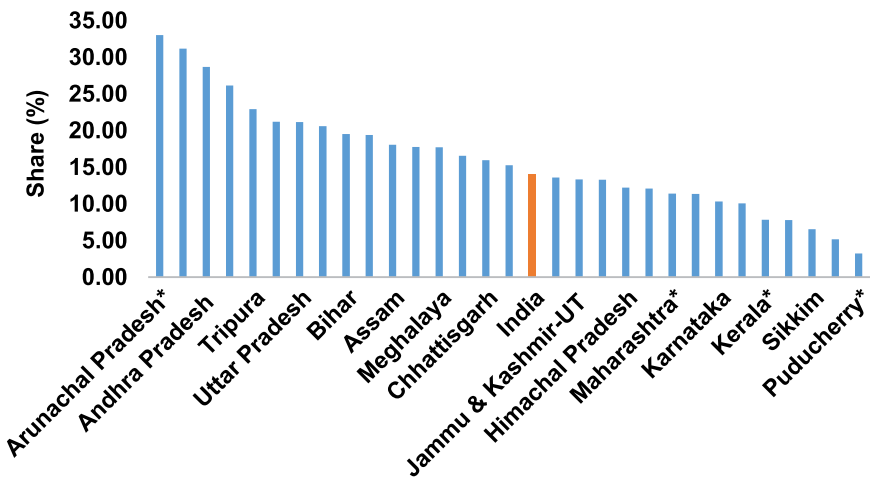


Source: *Ministry of Statistics and Programme Implementation (India, MoSPI2023a).*

agriculture by, among other things, improving land and labour productivity and creating off-farm jobs.

The share of agriculture and its allied sectors in the gross state domestic product (GSDP) exhibits stark variations across the states (Figure 2). At the all-India level, agricultural gross value added (GVA) constitutes a

Figure 2. *Agricultural GVA as a percentage of GSDP, 2023*



Source: *Periodic Labour Force Survey (PLFS), July 2022–June 2023(India, MoSPI 2023b); National Accounts Statistics 2023(India, MoSPI 2023).*

Note: *=fiscal year 2021/2022; GVA = Gross Value Added; GSDP = Gross State Domestic Product

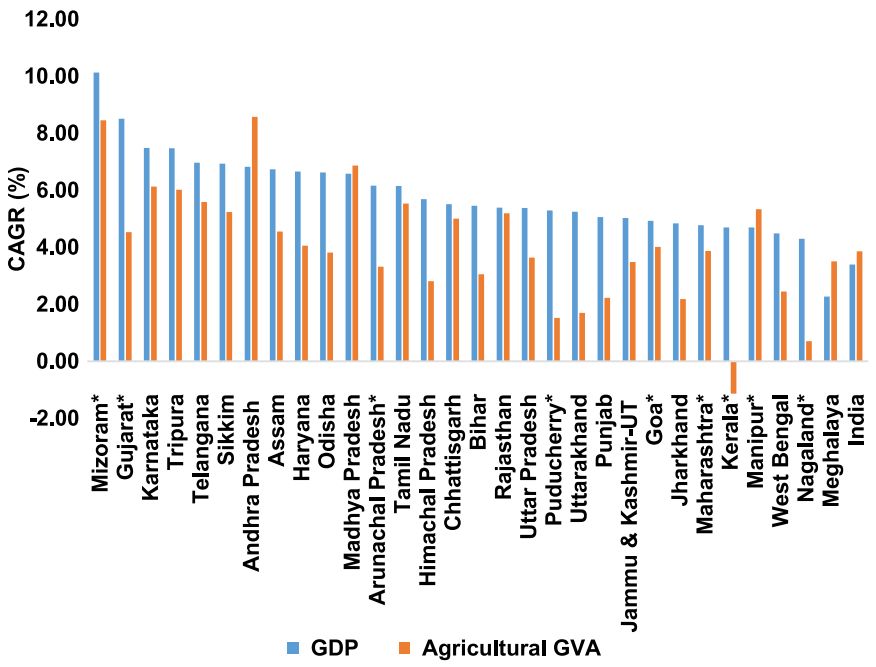
14 percent share of GDP. Among the states it varies from a meagre 3.3 percent share in Puducherry to a 33.3 percent share in Arunachal Pradesh. A higher share indicates a more significant contribution of agriculture to state-level economic output and a slower pace of growth in the industrial and services sectors. Madhya Pradesh follows closely on Arunachal Pradesh at 31.2 percent, which indicates the prominence of the agricultural sector in that state's economy. Andhra Pradesh, Rajasthan, and Tripura also exhibit noteworthy percentage shares at 28.7 percent, 26.1 percent, and 22.9 percent, respectively. Agriculture maintains a substantial share of 21.2 percent in both Punjab and Uttar Pradesh, which emphasises the continued importance of agriculture in their respective economies. Other states such as Bihar (19.5 percent), Manipur (19.4 percent), and Assam (18.1 percent) also demonstrate a considerable reliance on agriculture.

1.2. Agricultural Growth and Diversification

Despite global turmoil due to war, natural calamities, and pandemic-induced disruptions, India has maintained an annual growth momentum of 6 percent for over a decade, and in FY2023 it recorded a robust 7.2 percent annual rate of growth. The agricultural sector has shown a remarkable resilience under the prevailing uncertain conditions, as is evidenced by its 3.3 percent (FY2021) and 3.5 percent (FY2022) annual rate of growth in real prices. The compound annual growth rate (CAGR) during the past 12-year period ending FY2023 is close to 4 percent (Figure 3). The rate of growth, however, is not uniform across the states. Figure 3 reveals the state-wise CAGR of overall GDP and GVA in agriculture over the decade from 2011/2012 to 2022/2023. Among the eight states of India's North-Eastern Region, Mizoram's progress is significant in terms of GDP growth (10.1 percent); this is followed closely by Gujarat's 8.5 percent growth, and Karnataka's 7.5 percent growth. In terms of agricultural GVA, Andhra Pradesh takes the lead with 8.57 percent CAGR, followed by Mizoram at 8.45 percent and Tripura at 6.02 percent. These figures are indicative of the economic dynamism and agricultural prowess of these states. Among the states, Kerala has a negative CAGR in agriculture at -1.14 percent. A number of other states (Chhattisgarh, Bihar, Rajasthan, and Uttar Pradesh) have demonstrated consistent growth in both GDP and agricultural GVA.

Indian agriculture is on a high growth trajectory. One of the factors that has contributed to higher income growth is diversification toward allied activities. At the time of independence, the crop sector dominated; in the subsequent decades, however, especially after the 1980s, acceleration

Figure 3. *State-wise CAGR of agricultural GVA and GDP, 2012 to 2023*



Source: *Ministry of Statistics and Programme Implementation (India, MoSPI2023a).*

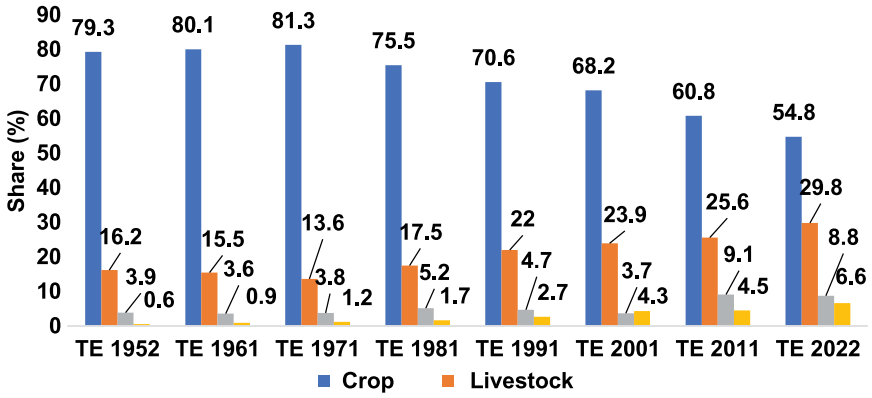
Note: CAGR =Compound Annual Growth Rate; GVA = Gross Value Added; * =fiscal year 2021/2022.

was seen in the share of livestock. The crop sector's share in agricultural GVA decreased from 79.3 percent in Triennium ending (TE) 1952 to 54.8 percent in TE 2022 while the share of livestock has almost doubled from 16 to 30 percent over the same period. The contribution of fisheries to total value of agricultural output has also increased from 0.6 percent in TE 1952 to 6.6 percent in TE 2022. The share of forestry in total agricultural GVA remains low (Figure 4).

Within the crop sector, the share of horticulture has increased from 10.8 percent in TE 1952 to 33.5 percent in TE 2022 (Figure 5).

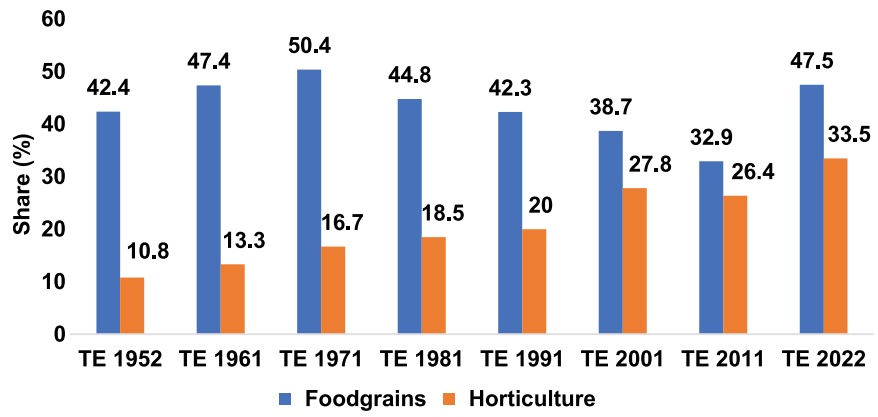
India can boast of achieving food security at the national and household levels and in recent years it can also be considered to have attained nutrition security. Due to rising per capita income, growing urbanisation, and a rapid increase in the integration of the domestic economy with the world economy, consumers are diversifying toward more nutrient-rich diets and the agricultural sector is able to meet their demand. Though the share of the crop sector in total income has been declining, it remains

Figure 4. *Share of different subsectors in gross value of agricultural output*



Source: *Ministry of Statistics and Programme Implementation (India, MoSPI 2023a).*

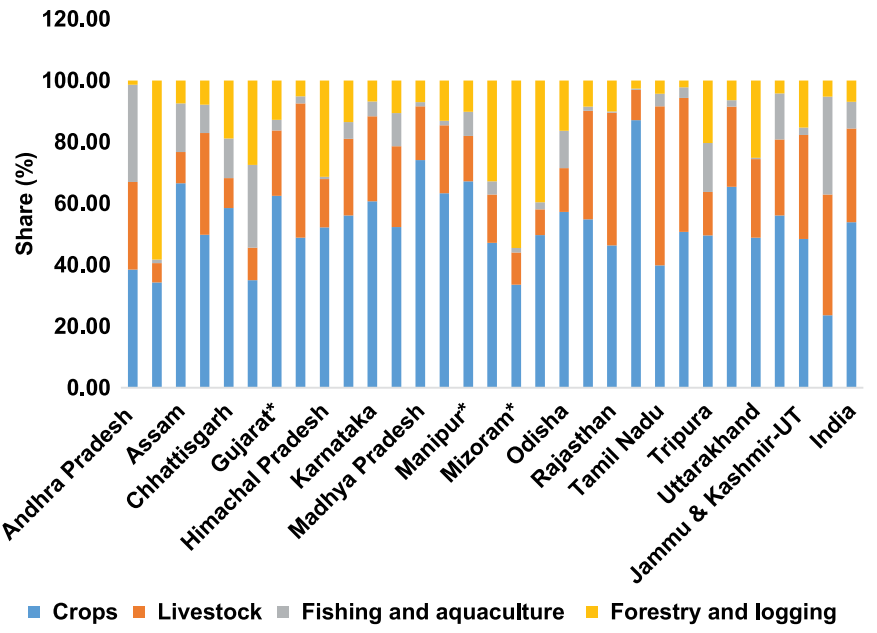
Figure 5. *Share of foodgrains and horticulture in value of crop output (percent)*



Source: *Ministry of Statistics and Programme Implementation (India, MoSPI 2023a).*

the principal source of income generation. The crop and livestock sectors complement each other and thus generate a strong synergy. As evident from Figure 6, the fisheries subsector is prominent in coastal areas and forestry is important in hilly regions. Among the states, Andhra Pradesh, Assam, and Karnataka place significant importance on crops, which constitute a 38.53, 66.58, and 60.73 percent share in their respective agricultural GVA totals. Within the crop sector, horticulture emerges as a significant contributor, as illustrated in Table A2 in the Appendix. In states such as Sikkim (87.3 percent), Kerala (43.4 percent), Himachal Pradesh

Figure 6. *Composition (percentage) of agricultural GVA, 2022/2023*



Source: *Ministry of Statistics and Programme Implementation (India, MoSPI 2023a).*

Note: GVA = gross value added; * =fiscal year 2021/2022.

(41.7 percent), and Meghalaya (41.5 percent), horticulture makes a noteworthy contribution to the agricultural GVA. Relative to other states, livestock's share of agricultural GVA is high in Haryana (43.73 percent) and Punjab (35.26 percent). Fishing and aquaculture activities are notable in Sikkim and Goa with 87.10 percent and 26.98 percent share in GVA, respectively. Forestry holds significant importance in the north eastern states, especially in Mizoram and Assam.

Table 1 presents the compound annual growth rate (CAGR) in each of the agricultural subsectors for the period 2011/2012 to 2022/2023 across states and union territories. Notably, a positive and high rate of growth in GVA crops can be observed in Madhya Pradesh (5.84 percent), Karnataka (4.76 percent), and Andhra Pradesh (4.37 percent);livestock GVA, on the other hand, shows a much higher rate of growth in Madhya Pradesh (13.48 percent), Assam (12.74 percent), and Tripura (12.99 percent).A few states exhibit a decline in the annual rate of growth of crop cultivation, including Kerala (-2.36 percent) and Nagaland (-10.33 percent). Fishing and aquaculture exhibit promising growth in Meghalaya (15.00 percent), Odisha (11.05 percent), and Chhattisgarh

Table 1. CAGR (percent) of different subsectors of agriculture, 2011/2012 to 2022/2023

State	Compound annual growth rate (%) 2011/2012 to 2022/2023*				Horticulture$
	Crops	Livestock	Fishing and aquaculture	Forestry and logging	
Andhra Pradesh	4.4	8.6	19.1	1.9	8.1
Arunachal Pradesh*	-3.9	6.2	5.5	10.4	-6.7
Assam	3.2	12.7	6.9	4.5	2.2
Bihar	0.0	8.4	7.6	5.1	0.6
Chhattisgarh	3.3	7.4	9.8	7.3	5.5
Goa*	-0.3	2.4	1.7	26.5	1.7
Gujarat*	2.5	6.1	5.5	1.6	4.4
Haryana	1.6	8.0	9.1	2.1	5.1
Himachal Pradesh	1.0	9.1	7.7	3.6	4.9
Jharkhand	1.2	5.3	12.1	0.1	-2.7
Karnataka	4.8	10.3	6.3	5.7	6.0
Kerala*	-2.4	-0.4	1.4	1.7	-1.7
Madhya Pradesh	5.8	13.5	14.5	5.3	11.5
Maharashtra*	2.4	6.5	0.8	7.4	3.0
Manipur*	7.5	1.0	3.5	2.3	2.4
Meghalaya	1.3	1.4	15.0	9.1	-0.2
Mizoram*	3.4	5.6	-0.2	16.4	0.6
Nagaland*	0.2	-10.3	3.2	7.6	2.6
Odisha	2.0	5.0	11.1	6.0	-1.6
Punjab	0.7	5.2	7.3	1.7	5.2
Rajasthan	2.0	11.0	8.2	3.3	4.9
Sikkim	5.4	5.6	7.6	0.0	1.4
Tamil Nadu	1.3	10.7	3.1	7.2	0.4
Telangana	3.8	8.3	6.7	1.4	-2.1
Tripura	4.2	13.0	9.5	5.6	2.0

Contd...

State	Compound annual growth rate (%) 2011/2012 to 2022/2023*				Horticulture$
	Crops	Livestock	Fishing and aquaculture	Forestry and logging	
Uttar Pradesh	3.3	4.2	7.1	3.8	6.3
Uttarakhand	0.2	2.9	5.0	3.9	-2.6
West Bengal	1.5	4.9	2.6	2.7	1.5
India	**1.7**	**7.6**	**4.6**	**8.6**	**3.5**

Source: *Ministry of Statistics and Programme Implementation (India, MoSPI 2023a).*

Note: CAGR = Compound Annual Growth Rate; * = Fiscal Year (FY) 2021/2022; $ = FY 2019/2020.

(9.76 percent). These state-level growth trends provide valuable insights into the evolving agricultural landscape, highlighting potential areas that may need attention if higher agricultural growth and sustainable development is to be achieved.

1.3. Trends in the Production of Major Agricultural and Allied Products

Over the past five years, both the area and production of major food crops have shown an increasing trend (Table 2). Between 2021/2022 and 2022/2023, total food grain production increased from about 298 million tons to 330 million metric tons: an increase of about 10 percent. Rice registered an incremental production about 17 million tons, while wheat production increased by about 3 million tons during this period. Total pulse production also witnessed an increase of 3 million tonnes. As per the first advance estimates for 2023/2024 (*Kharif* only), total *kharif* food grain production is estimated at 148.6 million tons, which is higher than the average *Kharif* production over the last three years (2020/2021 to 2022/2023).

Climate change has begun to adversely affect the agricultural sector (Pathak 2023a). During the 2022/2023 *Rabi* season, a heat wave due to delayed monsoon and erratic rainfall caused farmers to incur heavy losses, including a 3.7 percent decline in paddy production (Goswami *et al*. 2023).

The livestock and fisheries sectors of the economy have been playing a vital role in improving the socioeconomic conditions of farmers,

Table 2. Production status of major food crops

(Million tons)

Crops	2019/ 2020	2020/ 2021	2021/ 2022	2022/ 2023	2023/ 2024*
Rice	118.9	124.4	129.5	135.8	106.3
Wheat	107.9	109.6	107.7	110.5	
Nutri-cereals	17.3	18.0	16.0	17.3	12.7
Total cereals	274.45	285.3	288.3	303.6	141.5
Total pulses	23.0	25.5	27.3	26.1	7.1
Total foodgrains	297.5	310.7	315.6	329.7	NA
Oilseeds	33.2	35.9	37.9	41.4	21.5
Sugarcane	370.5	405.4	439.4	490.5	434.8
Cotton**	36.1	35.2	31.2	33.7	31.6
Jute and Mesta#	9.9	9.4	10.1	9.4	9.2

Source: *APY, Statistics, Directorate of Economics & Statistics, Department of Agriculture and Farmers Welfare, GoI*

Note: * = First advance estimates, Directorate of Economics & Statistics, Government of India; ** = million bales of 170 kgs each; #= million bales of 180 kgs each.

especially those operating at a small and marginal scale. In the last decade, the livestock sector has shown a continuous and stable CAGR of 7.9 percent. India is the world's largest milk-producing country, with a record production of 230.58 mT in 2022/2023. Globally, it is also the largest producer of buffalo meat, the second-largest producer of goat meat, and the third-largest producer of eggs and fish (Table 3).

Table 3. Production of major allied products in 2023

Year	Milk (mT)	Meat (mT)	Egg (millions)	Wool (million kg)	Fish (mT)
2019/2020	198.4	8.6	1,14,000	36.8	14.2
2020/2021	210.0	8.8	1,22,000	36.9	14.7
2021/2022	221.2	9.3	1,30,000	32.9	16.2
2022/2023	230.58	9.8	1,38,000	33.6	17.4

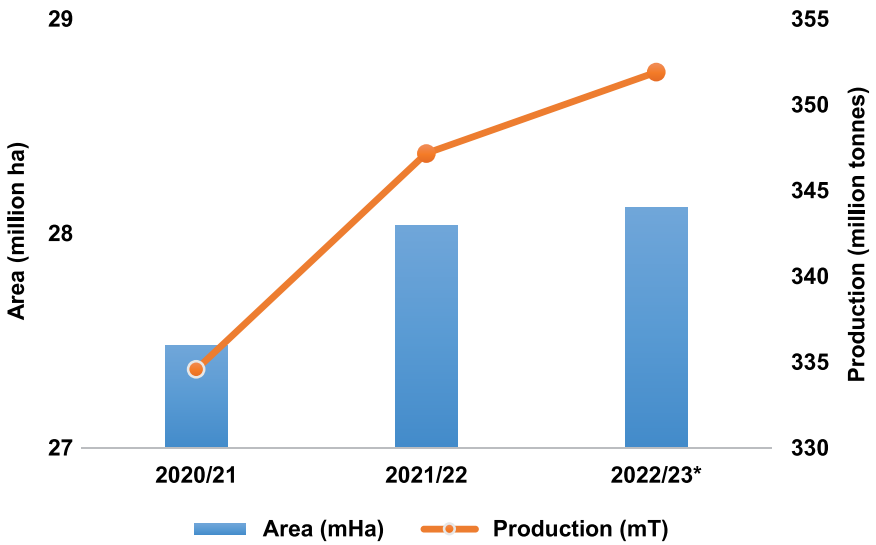
Source: *Basic Animal Husbandry Statistics (India, DAH&D 2023); Handbook on Fisheries Statistics 2022 (India, Department of Fisheries 2022).*

Note: mT = million tons.

