AGRICULTURAL DEVELOPMENT REPORT 2024

Harnessing Diversity, Technology, and Innovation for a Sustainable Future

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भा.कृ.अ.प.– राष्ट्रीय कृषि आर्थिकी एवम् नीति अनुसंधान संस्थान
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Agricultural Development Report

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Foreword

It is with great pleasure that I present the *Third Agricultural Development Report* of the ICAR–National Institute of Agricultural Economics and Policy Research. This edition is devoted to a critical and timely theme—regional disparities in agricultural development in India. As the country aspires towards inclusive and sustainable growth, understanding spatial variations in agricultural performance and their underlying determinants becomes imperative for effective policy formulation and targeted resource allocation.

This report offers a comprehensive and data-driven analysis of regional disparities in agricultural growth, encompassing not only output trends but also the key enablers of agricultural development. These include resource endowments, public and private investments, input usage, irrigation development, mechanization, access to institutional credit, and the robustness of market infrastructure and institutions. By addressing these multiple dimensions, the report seeks to illuminate the structural and policy-related factors that contribute to uneven development across regions.

Significantly, the scope of this report extends beyond crop husbandry to cover the livestock and fisheries sectors, which are increasingly pivotal to rural livelihoods, nutritional security, and income diversification. These sectors have emerged as vital engines of inclusive agricultural transformation. The report delves into their specific challenges and opportunities, including breed improvement, animal health systems, feed and fodder availability, and market access—factors that will shape their future trajectory.

By offering an integrated perspective on regional disparities across the entire agricultural ecosystem, this report aims to support evidence-based policymaking and promote balanced, resilient, and equitable agricultural growth. It is our hope that this publication will serve as a valuable resource for policymakers, researchers, and stakeholders engaged in shaping India's agricultural future.

I would like to convey my sincere appreciation to the Secretary, Department of Agricultural Research and Education (DARE) & Director General, ICAR, and to the Deputy Director General (Education), ICAR, for their continued guidance and encouragement. I also extend my heartfelt thanks to the dedicated team of scientists and staff at the Institute whose tireless efforts have made this report possible.

Pratap S Birthal
Director

Executive Summary

Agriculture continues to be a cornerstone of India's rural economy, vital not only for food and nutritional security, but also for employment, poverty alleviation, and inclusive growth. However, the sector's progress has not been uniform. While several regions have surged ahead, others remain mired in structural constraints. This inter-state imbalance is a defining feature of Indian agriculture today, shaped by historical disparities in access to natural resources, infrastructure, technology, credit, and markets.

Despite these challenges, the past decade has seen a resilient and dynamic agricultural performance. The sector has maintained a robust growth trajectory, averaging nearly 4% annually, and is projected to exceed 4.6% in 2024–25. Notably, this growth has been driven less by cereals and more by the rising contribution of high-value sectors like livestock, fruits, and vegetables. Yet, the uneven nature of this transformation points to an urgent need for region-specific policy and investment strategies that harness the untapped potential in lagging states.

Public investment plays a pivotal role in enabling such transformation. However, both the scale and composition of public agricultural expenditure vary widely across states. While central allocations prioritize food storage and warehousing, many states underinvest in crucial areas such as crop husbandry, livestock, and natural resource conservation. This skew limits the capacity of less developed regions to catch up. For instance, while Chhattisgarh demonstrates a strong agricultural orientation, larger states like Uttar Pradesh, Madhya Pradesh, and West Bengal still fall short in aligning investment with sectoral needs.

This disconnect becomes more evident when examining patterns of crop diversification. Some arid and semi-arid regions have shifted toward more diversified farming systems, improving resilience and income stability. In contrast, states like Punjab, Haryana, and Telangana have doubled down on rice and wheat due to entrenched procurement incentives under the MSP regime. This has created an ecological imbalance, over-extraction of groundwater, and a decline in the cultivation of climate-resilient crops like millets, pulses, and oilseeds. A lack of coherent market signals and post-harvest support further discourages diversification in other states, despite their agro-ecological suitability.

The uneven adoption of input use and technology reinforces yield disparities. Although India has seen improved access to irrigation, fertilizers, and quality seeds, substantial gaps persist in actual farm-level productivity. These yield gaps reflect not only resource constraints but also inefficiencies in input application and limited access to extension services. In the context of stagnant net sown area, bridging these yield gaps—especially in rainfed and underperforming regions—remains the most viable route to increase overall production and farm incomes.

Water availability is a critical factor underpinning both yield and diversification. Yet, irrigation infrastructure remains unevenly distributed, and water-use efficiency is low in many regions. With climate variability on the rise, the challenge has shifted from expansion to sustainable water management. Ensuring long-term agricultural sustainability requires harmonizing water supply with regional demand, strengthening institutions for participatory irrigation management, and promoting climate-smart irrigation technologies tailored to local contexts.

Closely linked to irrigation is the growing trend of farm mechanization, which has helped reduce labor drudgery and enhance productivity. However, mechanization remains heavily skewed in favor of large farmers and better-endowed states. Small and marginal farmers, who dominate the agricultural landscape, face multiple barriers—lack of affordability, limited custom hiring services, and poor after-sales support. Government schemes such as CHCs have made inroads, but far greater coordination is required to scale mechanization solutions that are appropriate, inclusive, and climate-adaptive.

Credit access is the enabler that ties together investment, technology adoption, and risk-taking. Institutional credit to agriculture has expanded, primarily through Scheduled Commercial Banks. However, there are persistent regional disparities in both the flow and structure of credit. Medium- and long-term finance crucial for capital investments in machinery, irrigation, and livestock remains inadequate in states with high potential but limited financial inclusion. Weak Kisan Credit Card (KCC) penetration in the North-East and Eastern states further constrains smallholders' ability to modernize and diversify.

The effectiveness of agricultural investments also depends on the strength of marketing infrastructure and institutions. Here too, the landscape is highly uneven. States like Maharashtra and Gujarat benefit from robust market connectivity, cold chain development, and active Farmer Producer Organizations (FPOs). Meanwhile, much of eastern and central India suffers from weak APMC infrastructure, inadequate storage, and limited farmer aggregation. The over-concentration of cold storage on select commodities like potatoes, and the lack of digital integration in warehousing, limits market access and price realization for perishable and high-value crops.

As agriculture diversifies beyond crops, livestock and fisheries have emerged as critical drivers of income growth. The livestock sector is already contributing more than a third of agricultural GDP, and yet its expansion remains spatially and structurally uneven. While northern states have established robust dairy ecosystems, others especially in the North-East, possess significant but underutilized potential in piggery and backyard poultry. Similarly, inland fisheries are growing fast in states like Andhra Pradesh and West Bengal, but most public investment remains concentrated in marine fisheries. Addressing these gaps can unlock inclusive growth and improve nutrition outcomes.

These interlinked challenges underscore the need for a systems-oriented, regionally differentiated approach to agricultural policy. The focus must shift from aggregate production targets to a more nuanced understanding of regional resource endowments, institutional capacities, and farmer aspirations. This calls for deeper coordination between central and state governments, improved governance of food systems, and participatory planning that reflects local realities.

Strategic Priorities for a Balanced Agricultural Growth Trajectory

- *Targeted Investment:* Align public spending with regional needs, focusing on underfunded sectors like livestock, fisheries, and inland irrigation. Boost R&D and adaptive technologies for vulnerable regions.
- *Diversification with Incentives:* Reform MSP and procurement policies to promote climate-resilient crops; support integrated farming systems and value chains for pulses, millets, and oilseeds.
- *Bridging Yield Gaps:* Expand access to irrigation, certified seeds, and balanced nutrients. Strengthen extension systems with localized, data-driven advisories.
- *Sustainable Water Use:* Develop state-specific water-use plans; invest in micro-irrigation, water harvesting, and governance mechanisms for equitable distribution.
- *Inclusive Mechanization:* Support affordable, small-farm-appropriate machinery and expand CHCs; integrate mechanization with skill development and credit access.
- *Financial Deepening:* Enhance credit flow to underserved regions and long-term lending for infrastructure and livestock; expand KCC and digital lending platforms.
- *Market Infrastructure:* Modernize markets and warehousing with digital platforms and e-NWRs; promote FPOs and cooperatives to enhance scale and bargaining power.

- *Livestock & Fisheries Development:* Invest in breed improvement, feed infrastructure, and veterinary networks; prioritize inland fisheries through dedicated funding and institutional support.

Ultimately, narrowing regional disparities in agriculture is not only a matter of fairness—it is an economic imperative. A more balanced and inclusive agricultural development pathway will ensure that growth reaches every corner of rural India, making the sector more resilient, productive, and sustainable. It will also serve as the foundation for India's next phase of economic development for *viksit bharat* 2047.

Pratap S Birthal
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1

Regional Dynamics of Agricultural Growth

Balaji, S J and Raka Saxena

Over the past decade, the agricultural sector has exhibited commendable resilience and performance, with annual growth approximating 4%. A consistent rise in quarterly gross value-added (GVA) indicates the agricultural growth may surpass 4.6% in 2024-25. The livestock subsector continues to serve as a critical driver of this growth trajectory. Despite persistent regional disparities, there are signs of productivity convergence in the crop subsector—an observation with significant implications for targeted investment strategies. The chapter delves into the role of high-value crops, particularly fruits and vegetables, in augmenting growth within the crop subsector. Furthermore, it examines the interface between primary agriculture and the food processing industry, drawing upon procurement patterns and support price trends to recommend strategies for enhancing crop diversification. While food exports have shown promise, the pressure of rising imports bills underscores the urgency of strengthening domestic production capabilities. The chapter concludes by addressing sustainability challenges, including the impact of climate change on crop yields, disparities in access to agricultural credit, and emerging geopolitical tensions that pose threats to food security.

1.1 Introduction

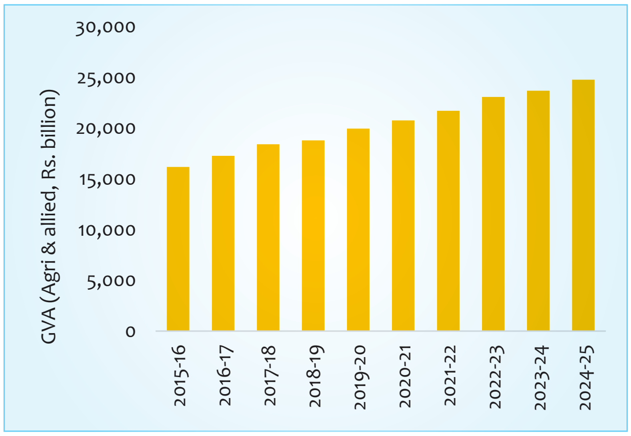
Agriculture has been the cornerstone of India's economic development. The sector has shown remarkable resilience in recent years amid global disruptions such as the COVID-19 pandemic and the Russia-Ukraine conflict. Over the past decade, agricultural gross value-added (GVA) has surpassed 6% growth in four years and 4% in three years, highlighting its contribution to economic development. Livestock subsector, which engages marginal and small farmers the most, has been the driver of agricultural growth in past, and this contribution remains true to date, improving the state of farm income equality. Fisheries has emerged as the sunrise sector, addressing both the domestic and international market demands.

However, persistent regional disparities remain a key concern, affecting the equitable distribution of farm income and exacerbating rural inequality (Birthal et al. 2011; Balaji & Pal 2014). These disparities are evident not only in output/GVA across various states but also within different subsectors, including crops, livestock, and fisheries, as well as in employment, wages, and profits, which impact the sustainability of Indian agriculture. This chapter undertakes a detailed exploration of growth patterns and regional disparities in agricultural sector and its subsectors over the last decade. It also assesses the impact of trade and level of import dependency on agricultural commodities that influence growth.

1.2 Performance at National Level

The agricultural sector has experienced consistent growth over the past decade. The GVA in agriculture, including allied sectors such as livestock, forestry, and fisheries, has increased from Rs. 16,161 billion in 2015-16 to Rs. 24,760 billion in 2024-25 (at constant 2011-12 prices), growing at an average rate of 4.7% per year (Figure 1.1). During this period, agricultural GVA growth exceeded 6% in four years and 4% in three years. It was as high as 6.8% in 2016-17, 6.6% in 2017-18, 6.2% in 2019-20, and 6.3% in 2022-23. Further, it was 4% in 2020-21, and 4.6% in 2021-22. The second advanced estimate released in February this year shows that growth in this sector is 4.6% in 2024-25, contributing about Rs. 1,087 billion to the previous year's GVA. Quarterly estimates reveal an upward trend, with growth increasing from 1.7% in the first quarter to 4.1% in the second and 5.6% in the third quarter.