At 9.7 mT annually, India stands eighth in the world for overall meat production. Poultry contributes significantly to the overall growth of the livestock sector, with a sustained increase observed in egg and poultry meat production. India's annual fish production has increased to a record 17.4 mT in 2022/2023 from 14.16 mT in 2019/2020, a 23 percent increase over a three-year period (Figure 8). It presently holds the distinction of being the world's second-largest aquaculture producer and fourth-largest capture fishery producer. During the past decade, fish production has registered an annual growth rate of about 8 percent. Inland fisheries currently contribute about three-fourths of the total fish production, with the remainder coming from marine capture fisheries. Over the past decade, fish production from capture fisheries (both marine and inland capture) has experienced stagnation; aquaculture, in the same period, has exhibited a robust performance, thereby driving most of the sector's growth. The major cultured species of inland freshwater fish include the major carps (Catla, Rohu, Mrigal) as well as other minor and exotic carps, murrels, and catfish. Marine capture fish production consists mainly of Indian oil sardines, Indian mackerel, threadfin breams, tuna, penaeid prawns, croakers, sharks, and skates. Mariculture involves the culture of marine species in enclosed structures; it is fast emerging as a prospective avenue for future marine production. Some of the promising mariculture enterprises include cage culture, seaweed culture, mussel and oyster culture, and ornamental fish culture (Jena *et al*. 2023).

Within the crop sector, horticulture contributes significantly to the economy with a 33 percent share in agricultural GVA. India currently shows a record production of 351.92 million tonnes of horticultural products which is produced on 28.12 million hectares (mHa) of land; this surpasses the area and production of food grains (Figure 7). The productivity of horticulture crops has increased by 50 percent over the past two decades; it now stands at 12.49 tons per hectare (t/ha), far exceeding the productivity of food grains (2.23 t/ha) (Jha *et al*. 2019). India is the world's second-largest producer of fruits and vegetables, with crops such as spices, plantation crops, and aromatic crops contributing significantly to the development of the country's horticultural sector. The Indian horticultural sector ensures nutritional security and also provides crop diversification activities, employment opportunities, and improved farm income; however, increasing population, uncertain supply and demand, and climate change impose challenges and constraints on horticultural production systems.

Figure 7. *Area and production status of horticultural crops in India*



Source: *Ministry of Agriculture & Farmers Welfare, GoI.*

Note: * = second advance estimates for year 2022/23 released by Ministry of Agriculture & Farmers Welfare

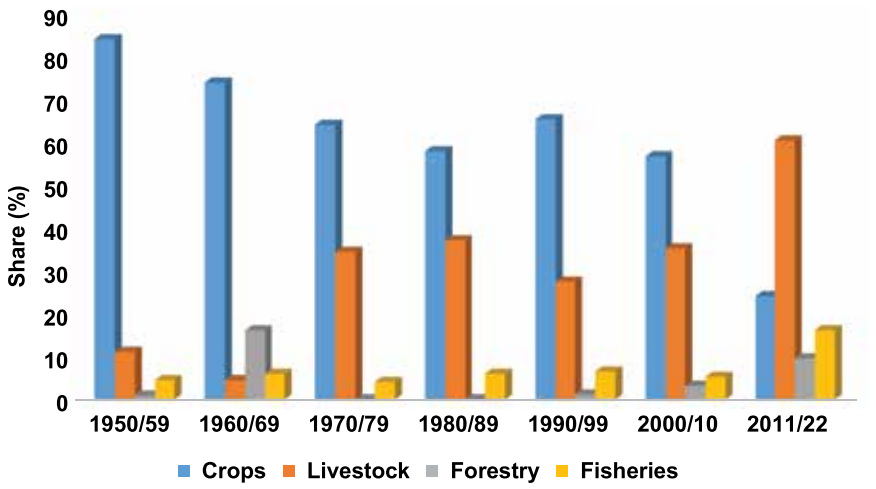
1.4. Sources of Agricultural Growth: Changing Role of Commodities

The crop sector, despite contributing significantly to the overall agricultural sector, is declining in importance, moving from about 79 percent in the 1970s to 60 percent in the 2000s; by 2023, it contributed only 24 percent to the total. Livestock, in contrast, has almost quintupled and now accounts for more than half of agricultural growth. Fisheries' contribution has also increased, moving from 0.88 percent in the 1950s to 16 percent in the 2011-to-2022 period. Over this period, forestry has exhibited a fluctuating trend (Figure 8).

1.5. Farmers' Income and Its Main Sources

The Government of India's paramount objective is the elevation of farmers' economic well-being. While Indian agriculture contributed only 19 percent to the country's GVA in FY 2021/2022 (India, MoA&FW 2023), it remains the primary sector for livelihood and employment, with over 45.5 percent of the nation's workforce engaged in agricultural and allied activities (India, MoSPI 2023). Notably, a higher growth is observed when real incomes are calculated using the Consumer Price Index for

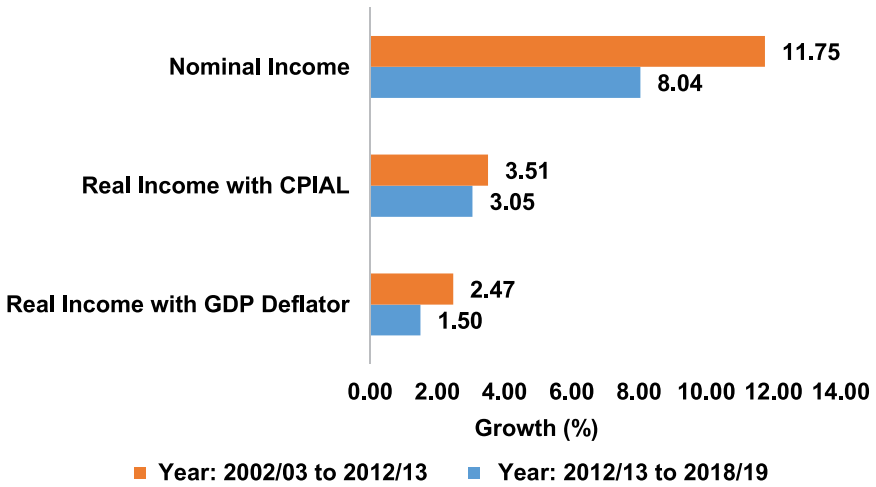
Figure 8. *Contribution of different subsectors to agricultural growth (percent)*



Source: *Base data: National Accounts Statistics 2023 (India, MoSPI 2023c).*

Agricultural Labour (CPIAL) as the deflator. Agricultural households generate income from various sources including crop cultivation, animal husbandry, wages and salaries, and non-farm business pursuits. The real income, adjusted with the GDP deflator, witnessed a growth of 2.47 percent per year between 2002/2003 and 2012/2013, but this slowed down to 1.5 percent in the 2012/2013 to 2018/2019 period (Figure 9).

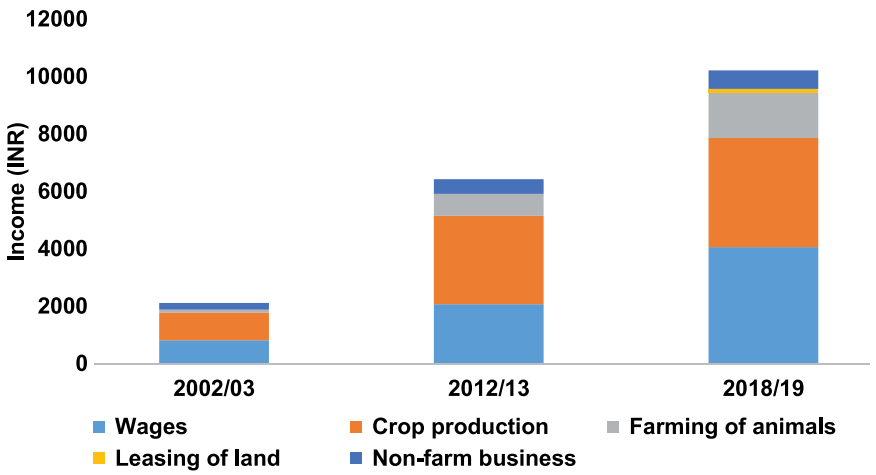
Figure 9. *Growth in household income, all India*



Source: *Base data: Situation Assessment Surveys (2002/03; 2012/13 and 2018-19), NSSO, (India, MoSPI 2023c).*

While overall income of agricultural households has increased (INR 2,115 to INR 10,218) a notable shift has occurred in the composition of income sources, specifically a decline in the proportion derived from crop cultivation. The surge in total income of farming households observed between 2012/2013 and 2018/2019 can be attributed mainly to substantially increased earnings from wages and animal farming; there has been, however, a worrisome 2.72 percent annual decline in income from crop cultivation (Saxena *et al*. 2023b) (Figure 10).

Figure 10. *Growth in farm household income across sources, all India, 2012/2013 to 2018/2019*



Source: *Base data: Situation Assessment Surveys (2002/03; 2012/13 and 2018-19), NSSO, (India, MoSPI)*

Concerted efforts have been made to address this trend; these include the introduction of enhanced crop varieties, micro-irrigation initiatives, risk management strategies, and price support programmes specifically designed to bolster the crop sector. Ensuring sustained growth, however, requires the effective implementation of these measures coupled with robust farm linkages. Animal and fish farming are, at the same time, emerging as promising sectors with significant growth potential. This positive shift underscores the need to explore and capitalise on opportunities within these domains, including the diversification of income sources within agricultural households. Nurturing these sectors through strategic policies and supportive frameworks can contribute not only to the resilience of the agricultural economy but also to the overall prosperity of farming communities.

A supportive policy environment is crucial for enhancing agricultural incomes and nutrition security. Its focus should be on the encouragement of off-farm activities, especially for smallholders. Agricultural households, irrespective of their landholding size, demonstrate a commendable level of financial inclusion, with nearly all possessing a bank account; this reflects the significant strides that have been made in financial accessibility. Challenges persist in specific domains, however, such as in crop insurance, where coverage under the *Pradhan Mantri Fasal Bima Yojana* (PMFBY) remains dismally low for marginal farmers. This gap in insurance protection constitutes a considerable level of vulnerability for this already-vulnerable segment of the farming community. Targeted interventions to enhance coverage and effectively mitigate risks are thus necessary.

At the same time, the landscape of registered farm organisations reflects the stark reality that only a tiny percentage of agricultural households are members of such organisations. This underscores a potential gap in collective empowerment and collaborative initiatives and signals the need for strategies that enhance farmers' participation in such organisations so as to foster a sense of community and amplify their collective voice. The involvement of marginal and small landholders in initiatives such as the Soil Health Card Scheme and Animal Health Card Scheme is also notably limited. These programmes are designed to empower farmers by providing crucial information and resources; they thus need to be more inclusive and to ensure that smallholders have access to vital tools for optimising soil and animal health. Bridging these participation gaps is integral to realising the comprehensive benefits of these schemes across all tiers of the agricultural community.

The potential industrialisation of rural areas hinges on prioritising labour-intensive agro-based industries, necessitating a booming rural non-farm economy to alleviate employment pressure on agriculture. Effective market intelligence is pivotal for enhancing farmers' income, urging the development of domestic marketing linkages and the adoption of electronic trading platforms such as the Electronic National Agriculture Market, or e-NAM. Amid the COVID-19 pandemic, successful government interventions, support payments, and enhancements to supply chains underscored the importance of addressing challenges and ensuring food security. Post-pandemic, however, global markets imposing stricter food safety requirements necessitate India's investment in food quality and safety infrastructure. The impact of the Russia–Ukraine war on global commodity prices underscores the uncertainty in global economic prospects

and suggests an urgent need for a robust domestic food production and trade strategy.

Amidst these challenges, climate change emerges as a critical factor requiring immediate attention and strategic planning (Pathak 2023a). Collaborative efforts at local, regional, and national levels are imperative to develop adaptive strategies that mitigate the impacts of climate change on Indian agriculture. This necessitates not only robust research collaborations but also dedicated funding for the development and implementation of climate-smart technologies, ensuring the sector's long-term sustainability (Pathak 2023a).

In embracing these challenges and proactively seizing opportunities, India's agricultural sector has the potential to foster resilience, sustainability, and improved livelihoods for its farming community. A holistic approach, encompassing strategic policy initiatives, technological advancements, and global competitiveness can pave the way for a thriving and resilient future for Indian agriculture.

1.6. Agricultural Trade

Historically, India's agricultural exports were characterised by spices, tea, fish and fishery products, cashew nuts, and other distinctive commodities. Evolving trade dynamics, however, have witnessed the ascendance of new export leads including basmati rice, meat (particularly buffalo meat), soybean meal, and groundnut seed. This diversification in export commodities signifies the adaptability and dynamism of India's agricultural trade, including its ability to respond to shifting global demands.

Table 4 compares the composition of agricultural sector exports and imports in 1992 and 2022. This period saw an increase in the export share of cereals, livestock, sugar and sugar products. As India moved toward and beyond self-sufficiency in these crops it began to export greater quantities, resulting in a significant increase in total agricultural exports. A decline was registered, on the other hand, in the share of exports of cotton, coffee, tea, spices, mate and cocoa, products and preparations of vegetables, and fruits and nuts. As for cotton, both its production and exports have exhibited fluctuations over the years, however a decline in cotton yield and the emergence of competitors like Vietnam has reduced the attractiveness of India's cotton in the international market (Mukherjee 2023; OEC 2023). Among imports, the share of animal or vegetable fats

Table 4. Composition of agricultural exports and imports, percent of total, 1992 and 2022

Particulars	1992		2022	
	Exports	Imports	Exports	Imports
Cereals and cereal products	8.1	28.7	26.0	1.0
Coffee, tea, spices, mate and cocoa	11.9	1.5	6.9	3.8
Cotton and silk	26.4	15.6	11.7	5.3
Fishing and aquaculture	13.2	0.0	11.0	0.4
Horticulture and horticultural products	24.0	29.4	12.8	23.5
Livestock and livestock K products	3.0	1.7	8.7	0.3
Miscellaneous products*	2.1	10.6	6.0	59.8
Oilseeds	2.3	1.0	3.2	2.4
Sugars and confectionery	2.8	0.4	10.5	1.0
Tobacco and tobacco products	3.6	0.1	2.0	0.2
Other products**	2.6	11.0	1.2	2.2

Source: *World Integrated Trade Solutions (WITS), 1992, 2022.*

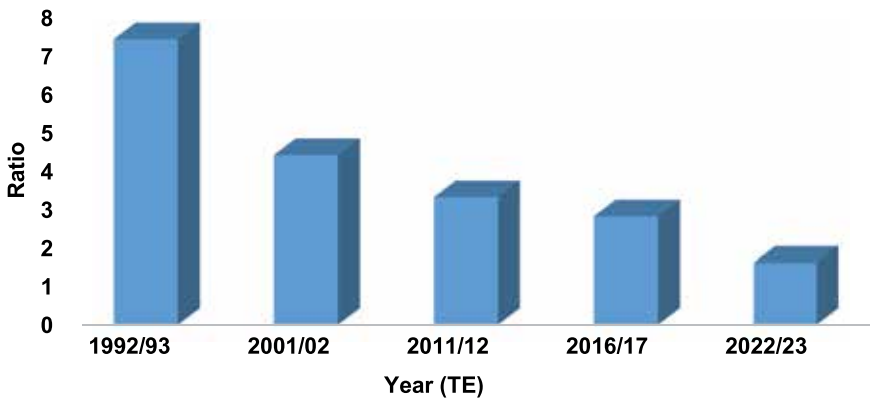
Note: * =animal or vegetable fats and oils, miscellaneous edible preparations; ** =wool, vegetable textile fibres, paper yarn, animal hair, and other fabrics.

and oils in total agricultural imports has increased significantly during the period. India's demand for vegetable oil has been on the rise over this period and domestic production has not been able to satisfy this demand (Damodaran 2023). A decline has been registered, on the other hand, in the share of imports of vegetables, fruits and nuts, cereal and cereal products, cotton, coffee, tea, mate, cocoa and spices. Over this period, India's dependence on cereal imports has fallen significantly, as its domestic production has increased due to the introduction of improved varieties. Despite rising domestic demand for vegetables, fruits, and nuts,the share of imports of these commodities has declined, indicating that Indian farmers are gradually moving from food grains to horticultural crops (*The Economic Times* 2023).

In the overall trade landscape, where India has consistently maintained a negative trade balance since the initiation of planned development in 1950/1951, the agricultural sector's consistent trade surplus stands out as a beacon of success. In 2022/2023, India garnered net foreign exchange

earnings of approximately US$20 billion from agricultural trade. The trajectory of both agricultural exports and imports has been noteworthy, albeit with distinct growth rates. Between 1992/1993 and 2022/2023, agricultural exports experienced a commendable annual growth of 9.5 percent, highlighting India's prowess in catering to international markets. Agricultural imports, in contrast, surged more rapidly, recording an annual growth rate in excess of 15 percent. This divergence has contributed to a substantial reduction in the ratio of agricultural exports to imports, dropping from 7.4 in 1992/1993 to a modest 1.6 in 2022/2023 (Table 5 and Figure 11).

Figure 11. *Trends in the ratio of agricultural exports and imports*



Source: *Latest Trade Figures Department of Commerce (India, Ministry of Commerce and Industry 2023)*

Crucially, the country's capacity to generate exportable surpluses emerges as a pivotal determinant in shaping its export prospects. This capacity is subject to fluctuations influenced by macro-economic shifts (mainly exchange rate) and changes in the production environment (Singh and Sain 2003). As India continues to navigate the complexities of the global market, sustaining and enhancing its export competitiveness will be pivotal for leveraging the full potential of its agricultural prowess on the international stage.

On the import front, a substantial 72 percent of India's agricultural imports in 2023 are in the categories of edible oils, pulses, and fresh and dried fruits. The escalating import of edible oils stands out as a major concern; in this, vegetable oils take the lead, constituting a significant 51.9 percent of the country's total agricultural imports and making India the world's largest importer of vegetable oils. Imports are also expected to double

Table 5. India's exports and imports of agricultural commodities

(US$ billion)

Year	Total merchandise exports	Total merchandise imports	Trade balance	Agri exports	Agri imports	Agri trade balance	Percent of agri imports to total national imports	Percent of agri exports to total national exports
2011/12	286	458	-172	36	14	22	3.0	12.5
2012/13	299	488	-189	42	18	24	3.6	13.9
2013/14	317	452	-135	44	14	29	3.2	13.8
2014/15	305	440	-135	39	20	19	4.4	12.6
2015/16	256	372	-116	32	21	11	5.6	12.6
2016/17	273	381	-108	33	24	9	6.4	12.3
2017/18	284	435	-151	36	22	14	5.1	12.9
2018/19	330	514	-184	39	20	20	3.8	11.9
2019/20	297	450	-153	34	20	14	4.4	11.4
2020/21	292	394	-102	42	21	21	5.3	14.3
2021/22	422	612	-191	50	31	19	5.1	11.9
2022/23	451	716	-265	53	36	17	5.0	11.8

Source: *Latest Trade Figures Department of Commerce (India, Ministry of Commerce and Industry 2023)*

to an estimated US$20.8 billion in 2023/2024 from US$10.8 billion in 2017/2018 (GTRI 2023).

This surge in imports poses challenges, but at the same time offers a compelling opportunity for India to bolster its self-sufficiency in edible oils. Despite a substantial yield gap of over 50 percent in oilseeds, there exists immense potential for enhancing domestic production through strategic technological interventions (Pathak 2023b). Most of these crops are cultivated under rainfed conditions on marginal lands and research shows that climate change is likely to have a negative impact on oilseed production (Birthal *et al*. 2021). Effectively addressing this multifaceted challenge thus necessitates a concerted effort, including an expansion of irrigation infrastructure, the provision of high-quality seeds, and the implementation of effective agricultural management practices. These

measures will be instrumental in bridging yield gaps in both oilseeds and pulse production within India, fostering a more resilient and sustainable agricultural landscape (Balaji and Sharma 2023).

In recent decade, supply chain disruptions stemming from global uncertainties have impacted trade and trade costs, leading to higher inflation. Government interventions have been commendable in ensuring supplies through new contracts and domestic policy interventions. Efforts have been made to explore new suppliers and import destinations, successfully averting the most adverse effects of the Russia–Ukraine conflict. To alleviate inflationary pressures on domestic prices, exports of wheat, rice, and sugar were restricted. As a result, in 2023/2024 major commodities such as non-basmati rice, pulses and sugar have exhibited negative growth, with basmati rice proving an exception. Although this negative trend began before trade restrictions, the ban on rice exports and the imposition of a 20 percent export tax on parboiled rice have acted as further contributing factors. The government also resorted to imposing a 40 percent export tax on onions in order to curb rising domestic prices. India's repeated attempts to restrict the export of major agricultural commodities such as the *sona masuri* rice variety, sugar, and onions have led to sharp spikes in the international prices of these commodities, however global economic prospects remain uncertain. The Russia–Ukraine conflict has motivated the opening up of avenues for new food trade, import substitution of edible oils, and innovations in fertiliser production and use.

India's presence in the global agri-food market is on the rise, demonstrating export competitiveness in commodities such as basmati and non-basmati rice, spices, and shrimps. Despite this, the untapped export potential of a number of commodities indicates scope for expanding the share of agricultural exports (Saxena *et al*. 2023a, 2023b). Lack of a well-developed infrastructure, however, poses a significant obstacle as it results in the spoilage of perishable goods and a reduction in export competitiveness. Transportation presents a major challenge, including congestion, the absence of dedicated cold chain transport corridors, and inefficient logistics management; these further impact the country's export capabilities by increasing costs and causing delays.

The second major challenge revolves around the quality and traceability of agricultural produce. Indian agricultural products often face difficulties in meeting rigorous international quality and traceability standards, which undermines their reputation and export potential. Ensuring consistent

product quality is made more difficult by diverse farming practices and variations in quality across farms. The complex and opaque nature of supply chains coupled with multiple intermediaries makes tracking the origin and handling of products more complicated; this heightens the risk of fraud and adulteration, which in turn impacts consumer trust and food safety. Despite ongoing efforts to implement farm-to-fork and traceability systems for various agricultural products, challenges persist in terms of scalability, cost, and infrastructure. A third challenge is related to non-tariff measures (NTMs) in export markets; these impact major Indian exports such as chilies, tea, basmati rice, milk, poultry, and bovine meat. Countries such as those of the EU, as well as Japan, China, the USA, South Korea, and Russia impose high NTMs in order to respond to factors such as higher pesticide levels and the presence of pests, and contamination issues such as foot and mouth disease. These issues often lead to the rejection of export consignments. Addressing these challenges requires upgrading domestic systems, reducing pesticide levels in food products, and ensuring adherence to international quality standards (Jha and Bathla 2021).

The fourth and final challenge is that which India faces at the World Trade Organization (WTO) regarding its agricultural policies. While maintaining a large public stockholding of staple food grains for food security, particularly rice and wheat, India's practices have been challenged at the WTO by developed countries, notably the US. The argument revolves around the perceived distortion of global agricultural markets, with India countering that its public stockholding programme is crucial for fulfilling its constitutional mandate of ensuring food security; it further argues that the Agreement on Agriculture provisions on domestic support are biased against developing countries. Successfully navigating these challenges is imperative if India is to sustain and enhance its position in the global agricultural landscape (Dhar 2023).

1.7. Processing and Value Addition of Agricultural and Allied Products

India holds a prominent position globally as a leader in food production, however there is a noticeable gap when it comes to efficiently processing its vast agricultural output. At 11.6 percent, the GVA of India's food processing industry (FPI) ranks among the lowest globally, compared to 30 percent in China and 60 to 80 percent in developed economies. India's evolving FPI nevertheless holds untapped potential which could

have a substantial impact on its economy. Over the five years ending in 2020/2021, the food processing sector has demonstrated remarkable growth, boasting an average annual growth rate of approximately 8.38 percent. This growth surpasses that of the agricultural and allied sector, which stood at around 4.87 percent (at 2011/2012 prices) during the same period. This robust performance underlines the resilience of the food processing sector and its increasing role in shaping India's economic landscape. It has emerged as a crucial player, contributing significantly and strategically to key economic indicators including GDP, employment generation, and attracting foreign investment. In 2020/2021, it constituted 10.5 percent of GVA in the manufacturing sector and 11.6 percent of the agricultural sector's GVA (Table 6).

Table 6. Share of food processing industries (FPI) on GVA at constant 2011/2012 prices

Year	GVA-FPI	Percent share of FPI in overall GVA	Percent share of FPI in GVA manufacturing	Percent share of FPI in GVA agriculture, forestry, and fishing
2012/2013	1.30	1.5	8.7	8.5
2013/2014	1.30	1.4	8.3	8.1
2014/2015	1.34	1.4	8.0	8.3
2015/2016	1.61	1.5	8.5	10.0
2016/2017	1.79	1.6	8.7	10.4
2017/2018	1.93	1.6	8.7	10.5
2018/2019	2.36	1.9	10.1	12.6
2019/2020	2.26	1.7	10.0	11.4
2020/2021	2.37	1.9	10.5	11.6

Source: *Annual Report 2022-23, Ministry of Food Processing Industries, GoI. (2023)*
Note: GVA = Gross Value Added.

To position itself as a frontrunner in food processing, India must elevate its current food processing standards. It must also address the harvest and postharvest loss of 25 to 30 percent of the country's total agricultural produce (Jha *et al*. 2015). This level of wastage makes the country unable to fully capitalise on its significant output of agricultural commodities. Light was shed on the magnitude of the issue by an extensive 2022 study

conducted by NABARD Consultancy Services Pvt. Ltd (NABCONS) which encompassed 54 agricultural products across 292 districts in 15 agro climatic zones. This NABARD study built on a previous examination by Indian Council of Agricultural Research–Central Institute of Post Harvest Engineering and Technology (ICAR–CIPHET), Ludhiana, in 2015, which assessed harvest and postharvest losses for 45 agricultural crops spanning 107 districts in 14 agro climatic zones. Table 7 draws on both study reports to present a comparative analysis of the postharvest losses for major agricultural crops and commodities in India.

Also relevant is the fact that developed nations predominantly export high-value-added food products while a considerable proportion of India's food exports consist of low-margin raw materials. There is thus a crucial need for India to shift its focus toward the export of more value-added processed food products rather than raw materials. Such a shift should be driven by the food processing industry, which holds

Table 7. Loss of major agricultural produce in India

Crops/commodities	Cumulative wastage (percent)	
	As per ICAR–CIPHET study (2015)*	As per NABCONS study (2022)**
Cereals	4.65 - 5.99	3.89-5.92
Pulses	6.39 - 8.41	5.65-6.74
Oilseeds	3.08 - 9.96	2.87-7.51
Fruits	6.70-15.88	6.02-15.05
Vegetables	4.58-12.44	4.87-11.61
Plantation crops & spices	1.18-7.89	1.29-7.33
Milk	0.92	0.87
Fisheries (inland)	5.23	4.86
Fisheries (marine)	10.52	8.76
Meat	2.71	2.34
Poultry	6.74	5.63
Eggs	7.19	6.03

Source: *Ministry of Food Processing Industries, GoI (2022)*

Note:*Jha *et al.* (2015) Report on assessment of quantitative harvest and post-harvest losses of major crops and commodities in India; **NABARD Consultancy Services (2022) Study to determine post-harvest losses of agri produce in India.

the potential to bring about transformative changes in the agricultural sector. Enhancements in food processing capabilities can play a pivotal role in reshaping the composition of India's food exports. As shown in Table 8, the value of processed food exports in 2021/2022 accounted for 22.6 percent of total food exports, and processed food exports have shown a robust 14.6 percent rate of growth, significantly outpacing the 5.4 percent growth observed in agricultural food exports.

Table 8. India's agri and processed food exports, 2021/2022

(US$ millions)

Year	Agrifood exports	Processed food exports	Percent share of processed food in food exports
2017/2018	35467.9	5273.9	14.9
2018/2019	35302.5	6389.2	18.1
2019/2020	32732.0	6264.0	19.1
2020/2021	38654.7	8565.6	22.2
2021/2022	46113.3	10420.0	22.6
CAGR (%)	5.4	14.6	

Source: *Annual Report 2022-23, Ministry of Food Processing Industries, GoI.*

Note: CAGR = Compound Annual Growth Rate.

2 Input Utilisation Patterns in Indian Agriculture

2.1. Requirements and Availability of Quality Seeds

Various interventions under the National Food Security Mission (NFSM), the Sub-Mission on Seeds and Planting Materials (SMSP), and the Rastriya Krishi Vikas Yojana (RKVY) have been undertaken by the central and state governments to distribute quality seeds to farmers in order to bring about sustainable improvements in production and India now enjoys a surplus of certified seeds (Table 9). The Government of India, in consultation with ICAR, ensures uniform prices for breeder seeds to minimise the cost of seed production.

Table 9. Requirement and availability of quality seeds, in 100,000 quintals

Year	Requirement	Availability	Surplus
2019/2020	387.31	431.01	43.7
2020/2021	443.16	483.66	40.5
2021/2022	465.36	498.83	33.47

Source: *Agricultural Statistics at a Glance 2022 (India, MoA&FW 2022).*

2.2. Investment and Mechanisation

In the 1960/1961 to 1969/1970 period, the average gross capital formation in agriculture and allied activities (GCFA) at constant 2011/2012 prices was INR 314 billion (about US$4 billion). In the 1980/1981 to 1989/1990 period, this increased to INR 566 billion (about US$ 7 billion). It remained somewhat stagnant for many years and then again began to increase from the early 2000s, reaching INR 1,583 billion (about US$ 20 billion) in the 2000/2009 period and then INR 2,639 billion (about US$ 33) in the decade from 2010/2011 to 2017/2018. The change in stock varies but constitutes roughly 5 to 9 percent of total GCFA. The private GCFA

Table 10. Public and private GCFA, GDPA (INR billions) and annual rate of growth (percent) at 2011/2012 prices

Average	INR billions				Annual rate of growth (%)			
	GCFA	GCFA Public	GCFA Private	GDPA	GCFA	GCFA Public	GCFA Private	GDPA
1960/1961 to 1969/1970	314	106	209	4,145	8.43	2.56	11.56	1.51
1970/1971 to 1979/1980	478	174	304	5,215	5.97	8.97	4.37	1.74
1980/1981 to 1989/1990	566	234	332	6,716	1.56	-3.96	5.43	2.97
1990/1991 to 1999/2000	770	175	595	9,245	2.66	-0.15	3.38	3.34
2000/2001 to 2009/2010	1,583	287	1,296	11,926	7.89	11.28	7.22	2.57
2010/2011 to 2017/2018	2,639	401	2,238	16,450	0.39	6.68	-0.76	4.10

Source: *National Accounts Statistics, MoSPI, GoI*

Note: GDPA = Gross Domestic Product for Agriculture, represented by Gross Value Added for Agriculture (GVAA);GCFA = Gross Capital Formation in Agriculture.

that is mainly by farm households witnessed a steady increase relative to public GCFA. The public GCFA revived from 2003/2004 but again declined from 2013/2014 (Table 10).

Private household investment accounts for 83 percent of total investment. Although many private companies are making forays into agriculture, their share in total GCFA remains low and stagnant at under 3 percent. Public GCFA pertains mainly to major, medium, and minor irrigation systems and its share has fallen steadily from 44 percent during the 1960s to 20 percent in the most recent decade. The steady decline in the share of public GCFA in total expenditure has been attributed to the diversion of government expenditure toward revenue accounts in the form of an increase in input subsidies (close to INR 1,000 billion/US$ 13 billion at 2011/2012 prices) as well as day-to-day expenses, inadequate funds, and the low priority placed by the government on agriculture and rural development (Bathla and Hussain 2022).

In terms of annual growth rate, during the 2000/2001 to 2009/2010 period,public and private GCFA was considerably higher at 11.28 percent

and 7.22 percent, respectively; it then declined to 6.68 percent and -0.76 percent, respectively, in the subsequent decade. A revival of private GCFA since the 2000s can be explained by a big push in public GCFA, complemented by favourable terms of trade, good weather conditions, and adequate flow of institutional credit. Other factors may include a growing number of holdings due to fragmentation, diversification toward high value crops, and an increase in the demand for processed foods. It is likely that these factors in combination helped agriculture sustain a steady annual 3 to 4 percent rate of growth after 1980 and into the 2000s. The GCFA share in gross domestic capital formation (GDCF) in the economy, however, has been declining steadily, moving from 16.6 percent in the 1960s to its current level of 6.0 percent, a situation that should be addressed.

As per the Government of India, Committee on Doubling Farmers' Income (2016), the required rate of growth in public investment (weighted agriculture, irrigation, rural roads/transport, and rural energy) must be 14.17 percent per year (base 2015/2016), and about 7.86 percent for private investment. The growth rate of investments is currently much lower at 6.68 percent and -0.76 percent, respectively. The marginal returns from public investment under these social and economic expenditure headings (that is, increased agricultural income and reduced rural poverty) are estimated to be very high, and are even higher for public spending on R&D at nearly 9 percent (Bathla, Joshi, Kumar 2020). Notably, that low public investment will not necessarily "crowd in" private investment (by households or corporates). One of the outcomes is the slow pace of mechanisation, which negatively affects productivity. India lags in crop productivity compared to most developed nations. Farm mechanisation in India ranges from 40 to 45 percent, as compared to 95 percent in the United States, 75 percent in Brazil, and 57 percent in China (Alagusundaram *et al*. 2017).

Table 11 shows that the highest level of mechanisation in paddy and wheat production in India is in harvesting and threshing operations and that sowing, planting, and plant protection operations are least mechanised, perhaps due to the involvement of manual operations in these practices (NCAER 2023). India's farm mechanisation is often characterised by its level of "tractorisation" due to the extensive adoption of tractors in crop production, especially in the northern states. Tractors and power tillers are widely used, with an adoption rate of more than 50 percent across the states (DoA&FW 2023). The steady increase in the sale of tractors and power tillers in recent years has also improved demand for other machinery such as transplanters, rotavators, threshers, weeders, and

Table 11. Extent of mechanization across farm operations

Operations	Mechanisation (%)
Ploughing and seedbed preparation	40
Sowing and planting	29
Plant protection practices	34
Harvesting and threshing	60 to 70 (mostly for paddy and wheat)

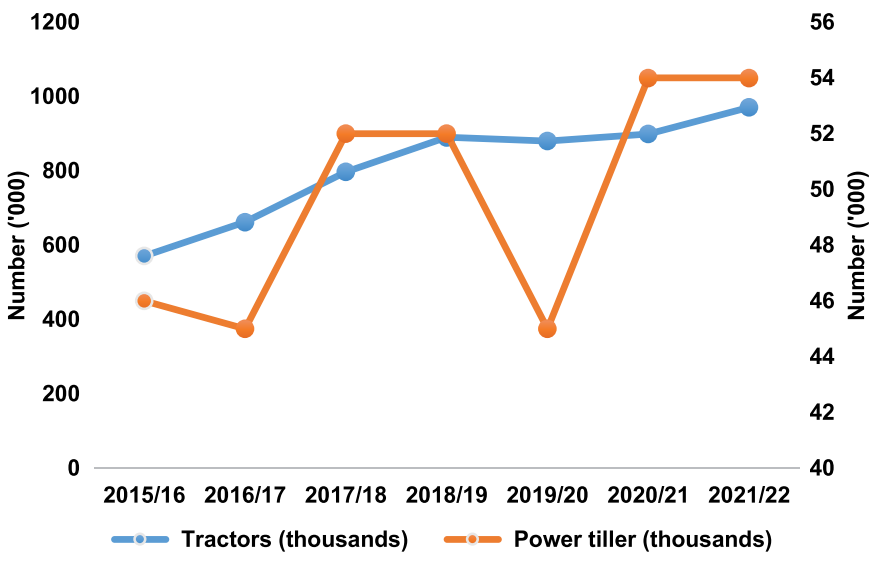
Source: *National Council of Applied Economic Research (NCAER 2023).*

laser levellers (Figure 12). India should make special efforts to turn its agricultural sector into a mechanisation-driven sector. The setting up of "Custom Hiring Centres" in various states and the policy of "Sub-mission on Agriculture Mechanization" can go a long way toward improving the extent of mechanisation among small and marginal farmers (ICFA 2017).

2.3. Fertilisers

India is increasingly reliant on Nitrogen-based fertilizers in its agricultural practices (Bora, 2022). Among the three pivotal nutrients used in crop production, that is, nitrogen (N), phosphorus (P), and potassium (K), the use of nitrogen exhibits a distinct upward trajectory, moving from 173 lakh

Figure 12. *Trends in sales of tractors and power tillers*

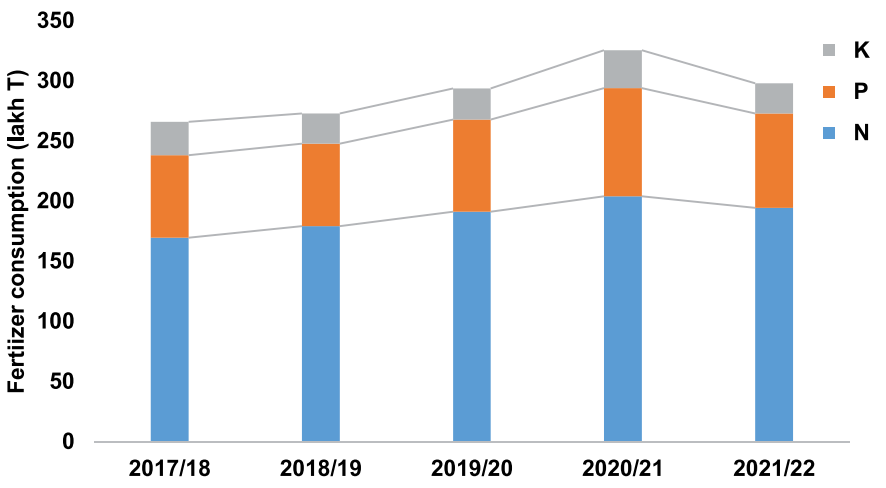


Source: *Agricultural Statistics at a Glance 2022 (India, MoA&FW 2022).*

tonnes in 2011/12 to 194.4 lakh tonnes in 2021/22. The consumption of phosphorus, by comparison, witnessed a more variable pattern with no clear trend, ranging between 56.33 lakh tonnes and 89.78 lakh tonnes. The consumption of potassium remains unchanged at about 25.75 lakh tonnes in 2011/12 and 25.29 lakh tonnes in 2021/22 (Figure 13).

Going by the current status of production, import, and consumption of different categories of fertilisers in India, it is clear that urea has a dominant place among all farmers(Tables 12 and 13). The requirement

Figure 13. *Fertiliser consumption in India: nitrogen (N), phosphorus pentoxide (P_2O_5), and potassium oxide (K_2O)*



Source: *India, Department of Fertilisers (2022).*

Table 12. Fertiliser production status in India (2022/2023)

(lakh tons)

Fertilisers	Urea	DAP	MOP	NPK	SSP	Total
Production	187.2	27.4	-	67.2	38.9	320.8
Imports	46.1	47.8	15.0	19.4	-	128.4
Consumption	232.5	83.5	11.2	74.2	-	401.5
Percents hare of imports in fertiliser consumption	19.8	57.2	133.7	26.2	-	32.0

Source: *India, Department of Fertilizers (2022).*

Note: DAP = di-ammonium phosphate; MOP = muriate of potash; NPK = nitrogen, phosphorus, potassium; SSP = single super phosphate.

for potassium is completely met by imports of 15 lakh tons. There is no domestic production of potassic fertilisers as glauconitic (a potassium-bearing green mica) sandstone is commercially unexploitable in India (India, Ministry of Mines 2019).

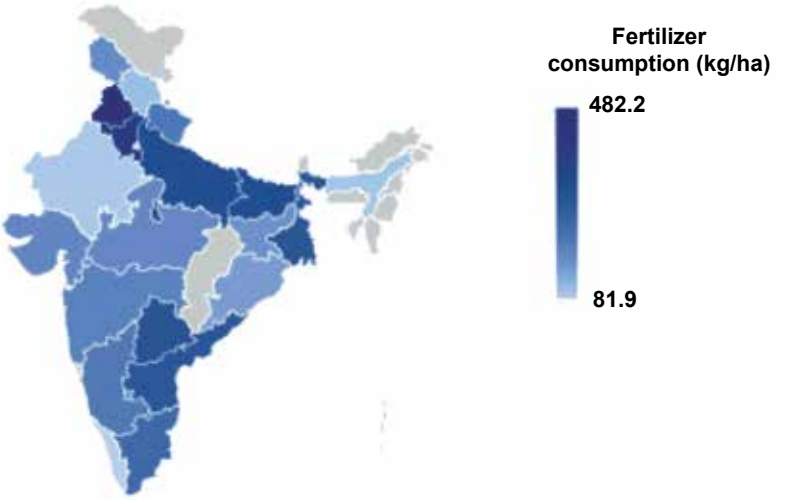
Table 13 and Figure 14 depict total state-wise consumption of fertilisers, which helps understand its India-wide consumption pattern. Uttar Pradesh

Table 13. State-wise fertilizer consumption, 2021/2022

State	Total consumption of fertilisers (lakh tons)	Net sown area ('000 ha)	Fertiliser consumption (kg/ha)
Uttar Pradesh	51.7	16368	315.8
Maharashtra	31.4	16722	187.5
Madhya Pradesh	26.5	15512	171.0
Karnataka	21.9	10804	202.9
Punjab	19.9	4127	482.2
Gujarat	17.0	9787	173.7
Andhra Pradesh	17.0	5884	288.9
Telangana	16.4	5500	297.5
Bihar	16.1	5077	317.7
Rajasthan	16.1	18032	89.3
West Bengal	15.4	5250	293.9
Haryana	13.7	3552	386.8
Tamil Nadu	11.3	4738	238.5
Chhattisgarh	7.6	4635	163.5
Odisha	5.9	4102	143.1
Assam	2.6	2699	97.1
Jharkhand	2.0	1291	156.5
Kerala	1.7	2026	81.9
Uttarakhand	1.3	638	208.5
Jammu & Kashmir	1.2	720	166.7
Himachal Pradesh	0.6	530	105.7

Source: *Agricultural Statistics at a Glance 2022 (MoA&FW 2022).*

Figure 14. *State-wise fertiliser consumption in India*



Source: *Agricultural Statistics at a Glance 2022 (MoA&FW 2022); Fertilizer Statistics 2021-22 (The Fertiliser Association of India 2022).*

consumes the highest amount of fertilisers, that is, 51.69 lakh tons (17.35 percent); this is followed by Maharashtra (10.52 percent), Madhya Pradesh (8.90 percent), Karnataka (7.36 percent), and Gujarat (6.68 percent). Northern and western states are heavy consumers of fertilisers due to their focus on paddy/rice and wheat-related cropping patterns; these two crops consume 37 percent and 24 percent of total fertiliser consumption in India, respectively (Usama and Khalid 2018). It is suggested, however, that fertilisers be applied in a balanced and integrated manner that involves biofertilizers and vermicompost; this may reduce the harmful effects of chemical fertilisers on the environment and improve soil health and nutrient use efficiency (Pathak and Fagodiya 2022).