Figure 1.1 Gross value added from agricultural sector GVA (2015-16 to 2024-25)

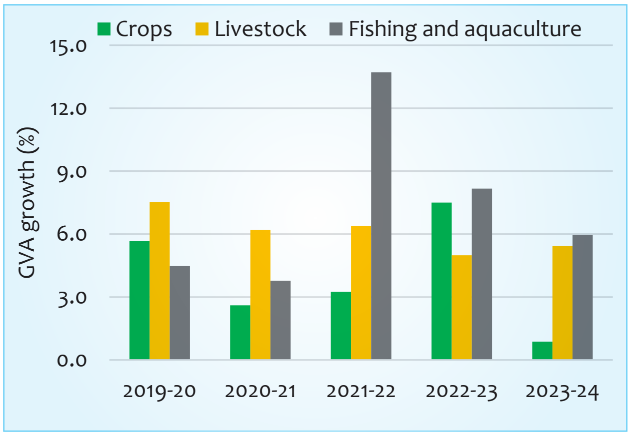


Note: Estimates are at constant 2011-12 prices.

Source: GoI (2025a).

While the sub-sectoral estimates for 2024-25 are awaited, prevailing trends reaffirm that the livestock subsector remains the leading contributor to agricultural growth (Figure 1.2). This represents 30% of GVA in agriculture, and in the past five years (from 2019-20), it grew by 7.5%, 6.2%, 6.4%, 5%, and 5.4%, respectively. The growth rate was as high as 10% in 2016-17. The crop subsector, which accounts for 54% of agricultural GVA, grew by less than 1% in 2023-24, down from 7.5% growth in the previous year. In most years, crop subsector growth lagged behind the livestock and fisheries subsectors. On average, the crop subsector's GVA grew by 2.6% annually since 2013-14, and the livestock subsector growth stands at 7.4%.

Figure 1.2 Growth within agriculture: sub-sectoral diversity (2019-20 to 2023-24)



Note: Reported are real GVA growth (at constant 2011-12 prices).

Source: GoI (2025a).

The fisheries subsector, while having exhibited strong performance in the earlier part of the decade, has shown signs of deceleration in recent years. Growth in this subsector was over 7% in 2013-14 and 2014-15, and hovered around 10% for two consecutive years. It reached as high as 15.2% in 2017-18. The period thereafter has witnessed a downfall in growth, leaving 2021-22. Growth declined to 3.8% in 2020-21. While the year 2021-22 registered a major recovery (13.7 %), growth declined later to 8.2% in 2022-23, and further to 5.9% in 2023-24. These shifts in growth dynamics across crops, livestock, and fisheries could significantly impact farmers' income and income convergence, which has slowed down recently (Balaji & Gopinath 2023). Given the increasing incidence of climate anomalies, these trends warrant urgent policy interventions, as climate-related hazards could impede growth, affecting productivity, income, and food security (Birthal et al. 2021).

1.3 Regional Heterogeneity

1.3.1 Sub-sectoral contribution to GVA

The crop subsector constitutes the largest share of agricultural GVA, though its relative contribution varies significantly across Indian states (Table 1.1). Nationally, crops accounted for 54% of the national agricultural gross value-added (GVA) in 2023-24. Notably, this share has reached 73% in Madhya Pradesh, 69% in Assam, 64% in Uttar Pradesh, and 63% in Gujarat. States such as Maharashtra, Odisha, Chhattisgarh, Karnataka, West Bengal, Punjab, and Kerala also exhibited crops' shares exceeding the national average. Conversely, Andhra Pradesh recorded the lowest contribution, comprising only 37% of the state's agricultural GVA. In Tamil Nadu, Rajasthan, Jharkhand, Uttarakhand, and Haryana, the crop subsector's share was below 50%, while it was slightly above 50% in Jammu and Kashmir, Bihar, Telangana, and Himachal Pradesh.

The contribution of livestock is notably higher in states where the crops' contributions are comparatively lower. For example, in Tamil Nadu, where crops accounted for only 41% of the agricultural Gross Value Added (GVA), the livestock share was 51% in 2023-24, the highest among all major states. Similarly, the crops' share in value-added is less than 50% in Haryana and Rajasthan, which are the second and third largest states in terms of higher value-added share from livestock, with both states recording 45%. In contrast, in Madhya Pradesh and Assam, which had the largest value-added share from the crop subsector, livestock share was merely 18% and 12%, respectively. Chhattisgarh has the lowest share in the livestock subsector (11 %).

In contrast, fisheries make a substantial contribution in specific states. In Chhattisgarh, fisheries accounted for 14% of agricultural GVA, while Andhra Pradesh topped the chart with fisheries contributing 32%. West Bengal and Assam also demonstrated significant contributions, with fisheries comprising around 16% of their respective agricultural GVAs. Odisha and Kerala followed with shares of 12% and 11%. Moderate shares (4%–10%) were observed in Bihar, Jharkhand, Karnataka, and Tamil Nadu, while relatively low contributions (2%–4%) were noted in Telangana, Gujarat, Haryana, Jammu and Kashmir, Uttar Pradesh, Madhya Pradesh, and Maharashtra.

Table 1.1 Composition of GVA of agricultural subsectors (%, 2023-24)

State	Crops	Livestock	Forestry	Fisheries	All
Andhra Pradesh	37	29	1	32	100
Assam	69	12	4	16	100
Bihar	51	32	7	9	100
Chhattisgarh	56	11	19	14	100
Gujarat*	63	21	12	3	100
Haryana	47	45	5	2	100
Himachal Pradesh	51	16	32	1	100
Jammu & Kashmir	51	34	13	2	100
Jharkhand	45	29	19	6	100
Karnataka	56	32	7	5	100
Kerala	54	25	10	11	100
Madhya Pradesh	73	18	7	2	100
Maharashtra	58	25	15	2	100
Odisha	58	14	15	12	100
Punjab	55	35	9	1	100
Rajasthan	45	45	10	0	100
Tamil Nadu	41	51	3	4	100
Telangana	51	43	2	3	100
Uttar Pradesh	64	28	6	2	100
Uttarakhand	46	28	25	1	100
West Bengal	55	24	5	16	100

*Note: Estimates are based on GVA at constant 2011-12 prices; *for Gujarat, estimates are for 2022-23; row totals may not tally due to round-off.*

Source: Authors' estimates based on GoI (2025b).

1.3.2 Growth in subsectors

Among the 21 major states studied, GVA in agriculture and allied sectors increased by over 4% annually in 12 states and between 2% and 4% annually in six states between 2013-14 and 2023-24 (Table 1.2). The average national growth rate was 4.4% during this period. Andhra Pradesh led with 7.9% growth. This was followed by Telangana, Karnataka, Madhya Pradesh and Tamil Nadu, with growth rates exceeding 5%. On the other hand, there was no growth in agriculture in Kerala, whereas Jharkhand and Uttarakhand had growth rates of less than 2%. The remaining states grew by 2% to 4%.

Table 1.2 % annual growth in GVA, 2013-14 to 2023-24

State	Crops	Livestock	Forestry	Fisheries	All
Andhra Pradesh	3.6	8.2	1.2	17.0	7.9
Assam	1.3	16.1	3.0	5.9	3.4
Bihar	2.1	7.8	5.0	7.2	4.4
Chhattisgarh	2.8	8.2	6.9	9.6	4.8
Gujarat*	3.2	6.0	14.4	4.8	4.8
Haryana	1.3	7.3	2.7	9.5	3.9
Himachal Pradesh	0.5	9.0	3.7	7.0	2.5
Jammu & Kashmir	2.8	5.3	5.9	3.6	4.0
Jharkhand	-0.1	6.4	-1.3	12.4	1.5
Karnataka	4.4	12.2	7.2	7.9	6.6
Kerala	-0.2	-1.2	2.4	2.0	0.0
Madhya Pradesh	5.7	11.3	5.0	15.5	6.6
Maharashtra	2.7	7.0	8.4	1.0	4.3
Odisha	3.4	5.6	5.6	11.1	4.7
Punjab	0.9	5.0	2.3	7.0	2.4
Rajasthan	1.9	10.4	1.5	8.2	4.9
Tamil Nadu	2.7	8.5	5.7	3.2	5.3
Telangana	6.7	8.4	2.4	7.4	7.2
Uttar Pradesh	4.7	4.9	4.3	8.0	4.8
Uttarakhand	0.1	2.1	2.9	7.2	1.3
West Bengal	1.5	5.3	4.3	3.1	2.6

*Note: Growth estimates are based on GVA at constant 2011-12 prices; *for Gujarat, estimates are for 2012-12 to 2022-23*

Source: Authors' estimates based on GoI (2025b).

In most states, the livestock subsector has driven growth throughout the decade. It grew more than 16% in Assam, followed by Karnataka (over 12 %), Madhya Pradesh (over 11 %), and Rajasthan (over 10 %). Growth rates ranged from 8% to 10% in Himachal Pradesh, Tamil Nadu, Telangana, Andhra Pradesh, and Chhattisgarh. In other major states, namely Bihar, Haryana, Maharashtra, Jharkhand, and Gujarat, the growth rates were between 6% and 8%. Kerala experienced a negative growth rate of -1.2%.

The crop subsector exhibited highly region-specific growth trends. States such as Telangana, Madhya Pradesh, Uttar Pradesh, and Karnataka achieved growth rates exceeding 4%, while others—such as Andhra Pradesh, Odisha, Gujarat, Jammu and Kashmir, Chhattisgarh, Maharashtra, Tamil Nadu, and Bihar—registered growth between 2% and 4%. In contrast, states like Kerala (-0.2%) and Jharkhand (-0.1%) experienced negative growth. Punjab, Himachal Pradesh, and Uttarakhand posted growth of less than 1%, while Rajasthan, West Bengal, Haryana, and Assam hovered between 1% and 2%.

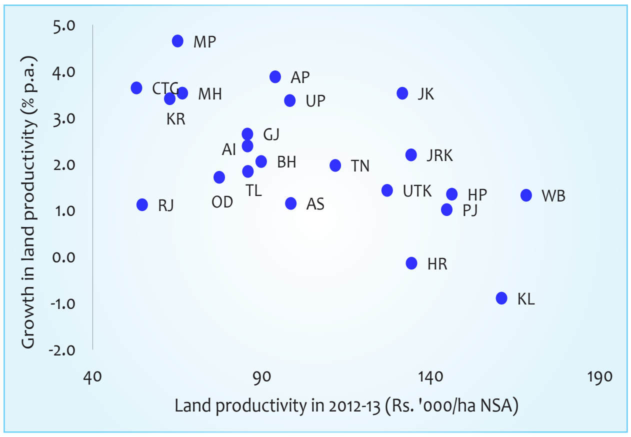
Fisheries, meanwhile, demonstrated strong growth during this period. Fisheries' GVA grew by over 10%. Andhra Pradesh led with a remarkable 17% annual growth, followed by Madhya Pradesh (15.5%), Jharkhand (12.4%), and Odisha (11.1%). Growth exceeded 8% in Chhattisgarh, Haryana, and Rajasthan; ranged from 6% to 8% in Uttar Pradesh, Karnataka, Telangana, Bihar, Uttarakhand, Himachal Pradesh, and Punjab; and stood between 4% and 6% in Assam and Gujarat. Jammu and Kashmir, Tamil Nadu, and West Bengal posted more modest growth rates of 3.6%, 3.2%, and 3.1%, respectively.

In summary, while the crop subsector experienced relatively sluggish growth in several states over the past decade, its deceleration was counterbalanced by sustained dynamism in the livestock and fisheries subsectors. Collectively, these developments have enabled India's agriculture sector to maintain a growth rate exceeding 4%.

1.4 Productivity Convergence in Crops

A noteworthy development in recent years has been the convergence of productivity growth within the crop subsector, even though its overall growth rate remains lower than that of livestock and fisheries. This trend suggests an encouraging movement toward inclusivity and balanced regional development within agriculture. An analysis of land productivity growth over the past decade (2012-13 to 2022-23), defined as the increase in the ratio of crop output value (at constant 2011-12 prices) to the net area sown, reveals that states with initially low land productivity levels (in 2012-13) have experienced relatively higher growth. Conversely, states with initially high productivity levels showed less growth, indicating a trend towards convergence (Figure 1.3).

Figure 1.3 Beta-convergence in land productivity (2012-13 to 2022-23)



Source: Author's estimates based GoI 2024(a&b).

In 2012-13, the states of Chhattisgarh, Rajasthan, Karnataka, Madhya Pradesh, and Maharashtra had relatively low levels of land productivity (ratio of output value to net sown area); approximately Rs. 55 thousand in Chhattisgarh and Rajasthan, and ranged between Rs. 63-66 thousand in Karnataka, Madhya Pradesh, and Maharashtra. from 2012-13 to 2022-23, productivity experienced annual growth rates of 4.6% in Madhya Pradesh, 3.6% in Chhattisgarh, 3.5% in Maharashtra, and 3.4% in Karnataka. Rajasthan was the only state to record a growth rate of one percent. By 2022-23, these growth rates have resulted in productivity levels reaching Rs. 1.02 lakh per hectare in Madhya Pradesh, Rs. 95 thousand in Maharashtra, Rs. 86 thousand in Karnataka, and Rs. 79 thousand in Chhattisgarh.

In contrast, productivity levels were much higher in West Bengal, Kerala, Himachal Pradesh, and Punjab. Land productivity in 2012-13 was Rs. 1.68 lakh per hectare in West Bengal, Rs. 1.61 lakh in Kerala, Rs. 1.46 lakh in Himachal Pradesh, and Rs. 1.45 lakh in Punjab. The land productivity growth in these states was 1.3%, -0.9%, 1.4%, and 1%, respectively. In Haryana, the other state where land productivity was Rs. 1.34 lakh, the productivity growth was -0.1%. This inverse relationship between land productivity growth and initial land productivity levels was also common across other states. This inverse relationship between initial productivity levels and growth supports the classical notion of diminishing returns to capital and highlights the potential for targeted investment in lagging states. Strengthening investment in low-productivity regions can not only accelerate growth in the crop subsector but also elevate its contribution to overall agricultural growth.

1.5 The Role of High-Value Crops

It should be noted that fruits and vegetables have brought about much growth in the crop subsector in most states. For instance, during 2012-13 and 2022-23, growth in the value of crop subsector output was 2.5% per year at the national level. Observing growth within the crop subsector, it stands that while the food grain output grew by 2.9% a year, the output of fruits and vegetables grew by 3.6% per year. Classifying the crop subsector components as (i) food grains (cereals and pulses), (ii) industrial crops (oilseeds, sugarcane, and cotton), (iii) high-value crops (fruits and vegetables), and (iv) the rest of all crops allows one to decompose the crop subsector growth and observe the contribution of fruits and vegetables over the rest to the growth.

Weighing the share of each component to crop subsector output by the growth of the component from 2012-13 to 2022-23 and dividing it by the sum of different components weighted by corresponding growth rates, it stands that while fruits and vegetables contribute around 27% of the value of output on average, they explain around 40% of the crop subsector growth during this period (Table 1.3). In several states, the contribution of fruits and vegetables are higher. Notably, the states of Andhra Pradesh, Jammu & Kashmir, and Chhattisgarh are worth mentioning. In Andhra Pradesh, fruits and vegetables contribute around 40% of crop output. Still, they contribute entire growth in the crop subsector, due to a declining growth in oilseeds, sugarcane, cotton, and other crops that were defined above. Likewise, in Jammu & Kashmir, fruits and vegetables comprise around 59% of the crop output, but they explain over 94% of crop subsector growth. Chhattisgarh is another state in which the contribution of fruits and vegetables is notably high.

Table 1.3. Fruits and vegetables' contribution to crop output growth in selected states (2012-13 to 2022-23)

S N	State	Growth in crop VOP (% p.a.)*	Share in crop VOP (%)*	Contribution to growth (%)
1	Karnataka	5.1	25.2	28.5
2	Madhya Pradesh	5.0	27.6	39.9
3	Telangana	3.7	17.0	-34.6
4	Chhattisgarh	3.5	46.0	66.5
5	Jammu & Kashmir	3.2	59.4	94.2
6	Uttar Pradesh	3.1	19.3	35.9
7	Andhra Pradesh	3.1	40.0	102.1
8	Maharashtra	2.9	27.4	28.2
9	All-India	2.5	27.3	39.7

*Note: 'VOP' is value of output; growth estimates are based on value of output at constant 2011-12 prices; *estimates correspond to the period 2012-13 to 2022-23.*

Source: Author's estimates based GoI 2024(a).

Their contribution is also significant in states with lower output growth in the crop subsector. Himachal Pradesh is one such state. Output growth in crop subsector was 0.9% a year in this state during 2012-13 to 2022-23. Decomposition estimates show 82% of this growth was contributed by fruits and vegetables. Likewise, in Bihar, where crop subsector output growth was 1.5% during this period, fruits and vegetables contributed 48% of the growth. Jharkhand had a 0.4% growth in crop output, and the contribution of fruits and vegetables was 52%. These findings underscore the importance of promoting high-value crops across all regions, particularly in states where crop productivity remains relatively low. Focusing on fruits and vegetables can drive agricultural diversification, enhance income for smallholders, and contribute meaningfully to inclusive agricultural transformation.

1.6 Sources of Growth across States: A Summary

While the fruits and vegetables cultivation has helped several states attain higher crop output growth, extending the decomposition analysis to the entire agriculture sector highlight interesting picture. This section examines the relative contributions of the crop, livestock, and fisheries subsectors, excluding forestry, to overall agricultural growth across states.

At the national level, it is evident that livestock subsector contributes the most to agricultural growth, followed by the crop and fisheries subsectors. During 2012-13 and 2022-23, on average, it contributed to 32% to agricultural (excluding fisheries) output but 47% to the agricultural growth (Table 1.4). The crop subsector, despite having a 62% share in agricultural output, its contribution was limited to 39%. Fisheries contributed the other 14% of the growth.

Interestingly, in several states, the crop subsector's contribution to growth was disproportionately low compared to its share in agricultural output. For instance, in Madhya Pradesh, where crops made up 77% of agricultural output during the past decade, their contribution to growth was limited to 65%, despite a healthy annual growth rate of 5% in crop output. Similarly, the share of crops in agricultural output was 73% in Chhattisgarh, 71% in Karnataka and Maharashtra, and 70% in Assam, Gujarat, and Himachal Pradesh in the past decade. In all these states, one shall observe the crop subsector's contribution less than its output shares.

Table 1.4 Diversity in sources of growth in agriculture (%, 2012-13 to 2022-23)

State	Crops	Livestock	Fisheries	All-3
Andhra Pradesh	16	28	56	100
Assam	31	20	48	100
Bihar	23	63	14	100
Chhattisgarh	59	15	26	100
Gujarat	59	39	2	100
Haryana	4	90	6	100
Himachal Pradesh	35	63	3	100
Jammu & Kashmir	55	43	2	100
Jharkhand	9	73	19	100
Karnataka	60	36	4	100
Madhya Pradesh	65	32	2	100
Maharashtra	58	42	0	100
Odisha	27	25	48	100
Punjab	29	68	3	100
Rajasthan	18	81	1	100
Tamil Nadu	22	76	3	100
Telangana	36	60	4	100
Uttar Pradesh	64	32	4	100
West Bengal	33	51	17	100
All-India	39	47	14	100

Note: Growth estimates are based on value of output at constant 2011-12 prices

Source: Authors' estimates based on GoI (2024a).

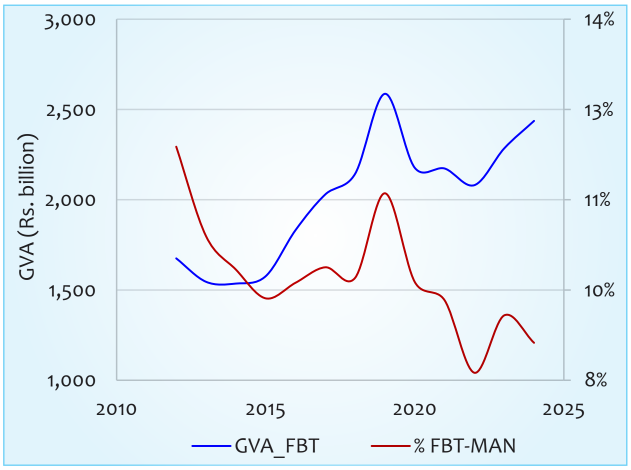
A key reason for this dichotomy is better growth performance of the livestock and fisheries subsectors. For instance, in Madhya Pradesh, between 2012-13 and 2022-23, livestock output grew by 8.5%, and fisheries output by 14.8% a year. This higher growth, relative to the crop output growth, had caused the latter contribute lesser to growth than the former two. One shall trace such patterns on other states mentioned earlier. On the other side, livestock subsectors' contribution to growth was more than 80% in Haryana and Rajasthan, between 70% and 80% in Tamil Nadu and Jharkhand, and between 50% and 70% in Punjab, Bihar, Himachal Pradesh, Telangana, and West Bengal. Observing the share of livestock subsector output in agriculture in this period, it was only 41% in Haryana, 44% in Rajasthan, 47% in Tamil Nadu, 32% in Jharkhand, and 35% in Punjab. Thus, one may ascertain that the livestock subsector contributes the most to agricultural growth than the crops and fisheries.

Still, fisheries act as the critical source of growth in Andhra Pradesh, Assam, and Odisha. It's contribution to growth during this period was as high as 56% in Andhra Pradesh, and 48% in Assam and Odisha. Observing the share of fisheries to agricultural output, it was 26% in Andhra Pradesh, 15% in Assam, and 12% in Odisha during 2012-13 and 2022-23. In West Bengal, where the output share was 15%, the contribution to growth was 17%. The relationship between output and growth contribution to agriculture from crop, livestock, and fisheries subsectors implies that while the former subsector contributes less to growth, the latter two contribute more, with varying degrees across states. These insights provide valuable guidance for designing state-specific, subsector-oriented strategies that prioritize investments according to each subsector's actual growth contribution.

1.7 Contribution to Secondary Agriculture

The interlinkages between the farm and non-farm sectors underscore agriculture's broader role in driving economic development. The GVA in food industries, including beverage and tobacco industries, a proxy to measure the contribution of primary agriculture to manufacturing, has increased over the years. GVA in the food industry increased from Rs. 1.5 trillion in 2013-14 to Rs. 2.4 trillion in 2023-24, growing at a rate of 4% a year (at constant 2011-12 prices) (Figure 1.4). During the same period, primary agriculture, including livestock and fisheries, grew by 4.4% per year, surpassing growth in the food industry. In contrast, the manufacturing sector grew by 5.4%. This has reduced the share of food industry GVA in manufacturing GVA from 10% in 2013-14 to 9% in 2023-24. However, the share remains at 10% with respect to agricultural GVA. Still, the GVA in food industry has grown by 9.8% in 2022-23 and 6.7% in 2023-24. A slowdown in food industry growth, despite increasing income per capita, calls for further inquiry. Addressing the constraints facing this sector—ranging from inadequate infrastructure and limited private investment to supply chain inefficiencies—will be essential to fully realize agriculture's potential as a catalyst for industrial transformation.

Figure 1.4 GVA in processed foods sector (2012-24)



Note: FBT is 'food, beverages, and tobacco' and MAN is 'manufacturing'

Source: GoI (2025a).

1.8 Employment and Wages

The agricultural sector's share of employment significantly exceeds its contribution to national output. Agriculture accounts for approximately 14.7% of the national gross value-added (GVA), yet it employs 42.4% of the total workforce. In the fiscal year 2023-24, approximately 36.2% of rural workers were self-employed in agriculture, while 8.3% were engaged as agricultural laborers. A substantial portion of workers were self-employed in non-agricultural sectors (17.1%), regular wage or salary earners (16%), or casual workers in non-agricultural sectors (15.2%) (Table 1.5). Similar to the GVA, the distribution of employment varies significantly across different states. For example, in 2023-24, the proportion of farmers among rural workers was approximately 54% in Chhattisgarh, 52% in Madhya Pradesh, and 40%–50% in Uttar Pradesh, Rajasthan, Karnataka, and Gujarat. In contrast, in Kerala and Tamil Nadu, the proportion is less than 20%. The prevalence of agricultural laborers is highest in Maharashtra, Andhra Pradesh, and Karnataka, with the share of casual workers in agriculture being 18%, 15.9%, and 15.4%, respectively. In Tamil Nadu, Telangana, and West Bengal, this share ranged between 11% and 13%.