2.4. Pesticides

Pesticide usage fluctuates, suggesting that its application is influenced by factors such as pest pressures, weather conditions, and evolving farming practices (Tudi *et al*. 2021). Notably, in the period from 2018/2019 to 2022/2023, the highest consumption is observed in 2021/2022 at 52000 mt (Table 14). Chemical pesticides comprise 92 percent of total pesticide consumption. Chemical pesticide consumption may remain stable due to the increased use of biopesticides and biocontrol agents as part of integrated pest management (IPM) practices (Devi,Thomas, Raju 2017).

Table 14. Pesticide consumption in India

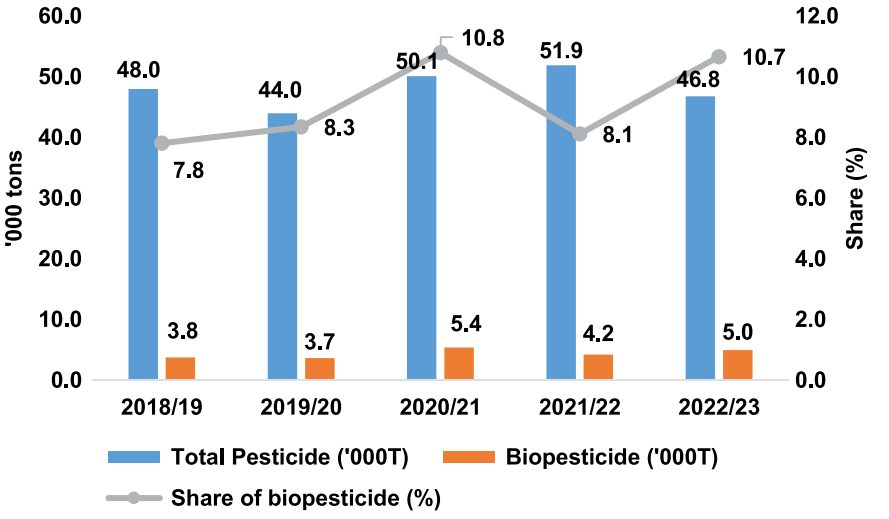
('000 tons)

Year	Pesticides	Crops									Total
		Cereals	Vegetables	Pulses	Oilseeds	Fruit	Plantation crops	Cash crops	Fibre	Other	
2018/19	Chemical	17.3	3.9	5.8	4.9	2.5	0.4	5.0	3.6	1.1	44.3
	Biopesticides	0.8	0.6	0.7	0.9	0.3	0.1	0.3	0.0	0.1	3.8
	Total	18.1	4.4	6.4	5.8	2.8	0.6	5.3	3.6	1.1	48.0
2019/20	Chemical	14.9	3.9	4.4	4.6	2.2	0.3	4.8	4.3	0.9	40.3
	Biopesticides	1.0	0.5	0.3	0.8	0.2	0.1	0.2	0.3	0.2	3.7
	Total	15.9	4.4	4.7	5.4	2.4	0.5	5.0	4.6	1.1	44.0
2020/21	Chemical	17.2	4.8	4.6	4.7	1.7	0.3	6.1	4.0	1.4	44.7
	Biopesticides	1.3	0.8	0.8	1.0	0.2	0.1	0.6	0.1	0.7	5.4
	Total	18.4	5.6	5.3	5.7	1.8	0.5	6.7	4.1	2.1	50.1
2021/22	Chemical	19.4	4.6	6.1	4.9	2.2	0.3	5.9	3.4	1.0	47.7
	Biopesticides	1.4	0.7	0.4	0.8	0.2	0.2	0.5	0.0	0.1	4.2
	Total	20.8	5.3	6.4	5.6	2.3	0.5	6.4	3.5	1.1	51.9
2022/23	Chemical	17.2	4.0	3.8	3.0	1.8	0.2	6.4	1.9	3.5	41.8
	Biopesticides	1.3	0.5	0.3	0.2	0.2	0.1	0.5	0.1	1.9	5.0
	Total	**18.4**	**4.5**	**4.1**	**3.2**	**2.0**	**0.3**	**6.8**	**2.0**	**5.4**	**46.8**

Source: *Statistical database, Directorate of Plant Protection, Quarantine and Storage, GoI.*

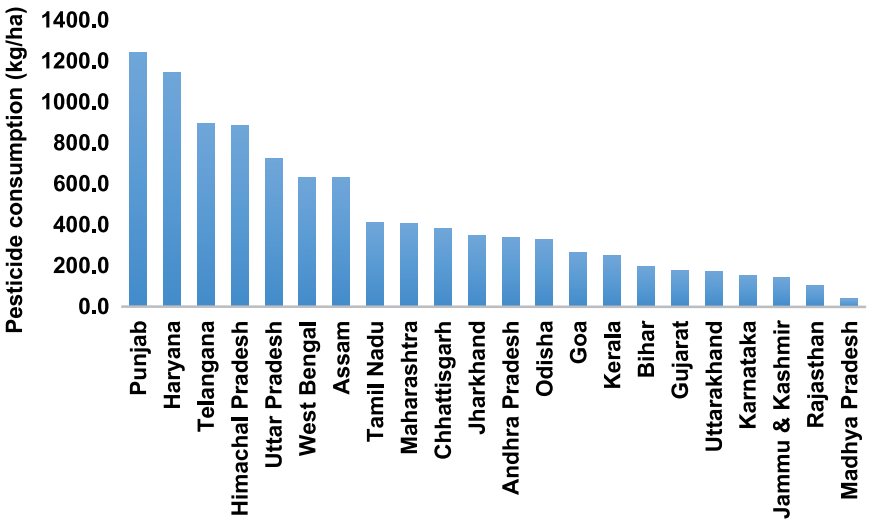
Overall, the states do not show a significant change in the consumption of chemical pesticides (Figure 15 and 16). Only Maharashtra and Jammu

Figure 15. *Trend in biopesticide consumption between 2018/2019 and 2022/2023*



Source: *Statistical database, Directorate of Plant Protection, Quarantine and Storage, GoI.*

Figure 16. *State-wise chemical pesticide consumption*



Source: *Statistical database, Directorate of Plant Protection, Quarantine and Storage, GoI.*

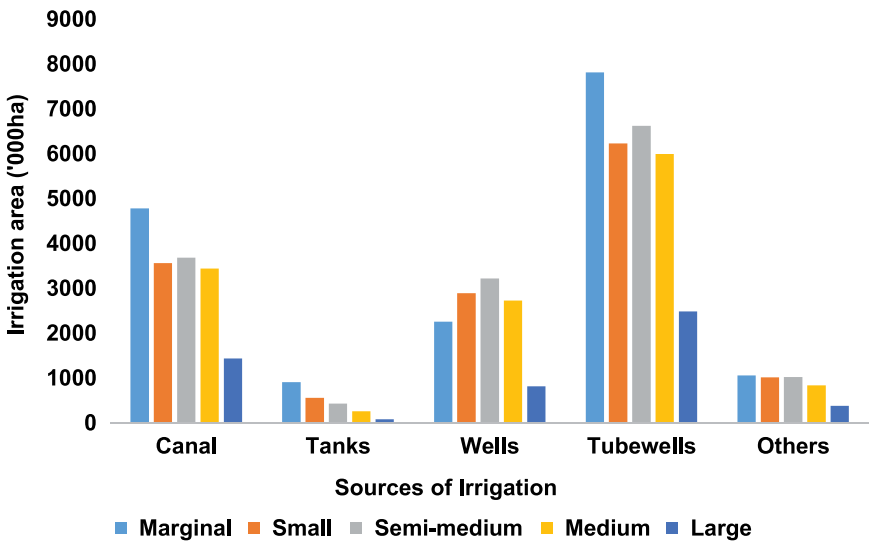
& Kashmir show a sharp decline in chemical pesticide consumption; this is due to an enhanced focus on the popularising of biopesticides and their inclusion in IPM packages (Singh and Narayanan 2015).

2.5. Irrigation

Across all categories of farmers, tubewells are the main source of irrigation water. Almost 7.8 million hectares (mHa) is irrigated by marginal farmers, 6.3 mHa by small farmers,6.6 mHa by semi-medium-sized farmers, 6 mHa by medium-sized farmers, and 2.5 mHa by large landholders (Figure 17). Besides tubewells, canals and wells also contribute to irrigation, and tanks and other sources represent a smaller proportion of overall irrigation infrastructure. Canals and electric tubewells constitute the highest proportion of the total irrigated area, which indicates both the popularity of flood irrigation among farmers and the availability of power subsidies to India's small and marginal farmers (Jain, Kishore, Singh 2019).

In recent years, micro-irrigation has been a focus and has gained limited coverage among mainly the eastern and northeastern states. In, these areas the quality of groundwater is good, and the water table is shallow. Micro-irrigation- more than flood irrigation or a check basin method of irrigation—constitutes a capital-intensive choice (Chand *et al*. 2020). It

Figure 17. *Major sources of irrigation across farm sizes*



Source: *Agricultural Census, 2015-16 (India, DoA&FW 2018).*

is therefore important to justify the economics of micro-irrigation systems and to determine the threshold value that determines whether or not it is implemented. Across India, micro-irrigation (drip and sprinkler) systems are currently emphasised mostly as a way to improve water use efficiency and maintain groundwater levels. The western and southern Indian states of Karnataka, Andhra Pradesh, Gujarat, Rajasthan, and Maharashtra have large areas under micro-irrigation because of water scarcity and uneven rainfall distribution patterns (Viswanathan, Kumar, Narayana moorthy 2016) and efforts are also being made in hilly northeastern regions such as Uttarakhand, Himachal Pradesh, and Jammu & Kashmir to increase the area covered under micro-irrigation (Patel *et al*. 2023). Drip and sprinkler irrigation needs to also be expanded in high-value crop regions that are currently dependent on flood and well irrigation. In 2018/2019, the Government of India launched the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY): Per Drop More Crop scheme, whose objective was to ensure a dependable supply of good quality irrigation water to farmers' fields and improve sustainable water management practices. To date, only 14.5 mHa is under micro-irrigation (Table 15).

Table 15. State-wise area covered under micro-irrigation as of March 31, 2022

(million ha)

States	Drip	Sprinkler	Total
Andhra Pradesh	1.4	0.5	1.9
Arunachal Pradesh	0.0	0.0	0.0
Assam	0.0	0.0	0.0
Bihar	0.0	0.1	0.1
Chhattisgarh	0.0	0.3	0.4
Goa	0.0	0.0	0.0
Gujarat	0.9	0.8	1.7
Haryana	0.0	0.6	0.7
Himachal Pradesh	0.0	0.0	0.0
Jammu & Kashmir	0.0	0.0	0.0
Jharkhand	0.0	0.0	0.0
Karnataka	0.8	1.6	2.4
Kerala	0.0	0.0	0.0

Contd...

States	Drip	Sprinkler	Total
Madhya Pradesh	0.4	0.3	0.7
Maharashtra	1.4	0.6	2.0
Manipur	0.0	0.0	0.0
Meghalaya	0.0	0.0	0.0
Mizoram	0.0	0.0	0.0
Nagaland	0.0	0.0	0.0
Odisha	0.0	0.1	0.2
Punjab	0.0	0.0	0.1
Rajasthan	0.3	1.8	2.1
Sikkim	0.0	0.0	0.0
Tamil Nadu	0.9	0.4	1.3
Telangana	0.2	0.1	0.3
Tripura	0.0	0.0	0.0
Uttar Pradesh	0.1	0.2	0.3
Uttarakhand	0.0	0.0	0.0
West Bengal	0.0	0.1	0.1
Total	**6.7**	**7.8**	**14.5**

Source: *Agricultural Statistics at a Glance 2022 (MoA&FW, 2022).*

2.6. Land Use Patterns

Land resources in India are categorised into several forms such as agricultural land, pasture, forest, and wasteland. Table 16 shows that the geographical area and reported area for land utilisation have been stable over the past five years; however, between 2015/2016 and 2019/2020 gross cropped area shows a 7 percent increase, moving from 198.12 mHa to 211.36 mHa. There has also been a 6 percent increase in cropping intensity in that period which is attributed to the increased crop diversification, and the introduction of more advanced production techniques (Sharma *et al*. 2018). The area under irrigation has also increased significantly over this period, which indicates the effectiveness of irrigation promotion schemes such as PMKSY and the Accelerated Irrigation Benefit Program (AIBP).

Table 16. Agricultural land use pattern in India

(million ha)

Classification	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019	2019/ 2020
Geographical area	328.73	328.73	328.73	328.73	328.75
Reporting area for land utilisation	307.49	308.06	307.51	307.53	306.54
Gross cropped area	198.12	201.16	200.88	201.18	211.36
Cropping intensity (%)	142.56	144.72	144.75	145.32	151.08
Gross irrigated area (GIA)	97.75	99.44	101.27	104.49	112.23
Net irrigated area (NIA)	67.77	69.22	70.08	72.19	75.46
Net sown area (NSA)	138.97	139.00	138.77	138.44	139.90
NIA (%)	48.77	49.80	50.50	52.15	53.94
GIA (%)	49.34	49.43	50.41	51.91	53. 10

Source: *Agricultural Statistics at a Glance 2022 (MoA&FW 2022).*

India has about 140 million farmers. Most landholdings belong to marginal and small farmers; this is followed by the number held by semi-medium, medium, and large farmers (Table 17). Since 2005/2006, the total number of holdings has increased by 14 percent. In contrast, between 2005/2006 and 2015/2016 the total area of landholdings has decreased from 158.3, mHa to 157.8 mHa. Over the past two decades the average size of landholdings has also declined, moving from 1.23 ha to 1.08 ha; this points out the extent of land fragmentation in India. Table 17 provides a comprehensive overview of land distribution and the prevalence of small-scale agricultural operations in India. A considerable number of India's farmers are tenants of their land, mainly in the small and marginal categories.

In the agricultural landscape of India landholding is categorised by the size of the operated area. A majority of landholdings (60 percent) are occupied by small and marginal farmers, who collectively manage 50 percent of total landholdings. Medium and large farmers together constitute only 18 percent of total farm holdings, which illustrates the extent of India's inequality of land distribution, fragmentation of landholdings, and small-scale agricultural practices. Policy efforts are necessary to encourage collective farming practices that ensure higher remuneration for farmers.

Table 17. Number and area of operational holding across farm categories

Category of holdings	No. of holdings (millions)			Area (mHa)			Average size of holdings (ha)		
	2005/06	2010/11	2015/16	2005/06	2010/11	2015/16	2005/06	2010/11	2015/16
Marginal	83.7 (64.8)	92.8 (67.1)	100.3 (68.5)	32.0 (20.2)	35.9 (22.5)	37.9 (24.0)	0.4	0.4	0.4
Small	23.9 (18.5)	24.8 (17.9)	25.8 (17.6)	33.1 (20.9)	35.2 (22.1)	36.2 (22.9)	1.4	1.4	1.4
Semi-medium	14.1 (10.9)	13.9 (10.0)	14.0 (9.6)	37.9 (23.9)	37.7 (23.6)	37.6 (23.8)	2.7	2.7	2.7
Medium	6.4 (4.9)	5.9 (4.2)	5.6 (3.8)	36.6 (23.1)	33.8 (21.2)	31.8 (20.2)	5.7	5.8	5.7
Large	1.1 (0.8)	0.9 (0.7)	0.8 (0.6)	18.7 (11.8)	16.9 (10.6)	14.3 (9.1)	17.1	17.4	17.1
All holdings	129.2 (100.0)	138.3 (100.0)	146.4 (100.0)	158.3 (100.0)	159.6 (100.0)	157.8 (100.0)	1.2	1.2	1.1

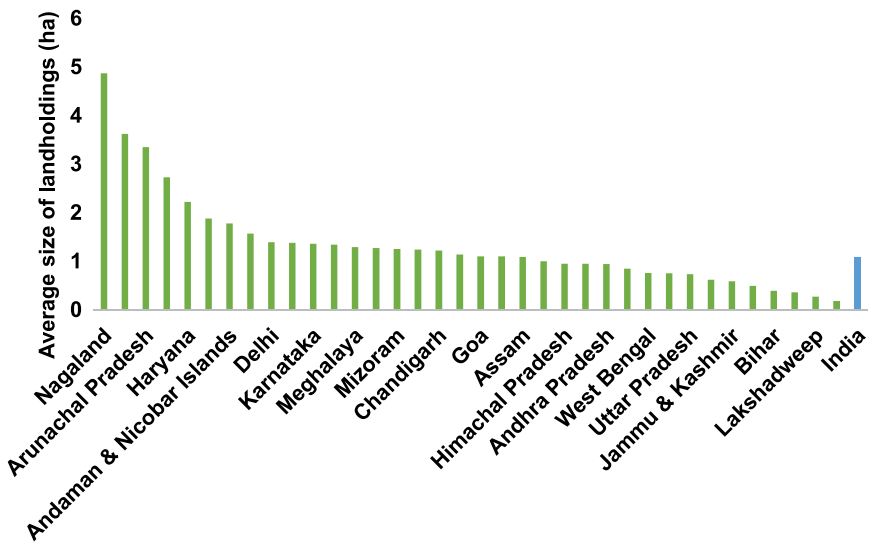
Source: *Agriculture Census 2015-16 (MoA&FW 2018).*

Note: Figures in parentheses indicate percentage share out of total landholdings/ area.

Both the number of landholdings and the area of operational holdings under marginal and small farmers have experienced a sharp increase between 2005/2006 and 2015/2016. Since 2005/2006,the number of holdings has increased by 3 percent; this land fragmentation should be considered a major reason for the low level of productivity poor mechanisation, and the reduced income from agriculture.

Analysis by state and union territory shows that Nagaland has the largest average size of landholdings (4.9 ha); this can be attributed to its vast land area of 1.7 mHa and its relatively small population of 1.5 million. Punjab has the second-largest average land area, at 3.6 ha, followed by Arunachal Pradesh, Rajasthan, and Haryana. Other northeastern states also have larger per capita landholdings than other states due to their vast geographical area and smaller populations. States such as Telangana, Himachal Pradesh, Odisha, Bihar, and Kerala, on the other hand, show average landholdings that are smaller than the all-India average (Figure 18).

Figure 18. *Average size of operational landholdings in states and union territories*



Source: *Agricultural Statistics at a Glance 2022 (MoA&FW 2022).*

2.7. Issues and Challenges of Input Utilisation Patterns

Imbalance and irrational use of agricultural inputs and input services: Across regions and landholding sizes, it is often reported that the use of agricultural inputs such as seeds, fertilisers, plant protection chemicals, and irrigation water is not rational or balanced. Indeed, the overuse of scarce resources such as groundwater for irrigation can degrade the environment. Over time, higher use of fertilisers and plant protection chemicals can cause a deterioration in soil quality, can lead to water pollution, and can undermine the health of farmers and consumers (Sharma, Chatrath, Sendhil 2013; Sendhil *et al*. 2018).

Fragmentation and small landholdings: Owing to land fragmentation, the average farm landholding size continues to decline, moving from 2.30 ha in Agricultural Census 1970-71 to 1.08 ha per farmer in Agricultural Census 2015-16 (India, MoA&FW 2018). According to the 2015/2016 agricultural census, 87 percent of the total 146.4 million landholdings are in the "small" category; this makes it a challenging to adopt modern crop production technologies (Singh 2019; Gulati and Juneja 2022).

Heavy reliance on monsoons: Indian farmers rely heavily on monsoon rains for crop production. Climate change related uncertainties in the monsoon such as erratic rainfall and temperature anomalies are increasingly affecting resource use planning and farm profitability.

Access to technological interventions and innovations: Social and economic restrictions on access to modern crop production technologies and resources affect production efficiency and thereby profitability. Access to technologies is also limited by distance and farm location.

Escalating input costs: As 87 percent of farmers are small holders, the rising cost of inputs such as seeds, fertilisers, plant protection chemicals, labour, and energy will reduce farmers' net returns and economic sustainability and will thus erode their interest in continuing to farm.

Reliable information: With the advent of the Internet of Things (IoT) and the transformation of day-to-day life brought out by information and communication technologies (ICT), farmers have begun to get information from multiple sources including unverified social media. This can create confusion as to the most optimal and judicious use of resources. Multilateral- and multistake holder-based extension advisories and services are thus crucial.

2.8. Opportunities for Efficient Input Utilisation

Adoption of integrated technologies: Integration of validated technologies with a data analytics platform will enhance resource use efficiency. Possible innovative new technologies include precision farming, satellite imaging, micro-irrigation, and IoT-based interventions such as block chain technology.

Diversification: Promoting crop and enterprise diversification and encouraging high-value crop production will reduce the risks of farming and will increase business opportunities with gross capital formation and better market access (Chand and Kumar 2004; Bathla 2014); it will also optimise and enable judicious resource use and improve overall livelihoods.

State intervention: Government initiatives and interventions such as providing incentives, supplying quality seeds, facilitating credit, and improving technology transfer through, for example, demonstrations will increase access to and adoption of technologies.

Organic production: Increasing consumer interest in organic practices and products creates an incentive to reduce the use of agricultural chemicals. Organic produce earns premium prices in the market and promotes a sustainable ecosystem.

Input management: Efficient technologies can help in the judicious use of scarce resources. Micro-irrigation techniques such as sprinkler and drip irrigation, for example, can increase water productivity and water use efficiency, and the use of good quality seeds from authentic sources can address the problem of poor rates of germination.

Capacity building: If they are to take advantage of available opportunities, farmers need to be educated on recent technological interventions and innovations and on new practices. Such knowledge transformation requires appropriate investment and the involvement of extension personnel.

3 Agricultural Finance, Markets, and PM-KISAN

3.1. Institutional Credit

Production credit, a key indicator of financial support to the agricultural sector, has displayed a consistent upward trajectory in the last two decades and medium- and long-term credit has at the same time undergone a notable expansion. The aggregate total credit has experienced a significant surge, advancing from INR 5,11,0 billion (US$ 64 billion) in 2011/2012 to an impressive INR 15,89,4 billion (approx. 200 billion US$) in 2022/2023 (Table 18). This trend underscores

Table 18. Disbursement of short-, medium-, and long-term institutional credit to the agricultural sector

(INR billions)

Year	Production (ST credit)	MT/ LT credit	Total credit
2011/2012	3,961.6	1,148.7	5,110.3
2012/2013	4,735.0	1,338.8	6,073.8
2013/2014	5,484.4	1,816.9	7,301.2
2014/2015	6354.1	2,099.2	8,453.3
2015/2016	6,653.1	2,501.9	9,155.1
2016/2017	6,894.6	3,762.9	10,657.6
2017/2018	7,532.1	4,094.0	11,626.2
2018/2019	7,522.1	5,046.2	12,568.3
2019/2020	8,251.5	5,675.8	13,927.3
2020/2021	8,937.6	6,816.4	15,753.9
2021/2022	10,996.8	7,636.9	18,633.6
2022/2023	10,144.4	5,749.6	15,894.0

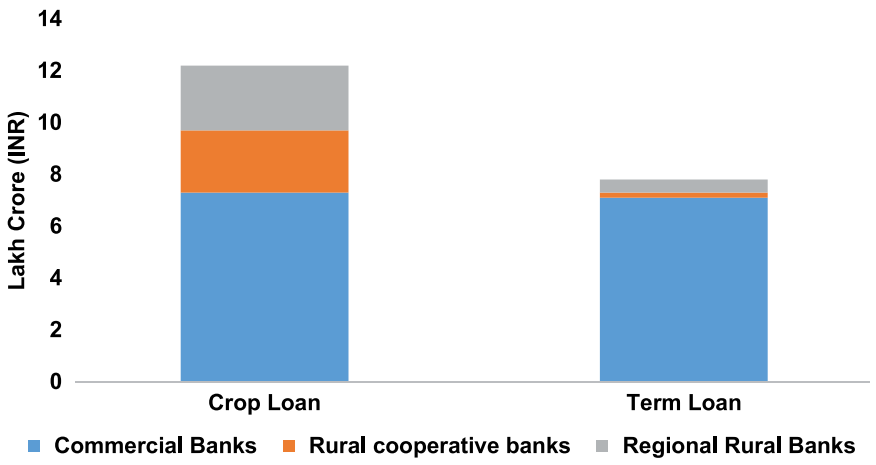
Source: *Annual report 2022-23 (NABARD 2023).*

Note: ST = short-term; MT = medium-term; LT = long-term.

the integral role of institutional credit in supporting the agricultural sector.

During FY2023, INR 21.7 lakh crore was disbursed provisionally against the target of INR 18.5 lakh crore, registering a 117 percent achievement. The agriculture credit target for FY2024 has been fixed at INR 20 lakh crores. So far, crop loans comprised more than 60 percent of the total credit disbursed to the sector; this has come from commercial banks (60.3 percent),regional rural banks (20.7 percent), and rural cooperative banks (19.8 percent) (Figure 19).

Figure 19. *Ground-level credit targets for agriculture by NABARD, FY 2024*



Source: *Annual report 2022-23 (NABARD 2023).*

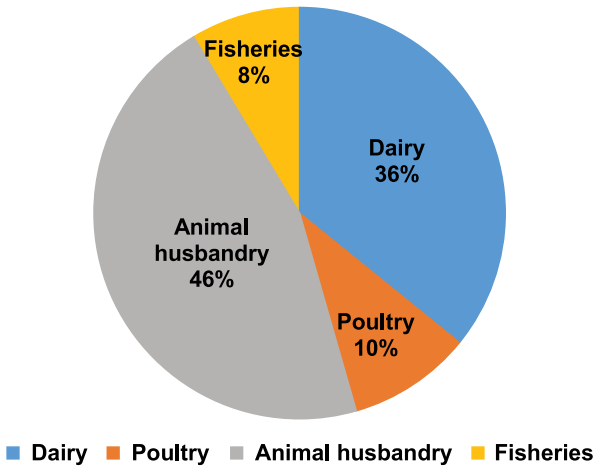
Note: NABARD = National Bank for Agriculture and Rural Development

Despite these developments, there is a huge regional disparity in access to credit, with eastern and northeastern states lagging behind. A high proportion of total agricultural credit needs (40 percent) are met by informal credit; this is problematic as it involves high interest rates, which ultimately worsen farmers' economic welfare (NABARD 2023).Across the country, the dominance of informal credit is particularly notable in the marine fisheries sector, where most of the day-to-day credit requirement of the fishers is met by auctioneers and other informal agents. Even though informal financing provides considerable flexibility in disbursement as well as repayment and has been an important source of credit in the agricultural sector measures such as greater coverage by Kisan Credit Cards (KCC) and strengthening of fishery cooperatives are needed to enhance financial inclusion within the marine fishery sector given the

increasing requirement for investment in fishing and allied activities (Parappurathu *et al*. 2019)

Figure 20 illustrates the composition of ground-level credit targets for the allied sector in the fiscal year 2024, with a total credit target of INR 2,93,000 crore. These financial targets represent a significant investment in the allied sector, which in turn plays a vital role in supporting livelihoods and contributing to food security and economic growth.

Figure 20. *Composition of total ground-level credit targets for the allied sector, FY 2024*



Source: *Annual report 2022-23 (NABARD 2023).*

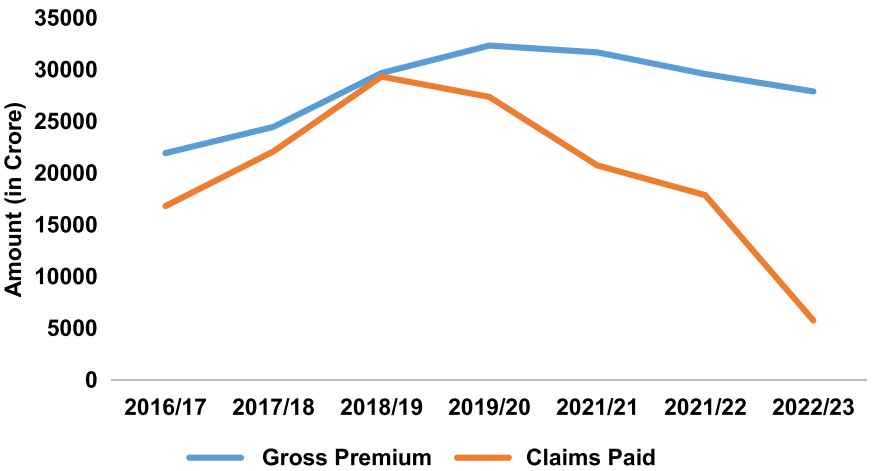
3.2. Insurance

Insurance in agriculture holds significant importance owing to India's increasingly uncertain climatic conditions. To minimise economic losses and safeguard farmers' welfare, several government agricultural insurance schemes are in place such as the Pradhan Mantri Fasal Bima Yojana (PMFBY) and the Restructured Weather Based Insurance Scheme (RWBCIS). (Table A1 in the Appendix presents an overview of progress under the key government agricultural insurance schemes.)

Despite its critical role, crop insurance coverage in India is still low. In 2014, only 6.7 percent of farmers were covered, highlighting the need for increased awareness and uptake (Alawadhi 2023). In 2016, the government launched PMFBY, however its implementation has been riddled with problems.

Every year, protests are organised by farmers over non payment or delayed payment of claims. Gross premium collections have fallen gradually since 2019/2020, while at the same time there has been a drastic decline in the amount paid out in claims (Figure 21). According to experts, there is no direct contact between the insurance company and the farmers, due to which farmers do not know whom to contact within 72 hours of crop loss (Choubey 2023).

Figure 21. *Overview of premium and claims paid under the Pradhan Mantri Fasal Bima Yojana (PMFBY) insurance scheme since its launch in 2016*



Source: *PMFBY, Progress and Achievements, 2016-2021 Ministry of Agriculture and Farmers Welfare, GoI.*

There is also a need to strengthen and widen the coverage of livestock and fisheries insurance in the country. Several technologies have become available in recent times that can be used to increase livestock insurance. The use of radio frequency identification (RFID) technology, for example, can replace retagging of animals at the time of policy renewal. Portability of tag numbers across insurers can be operationalised for continuation of insurance. Index-based insurance schemes and ICT technologies can be piloted in both the livestock and fishery sectors. There are, however, several institutional and policy issues related to livestock and fisheries insurance that need to be addressed (Aggarwal *et al*. 2016).

3.3. PM-KISAN

Over the last three years, the Pradhan Mantri Kisan Samman Nidhi (PM-KISAN) scheme has successfully provided more than INR 2.4 lakh crores of assistance to over 80 million needy farmers (Table 19). Varshney *et al*. (2020) conducted an empirical study which found that the PM-KISAN scheme has successfully addressed the liquidity constraints experienced by farmers when buying agricultural inputs. The scheme has also helped small and marginal farmers meet their other expenses including purchase of consumer goods, education fees, and health care costs.

Table 19. Period-wise details regarding the benefits released under the PM-KISAN scheme since its inception on March 9, 2023

Financial year	Period	Amount (INR billions)
2018/2019	Dec–March	63.2
2019/2020	April–July	132.7
	Aug–Nov	175.3
	Dec–March	179.3
2020/2021	April–July	209.9
	Aug–Nov	204.7
	Dec–March	204.7
2021/2022	April–July	223.3
	Aug–Nov	223.9
	Dec–March	223.2
2022/2023	April–July	225.5
	Aug–Nov	179.8
	Dec–March	171.1
Total		**2,416.5**

Source: *Ministry of Agriculture and Farmers Welfare, GoI.*

Despite its success, some eligible farmers have failed to receive payments due to, for example, technical issues around Aadhar verification or network failure (Kancharla 2021).

3.4. Market Access

There are 2,477 principal markets and 4,843 sub-market yards Agricultural Produce Market Committee (APMC) markets in India. The trade (value

and quantity) that takes place in these markets runs into tens of millions of rupees. The GoI is in the process of linking APMC markets with the Electronic National Agriculture Market (e-NAM)in order to respond to the various anomalies in these markets such as poor price discovery, large inefficiencies due to multiple intermediaries, and low prices received by the farmers. As of July 3, 2023,1,361 *mandis* (markets) are connected with e-NAM. These *mandis* are distributed across 23 states and four union territories, forming a robust network for trade in agricultural commodities. Within this system, a significant number of stakeholders are involved, with 17.5 million farmers participating in e-NAM transactions, alongside 245, 000 traders. Notably, the volume of traded commodities is vast, amounting to 79.7 crore million tons, with a total trade value of INR 258.2 million rupees (Table 20).

Success Story

***Vidyasagar**, resident of Balkonda Mandal, Telangana, owns 7 acres of land and has 20 years of experience in agriculture and marketing. Shri Vidyasagar cultivates paddy, maize, and soybeans. He recently sold 26.16 quintals of soya white through e-NAM (Direct Purchase Centre) and saved a substantial amount. He accumulated INR 1,427 through additional commission and INR 1,501 via reduced hamali (loading) charges. He received a benefit of INR 2,929 in a single transaction of produce worth about INR 70,000. By selling 270 quintals of soya, Vidyasagar earned more than INR 30,000 that otherwise would have gone to fill the coffers of commission agents. The online transaction platform also ensured that Vidyasagar received payment for his produce within 24 hours of the sale, further enhancing the efficiency of his agricultural endeavours.*

***Source:** e-NAM website, Success Stories, Ministry of Agriculture and Farmers Welfare, GoI.*

Table 20. Overview of market access via e-NAM as of July 3, 2023

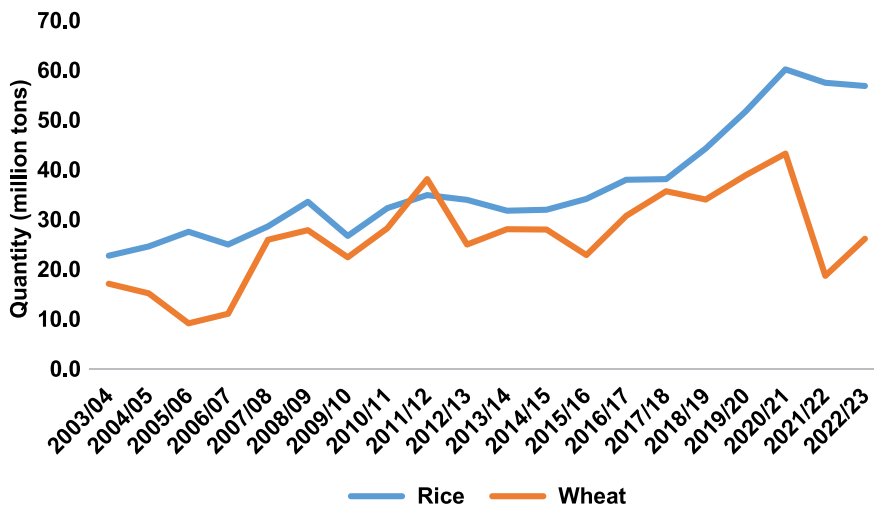
Particulars	Value
Number of *mandis*	1,389
Number of states	23
Number of union territories	4
Number of farmers (10 million)	17.55
Number of traders	245,000
Volume of commodities (crore million tons)	79.77
Value of trade (million)	258.2

Source: *e-NAM website, Ministry of Agriculture and Farmers Welfare, GoI.*

3.5. Procurement Operations and Minimum Support Price

Over the last two decades, the trends in the procurement of two prime commodities, wheat and rice, have exhibited a fluctuating pattern. In FY 2023, the Food Corporation of India (FCI) and state government agencies procured 56.9 million tons of rice, provided benefits of more than INR 1.6 lakh crore to over 11.2 million farmers (Figure 22).

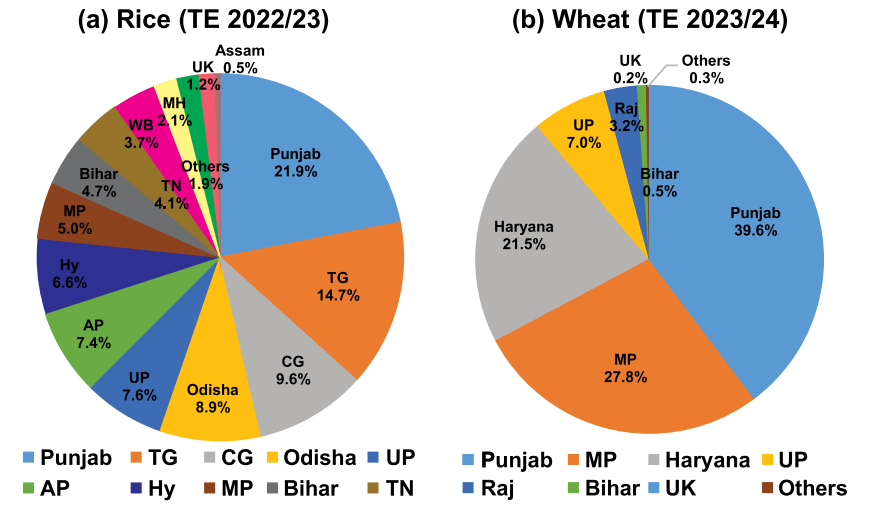
Figure 22. *Procurement of rice and wheat between 2003/2004 and 2022/2023*



Source: *Statistical data, Food Corporation of India.*

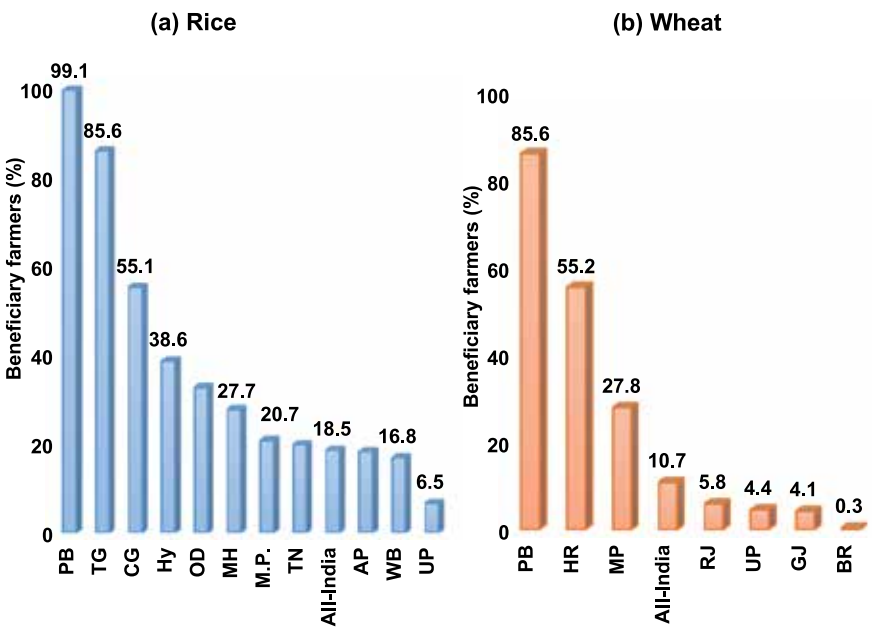
One of the challenges surrounding foodgrain procurement is how to implement it across states so as to maximally benefit farmers. Figures 23

Figure 23. *Procurement of rice and wheat from different states*



Source: *Statistical data, Food Corporation of India.*

Figure 24. *Percentage of beneficiary farmers in different states in 2022/2023*



Source: *Statistical data, Food Corporation of India.*

and 24 illustrate disparities between states in terms of how the procurement system is implemented. In the case of rice, Punjab, Telangana, Chattisgarh, Odisha, and Uttar Pradesh constitute 60 percent of the procurement share, which benefits a high proportion of farmers from these states. In the case of wheat, more than 90 percent of the procurement is from Punjab, Madhya Pradesh, Haryana, and Uttar Pradesh, which illustrates the low coverage of procurement operations in the majority of states. The percentage of farmers benefitting from rice procurement ranges from 6.5 percent in Uttar Pradesh to 99.1 percent in Punjab. In the case of wheat, out of all farmers selling to government agencies, the largest share of beneficiary farmers is from Punjab at 85.6 percent and the smallest share is from Bihar at 0.3 percent.

The government has undertaken various measures in order to shift production from environmentally taxing and low-nutrient grains such as rice and wheat to healthier coarse grains such as millets, pulses, and oilseeds. The United Nations, at the behest of the Government of India, has recognised 2023 as the "International Year of Millets".

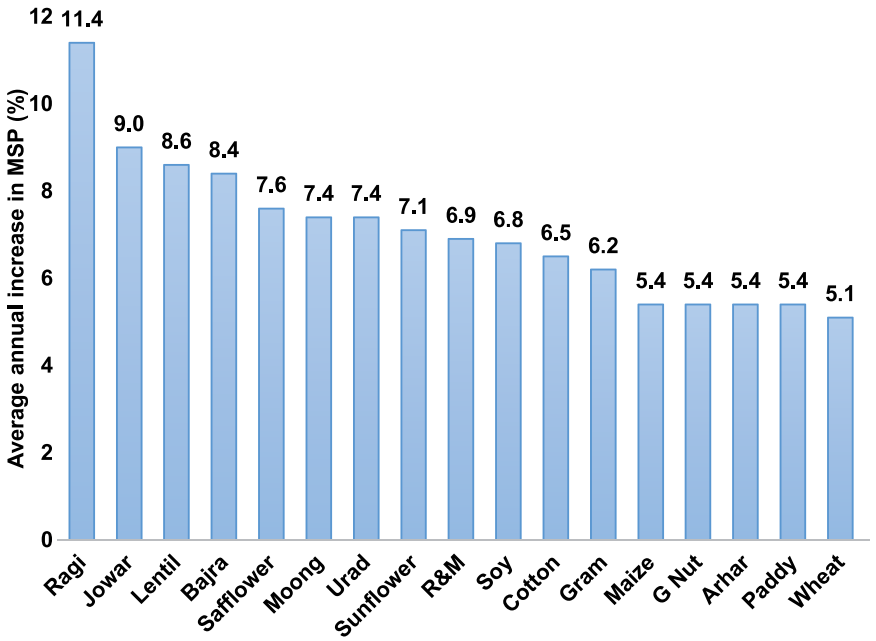
On the policy front, the average rate of growth in Minimum Support Price (MSP) has been much higher for millets, pulses, and oilseeds than for rice and wheat (Figure 25). The central government has initiated procurement of pulses, onions, and maize at pre-announced or market prices through the National Agricultural Cooperative Marketing Federation of India (NAFED) and the National Cooperative Consumers' Federation of India (NCCF). With the aim of making India self-reliant in pulses by 2027, a higher MSP announced for pigeon pea (*toor* dal), which will be followed in due course by a similar announcement for black gram (*urad*), lentils (*masoor*) and maize. This is expected to incentivise farmers to grow and sell to these new procurement initiatives. Proceeds from a sale will be registered in the portal and will go directly into the seller's bank account. This move will increase pulse production in India and also help ensure nutritional security, soil fertility, and water conservation.