An examination of changes since 2017-18 reveals interesting trends in rural employment composition. The share of cultivators has increased in states such as Kerala, West Bengal, Andhra Pradesh, Tamil Nadu, Uttar Pradesh, and Karnataka. Additionally, Bihar, Madhya Pradesh, and Telangana experienced a slight increase. Conversely, in other states, the share has decreased. The most significant decline occurred in Assam, where the proportion of farmers decreased from 36.9% in 2017-18 to 24.2% in 2023-24. This was followed by Jharkhand, with shares of 44.4% in 2017-18 and 33.4% in 2023-24. Uttarakhand, Odisha, and Gujarat were the other major states that experienced a notable decline in the share of cultivators.

In the states of Andhra Pradesh, West Bengal, and Madhya Pradesh, there has been a significant reduction in the proportion of agricultural laborers. Specifically, the share of agricultural laborers within the rural workforce in these states was 25%, 18.6%, and 15.6% in 2017-18. Other states, including Telangana, Tamil Nadu, Gujarat, Uttar Pradesh, and Maharashtra, also experienced notable decline. Conversely, in Uttarakhand, the share of agricultural laborers has increased slightly

Table 1.5. Distribution of agriculture workforce in major states (2017-18 and 2023-24)

State	Self-employed in agriculture (%)		Casual laborers in agriculture (%)		All others (%)	
	2017-18	2023-24	2017-18	2023-24	2017-18	2023-24
Andhra Pradesh	25.3	27.7	25.0	15.9	49.7	56.4
Assam	36.9	24.2	6.3	4.8	56.8	71.0
Bihar	35.2	36.1	10.6	6.9	54.2	57.0
Chhattisgarh	58.2	54.3	9.4	7.4	32.4	38.3
Gujarat	49.6	40.7	13.5	9.5	36.9	49.8
Haryana	28.3	24.5	7.0	3.4	64.7	72.1
Himachal Pradesh	34.4	30.4	2.1	0.9	63.5	68.7
Jharkhand	44.4	33.4	2.1	0.7	53.5	65.9
Karnataka	40.8	41.8	18.5	15.4	40.7	42.8
Kerala	12.6	17.3	8.1	7.0	79.3	75.7
Madhya Pradesh	51.7	52.3	15.6	9.5	32.7	38.2
Maharashtra	41.6	37.0	21.8	18.0	36.6	45.0
Odisha	38.5	29.4	7.4	4.4	54.1	66.2
Punjab	26.6	23.0	9.0	8.4	64.4	68.6
Rajasthan	45.7	44.3	3.3	2.0	51.0	53.7
Tamil Nadu	16.0	17.5	17.2	12.8	66.8	69.7
Telangana	38.8	39.0	16.9	12.2	44.3	48.8
Uttarakhand	40.5	31.3	2.5	3.1	57.0	65.6
Uttar Pradesh	47.4	48.5	6.8	2.9	45.8	48.6
West Bengal	24.9	27.3	18.6	11.2	56.5	61.5
All India	37.8	36.2	12.1	8.3	50.1	55.5

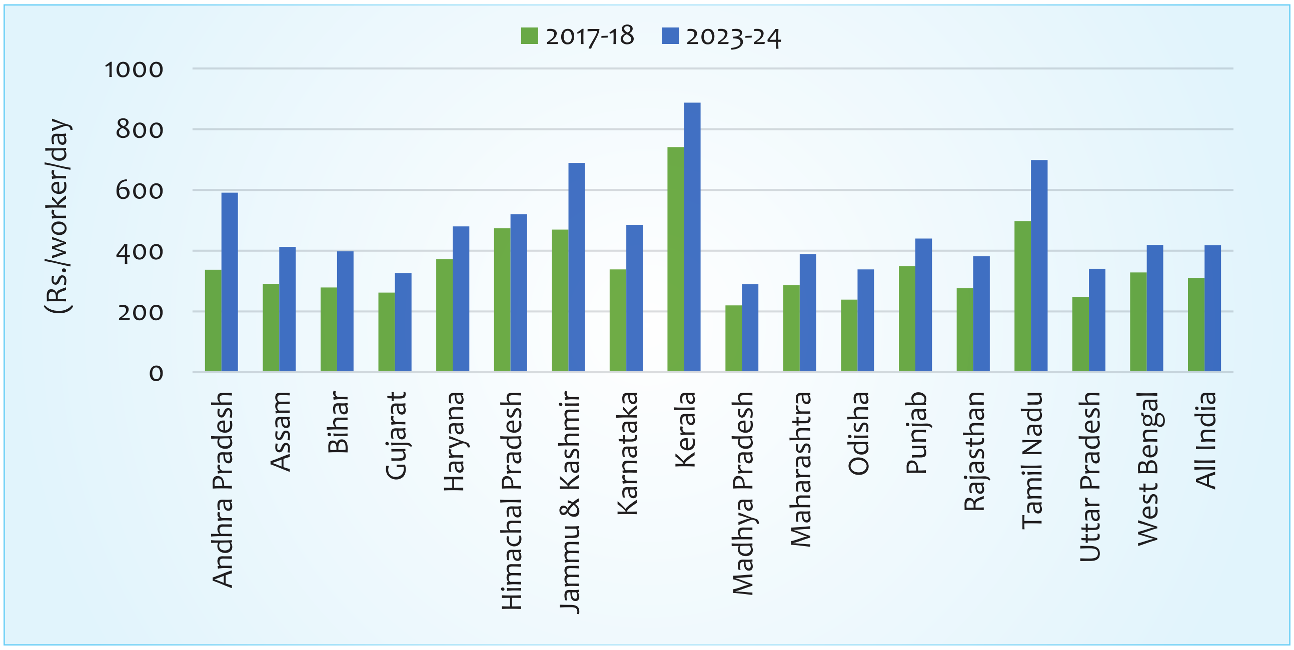
Note: Total may non tally to 100.0 due to round-off.

Source: GoI (2019) & GoI (2024c).

from 2.5% in 2017-18 to 3.1% in 2023-24. The pace and direction of change varies across other states.

Increased participation in non-agricultural sectors has partially contributed to the rise in agricultural wages. Nationally, the average daily wage for male laborers engaged in ploughing land was Rs. 311 in 2017-18, which increased to Rs. 418 per worker per day in 2023-24, representing a 35%

Figure 1.5 Average wage rates for ploughing (2017-18 and 2023-24, male)



Source: GoI (2024d).

Note: Annual estimates are computed as the averages of monthly wages.

increase in nominal terms (Figure 1.5). In the states of Kerala and Tamil Nadu, where the proportion of cultivators and agricultural workers is relatively low, the wage rates were notably higher, at Rs. 887 and Rs. 699, respectively, in 2023-24. In contrast, the wages were Rs. 689 in Jammu and Kashmir, Rs. 591 in Andhra Pradesh, and Rs. 520 in Himachal Pradesh. Conversely, wages were only Rs. 290 in Madhya Pradesh, Rs. 326 in Gujarat, Rs. 339 in Odisha, and Rs. 340 in Uttar Pradesh. Other states, such as Rajasthan, Maharashtra, Bihar, and Assam, also reported wage rates below the national average.

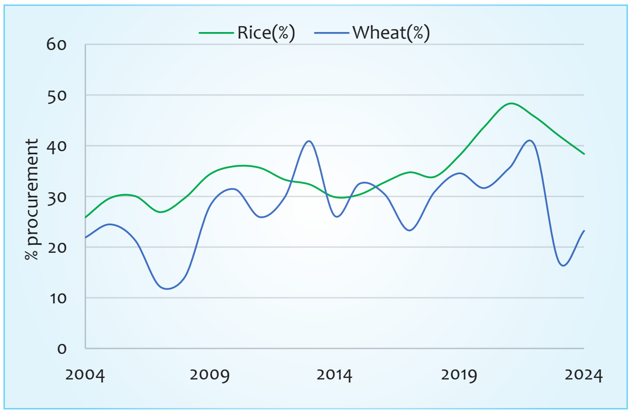
In nominal terms, the most significant increase in agricultural wages is observed in Andhra Pradesh. In this state, the average wage rate for men engaged in ploughing was Rs. 337 per day in 2017-18, which rose by 75% to Rs. 591 per day in 2023-24. The wage increase was 47% in Jammu & Kashmir, 43% in both Karnataka and Bihar, 42% in Odisha and Assam, and 40% in Tamil Nadu. The average nominal wage increase during this period was 35%. Himachal Pradesh and Kerala recorded the lowest wage increases, with only a 10% rise in Himachal Pradesh and a 20% rise in Kerala. In Gujarat, Punjab, West Bengal, Haryana, and Madhya Pradesh, the increases were 24%, 26%, 28%, 29%, and 32%, respectively. The substantial increase in agricultural wages, while beneficial to the laborers, has increased the cost of farm operations. This rise in operational expenses may partially explain the declining share of cultivators in several states, particularly those facing mounting input costs and limited access to mechanization.

1.9 Procurement and Support Prices

To ensure food security and provide remunerative prices to farmers, the government undertakes the procurement of key agricultural commodities at minimum support prices (MSPs). The procurement of rice and wheat forms the cornerstone of this strategy, with procurement volumes increasing significantly over the years. In the 2003-04, the country produced 88.5 million tons of rice, of which the government procured approximately 22.9 million tons, accounting for around 26% of the total production. This procurement-to-production ratio further increased to 30% in 2007-08, 33% in 2011-12, 35% in 2016-17, and reached as high as 48% in 2020-21 (Figure 1.6). Similarly, wheat procurement rose from 12% in 2006-07 to 41% in

2012-13. Although it has declined to 23% in 2016-17, it has subsequently increased, reaching 40% in 2021-22. However, the share of procurement declined in recent years. As of February 2025, 45.8 million tons of rice and 26.6 million tons of wheat were procured during 2024-25, marking a reduction of 6 million tons compared to 2023-24 and a decrease of 28 million tons from 2021-22. Notably, wheat procurement decreased by 16.7 million tons relative to 2021-22.

Figure 1.6 Rice and wheat procured as a share of production (2003-04 to 2023-24)



Source: GoI (2025e).

Table 1.6. Procurement shares across states (2013-14 to 2023-24)

State	Procurement (%)		
	2013-14	2018-19	2023-24
Rice			
Punjab	72	88	86
Haryana	60	87	66
Uttar Pradesh	8	21	23
Andhra Pradesh	54	58	27
Telangana	76	78	37
Madhya Pradesh	37	31	39
Odisha	37	58	56
Tamil Nadu	13	21	29
West Bengal	9	12	11
Chhattisgarh	64	61	86
Uttarakhand	80	75	76
All-India	30	38	38
Wheat			
Punjab	62	70	68
Haryana	50	70	56
Rajasthan	15	15	5
Madhya Pradesh	49	44	31
All-India	26	35	23

Source: GoI (2024e).

The share of procurement varies across states, in the case of both rice and wheat (Table 1.6). In Uttar Pradesh, the largest rice-producing state, the share of rice procured was only 8% in 2013-14. This has increased rapidly to 21% in 2018-19, and further to 23 in 2023-24. This trend is reversed in Telangana, the second-largest rice-producing state. Approximately 76% of the rice produced was procured in 2013-14, and this has declined by half to 37%. West Bengal, the other largest rice producer, has witnessed a marginally increase. In the case of wheat, the procurement share is highest in Punjab and Haryana, that is, 68% and 56%, respectively in 2023-24. The share has declined in Madhya Pradesh from 49% in 2013-14 to 44% in 2019-20, and further to 31% in 2023-24.

Conversely, there has been an upward adjustment in the support prices. The Minimum Support Price (MSP) for paddy (common) is Rs. 2,300 and Rs. 2,320 for paddy (Grade A) per quintal in 2024-25, compared to Rs. 2,183 and Rs. 2,203, respectively, in 2023-24. The MSP for wheat has risen to Rs. 2,425 in 2024-25 from Rs. 2,275 in the previous year. This upward trend extends to most crops, with the MSP for ragi increasing as high as by 11.5%, arhar by 7.9%, sunflower seed by 7.7%, sesamum by 7.3%, cotton (long staple) by 7.1%. There has been a 6%-7% increase for barley, wheat, urad, maize, groundnut, soybean, and jowar in 2024-25.