3.6. Agricultural Price Movements

3.6.1. Wholesale Price Index (WPI)

The Wholesale Price Index (WPI) is an important tool for monitoring the ever-changing landscape of price dynamics at the wholesale level. WPI stands out as a crucial instrument employed by policymakers, economists, and businesses to assess inflationary pressures and trends within the economy. The WPI data presented in Table 21 makes it apparent that the

Figure 25. *Average annual increase in Minimum Support Price (MSP) of various crops*



Source: *Commission of Agricultural Costs and Prices, Ministry of Agriculture & Farmers Welfare, GoI*

Table 21. Wholesale Price Index numbers for major commodities

Commodities	November 2022	November 2023*	Percent change over year
All commodities	152.5	152.9	0.26
I. Primary articles	178.4	186.9	4.76
A. Food articles	181	195.8	8.18
Cereals	182.7	195.7	7.12
Pulses	178.4	217	21.64
Vegetables	232.8	257.1	10.44
Fruits	173.3	187.8	8.37
Milk	167.3	180.6	7.95
Eggs, meat & fish	166.8	169.2	1.44
B. Non-food articles	168.8	163.4	-3.20

Contd...

Commodities	November 2022	November 2023*	Percent change over year
Oilseeds	199.7	185.4	-7.16
II. Fuel & power	162.8	155.3	-4.61
III. Manufactured products	141.3	140.4	-0.64
Food products	164.6	161.9	-1.64
Beverages	129.1	131.7	-18.43

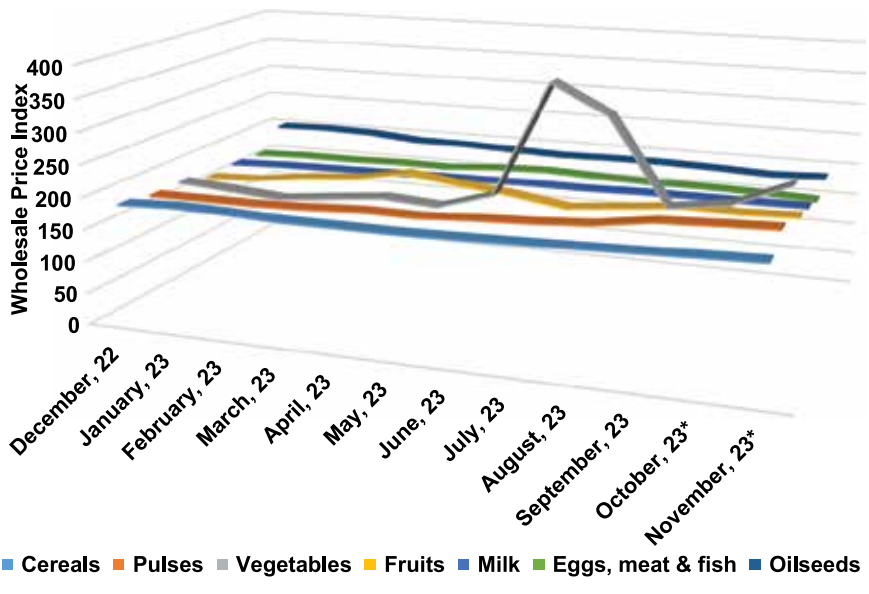
Source: *Latest trade figures, Ministry of Commerce and Industry, GoI.*

Note: * =provisional figures.

WPI number for "all commodities" has experienced a modest 0.26 percent increase. Notably, a surge is observed in the primary articles category, particularly pulses and vegetables. In other categories, by contrast, WPI numbers show a decline. This dip in the index may be attributed to various factors including global market dynamics and shifts in demand and supply patterns.

The graphical representation in Figure 26 illustrates the monthly WPI numbers for major primary articles over the span of a year. The data

Figure 26. *Month-wise Wholesale Price Index changes for primary commodities over the course of 2023*

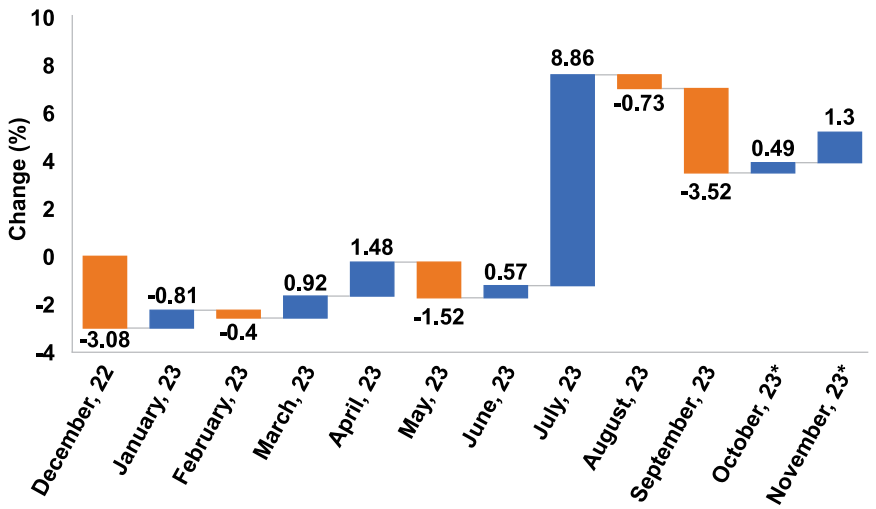


Source: *Latest trade figures, Ministry of Commerce and Industry, GoI.*

reveals that, apart from vegetables, the WPI has maintained stability throughout the year. Vegetables, specifically tomatoes, experienced a significant surge in prices in 2023, particularly during the monsoon season. This unprecedented increase in vegetable prices made a key contribution to the substantial overall rise in the index numbers.

Figure 27 depicts the monthly fluctuations in WPI over the course of 2023. It offers a comprehensive perspective on the evolution of the WPI for primary articles over this time span. The large change that occurred in July reflects a significant surge in the prices of food articles. The continuous month-to-month change in the WPI for primary articles signals a noteworthy shift in the pricing dynamics during the period. This serves as an important indicator of the economic landscape, prompting further exploration into the factors influencing these fluctuations and contributing to a deeper understanding of the trends observed in the primary articles market.

Figure 27. *Percent change in Wholesale Price Index for all primary commodities in 2023*



Source: *Latest trade figures, Ministry of Commerce and Industry, GoI.*

The calculation of the inflation rate based on the movement of the Wholesale Price Index serves as a crucial measure for monitoring the dynamic shifts in prices. In November 2023, the annual (provisional) inflation rate as derived from the All-India Wholesale Price Index is recorded at 0.26 percent compared to November 2022. This positive inflation rate is primarily attributed to a rise in the prices of food articles. Notably, the

inflation rate of the food index encompassing "food articles" from primary food items and 'food products' from manufactured items increased from 1.07 percent in October 2023 to 4.69 percent in November 2023. Table 22 provides index numbers and inflation rates for all commodities and individual components of the WPI over a three-month period.

Table 22. Index numbers and annual rate of inflation (base year: 2011/2012=100)

(Percent)

Major groups	Weight	September 2023		October 2023		November 2023*	
		Index	Inflation	Index	Inflation	Index	Inflation
All commodities	100.0	151.8	-0.07	152.1	-0.52	152.9	0.26
I. Primary articles	22.6	183.6	4.38	184.5	1.82	186.9	4.76
II. Fuel & power	13.2	153.1	-3.35	154.1	-2.47	155.3	-4.61
III. Manufactured products	64.2	140.4	-1.27	140.3	-1.13	140.4	-0.64
Food index	24.4	178.4	1.88	179.6	1.07	183.1	4.69

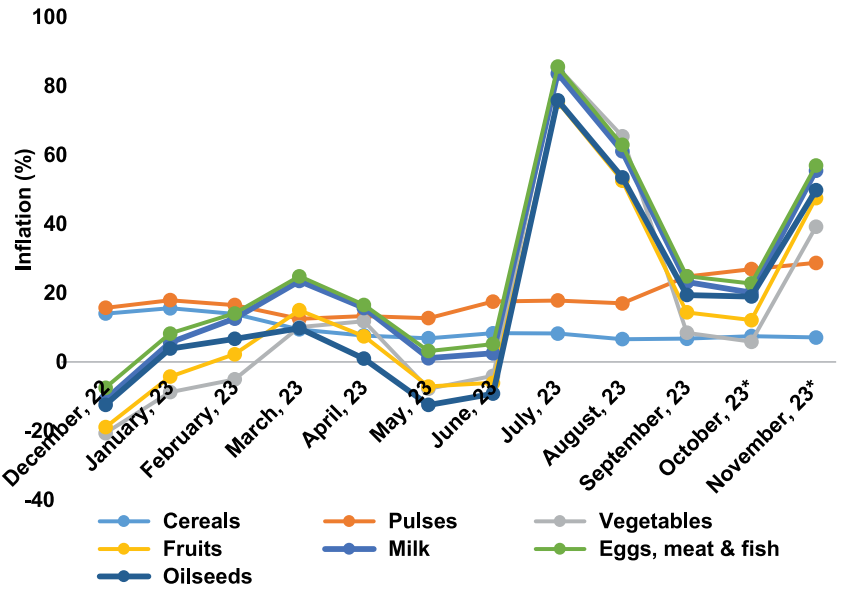
Source: *Latest trade figures, Ministry of Commerce and Industry, GoI.*

Note: * = provisional; annual rate of WPI inflation is calculated over the corresponding month of the previous year.

Figure 28 encapsulates the WPI-based inflation trends for primary commodities over the course of a year. Using a visual representation, it provides a clear and concise overview of how inflation rates fluctuate month-on-month within the primary commodities sector. The graph illustrates the dynamic patterns exhibited by vegetables, oilseeds, and eggs, meat, and fish, highlighting their significant contribution to the overall inflation in the food index.

The graphical representation provides a detailed insight into the dynamic behaviour of key components. This behaviour is often associated with a degree of price volatility where these specific commodities experience notable price fluctuations over time. This association between dynamic behaviour and price volatility is further affirmed by Table 23, which unveils the price volatility observed in key primary commodities. Calculated using the Cuddy-Della Valle Index and utilising monthly data spanning from January 2014 to December 2023, Table 23 highlights that while cereal prices demonstrate a relatively stable pattern, pulses, oilseeds, and vegetables exhibit significant levels of instability. The

Figure 28. *WPI-based inflation of primary commodities over one year*



Source: *Latest trade figures, Ministry of Commerce and Industry, GoI.*

Table 23. Instability among major primary crops, 2014–2023

	Wheat	Rice	Arhar	Moong	Masoor	Groundnut	Soybean	Sunflower	Tomato	Onion	Potato
Jan	5.7	3.4	24.8	13.5	15.1	8.7	12.9	14.5	21.1	47.5	20.3
Feb	5.8	3.4	22.8	13.0	14.0	8.4	12.6	13.9	11.1	35.2	14.7
Mar	4.6	3.4	21.5	13.2	13.8	9.0	14.5	16.1	11.1	27.4	15.8
Apr	4.7	3.9	22.1	13.8	13.5	8.8	15.6	17.1	16.9	19.6	20.5
May	5.1	3.8	22.8	13.9	13.9	9.1	17.5	18.8	38.9	16.9	19.3
Jun	4.5	3.7	23.0	13.0	14.4	9.2	17.8	19.0	38.4	20.8	19.7
Jul	4.5	4.0	23.7	12.6	15.2	9.3	16.5	18.2	49.6	24.9	22.7
Aug	4.9	4.5	22.5	12.1	15.6	9.3	16.2	17.8	50.9	31.7	26.8
Sep	4.9	5.3	22.6	11.9	16.1	9.1	15.5	16.9	27.3	40.5	31.5
Oct	4.7	5.2	26.8	13.7	16.4	8.9	15.3	16.3	23.2	37.4	32.3
Nov	4.7	5.2	28.1	14.3	15.9	8.6	15.1	16.2	29.1	38.7	35.1
Dec	5.0	5.1	27.5	14.0	15.4	7.9	13.7	15.2	30.0	61.4	28.4

Source: *Author's own calculation based on data from Price monitoring division, Ministry of Consumer Affairs, GoI.*

alignment between the insights provided by the graphical representation and the quantified volatility in Table 23 reinforces the understanding that certain commodities contribute to overall price volatility, influencing market dynamics.

3.6.2. Consumer Price Index

The Consumer Price Index (CPI) is a crucial benchmark that serves as a key measure of inflation. It provides insights into the average changes in the prices paid by consumers for a basket of goods and services. The General Index, on the other hand, encompasses a broader spectrum of economic sectors, offering a holistic view of overall price movements. Table 24 offers a comprehensive overview of key economic indicators; it features the General Consumer Price Index (CPI-General) and the Consumer Food Price Index (CFPI). Notably, since 2012/2013 there has been an increase of approximately 5 percent. This increase indicates a favourable trend, commonly referred to as inflation, which represents the evolving price dynamics that consumers encounter over time when paying for a basket of goods and services.

The inflation rate calculated based on the CPI-General and CFPI categorised for rural and urban monthly has been presented in Table 25. In July 2023,

Table 24. Consumer Price Index numbers

(base: 2012=100)

Year	General index (all groups)	Consumer food price index
2012/2013	102.5	103.4
2013/2014	112.2	115.9
2014/2015	118.9	123.2
2015/2016	124.7	129.2
2016/2017	130.3	129.2
2017/2018	135	137.1
2018/2019	139.6	137.3
2019/2020	146.3	146.5
2020/2021	155.3	157.8
2021/2022	165.1	165.0
CAGR(%)	4.9	4.8

Source: *Agricultural Statistics at a Glance 2022 (MoA&FW 2022).*

Note: CAGR = compound annual growth rate.

Table 25. Inflation rates based on CPI-General and CFPI, 2023

(base: 2012=100)

Particulars	January		February		March		April	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
Index								
CPI-General	177.8	174.9	177.9	175.6	178.0	176.3	178.8	177.4
CFPI	173.3	177.4	172.9	177.4	173.0	178.4	173.7	180.0
Inflation								
CPI-General	6.8	6.0	6.7	6.1	5.5	5.9	4.7	4.8
CFPI	6.6	4.8	6.6	5.1	4.7	4.8	3.9	3.7
Particulars	**May**		**June**		**July**		**August**	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
Index								
CPI-General	179.8	178.2	181.9	179.9	187.6	184.7	187.6	184.5
CFPI	175.1	181.1	179.2	186.4	190.1	200.7	189.4	198.2
Inflation								
CPI-General	4.2	4.3	4.8	4.9	7.6	7.2	7.0	6.6
CFPI	3.3	2.4	4.7	4.3	11.0	12.4	9.7	10.4
Particulars	**September**		**October**		**November***			
	Rural	Urban	Rural	Urban	Rural	Urban		
Index								
CPI-General	185.8	182.2	187.0	183.4	188.2	184.2		
CFPI	186.1	192.5	188.1	194.7	190.1	196.7		
Inflation								
CPI-General	5.3	4.7	5.1	4.6	5.8	5.3		
CFPI	6.7	6.4	6.6	6.6	8.4	9.3		

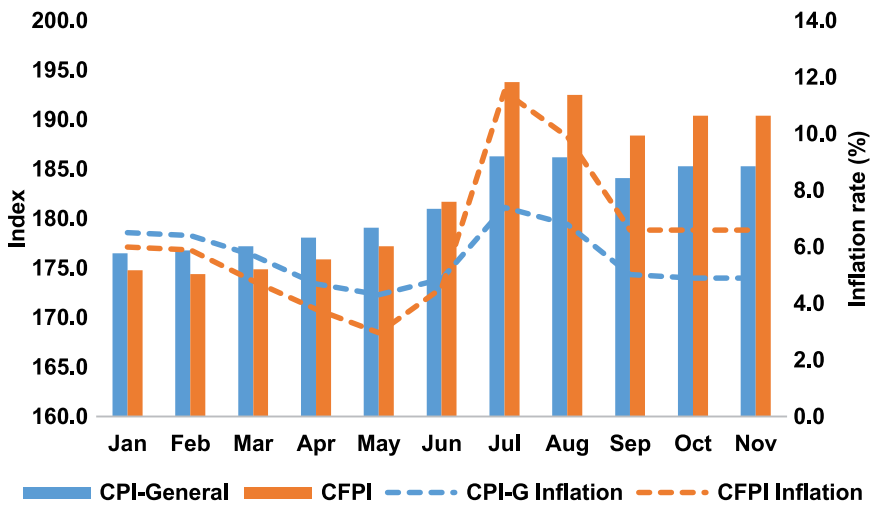
Source: *CPI data, MoSPI,GoI.*

Note:* =provisional; CPI-General = General Consumer Price Index; CFPI = Consumer Food Price Index.

the inflation rate in rural areas stood at 7.6 percent while in urban areas it was recorded at 7.2 percent; during the same period, by contrast, the CFPI, which specifically gauges inflation in food prices, reached record highs of 11 percent in rural areas and 12.4 percent in urban areas.

Figure 29 presents a month-by-month graphical representation of both inflation rates and indexes for combined (rural and urban) set for 2023.

Figure 29. *Inflation rates based on CPI-General and CFPI (combined) (base: 2012=100)*



Source: *CPI data, MoSPI, GoI.*

The Consumer Price Index for Agricultural Labourers (CPIAL) serves as a pivotal economic indicator, offering insights into changes in the average prices of goods and services. This index is specifically tailored to reflect the consumption patterns and expenditure behaviour of this demographic, providing a more accurate representation of the cost of living for those engaged in agricultural work. The growth rate further emphasises the pace at which overall prices of essential goods and services are changing over a specific period. Table 26 provides a comprehensive snapshot of inflation trends over the years, underscoring a notable evolution in the economic landscape. The data reveals a significant increase from negative inflation reported in 2014/2015 to levels of 6 to 7 percent in 2022/2023. These percentages are calculated using the base year of 1986/1987, which serves as a reference point for assessing the relative changes in price levels.

Table 26. CPI for Agricultural Labourers and its growth rate (inflation)

(base: 1986/1987=100)

	Weight	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23
Jan	849	799 (-5.9)	822 (2.9)	877 (6.7)	884 (0.8)	902 (2.0)	958 (6.2)	1021 (6.6)	1061 (3.9)	1131 (6.6)
Feb	843	808 (-4.2)	832 (3.0)	876 (5.3)	894 (2.1)	907 (1.5)	965 (6.4)	1026 (6.3)	1066 (3.9)	1140 (6.9)
Mar	843	811 (-3.8)	839 (3.5)	873 (4.1)	893 (2.3)	910 (1.9)	976 (7.3)	1037 (6.3)	1067 (2.9)	1149 (7.7)
Apr	848	813 (-4.1)	849 (4.4)	876 (3.2)	901 (2.9)	913 (1.3)	987 (8.1)	1052 (6.6)	1081 (2.8)	1159 (7.2)
May	860	813 (-5.5)	853 (4.9)	878 (2.9)	905 (3.1)	914 (1.0)	1000 (9.4)	1060 (6.0)	1092 (3.0)	1167 (6.9)
Jun	869	807 (-7.1)	853 (5.7)	876 (2.7)	900 (2.7)	913 (1.4)	1014 (11.1)	1047 (3.3)	1097 (4.8)	1167 (6.4)
Jul	877	804 (-8.3)	849 (5.6)	870 (2.5)	895 (2.9)	915 (2.2)	1016 (11.0)	1038 (2.2)	1095 (5.5)	1170 (6.8)
Aug	876	803 (-8.3)	843 (5.0)	869 (3.1)	889 (2.3)	917 (3.1)	1010 (10.1)	1037 (2.7)	1095 (5.6)	1171 (6.9)
Sep	873	803 (-8.0)	843 (5.0)	866 (2.7)	887 (2.4)	924 (4.2)	1007 (9.0)	1035 (2.8)	1098 (6.1)	1175 (7.0)
Oct	876	805 (-8.1)	848 (5.3)	870 (2.6)	888 (2.1)	932 (5.0)	1014 (8.8)	1041 (2.7)	1108 (6.4)	1180 (6.5)
Nov	878	811 (-7.6)	860 (6.0)	872 (1.4)	891 (2.2)	940 (5.5)	1019 (8.4)	1049 (2.9)	1119 (6.7)	1186 (6.0)
Dec	876	820 (-6.4)	869 (6.0)	877 (0.9)	894 (1.9)	950 (6.3)	1018 (7.2)	1057 (3.8)	1125 (6.4)	1196 (6.3)

Source: *Labour Bureau, Ministry of Labour and Employment, GoI.*

Note: Figures in parentheses show percentage growth rate (inflation) of Consumer Price Index for Agricultural Labourers.