The concurrent decline in procurement and rise in support prices can be interpreted as a strategic move toward encouraging crop diversification. By reducing excessive reliance on rice and wheat procurement and enhancing the attractiveness of alternative crops, the government aims to promote a more sustainable and diversified agricultural landscape. Several recent policy initiatives have been introduced in support of this objective.

1.10 Exports and Imports

The Covid-19 pandemic has augmented India's potential in the food trade sector (Saxena et al. 2022). Marine products constitute a major share of agricultural exports. In TE 2023-24, the share of marine products in total agricultural exports was over 15%, amounting to over Rs. 613 billion (Table 1.7). Frozen shrimp formed 69% of marine products exports. Frozen fish comprised 8%, frozen squid 5%, and frozen cuttle fish 4%. This was followed by non-basmati and basmati rice, which together contributed to over 20% of the total exports. The earnings from sugar, spices, and buffalo meat were Rs. 347 billion, Rs. 316 billion, and Rs. 271 billion, respectively. Of the fruits and vegetables exported as fresh and processed, 30% were fresh fruits. Fresh vegetables and processed fruits each accounted for 27%, and the remaining 16% were processed vegetables.

Table 1.7. India's agricultural exports composition (TE 2023-24, Rs. billion)

Item	Export Value	%
Marine products	613	15.3%
Rice - non basmati	448	11.2%
Rice - basmati	378	9.4%
Sugar	347	8.6%
Spices	316	7.9%
Buffalo meat	271	6.7%
Fruits & vegetables (fresh + processed)	259	6.4%
Others	1385	34.5%
All	4017	100.0%

Source: GoI (2024f).

Vegetable oil constitutes a major share of agricultural imports. Statistics for TE 2023-24 shows over 56% of the agricultural import bill was through vegetable oils (Table 1.8). Vegetable oil import has increased from 13.5 million tons in the oil year (Nov-Oct) 2019-20 to 16.2 million tons in 2023-24. Crude palm oil constituted 44% of the import demand (in TE 2023-24, Nov-Oct) and soybean oil constituted 24% of the demand. The shares of sun-seed oil and RBD palmolein were 18% and 13%, respectively. Pulse imports constituted 8.4% and fresh fruit constituted 8%. The share of cashews and spices was 4.7% and 4.2%, respectively. Alcoholic beverages, cotton, and sugar were the other major imports.

Table 1.8. Composition of agricultural imports (TE 2023-24, Rs. billion)

Item	Import Value	%
Vegetable oils	1396	56.2
Pulses	208	8.4
Fresh fruits	198	8.0
Cashew	116	4.7
Spices	105	4.2
Alcoholic beverages	73	2.9
Cotton (raw incld. waste)	67	2.7
Sugar	66	2.7
Others	253	10.2
All	2481	100.0

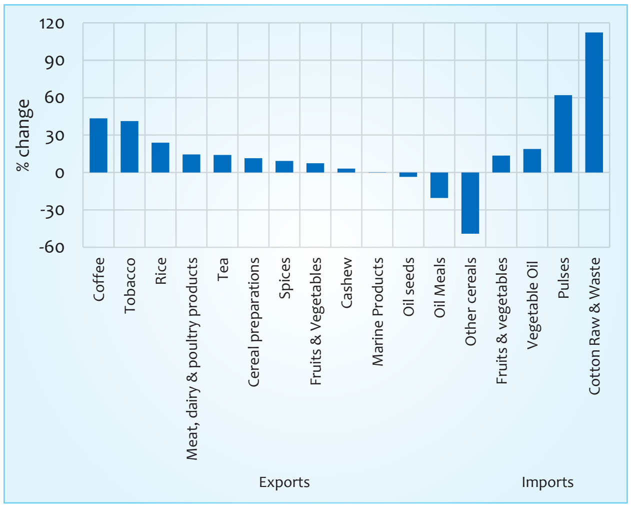
Source: GoI (2024f).

Observing the trade growth in major agricultural items, according to the estimates released in February this year by the Ministry of Commerce and Industry, rice, including basmati, represents the largest export segment, followed by marine products, meat, dairy and poultry products, and spices. Rice exports experienced a 24% increase this year (April–February) (Figure 1.7). The monetary value of rice exports increased from Rs. 771 billion in 2023-24 to Rs. 955 billion in 2024-25. Similarly, there has been a 14.5% increase in exports of meat, dairy, and poultry products, whereas cereal preparations have seen an 11.4% increase. Spices recorded a 9.2% increase, and the fruits and vegetables exports increased by 7.4%. Coffee and tobacco exports surged by more than 43% and 41%, respectively. Tea and cashews have shown export growth exceeding 10%. By contrast, marine product exports remained largely unchanged, with a marginal increase of 0.2%. In 2024-25, the value of marine product exports was approximately Rs. 568 billion.

However, imports have increased significantly. This surge was primarily due to a significant increase in imports of vegetable oils and pulses. During April 2023-February 2024, India imported vegetable oils worth Rs. 1.1 trillion, which increased to Rs. 1.4 trillion between April 2024-February 2025, reflecting an increase of approximately 19%. Given that a substantial portion of the country's edible demand is satisfied through imports, and that tariffs have a limited impact on enhancing domestic production, ongoing efforts to advance technology in oilseed production are essential (Balaji et al. 2022).

Similarly, pulse imports increased from Rs. 263 billion to Rs. 426 billion. Imports of raw cotton also rose from Rs. 45 billion to Rs. 96 billion. These developments highlight vulnerabilities in domestic production systems and underscore the urgency of strengthening India's agricultural value chains to reduce external dependence. Enhancing productivity through research and development, diversifying production systems, and promoting public–private partnerships will be critical in building a robust and self-reliant agri-trade regime.

Figure 1.7 Export growth in selected commodities: 2023-24 -vs- 2024-25



Source: GoI (2024f).

1.11 Sustainability Issues and Way Forward

The significant expansion of the livestock subsector has contributed to a 4% growth rate in agriculture in the past decade. However, a notable trend reversal has been evident in recent years, characterized by a decline in the growth of the fisheries subsector, which warrants attention. Persistent regional disparities are also concerning. While growth in the livestock subsector is becoming more inclusive, the concentration of crop subsector growth in a limited number of states requires further examination. To sustain growth, policies must be implemented to promote inclusive growth across all the regions. The recent decline in the procurement of paddy and wheat, coupled with an increase in support prices, suggests a shift towards greater sustainability and diversification, given the reduced returns from these crops. Encouraging millet production would further bolster these efforts. Research indicates that reallocating a portion of agricultural land for millet cultivation could conserve resources while reducing emissions (Balaji 2024). The increase in agricultural exports, offset by imports, particularly the heavy reliance on edible oil, underscores the need to enhance domestic production capacities. This is pertinent for both oilseeds and edible oil production in the country.

In light of the evolving climate and increasing pressure on natural resources, conservation and management are anticipated to become increasingly pivotal in the future. Empirical evidence of rising temperatures indicates that crops cultivated in various seasons may experience substantial declines in yield. This decline is expected to affect staple crops, such as paddy and wheat, pulses, such as chickpeas, and commercial crops, such as cotton. Specifically, paddy (rice), which is the largest revenue generator through trade at present, is projected to experience a 5.5% yield decline under RCP 4.5 scenario during the period 2040-2060. This decline is expected to escalate to as much as 22% during 2061-2080, raising significant concerns regarding future food security (Birthal et al. 2021). Under the RCP 8.5 scenario, these projections increase to 21% and 43% for the periods 2040-2060 and 2061-2080, respectively, underscoring the urgency of addressing these issues in the near term. Pulses, which are predominantly cultivated under limited irrigation and are often imported, thereby inflating public exchequer, are similarly affected. This situation is analogous for maize, whose industrial applications are being increasingly explored to meet clean energy targets. The projected yield decline for maize ranges from 5% to 37% over the medium- and long-term, which, if not addressed promptly, could jeopardize both food and energy security.

Although agricultural credit has expanded considerably, stark inequalities persist in access, particularly for small and marginal farmers. Research suggests that access to credit can enhance productivity by 24% and mitigate downside risk by 16% (Birthal et al. 2025). Nevertheless, small-scale farmers face substantial limitations in accessing credit, which severely restricts their capacity to invest in strategies for managing agricultural risks. For instance, large-scale farmers invest 25 times more than small-scale farmers with less than one acre of land (Saxena et al. 2023). This disparity limits mechanization, input adoption, and diversification, pushing smallholders toward low-investment activities such as livestock and poultry rearing.

Geopolitical risks continue to evolve and pose significant threats to food security. The conflict between Russia and Ukraine has had notable implications for the Indian food system (Balaji & Babu 2022). Although a resolution appears to be on the horizon, recent patterns of reciprocal tariff escalations suggest that trade uncertainty may persist. The global trend toward protectionism and the emergence of bilateral trade arrangements over multilateralism could further complicate India's agricultural trade strategy.

In this context, enhancing the governance of food systems—by fostering multi-stakeholder platforms and participatory decision-making—will be essential. A systems-oriented approach that balances national production goals with global trade realities, environmental constraints, and regional aspirations will be key to sustaining India's agricultural growth over the long term.

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2

Public Investment in Agriculture

Ankita Kandpal and Kiran Kumara T M

Public investment in Indian agriculture has increased more than eightfold since 1990–91, with sharp growth after 2000–01. However, the sector continues to be underfunded relative to its economic significance—accounting for only 4.22% of total public expenditure in 2022–23, despite contributing 18.2% to gross value added (GVA). While the central government plays a dominant role, focusing on food storage and warehousing, states, whose share in investment has declined over time, focus on crop husbandry, livestock, and resource conservation. Chhattisgarh stands out for prioritizing agriculture, whereas several agrarian states, including West Bengal, Uttar Pradesh, Madhya Pradesh, and Rajasthan, allocate relatively less. To ensure inclusive and sustainable agricultural growth, public investment must pivot towards high-potential areas like dairying, animal husbandry, and fisheries. Equally critical are enhanced allocations for agricultural R&D and climate-resilient infrastructure. A more balanced and coordinated investment strategy is essential to unlock the full potential of Indian agriculture.

2.1 Introduction

Public investment plays a crucial role in agricultural and rural development. It encompasses diverse components such as infrastructure, irrigation, research and development (R&D), rural roads, and storage. These investments modernize farming practices, enhance productivity, reduce post-harvest losses improve market access, thereby increasing the overall efficiency of the agri-food system. The impact of public investment in agriculture extends beyond the immediate impact on farming communities. It creates a multiplier effect across the broader economy by catalyzing growth in agro-processing, logistics and rural service sectors. Improved agricultural productivity also contributes to food security, price stabilization, and reduced imports dependency. By focusing on sustainable agricultural practices and climate-resilient farming methods, public investments are crucial for mitigating the impacts of climate change on agriculture and ensuring long-term food security. Furthermore, the discourse on public investment in agriculture in India is intricately connected to broader policy imperatives, including rural development, poverty alleviation, social equity, and across environmental sustainability. This chapter evaluates national and sub-national trends in public investment in agriculture, highlights compositional shifts, and identifies regional disparities in resource allocation.

2.2 Trend in Public Investment

Public investment in agriculture and related activities has increased eightfold, from Rs. 498 thousand million in 1990-91 to Rs. 4415 thousand million (at 2011-12 prices) in 2022-23, with a sharp uptrend after 2000-01. This growth is largely drive by central government. (Figure 2.1). The growth of public investment in agriculture accelerated from 6.01% during 1993-94 to 2002-03 to 12.85% per annum during 2003-04 to 2012-13, but experienced a slight decline to 9.05% in the latest decade (2013-14 to 2022-24). During the earlier period of 1993-94 to 2002-03, central investment showed a substantially higher growth (8.86%) compared to the sluggish growth in state investment (2.64%). However, in the period from 2013-14 to 2022-24, the growth rates of central and state agricultural investments appear to converging; 10% and 8.07%, respectively, following their peak growth rates of 14.5% and 9.5% during 2003-04 to 2012-13 (Table 2.1).

Figure 2.1 illustrates that public investment in agricultural sector predominantly originates from central investment. During the initial period from 1993-94 to 2002-03, there was a relatively balanced distribution of investment between the central and state governments, with the central government contributing 51.87% and the state governments sharing 48.13% of the total investment (Table 2.2). However, as central government investment increased significantly during the initial periods, the ratio of central to state government investment in agriculture widened to 67:33 during 2003-04 to 2012-13, and subsequently adjusted to 61:39 in the recent period i.e. 2013-14 to 2022-24 (Table 2.2).

Table 2.1. Decadal growth rate in public investment in agricultural sector

Period	Growth rate in investment (%)		
	Centre	State	India
1993-94 to 2002-03	8.86	2.64	6.01
2003-04 to 2012-13	14.52	9.50	12.85
2013-14 to 2022-24	10.00	8.07	9.50

Source: Authors' computations based on data from GoI[a]; State Finances, RBI.

Table 2.2. Investment in agricultural sector by source (%)

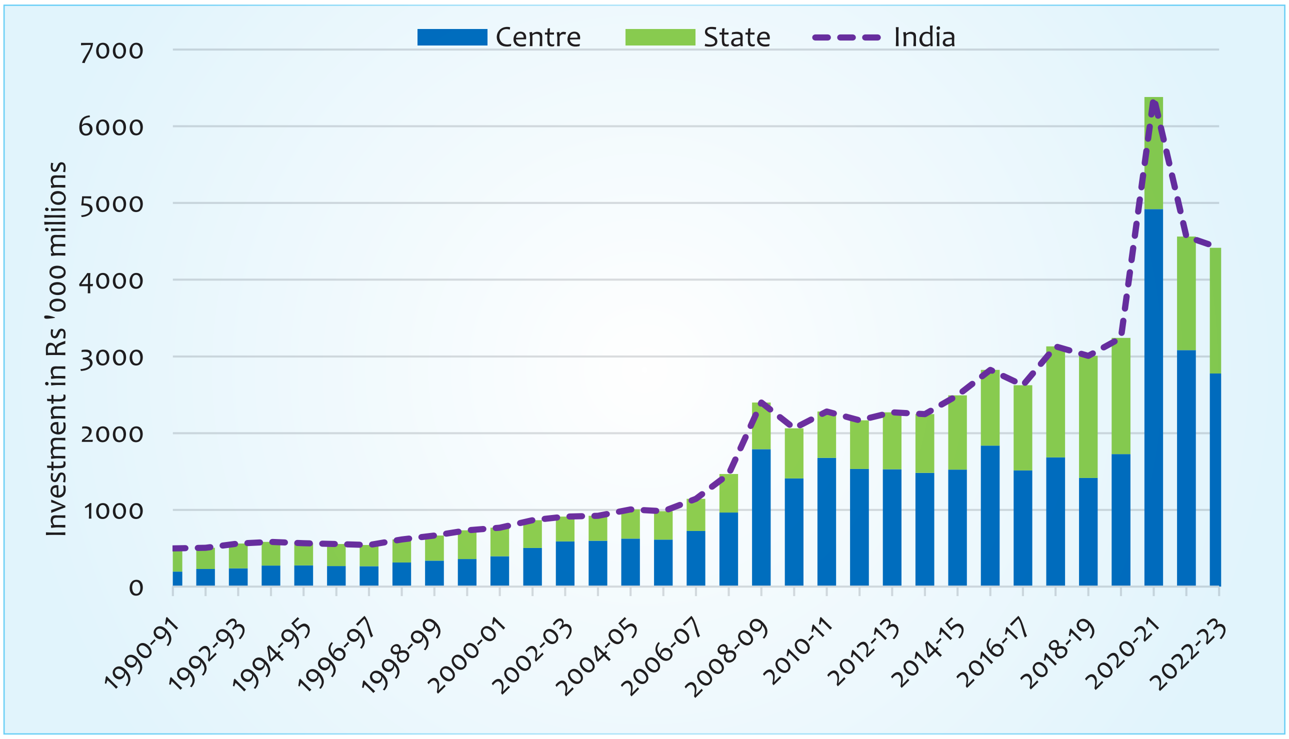
Period	Centre	State
1993-94 to 2002-03	51.87	48.13
2003-04 to 2012-13	67.30	32.70
2013-14 to 2022-24	61.16	38.84

Source: Authors' computations based on data from GoI[a]; State Finances, RBI.

2.3 Share of Agriculture in Total Public Investment

The investment intensity, measured as the share of investment in agricultural sector in the total public investment, indicates the priority accorded to the agricultural sector in development planning. As illustrated in Figure 2.2, investment intensity has experienced considerable fluctuations over the past three decades. Initially, it remained relatively stable, averaging approximately 5.4% during 1990-91 and 2002-03. However, it subsequently declined sharply to 2.7% between 2003-04 and 2007-08, representing a reduction to half of its previous level. A modest increase in agricultural investment intensity to 4% was observed in 2008-09, followed by a gradual decrease to 2.8% by

Figure 2.1. Trends in public investment in agricultural sector (at 2011-2 prices)



Source: GoI[a]; State Finances, RBI.

2019-20. Notably, it rose to 5.28% in 2020-21, before settling at 4.22% in 2022-23.

During the same period, the share of agricultural sector in the total gross value added (GVA) experienced a gradual decline, from approximately 29.8% in 1990-91 to 18.2% in 2022-23. Despite this reduction, its contribution to the total GVA remained significantly higher—on average, 5.7 times greater—compared to the budgetary allocations for agriculture.

2.4 Composition of Public Investment in Agriculture

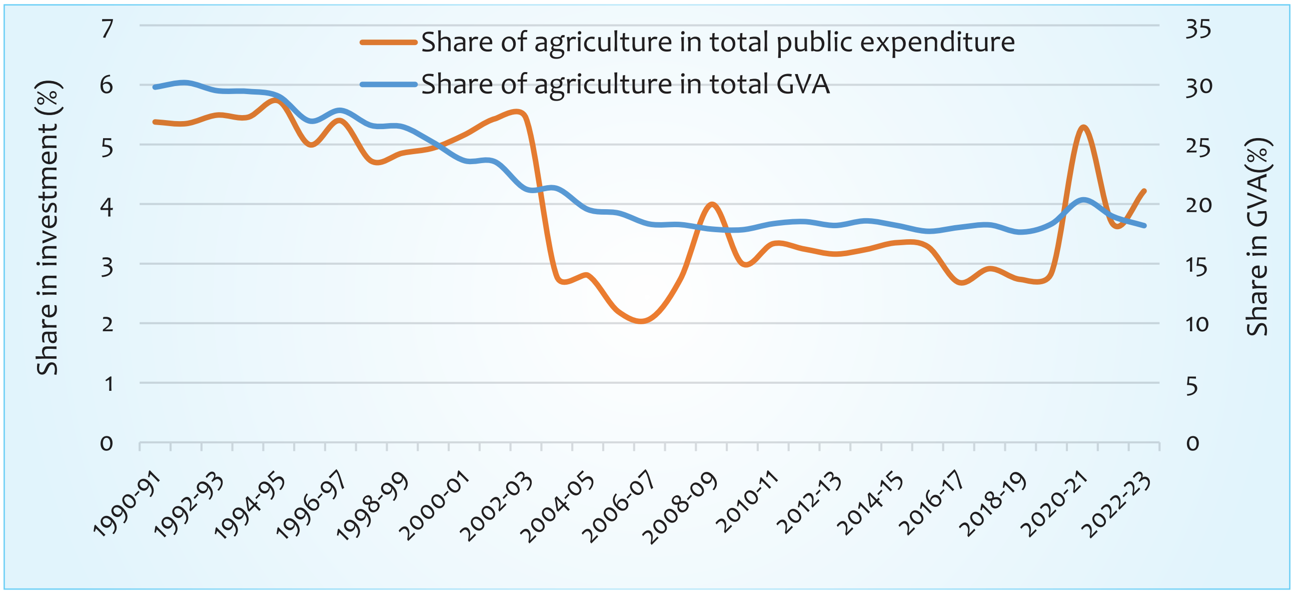
The development expenditure in agriculture and allied activities is classified in 12 major components:

i. Crop husbandry,
ii. Soil and water conservation,
iii. Animal husbandry,
iv. Dairy development,
v. Fisheries,
vi. Forestry & wildlife,
vii. Plantations,
viii. Food storage & warehousing,
ix. Agricultural research & education,
x. Agricultural financial institution,
xi. Cooperation and
xii. Other agricultural programmes

The allocation of agricultural expenditure by both central and state governments is determined by their respective priorities. While funding for agricultural finance institutions, plantations, and food storage and warehousing is predominantly sourced from central government, activities such as cooperation, animal husbandry, soil and water conservation, and forestry and wildlife are primarily financed through state government budgets. The distribution of investment between central and state governments is relatively balanced only for crop husbandry and agricultural research and education (Table 2.3).

The temporal trend reveals a slight change in the composition of expenditure on activities such as crop husbandry, forestry and wildlife, food storage and warehousing, and agricultural research and education between the periods 1993-94 to 2002-04 and 2013-14 to 2022-23. Notably, there was a significant increase in the central share of expenditure on dairy development, from 13.1% to 23.7%, accompanied by a marked decrease in in investment in other agricultural programs, from 33.1% to 13.4%, and on fisheries, from 12.4% to 5.9%.

Figure 2.2. Share of public investment in agriculture of the total public investment



Source: Authors' estimation based on data from GoI[a,b], State finances, RBI.

Table 2.3. Source of funds for major activities of agricultural sector

Activities		Share in total expenditure (%)			
		Centre		State	
		1993-94 to 2002-03	2013-14 to 2022-23	1993-94 to 2002-03	2013-14 to 2022-23
i.	Crop husbandry	47.35	46.12	52.65	53.88
ii.	Soil and water conservation	2.17	0.46	97.83	99.54
iii.	Animal husbandry	2.62	5.65	97.38	94.35
iv.	Dairy development	13.10	23.75	86.90	76.25
v.	Fisheries	12.41	5.92	87.59	94.08
vi.	Forestry and wild life	4.61	3.02	95.39	96.98
vii.	Plantations	90.47	97.54	9.53	2.46
viii.	Food storage & warehousing	89.76	87.96	10.24	12.04
ix.	Agricultural research & education	47.26	43.64	52.74	56.36
x.	Agricultural financial institutions	100.00	100.00	0	0
xi.	Cooperation	4.29	1.57	95.71	98.43
xii.	Other programmes	33.14	13.40	66.86	86.6

Source: Authors' computations based on data from GoI[a]; State Finances, RBI.

2.4.1 Priorities of the central government

The central government's investment is mainly concentrated on the development of food storage & warehousing infrastructure (> 50% share). Next major development priority is crop husbandry, which receives 23-25% of the investment, followed by agricultural research and education as well as agricultural financial institutions (Table 2.4). All the other activities have negligible share in central government investment. In addition, there is a decline in share of soil and water conservation, dairy, fisheries, forestry and wildlife, plantation, research and education, cooperation, and other agricultural programs. While crop and animal husbandry have experienced an increase in their share of total agricultural investment during 2003-04 to 2012-13 from 1993-94 to 2002-03, there is a slight decline during 2013-14 to 2022-23. Furthermore, although agricultural financial institutions consistently have gained in their share of the central government investment, food storage and warehousing has regained its share during 2013-14 to 2022-23 after experiencing a slight reduction during 2003-04 to 2012-13.

Table 2.4. Trends in allocation of central government expenditure on agricultural sector

Components		Share in total central expenditure in agriculture (%)		
		1993-94 to 2002-03	2003-04 to 2012-13	2013-14 to 2022-24
i.	Crop husbandry	23.16	39.42	24.89
ii.	Soil and water conservation	0.15	0.02	0.01
iii.	Animal husbandry	0.28	0.37	0.32
iv.	Dairy development	1.08	0.40	0.32
v.	Fisheries	0.35	0.16	0.08
vi.	Forestry and wild life	0.91	0.64	0.22
vii.	Plantations	0.93	0.62	0.18
viii.	Food storage & warehousing	65.28	51.37	65.85
ix.	Agricultural research & education	5.58	3.33	2.35
x.	Agricultural financial institutions	1.05	3.30	5.41
xi.	Cooperation	0.35	0.10	0.09
xii.	Other programmes	0.90	0.27	0.27
xiii.	Total	100.00	100.00	100.00

Source: GoI[a].