4 Climate Change and Sustainability

How agricultural activities are practised has a serious effect on natural resources such as land, soil, air, and water. The Indian agricultural sector accounts for about 80 percent of water use and 40 percent of land use; it thus significantly affects the quality of natural resources across the country. In most of the states where a wheat–paddy rotation is followed and sugarcane is cultivated, the water table has been in a consistent decline. Overuse and imbalance in nitrogen, phosphorus and potassium (NPK) fertiliser use have negatively affected soil and water quality (Pathak and Fogodiya 2022). Soil erosion and land degradation have also occurred in many states (Gulati, Kapur, Bouton 2020). In a population-rich country like India where food surplus and security are of prime concern, the conservation of natural resources is of utmost importance (NAAS 2010).

4.1. Groundwater Extraction

In India, water withdrawal exceeds water recharge, which has already led to a 36 percent decline of the groundwater table. Table 27 shows

Table 27. Extent of groundwater extraction in various states of India

State	Total units assessed (no.)	Extent of extraction (%)				
		Safe	Semi-critical	Critical	Over-exploited	Saline
Andhra Pradesh	667	82.6	6.0	2.3	3.5	5.7
Arunachal Pradesh	11	100.0	0.0	0.0	0.0	0.0
Assam	28	100.0	0.0	0.0	0.0	0.0
Bihar	534	88.2	9.6	0.9	1.3	0.0
Chhattisgarh	146	75.3	18.5	6.2	0.0	0.0
Delhi	34	8.8	20.6	20.6	50.0	0.0

Contd...

State	Total units assessed (no.)	Extent of extraction (%)				
		Safe	Semi-critical	Critical	Over-exploited	Saline
Goa	12	100.0	0.0	0.0	0.0	0.0
Gujarat	248	73.4	9.7	1.6	10.1	5.2
Haryana	141	21.3	9.9	8.5	60.3	0.0
HP	10	100.0	0.0	0.0	0.0	0.0
Jharkhand	259	94.2	3.9	0.8	1.2	0.0
Karnataka	227	57.3	15.4	4.4	22.9	0.0
Kerala	152	79.0	19.1	2.0	0.0	0.0
MP	317	73.5	15.8	2.5	8.2	0.0
Maharashtra	353	76.8	17.9	2.3	2.8	0.3
Manipur	9	100.0	0.0	0.0	0.0	0.0
Meghalaya	12	100.0	0.0	0.0	0.0	0.0
Mizoram	26	100.0	0.0	0.0	0.0	0.0
Nagaland	11	100.0	0.0	0.0	0.0	0.0
Odisha	314	96.2	1.9	0.0	0.0	1.9
Punjab	150	11.3	6.7	4.0	78.0	0.0
Rajasthan	295	12.5	9.8	7.8	68.8	1.0
Sikkim	4	100.0	0.0	0.0	0.0	0.0
Tamil Nadu	1166	35.1	19.3	5.4	37.3	2.9
Telangana	589	54.5	30.6	7.5	7.5	0.0
Tripura	59	100.0	0.0	0.0	0.0	0.0
Uttar Pradesh	830	65.2	21.0	5.9	8.0	0.0
Uttarakhand	18	77.8	22.2	0.0	0.0	0.0
West Bengal	268	71.3	28.4	0.4	0.0	0.0
A & N	36	97.2	0.0	0.0	0.0	2.8
Daman & Diu	2	50.0	0.0	0.0	50.0	0.0
J&K	20	100.0	0.0	0.0	0.0	0.0
Ladakh	2	100.0	0.0	0.0	0.0	0.0
Lakshadweep	9	77.8	22.2	0.0	0.0	0.0
India	**6965**	**63.6**	**15.2**	**3.9**	**16.0**	**1.4**

Source: *Ministry of Jal Shakti, GoI.*

states and union territories that are experiencing significant stress on their groundwater resources. A number of areas record large declared critical areas due to over-exploitation of groundwater; these include Punjab (78.0 percent), Haryana (60.3 percent), Rajasthan (68.8 percent) and Tamil Nadu (37.3 percent). Other states, on the other hand, are considered "safe" in terms of water use efficiency, including states of the northeast, Goa, and Himachal Pradesh. The union territories have shown varying trends in groundwater extraction, with Delhi and Daman & Diu having exceeded the groundwater extraction limit and being classified as "critical" zones. Groundwater extraction does not follow any particular regional trend and varies across states and union territories. Emphasis must thus be given to tailored water management strategies to control over-extraction of water and maintain the groundwater table.

4.2. Salt-Affected Soils

Increasing land degradation in the form of salt-affected (either saline or sodic) soils in India imposes serious threats to the national food supply in terms of production and monetary losses (CSSRI-NAIP 2014). India has over 6.7 mHa of salt-affected lands, which cause an annual loss of about 16.84 million tons of farm produce with a value of over INR230 billion (CSSRI 2015).

Soil salinity is most extensive in Gujarat (1.2 mHa); this is followed by Maharashtra (0.17 mHa) and Haryana (0.04 mHa) (Table 28). Alkali soils with elevated levels of sodium are particularly widespread in Uttar Pradesh (1.3 mHa), Gujarat (0.5 mHa), and Maharashtra (0.4 mHa). Salinity of coastal soils is significant in Gujarat (0.46 mHa), West Bengal (0.44 mHa), and Andhra Pradesh (0.07 mHa). Among the states, Uttar Pradesh reports the highest production loss (7.69 million tons), followed by Gujarat (4.83 million tonnes). Gujarat faces challenges from all three types of soil degradation, with a total affected area of 2.2 mHa and a monetary loss of INR 100.63 billion (Mandal *et al*. 2018). Gujarat and Uttar Pradesh have the largest salt affected area (>50% of cultivated area) in the country. Gujarat is experiencing a loss of 74 percent of its total income from agricultural production and UP is experiencing a 79 percent loss (Sharma and Chaudhari 2012). The adverse effects of problematic soils can be reversed by introducing a combination of crop management practices and interventions of surface and subsurface drainage in affected regions.

Table 28. Extent and distribution of salt-affected soils in India

(in hectares)

State	Saline soils	Alkali soils	Coastal saline soil	Total
Andhra Pradesh	0	196,609	77,598	274,207
A &N Islands	0	0	77,000	77,000
Bihar	47,301	105,852	0	153,153
Gujarat	1,218,255	541,430	462,315	2,222,000
Haryana	49,157	183,399	0	232,556
J&K	0	17,500	0	17,500
Karnataka	1,307	148,136	586	150,029
Kerala	0	0	20,000	20,000
Madhya Pradesh	0	139,720	0	139,720
Maharashtra	177,093	422,670	6,996	606,759
Odisha	0	0	147,138	147,138
Punjab	0	151,717	0	151,717
Rajasthan	195,571	179,371	0	374,942
Tamil Nadu	0	354,784	13,231	368,015
Uttar Pradesh	21,989	1,346,971	0	1,368,960
West Bengal	0	0	441,272	441,272
India	**1,710,673**	**3,788,159**	**1,246,136**	**6,744,968**

Source: *Vision 2050, ICAR-CSSRI.*

Note: J&K = Jammu and Kashmir

4.3. Soil Erosion and Land Degradation

Soil erosion in the cultivable areas of several states poses a threat to agricultural production and to state-level earnings (Aulakh and Sidhu 2015). In India, a total of 9.2 mHa is affected by soil erosion, which is almost 6 percent of the total cultivable land area (Table 29).

Among the states, Rajasthan suffers the most from soil erosion (20.65 percent) due to extensive arid and semi-arid zones, with large desert areas that receive less rainfall every year (Pal 2019). Uttar Pradesh and Madhya Pradesh follow Rajasthan closely and these three states together comprise 50 percent of total soil erosion in India (Kumar and Sharma 2020). Soil

Table 29. State-wise cultivable area affected by soil erosion in India

State	Area ('000 ha)
Andhra Pradesh (including Telangana)	8,093
Arunachal Pradesh	666
Assam	3,248
Bihar	851
Chhattisgarh	3,733
Goa	1
Gujarat	984
Haryana	306
Himachal Pradesh	982
Jammu & Kashmir	1,369
Jharkhand	3,219
Karnataka	7,522
Kerala	490
Madhya Pradesh	**12,262**
Maharashtra	8,799
Manipur	122
Meghalaya	302
Nagaland	46
Odisha	2,227
Punjab	229
Rajasthan	**19,029**
Sikkim	45
Tamil Nadu	2,308
Tripura	109
Uttar Pradesh	**13,075**
Uttarakhand	1,018
West Bengal	1,332
Total	**92,400**

Source: *Degraded and Wastelands of India: Status and Spatial Distribution (NAAS2010).*

conservation practices must be prioritised based on the severity of the degradation, and a region-wise land management framework should be developed to control soil degradation due to water and wind erosion and anthropogenic activities.

An assessment of land degradation by various agencies and organisations is presented in Table 30. It shows that the overall degraded land in India has declined by 63 percent from 148 mHa to 55 mHa over the past five decades. According to a study conducted by the National Remote Sensing Centre in 2019, total wasteland in India has declined from 17.22 percent in 2010 to 16.96 percent of the total geographic area in 2019.

Table 30. Assessment of land degradation in India by different agencies/ organisations

Agencies/organisations	Year	Area (mHa)
National Commission on Agriculture	1976	148.09
Ministry of Agriculture (Soil and Water Conservation Division)	1978	175
National Remote Sensing Agency (NRSA)	1985	53.28
Ministry of Agriculture	1985	173.64
Ministry of Agriculture	1994	107.43
ICAR-National Bureau of Soil Survey and Land Use Planning (NBSS&LUP)	1994	187.7
ICAR-NBSS&LUP (Revised)	2004	146.82
Indian Council of Agricultural Research, National Academy of Agricultural Sciences (NAAS) based on harmonised database	2010	120.7
Space Applications Centre (SAC), Indian Space Research Organisation (ISRO), Ahmedabad based on Indian Remote Sensing Satellite (IRS) Advanced Wide Field Sensor (AWiFS) data	2016	96.4
Department of Land Resources in collaboration with the National Remote Sensing Centre (Wastelands Atlas of India)	2019	55.77

Source: *Survey on Soil Erosion (MoA&FW 2022).*

4.4. Climate Variations and Natural Calamities

The growth and development of agriculture has been significantly affected by extreme weather events in the form of frequent floods, cyclones, droughts, heat and cold waves, landslides, hailstorms, and thunder storms. The total number of recorded natural disasters has increased from 50 during the 1971-to-1980 period to more than 100 between 2011 and 2020 (Table 31).

Table 31. Number of extreme weather events in India over the past five decades

Year	Floods	Cyclones	Heatwaves	Droughts	Earthquakes	Tsunami	Total
1971/1980	21	20	4	2	3	0	50
1981/1990	33	21	4	2	3	0	63
1991/2000	46	19	4	3	5	0	77
2000/2010	99	15	7	2	3	1	127
2011/2020	71	17	6	2	6	0	102

Source: *Economic and Social Commission for Asia and the Pacific (ESCAP), Risk and Resilience portal*

Floods and cyclones predominate among climate hazards. Floods have been consistent over time and across regions while cyclones occur mostly in coastal regions causing billions in economic losses to agriculture. Creation of an area-specific and timely disaster management policy is essential; it should include appropriate crop planning to increase the resilience of vulnerable farming communities and help them recover from disasters. Flood-resilient crop varieties exist in the case of paddy but much more progress can be made in this area of disaster management.

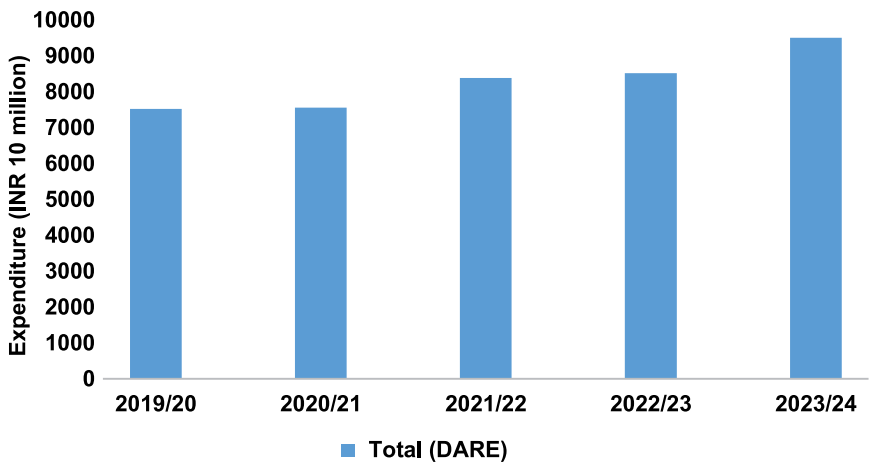
5 Technology Development

5.1. Agricultural R&D Budget

As per the 2023/2024 budget, the Ministry of Agriculture and Farmers Welfare accounts for 2.8 percent of the total Union Government budget. Total allocations to the sector have increased by 5 percent from the previous year's revised estimate of INR 1,25,036 crore.

Since research is a critical channel of agricultural development and farmers welfare, the Department of Agricultural Research and Education (DARE) has been allocated INR 95 billion, an increase of 10 percent from the revised estimate of FY 2023 (Figure 30).

Figure 30. *Expenditure on the Department of Agricultural Research and Education (DARE) by the MoA&FW*



Source: *Budget Documents, Ministry of Finance.*

Note: Actual expenditure and budget allocations are net of recoveries; MoA&FW = Ministry of Agriculture and Farmers Welfare.

5.2. Research Output

Technological improvements are key to efficient and profitable production in agriculture. The Indian Council of Agricultural Research (ICAR) has displayed an unwavering dedication to agricultural research and innovation, resulting in the development of a remarkable total of 2020 technologies across diverse domains. Each sector within ICAR has made substantial contributions to this endeavour, as revealed by the data. In the field of agricultural education, 87 technologies have been devised to improve the quality of agricultural education and outreach. Agricultural engineering, with 75 technologies, has focused on mechanising and enhancing agricultural processes. Animal science has produced 244 technologies, enriching livestock management and health. Crop science with 332 technologies, concentrates on crop improvement and protection. Fisheries science has contributed 138 technologies, promoting sustainable aquaculture and fisheries management. Horticultural science shines with 554 technologies, driving progress in fruit and vegetable cultivation. Natural resource management has meanwhile produced an impressive 590 technologies emphasising sustainable land use, water management, and environmental conservation. These achievements underscore ICAR's pivotal role in advancing agricultural practices, enhancing food security, and ensuring India's resilience in a dynamic agricultural landscape.

As shown in Table 32, between 1969 and 2023 extensive efforts were made to create and release a multitude of crop varieties. In the realm of cereals, 3,176 varieties were released over this period. Between 2014 and 2023, 2,593 varieties were introduced, including 2,177 climate-resilient varieties and 150 biofortified varieties. In the category of oilseeds, 1045 varieties have been released over the years, with 383 emerging between 2014 and 2023. These included 356 climate-resilient varieties and 19 biofortified varieties. In pulses, 1,165 varieties have been released over the years, with 398 introduced in the last 10 years encompassing 391 climate-resilient varieties and 6 biofortified varieties. The data also extends to forage crops, fibre crops, and sugar crops, highlighting the development and release of numerous varieties.

5.3. Challenges and Opportunities in Agricultural Technology Development and Adoption

5.3.1. Challenges

Cost and time boundedness: Technology developers operate in a competitive research ecosystem with regard to time and financial resources.

Table 32. Varieties developed by ICAR

Crops	No. of varieties released (1969 to 2023)	No. of varieties released (2014 to 2023)	Climate-resilient varieties (2014 to 2023)	Biofortified varieties
Cereals	3,176	1,248	1,041	107
Oilseeds	1,045	383	356	19
Pulses	1,165	398	391	6
Forage crops	259	155	117	-
Fibre crops	585	313	209	-
Sugar crops	158	79	53	-
Others	50	17	10	18 (Horticulture)
Total	**6,438**	**2,593**	**2,177**	**150**

Source: *Ministry of Agriculture and Farmers Welfare, GoI, 2023.*

Demand, policy shifts, and emerging threats in agriculture need to be addressed with suitable technological intervention. Iterative procedures are also followed in improving the existing technology. Sufficient financial resources with allotment of enough time from conceptualisation to development thus facilitate the development of cost-effective technologies and cater to the needs of the resource-constrained farming community.

Limited awareness and skills: The goal here is the achievement of accelerated adoption of modern agricultural technologies and innovations. One challenge is the remote location of a majority of small and marginal farmers, which restricts their access to modern agricultural technologies. A second challenge that needs to be addressed is the lack of awareness, education, skills, and financial resources.

Fragmentation of operational holdings: Indian agriculture comprises mainly small and marginal landholders. In most states, landholdings are fragmented; as a result, diseconomies of scale and the resulting high costs prohibit farmers from implementing technologies such as combine harvesters and modified combines that allow for super straw management systems, which provide a practical and more ecological (non-burning) way to handle rice straw.

Gap in rural infrastructure: Rural regions often suffer from inadequate infrastructure and facilities including lack of storage, poor logistics, and

difficulties of market access. These conditions impede the introduction of new technology which, in turn, delays integration into the regional and global agricultural value chain.

Challenges of climate change: Agricultural production, being biological in nature, is vulnerable to increasing uncertainties and fluctuations in agro-meteorological variables and to more frequent floods, droughts, and other climate change related disasters. Climate-resilient technology is thus urgently called for, as is research into the optimal conditions for its accelerated rate of adoption and successful implementation.

Data management and confidentiality: In the era of IoT, data-driven technologies such as automated precision farming raise concerns about user privacy, copyrights, and possible misuse.

5.3.2. Opportunities

India is well poised to take advantage of a range of new technologies that will move it forward on a trajectory of inclusive development. It will thus do well to consider the available opportunities for adoption and dissemination of these improved technologies and strategies.

Capitalising digital agriculture: Taking advantage of modern digital technologies such as automated precision farming, drones, sensors, satellite imagery, and block chain will help India to optimise resource use, increase productivity, and reduce ecological impacts. Digital platforms and mobile apps will also facilitate the flow of knowledge and information among stakeholders (Klerkx, Jakku, Labarthe 2019).

Shifting to secondary agriculture: Shifting the focus from primary to secondary agriculture through mechanisation will improve efficiency and profitability and will widen the market for exports.

Harnessing the potential of cutting-edge sciences: The increased thrust of research and development into frontier sciences like biotechnology, bioinformatics, nanotechnology, and artificial intelligence will help develop customised technologies such asclimate-resilient high-yielding seed varieties.

Agri-tech startups: The massive growth of agri-tech startups in India in recent years showcases the opportunity for technological development and dissemination. A number of these startups specialise in different aspects of the value chain, addressing challenges in farm management, storage, processing, logistics, and market access.

State intervention and collaboration: Several government initiatives focus on inclusive development by providing farmers with credit and assistance in technology adoption; these include Pradhan Mantri Kisan Samman Nidhi (PM-KISAN) and the National Mission for Sustainable Agriculture (NMSA).The government's ongoing focus on enhanced collaboration with line departments will further facilitate knowledge transfer, technology swap, and access to the best agricultural practices.

To address the present and future challenges in Indian agriculture, concerted efforts and a multistake holder approach are called for. This should include producers, researchers, government representatives and agencies, the private sector, institutions, and civil society organisations. Such collaboration will help unlock the country's potential and ensure robust technology-driven, inclusive, and sustainable development.

6 Way Forward for Sustainable and Inclusive Agricultural Growth

Indian agriculture is positioned to take advantage of multiple opportunities and at the same time faces numerous challenges. Given the diverse nature of agricultural practices across the country, a one-size-fits-all policy approach may not work. Some general action points that could be adopted in each state to address challenges and unleash opportunities in Indian agriculture are summarised below.