2.4.2 Priorities of states

While the central government's investment is predominantly targeted towards the development of food storage and warehousing, state government investments in agriculture exhibits a more balanced allocation of resources (Table 2.5). The highest priority is accorded to the crop husbandry, followed by forestry and wildlife, animal husbandry, food storage and warehousing, and cooperatives.

Over the period from 1993-94 to 2022-23, there was a notable increase in investment in crop husbandry, food storage and warehousing. However, several other activities have experienced a decline in their share. The critical areas needed to boost agricultural income and production system sustainability such as soil and water conservation, animal husbandry, dairy and forestry have witnessed a significant decline in their share. The share of agricultural research and education has also declined from 6.6% during 1993-94 to 2002-03 to 4.7% during 2013-14 to 2022-24.

Table 2.5. Trends in the allocation of state government expenditure on agriculture and allied sector

Components	% share in states' expenditure in agriculture		
	1993-94 to 2002-03	2003-04 to 2012-13	2013-14 to 2022-24
Crop husbandry	27.1	30.2	42.7
Soil and water conservation	7.1	5.4	3.0
Animal husbandry	11.3	10.6	7.9
Dairy development	7.8	3.0	1.6
Fisheries	2.7	2.7	2.1
Forestry and wild life	20.7	17.6	11.2
Plantations	0.1	0.04	0.01
Food storage & warehousing	8.2	11.3	11.6
Agricultural research & education	6.6	6.6	4.7
Agricultural financial institutions	7.8	11.8	8.9
Cooperation	0.7	0.7	6.3
Total	100.00	100.00	100.00

Source: State Finances, RBI.

2.4.3 Expenditure on agricultural sector in states

Table 2.6 indicates the state-level investment in agricultural sector in both absolute (average annual expenditure) and relative terms i.e. average annual expenditure per hectare of gross cropped area (GCA) during 2013-14 to 2022-23. The investment intensity is shown in terms of share of agricultural expenditure in total public expenditure reflecting the focus given to agriculture in the state's budget and the share of agricultural GVA in the state's total GVA to reflect the importance of agriculture in the state.

During this period, the maximum annual investment in agricultural development was in Maharashtra (Rs. 1,75, 273 million), followed by Karnataka (Rs. 1,16,753 million) and Tamil Nadu (Rs. 98,890 million) whereas the lowest investment was recorded in Goa (Rs. 3066 million) and Sikkim (Rs. 3213 million) during the period. In terms of per hectare, Odisha (Rs. 41,677), Mizoram (Rs. 32,330), Arunachal Pradesh (Rs. 22,338), and Sikkim (Rs. 21,913) invested more whereas lowest investment was found in Rajasthan (Rs. 2,202) and Madhya Pradesh (Rs. 3,381), despite possessing vast agricultural land.

The investment intensity in agriculture is highest in Chhattisgarh (6.3% of total expenditure) followed by Mizoram (5.1%), Punjab (4.88%), Jammu & Kashmir (4.52%). On the contrary, agricultural sector received less than 1% share of total public expenditure in West Bengal (0.75%) and Uttar Pradesh (0.93%) while the sector contributed more than 20% in the economy of these states.

Thus, a huge gap exists between the priority accorded to agricultural sector in a particular state and the role of agriculture in state's economy. The states showing maximum disparity are West Bengal, Uttar Pradesh, Madhya Pradesh, Rajasthan, Bihar and Tripura where there is not only a huge mismatch in agricultural focus in total state expenditure and its relative contribution, but the amount invested in agricultural development per unit of land is also insufficient for advancements of the sector.

Table 2.6. Comparative insights on the magnitude of agricultural expenditure across states (2013-14 to 2022-23)

States	Annual expenditure in agriculture at 2011-12 prices (in Rs. millions)	Agricultural development expenditure per GCA (Rs./ha)	% total public expenditure	Share of GVA_{Ag} in states' GVA (%)
Andhra Pradesh	60203	8156	2.49	34.10
Arunachal Pradesh	7160	22338	1.26	37.44
Assam	26878	6715	1.86	21.25
Bihar	34074	4578	1.81	24.33
Chhattisgarh	90807	16031	6.31	20.86
Goa	3066	20423	1.54	7.39
Gujarat	53274	3999	1.57	16.51
Haryana	28417	4323	2.27	18.30
Himachal Pradesh	15615	17118	4.39	14.60
Jammu & Kashmir	23702	20779	4.52	18.48
Jharkhand	19043	11017	1.47	17.69
Karnataka	116753	8838	2.25	12.90
Kerala	49368	19165	1.93	11.81
Madhya Pradesh	90013	3381	2.18	39.92
Maharashtra	175273	7313	3.57	11.85
Manipur	4279	10777	2.95	24.31
Meghalaya	5722	17953	2.73	20.37
Mizoram	5545	32330	5.07	26.21
Nagaland	4779	9836	3.53	30.71
Odisha	41677	41677	1.42	20.90
Punjab	59812	7571	4.88	28.72
Rajasthan	57949	2202	2.03	27.44
Sikkim	3213	21913	3.30	9.51
Tamil Nadu	98890	16619	2.23	12.53
Telangana	66941	10098	4.41	16.61
Tripura	5932	5932	2.17	33.72
Uttarakhand	19522	19032	4.09	10.35
Uttar Pradesh	91715	3390	0.93	25.49
West Bengal	41119	4131	0.75	23.37

2.4.4 Composition of agricultural expenditure in various states

This section examines the composition of agricultural development expenditure across states, highlighting the developmental priorities within the agricultural sector in each state. It also assesses the relative contributions of major sub-sectors, including crops, livestock, fisheries, and forestry, to agricultural GVA. As illustrated in Table 2.7, there is a significant emphasis on the development of crop husbandry in several states.

States like Andhra Pradesh, Telangana, Odisha, Punjab, Tamil Nadu, Uttar Pradesh and West Bengal allocate more than half of their agricultural expenditure to crop husbandry. Additionally, crop husbandry is given the topmost priority in most the states, except Kerala, Jammu & Kashmir, Maharashtra, and Arunachal Pradesh.

Investment in soil & water conservation receives the highest focus in Meghalaya (18% of the total state agricultural investment), Jharkhand (10%), Manipur (9%), Maharashtra, Arunachal Pradesh & Nagaland (each with 8%), and the least priority (i.e. less than 1%) in Uttarakhand, Andhra Pradesh, Telangana, Madhya Pradesh, Rajasthan, and Chhattisgarh.

Animal husbandry receives notable focus in Haryana (19%), Jammu & Kashmir and Manipur (17% each), whereas it accounts for less than 5% share out of total agricultural investment in Chhattisgarh, Telangana, and Maharashtra. Further, except in Goa (13.5%), Karnataka (7.3%) and Jharkhand (5.9%), the allocation to dairy development is less than 5% across all the states during this period. Notably, a huge disparity exists between the focus given to livestock sector in agricultural planning and its relative contribution to agricultural GVA in the states of Telangana, Tamil Nadu, Rajasthan, Andhra Pradesh, and Punjab (Figure 2.3).

The development of fisheries receives highest priority in the coastal states of Goa (11.47%), Kerala (8.35%), Tamil Nadu (5.06%), and also in all the northeastern states. The investment priority given to fisheries subsector closely imitates its contribution made in agricultural GVA in almost all the states, barring Andhra Pradesh and Telangana.

Further, a reasonable focus is given to the development of forestry & wildlife in all the states

Table 2.7. Annual expenditure in agricultural sector (Rs. in millions) during 2013-14 to 2022-23 at 2011-12 prices

States	Share of sub-sectors in total agricultural expenditure of state (%)										
	Crop Husbandry	Soil & Water Conservation	Animal Husbandry	Dairy Development	Fisheries	Forestry & Wildlife	Plantations	Food storage and warehousing	Agricultural Research & Education	Co-operation	Other Agricultural Programmes
Andhra Pradesh	52.37	0.49	9.13	0.00	1.97	3.94	0.00	0.79	10.36	1.84	10.83
Arunachal Pradesh	28.37	7.85	13.23	0.54	4.30	28.97	0.00	11.61	2.69	1.87	0.63
Assam	31.69	4.51	10.39	0.97	2.82	19.65	0.00	15.41	9.03	3.39	0.83
Bihar	46.03	2.15	8.09	2.47	2.64	9.60	0.00	9.91	9.39	8.61	0.22
Chhattisgarh	40.41	0.99	3.33	0.09	0.69	10.05	0.00	35.06	1.24	6.07	2.55
Goa	34.51	2.56	10.54	13.53	11.47	16.37	0.85	3.66	0.63	5.11	0.30
Gujarat	40.40	2.47	8.51	0.78	3.95	16.68	0.00	2.59	9.97	14.01	0.62
Haryana	33.22	2.15	18.93	0.02	1.42	8.03	0.79	14.86	8.33	11.86	0.04
Himachal Pradesh	27.60	4.60	16.19	1.07	1.23	24.38	0.06	12.39	10.40	1.80	0.33
Jammu & Kashmir	25.35	2.38	16.87	0.00	3.17	27.60	0.00	11.54	9.24	2.80	0.95
Jharkhand	36.00	9.76	7.71	5.92	3.53	21.50	0.00	0.82	5.31	9.19	0.22
Karnataka	29.61	2.19	6.65	7.29	1.80	10.68	0.00	20.59	4.13	17.00	0.03
Kerala	21.20	2.44	8.92	2.36	8.35	8.53	0.00	29.83	7.43	6.19	4.46
Madhya Pradesh	46.73	0.54	7.11	0.00	0.76	18.57	0.00	16.06	1.39	8.84	0.003
Maharashtra	23.18	8.03	4.99	2.18	1.25	12.44	0.00	12.90	4.37	7.08	24.40
Manipur	33.75	9.29	17.34	0.36	6.04	18.31	0.01	9.34	0.99	4.02	0.06
Meghalaya	26.59	18.88	15.60	2.45	4.68	21.45	0.00	0.02	2.37	3.74	4.23
Mizoram	33.62	4.30	13.30	0.27	3.07	17.84	0.00	20.22	1.92	2.36	3.04
Nagaland	41.17	7.85	13.96	0.24	5.07	16.14	0.00	9.74	1.97	3.67	0.18
Odisha	51.17	3.03	5.94	0.90	2.48	8.84	0.00	24.25	2.43	10.00	0.31
Punjab	82.30	1.53	5.28	0.18	0.28	2.47	0.00	0.03	4.79	3.09	0.05
Rajasthan	38.14	0.82	14.90	1.48	0.20	12.13	0.00	0.00	3.02	28.36	0.95
Sikkim	38.61	4.72	12.02	1.14	2.77	26.11	1.60	5.25	0.00	3.86	3.87
Tamil Nadu	55.19	1.11	7.40	0.65	5.06	3.83	0.00	1.35	6.05	16.96	2.38
Telangana	66.16	0.61	3.74	0.01	0.56	4.09	0.00	0.07	3.33	0.83	19.25
Tripura	46.27	2.11	12.62	0.37	8.05	20.82	0.00	4.42	0.30	3.30	1.70
Uttarakhand	33.64	0.00	8.16	1.75	0.89	26.10	0.02	19.11	7.28	2.49	0.00
Uttar Pradesh	51.24	5.66	10.64	0.84	0.99	8.74	0.05	12.19	2.22	7.26	0.16
West Bengal	55.86	1.16	9.18	1.97	3.53	10.06	0.00	6.39	3.43	5.38	3.00

Source: State Finances, RBI.