6.1. Accelerate Public and Private Investments in Agriculture

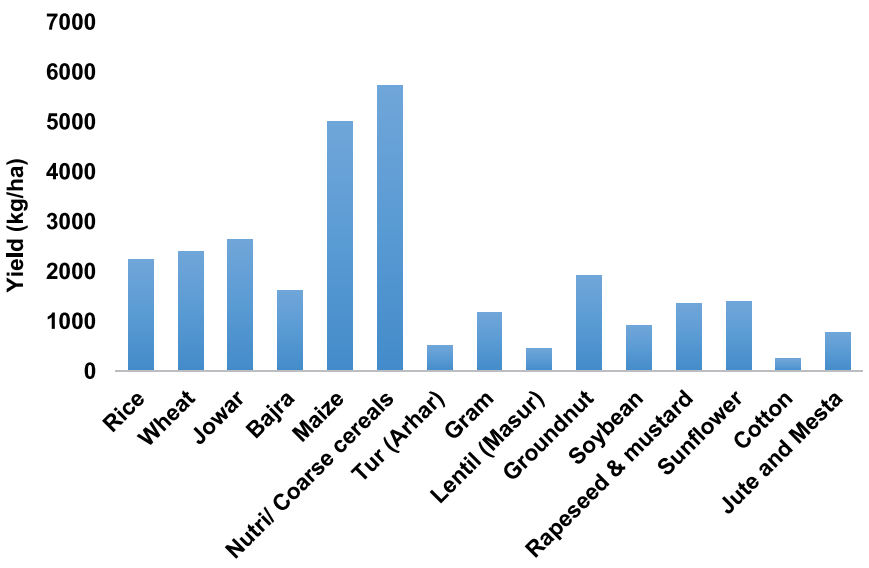
In India, investment in agriculture is lower than that allocated for other economic and social services. According to figures for various years from India's Planning Commission, the resources allocated to subsectors such as crops, veterinary services, dairy, and fisheries do not match what they contribute to the value of outputs. There is thus a call for greater allocation of resources to the agricultural sector, especially for improving productivity, promoting agricultural diversification, and developing infrastructure for flood control, irrigation and drainage management, and land development. Investment in livestock should be enhanced, especially to provide better breeding and veterinary services, and the dairy subsector shows immense potential with a strong smallholder bias. Fruit and vegetable growing also offers huge potential and there needs to be further strengthening of markets as well as cold storage, cold chain, and warehouse infrastructure. Business models may be developed to attract the private sector to invest in production as well as in postharvest and marketing activities. The agricultural research and extension system needs to be reenergised and sufficient resources should be allocated for undertaking needs-based research. Higher allocation of resources to agriculture will lead to more inclusive growth and alleviate poverty and under nourishment. Provision of input support on fertilisers, irrigation, and power should not be at the cost of investment in agriculture. Input subsidies should be rationalised by targeting states, tenant farmers, women

farmers, and small and marginal farmers. Farmers cards should be issued to all so that they may reap the benefits of government schemes.

6.2. Bridge the Yield Gaps

Huge yield gaps exist for most crops as a result of different farming practices and levels of technology integration. Even with existing levels of technology, important opportunities are available for transforming agriculture. Adoption of higher yielding varieties and improved technologies and practices can considerably enhance crop yields. Through Front Line Demonstrations, researchers interface directly with farmers in the process of introducing, monitoring and receiving feedback around new technologies. The increased yields resulting from this unique approach indicate the potential of proactively introducing improved technologies into existing farm practices. In addition to newer high-yielding varieties, better management practices also have enormous potential to increase agricultural productivity. Better soil and water management, seed replacement, adoption of resource conservation technologies such as conservation agriculture, laser land levelling, and direct seeded rice could prove very effective in raising crop yields, especially in agriculturally underdeveloped states (Pathak *et al*. 2021) (Table 33 and Figure 31).

Figure 31. *Yield gap of major crops*



Source: *Agricultural Statistics at a Glance 2022 (MoA&FW 2022).*

Table 33. Yield gap of major crops, 2021/2022

	Maximum yield (state)	Yield (kg/ha)	Minimum yield (state)	Yield (kg/ha)	Difference
Cereals					
Rice	Punjab	4,340	Chhattisgarh	2,101	2,239
Wheat	Haryana	4,533	Maharashtra	2,117	2,416
Jowar	Andhra Pradesh	3,166	Haryana	527	2,639
Bajra	Madhya Pradesh	2,533	Maharashtra	903	1,630
Maize	West Bengal	7,158	Rajasthan	2,149	5,009
Nutri/coarse cereals	West Bengal	7,028	Rajasthan	1,280	5,748
Pulses					
Tur (arhar)	Uttar Pradesh	1,196	Karnataka	666	530
Gram	Gujarat	1,908	Chhattisgarh	725	1,183
Lentil (masur)	Rajasthan	1,321	Bihar	850	471
Total pulses	Gujarat	1,526	Karnataka	617	909
Oilseeds					
Groundnut	Tamil Nadu	2,553	Andhra Pradesh	630	1,923
Soybean	Telangana	1,716	Rajasthan	801	915
Rapeseed & mustard	Gujarat	1,996	Assam	636	1,360
Sunflower	Haryana	1,926	Maharashtra	531	1,395
Oilseeds	Tamil Nadu	2,290	Karnataka	942	1,348
Commercial crops					
Cotton	Rajasthan	558	Maharashtra	306	252
Jute and mesta	West Bengal	2,900	Assam	2,117	783

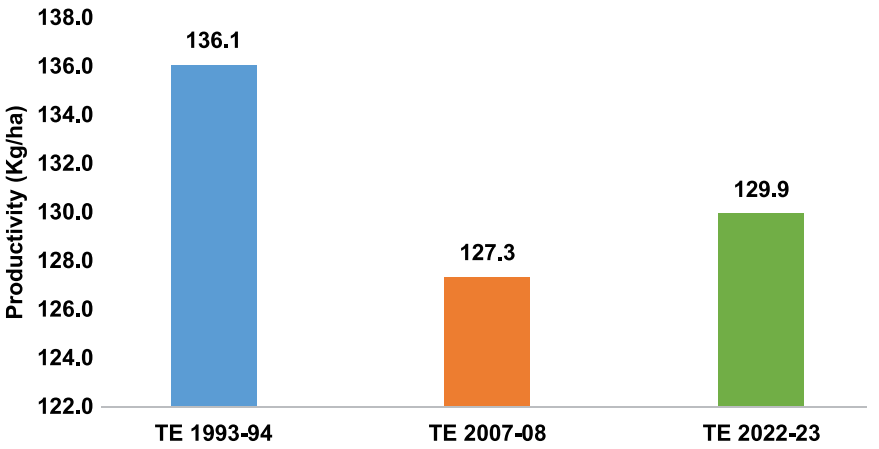
Source: *Agricultural Statistics at a Glance 2022 (MoA&FW 2022).*

6.3. Address Low Productivity and High Vulnerability

Low productivity and high vulnerability stand out as critical constraints within the landscape of Indian agriculture. They cast a shadow on the

sector's overall stability and sustainability. Despite substantial efforts to modernise and adopt advanced farming techniques, the average yield per hectare is decreasing. Figure 32 demonstrates a sustained decrease in productivity index numbers for all crops in India over three distinct durations. This persistent low productivity can be attributed to a variety of factors, including outdated agricultural practices, inadequate infrastructure, and limited access to modern technology and information.

Figure 32. *Index number of productivity in all crops of India*



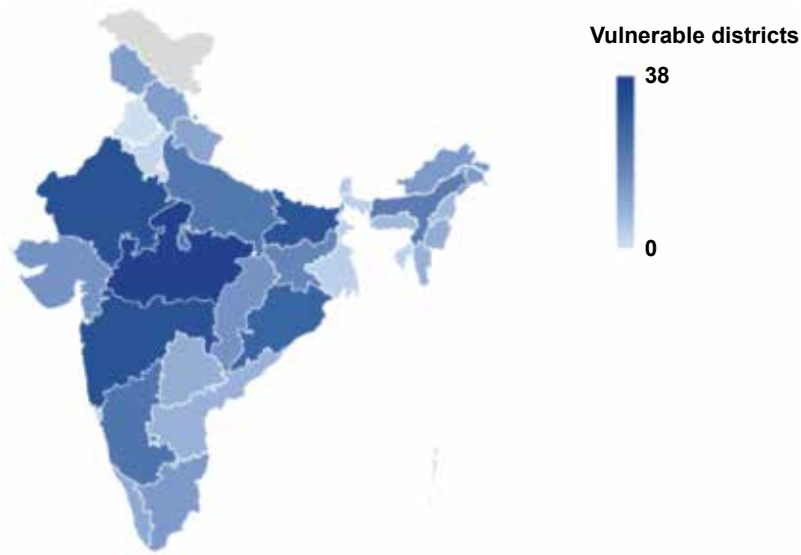
Source: *Ministry of Agriculture and Farmers Welfare, GoI.*

The sector at the same time grapples with high levels of vulnerability that stem primarily from the impacts of climate change, erratic weather patterns, and natural disasters. Figure 33 shows the districts in India that experience medium to high vulnerability to climate change. Farmers are often at the mercy of unpredictable conditions, making their livelihoods precarious. Addressing the twin challenges of low productivity and high vulnerability to climate change, natural disasters and increasingly erratic weather patterns requires comprehensive reforms that encompass technological advancements, improved infrastructure, and robust policies that are aimed at enhancing productivity, reducing vulnerabilities, and fortifying the resilience of Indian agriculture in the face of a rapidly changing environment.

6.4. Increase Crop Diversification

Inadequate crop diversification stands as a prominent constraint within the framework of Indian agriculture, posing multifaceted challenges to the sector. The prevailing reliance on a limited set of crops not only

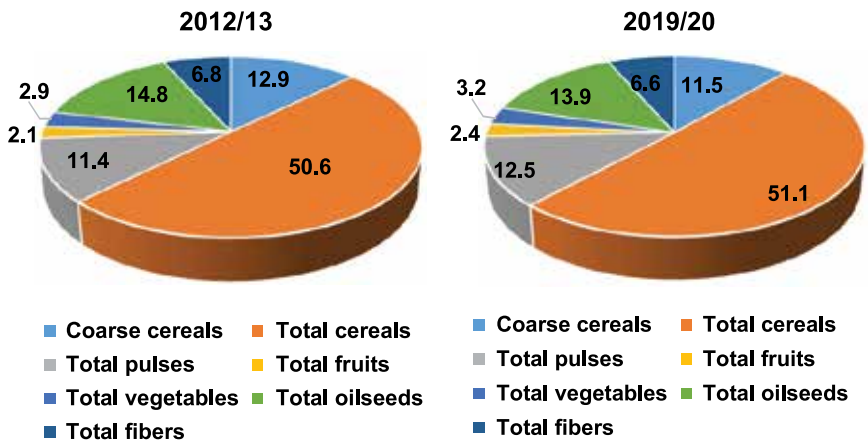
Figure 33. *State-wise distribution of districts experiencing high vulnerability to climate change*



Source: *Risk and Vulnerability Assessment of Indian Agriculture to Climate Change (Rama Rao et al. 2019).*

compromises the resilience of agricultural systems but also exposes farmers to heightened risks associated with fluctuating market conditions and climatic uncertainties. Figure 34 shows the distribution of gross cropped

Figure 34. *Percentage share of area to gross cropped area in two distinct periods*



Source: *Agricultural Statistics at a Glance 2022 (MoA&FW 2022).*

area percentages at two distinct times (2012/2013 and 2019/2020), demonstrating a nearly identical distribution. The predominant focus on staple crops such as rice and wheat has led to an imbalance in the agricultural landscape, hindering the potential for sustainable growth and economic diversification. The lack of crop diversity also contributes to soil degradation and reduces the nutritional value of the land. This constraint not only undermines the long-term productivity of Indian agriculture but also impedes farmers' adaptability to changing environmental conditions.

6.5. Promote Agricultural Diversification

Agricultural diversification toward high value commodities such as fruits, vegetables, fisheries, poultry etc. in India has emerged as one of the most important strategies for ensuring sustainable and inclusive agricultural growth. The share of high value commodities in total value of agricultural output is increasing and their consumption is also growing much faster than cereals and food grain crops. In the long run, increased crop yields and prices contribute significantly to the growth of the crops sector. Increased farm prices(terms of trade), however, may not be a sustainable source of growth. Price-led growth would also not be pro-poor and would threaten the food security of landless agricultural labourers and even marginal farmers. Emphasis should be on a sustained increase in crop yields through technological upgradation and diversification toward high value commodities; this which constitute sustainable and inclusive sources of growth.

Further promotion of horticulture, livestock, and fisheries will not only contribute to agricultural growth but will also enhance farm income. These commodities are very well-suited to the needs of smallholders as they use mostly the family labour and provide regular and high returns. These commodities, however, have higher risk of perishability and price volatility. Linking producers with remunerative markets and developing appropriate infrastructure such as cold storage and refrigerated vans would be a prerequisite for promoting high value commodities. Several innovative integrated marketing models have emerged. Conducive policies and institutional frameworks should be developed to improve smallholders' access to these marketing models. To promote and sustain agricultural diversification in the long run, greater emphasis should be placed on value addition and on processing across the value chain of high value commodities. India's level of value addition and processing is currently the lowest at approximately 10 percent; this compares to 40 to 50 percent in developed countries (Bathla and Gautam 2021).

6.6. Link Farmers with Markets

Agriculture in India is dominated by marginal and small farmers. As per the latest agricultural census, 85 percent of farm households undertake farming on landholdings of less than 2 hectares and 68 percent of farmers operate on less than 1 hectare. Their small scale prevents them from marketing and retailing perishable and high value commodities. They also lack information on the grades and standards that are imposed by supermarkets and on the sanitary and phytosanitary (SPS) measures that are required under the current trade regime. There is thus a need to effectively link these small producers with remunerative domestic and global markets. Successful models are already available in the country but need to be upscaled. Attracting the corporate sector for investment in markets, agro-processing, and land development is still a challenge.

6.7. Strengthen Institutions and Improve Rural Infrastructure

In India, institutions have already been significantly strengthened and infrastructure has been much improved. In many parts of the eastern and northeastern regions, however, much needs yet to be done. Tremendous progress has occurred in recent years in improving land records, however correcting land records, settling disputes on ownership, and correcting land lease markets remain a major challenge. To enhance the participation of smallholders, it is important to strengthen cooperatives, farmers' associations, self-help groups and the like for collective production and marketing. Strengthening credit, insurance, input services, and extension services would also assist in meeting the needs of smallholders. There has been significant improvement in basic infrastructure, especially the rural roads network, market facilities, and the power sector; these improvements importantly support developmental activities in the agricultural sector. This momentum needs to be maintained. The irrigation and drainage network also needs to be prioritised for improvement in order to increase production and minimise risk.

6.8. Harness Frontier Technologies and Agri-Startups

Many fascinating innovations have emerged in the agricultural sector which, among other things, improve efficiency, precision, and safety; however the pace of diffusion of these frontier technologies in India is

slow. Frontier technologies that have immense potential to improve the welfare of farming communities include: (1) biotechnology, (2) digital technology, (3) nanotechnology, (4) space science and global positioning system (GPS) tools, and (5) advanced engineering technologies including sensors and unmanned aerial vehicles (UAVs). Breakthroughs in these fields have enormous potential for application in crop production, animal husbandry, fishing, and agri-business. These technologies can significantly benefit producers and consumers, as well as the ecology, society, and the economy more generally. The benefits can be realised through enhancing productivity, reducing cost, increasing efficiency, empowering informed decision-making, minimising pre-and postharvest losses, improving the quality and safety of the produce, reducing emissions, and promoting climate change mitigation and adaptation. Most of the emerging technologies that have huge potential for revolutionising agriculture are being developed in different agricultural and non-agricultural disciplines and institutes. Their application is expected to help usher in future revolutions in agriculture. Agri startups have emerged as significant players in the introduction of innovations to the entire agricultural value chain and the agri startup culture needs to be further nurtured.

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Table A1. State-wise progress under PMFBY and RWBCIS-combined, 2016/2017 to 2022/2023

State/UTs	Total farmer applications (100,000)	Area insured (100,000 hectares)	Sum insured (INR 10 million)	Farmers share in premium (INR 10 million)	Gross premium (INR 10 million)	Total claims (INR 10 million)	Paid claims (INR 10 million)	Claims outstanding (INR 10 million)
A & N	0.0	0.0	8.0	0.0	0.7	0.2	0.2	0.0
AP	88.4	76.9	49159.9	710.6	4,988.4	4,838.4	4,828.1	13.9
Assam	41.6	25.5	17402.9	14.2	705.1	271.0	210.8	60.2
Bihar	50.2	46.1	21749.1	383.9	2,444.9	749.4	749.4	0.0
Chhattisgarh	272.4	163.8	59475.1	1,161.3	7,328.2	6,309.6	6,220.9	88.6
Goa	0.0	0.0	14.7	0.2	0.2	0.1	0.1	0.0
Gujarat	84.0	112.3	53812.1	1,499.4	12,045.3	5,417.5	5,232.6	258.9
Haryana	101.1	130.6	87252.7	1,875.7	6,584.4	6,057.7	5,891.3	166.5
HP	19.9	77.1	4526.8	172.2	543.6	308.2	291.3	18.6
J & K	4.5	3.3	2031.9	36.7	181.1	91.9	88.0	3.9
Jharkhand	44.6	19.4	10,733.5	75.2	1,236.8	572.7	98.1	797.1
Karnataka	148.5	138.8	63,746.4	1,706.4	14,117.1	10,151.2	10,123.1	153.5
Kerala	4.9	3.1	2,283.1	45.2	421.5	377.9	333.9	44.1

Contd...

State/UTs	Total farmer applications (100,000)	Area insured (100,000 hectares)	Sum insured (INR 10 million)	Farmers share in premium (INR 10 million)	Gross premium (INR 10 million)	Total claims (INR 10 million)	Paid claims (INR 10 million)	Claims outstanding (INR 10 million)
MP	573.8	782.4	275,284.6	5,179.3	34,625.7	25,728.0	25,674.1	77.7
Maharashtra	841.8	485.7	187,318.8	5,012.9	38,385.6	26,114.1	25,849.8	483.3
Manipur	0.3	0.4	142.4	2.6	10.0	5.2	5.2	0.0
Meghalaya	0.1	0.0	26.4	0.8	1.0	0.5	0.5	0.0
Odisha	365.0	91.7	57,068.4	1,126.1	8,654.0	6,232.5	6,150.0	83.1
Puducherry	0.8	0.5	307.7	0.2	22.3	29.1	15.7	17.9
Rajasthan	1,086.1	683.2	220,273.0	4,548.7	31,356.0	21,772.3	20,403.7	1,408.6
Sikkim	0.1	0.0	8.2	0.2	0.2	0.7	0.7	0.0
Tamil Nadu	238.6	96.2	58,874.5	959.9	14,129.4	12,758.8	12,699.8	58.9
Telangana	36.4	37.8	25,529.7	652.9	2,222.2	1,845.8	1,811.7	34.1
Tripura	8.9	1.5	1,014.6	2.6	29.8	5.1	5.1	0.0
UP	350.9	283.6	135,337.9	2,473.5	9,614.7	4,119.6	4,060.1	71.8
Uttarakhand	14.8	55.3	5,904.9	186.7	791.5	500.5	487.5	13.3
West Bengal	134.9	55.9	37,345.9	305.5	2,086.8	1,222.8	1,218.5	4.3
Total	**4,512.6**	**3,370.8**	**1,376,633.3**	**28,133.0**	**192,526.3**	**135,480.7**	**132,450.3**	**3,858.3**

Source: *DA&FW, GoI.*

Note: PMFBY = Pradhan Mantri Fasal Bima Yojana (PMFBY); RWBCIS = Restructured Weather Based Insurance Scheme.

Table A2. Share of horticulture value added in agriculture across states

(Percent)

State\union territory	2011/ 2012	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019	2019/ 2020
Andhra Pradesh	24.42	22.53	26.89	25.68	25.70	25.04
Arunachal Pradesh	47.06	42.17	29.62	29.68	24.01	17.59
Assam	34.74	37.02	35.06	34.38	34.99	30.76
Bihar	24.47	24.71	22.13	21.28	22.55	22.36
Chhattisgarh	35.04	41.49	36.15	42.23	38.88	38.02
Goa	47.02	50.23	46.69	45.68	42.36	40.46
Gujarat	23.69	23.49	18.99	18.04	17.68	16.24
Haryana	8.65	10.51	9.77	10.59	9.80	10.00
Himachal Pradesh	38.52	49.91	42.08	42.32	37.02	41.74
Jharkhand	41.50	33.27	30.11	31.23	33.58	28.42
Karnataka	35.27	40.89	45.21	38.00	47.33	43.38
Kerala	31.18	36.88	34.17	32.93	31.82	30.59
Madhya Pradesh	22.76	27.65	26.76	28.76	34.46	32.25
Maharashtra	22.68	26.06	22.55	25.33	22.98	24.26
Manipur	53.17	62.00	58.08	37.99	44.10	41.49
Meghalaya	51.96	52.51	39.08	35.40	35.94	37.68
Mizoram	53.27	25.52	25.67	28.30	27.20	24.18
Nagaland	24.73	35.12	33.65	32.39	29.94	24.98
Odisha	48.02	40.70	34.36	38.53	36.02	30.26
Punjab	7.79	9.39	9.44	9.61	9.91	10.42
Rajasthan	5.46	5.04	5.40	5.29	5.61	5.71
Sikkim	128.04	78.13	82.81	103.82	96.39	87.29
Tamil Nadu	43.74	39.74	38.71	35.70	34.83	31.23
Telangana	25.47	21.66	14.08	15.46	14.89	13.32
Tripura	33.46	30.84	25.68	26.18	23.61	22.69
Uttar Pradesh	11.98	18.53	18.42	17.85	17.14	16.80
Uttarakhand	30.60	24.75	24.02	24.66	25.35	21.82
West Bengal	37.28	36.17	36.88	36.70	35.77	34.73
Jammu & Kashmir	45.48	34.65	43.12	40.78	38.11	40.32

Source: *Horticultural Statistics at a Glance, 2021 and MoSPI, GoI.*

Published by:

National Academy of Agricultural Sciences

NASC Complex, Dev Prakash Shastri Marg
P.O. Pusa, New Delhi - 110 012, India
Email: naas-mail@naas.org.in