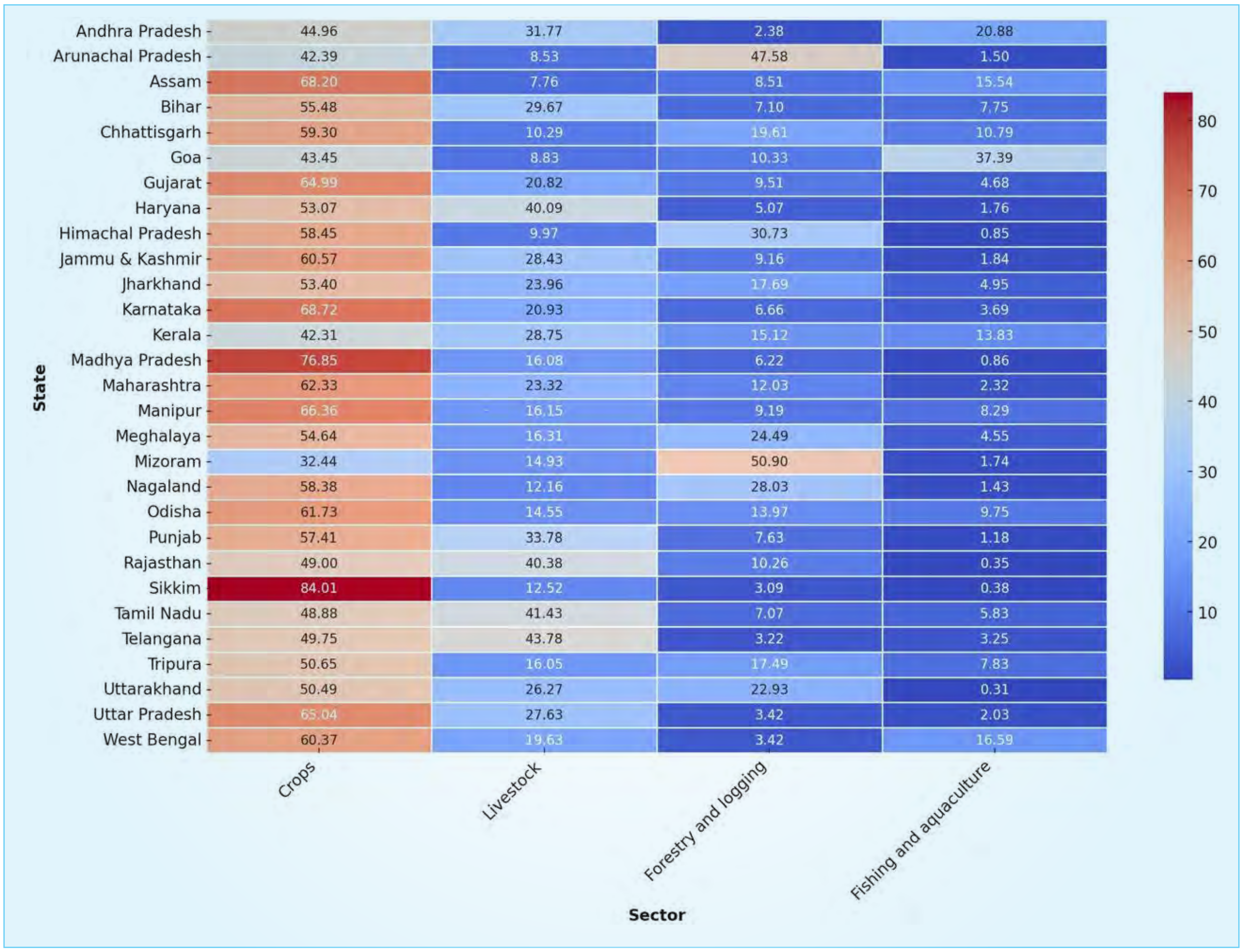
with highest focus in Arunachal Pradesh (28.97%), Jammu & Kashmir (27.6%), Sikkim and Uttarakhand (26.1%), and Himachal Pradesh (24.38%), given the importance of forest conservation, biodiversity preservation, and ecological balance in these ecologically sensitive and mountainous regions. It is important to note that forestry had a dominant contribution in agricultural GVA in the states of Mizoram (50.9%), Arunachal Pradesh (47.58%) and Himachal Pradesh (30.73%) during this period. Only a handful of states viz. Sikkim, Goa, Haryana, Uttarakhand, Uttar Pradesh, Himachal Pradesh, and Manipur allocate funds for plantation development, each contributing less than 2% of their total agricultural expenditure in the activity.

Food storage & warehousing receive maximum priority in Chhattisgarh (35%), Kerala (30%), Odisha (24%) and Karnataka (21%) and least in Rajasthan, Meghalaya, Punjab and Telangana. The focus on agricultural research and education is maximum in Himachal Pradesh, Andhra Pradesh and Gujarat (10% each) and least in Sikkim, Tripura, Manipur and Goa. Lastly, cooperation and other agricultural programs receive the highest priority in Rajasthan and Maharashtra and the least focus in Telangana and Uttarakhand, respectively.

2.5 Conclusions

Public investment in agriculture and allied activities is pivotal for fostering broad-based economic development and ensuring long-term sustainability of the sector. Over the years, there has been a substantial increase in investment by both the central and state governments,

Figure 2.3. Relative contribution (%) made by major sub-sectors in agricultural GVA in various states (2013-14 to 2022-23)



reflecting the growing recognition of agriculture's critical role in livelihoods and food security. The composition of public investment has evolved over time, shaped by shifting policy priorities and emerging challenges. At the central level, there has been a strong emphasis on developing food storage and warehousing infrastructure to reduce post-harvest losses and strengthen the food supply chain. In contrast, crop husbandry has consistently remained the top priority at the state level, although the focus on other crucial sectors, such as soil and water conservation, animal husbandry, dairy development, and fisheries, has varied considerably across states.

To enhance impact and efficiency, public investment must strategically target region-specific priorities. In the context of increasing climate variability and natural resource degradation, there is an urgent need to significantly step up investment in soil and water conservation. Paradoxically, this critical component is getting the least attention with declining investment growth in each successive decades. Furthermore, to raise farmers' incomes and create more resilient livelihood options, greater emphasis is required on high-potential sectors such as dairy, animal husbandry, and fisheries, supported by robust technological innovations. Integrating rural development initiatives with agricultural investment can generate strong multiplier effects, addressing rural poverty, promoting inclusive growth, and contributing meaningfully to sustainable and equitable economic development.

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3

Crop Diversification

Prem Chand, Subhash Chand, and Kalu Naik

This chapter analyses spatial patterns in crop diversification and proposes strategies for its promotion. There is considerable spatial diversity in crop patterns, with the Arid Western and Southern Semi-Arid regions showing a higher level of diversification compared to the Indo-Gangetic plains. North-Eastern region displays a notable increase in diversification, accompanied by substantial increase in horticultural area. Conversely, Chhattisgarh, Telangana, Punjab, and Haryana show a shift towards crop specialization. The chapter underscores that the expansion of rice cultivation has predominantly come at the cost of oilseeds and millets that are both climate resilient and nutritionally important. This pattern is largely shaped by assured procurement and better price incentives under the minimum support prices (MSP) regime. To foster crop diversification, the chapter advocates a multi-faceted approach: improving productivity and profitability of alternative crops, reducing cultivation costs, and ensuring market support through processing and value addition. It also recommends the promotion of agroforestry-based integrated farming systems to mitigate flood impacts, improve soil health, and stabilize farmers' incomes. Other proposed measures include diversifying procurement beyond rice and wheat, implementing incentive-driven energy and water policies, and developing multiple stress-tolerant crop varieties and establishing risk transfer mechanisms. A broader shift in policy focus is necessary to create a more equitable and sustainable agricultural system.

3.1 Introduction

The Green Revolution marked a defining moment in India's agricultural development, ushering in a significant rise in the production of staple grains, particularly rice and wheat. The combination of technologies, policies, and institutions have helped country achieve self- sufficiency in food grains and reduce dependence on imports. However, the prolonged focus on these crops has resulted in significant environmental costs, including the depletion of groundwater resources, degradation of soils, and disruption of the ecological balance (Chand 1999). Excessive focus on paddy and wheat has also led to a reduction in agricultural biodiversity. This loss of diversity presents a potential risk to the sustainability of India's food production systems, particularly in the context of climate change. Recent assessments indicate that while Indian agriculture is moderately sustainable, regions dominated by rice monoculture pose serious sustainability concerns (Chand et al. 2024). Simultaneously, dietary patterns have evolved, with a noticeable shift toward high-value food items such as fruits, vegetables and animal based products. This transformation in consumer preferences calls for a reassessment of cropping priorities to align agricultural production with market demands and nutritional needs while minimizing environmental damage.

Crop diversification is crucial for fostering increased productivity, income generation for smallholders, sustainable resource management, poverty alleviation, and improved nutritional outcomes (Joshi et al. 2006; Bigsten and Tengstam 2011; Birthal et al. 2015; Michler and Josephson 2017; Anuja et al. 2020). Crop diversification has emerged as an essential adaptation strategy in response to climate change. As climate change affects agricultural systems, the capacity of diversified cropping systems to endure and recover from extreme weather events has become progressively significant (Abu-Zaitoun et al. 2018; Aggarwal et al. 2018; Kozicka et al. 2020). Furthermore, diversification can address consumers' evolving dietary preferences, thereby contributing to a more varied and nutritious food supply. This approach not only enhances the resilience of individual farms but also contributes to the overall sustainability of agricultural systems at both the regional and global levels. Crop diversification is of particular significance for smallholders as they benefit from the increased income stability and improved household nutrition by producing a variety of food crops for both consumption and sale (Joshi et al. 2006; Birthal et al. 2015; Anuja et al. 2020).

Despite an increase in the cultivation of high-value crops (Joshi *et al*. 2004), regional disparities persist. For instance, studies indicate a concerning decline in crop diversification and the concurrent degradation of natural resources in the Trans-Gangetic plains of India (Singh and Sidhu 2004; Roul *et al*. 2022). The policies and strategies so far have struggled to break the rice-wheat cycle to mitigate groundwater depletion. Therefore, addressing this issue requires a paradigm shift in policies and strategies (Chand *et al*. 2022). Conversely, eastern India requires tailored approaches that consider its unique resource endowment, climatic conditions, and agricultural priorities, such as targeting rice-fallow areas and increasing areas under irrigation. Hence, understanding the regional dynamics of cropping patterns is critical for crafting context-specific and regionally differentiated strategies to promote crop diversification. Such an approach will contribute not only to sustainable agricultural development but also to climate resilience, nutritional security, and economic well-being.

3.2 Shift in Cropping Pattern at National Level

Over the past four decades, the cropping pattern in India has undergone a significant transformation. This change is attributed to the expansion of irrigated land, adoption of high-yielding varieties, and intensified input usage, resulting in a substantial increase in the total cropped area by approximately 25 million hectares (m ha), from 169.29 m ha in the mid-1980s to 194.55 m ha in 2019-20 (Table 3.1). Throughout this period, cereals, primarily rice and wheat, dominated cropping patterns. Although the absolute area under cereals has remained relatively stable or has experienced a slight decline, there has been a notable shift in the relative share of these crops since TE1986/87. Although the area under water-intensive rice and wheat crops has expanded, this trend is predominantly attributed to a significant reduction in the cultivation of millets, which are both climate-resilient and rich in nutrients, particularly dietary fiber and minerals.

Conversely, the horticulture production underwent a significant transformation. The acreage under fruits, vegetables, and spices has more than doubled. Similarly, the cultivation of pulses has experienced notable change, with the area under pulses expanding from approximately 23 to 24 m ha up to TE 2010-11, to over 27 m ha in the past decade. The performance of oilseeds has been largely driven by an expansion in the cultivation of rapeseed & mustard, and other oilseeds such as soybean. However, there has been a decline in the area allocated to groundnuts, both in absolute terms and relative share.

3.3 Shift in Cropping Pattern at Subnational Level

The subnational level analysis of cropping patterns encompassed 29 states and two Union Territories (Jammu and Kashmir and Ladakh), which collectively account for over 95% of the country's cultivated land. For ease of interpretation, these states have been categorized into nine broad regions (Table 3.2), considering climatic and physiographic conditions, as well as data availability. This grouping aims to provide a comprehensive and nuanced understanding of the cropping patterns and potential interventions tailored to the specific needs of each region to promote crop diversification.

Table 3.1. Area under major crops in India

(million ha)

Crops	TE 1986-87	TE 2000-01	TE 2010-11	TE 2019-20
Rice	41.11 (24.28)	44.83 (24.81)	43.64 (23.45)	46.16 (23.73)
Wheat	23.27 (13.75)	26.88 (14.88)	28.84 (15.50)	32.67 (16.80)
Millets	34.05 (20.11)	24.15 (14.27)	19.69 (11.63)	14.29 (8.44)
Total Cereals	**104.29 (61.60)**	**102.28 (56.61)**	**100.40 (53.96)**	**102.31 (52.59)**
Chickpea	7.21 (4.26)	6.72 (3.72)	8.26 (4.44)	9.30 (4.78)
Pigeon pea	3.20 (1.89)	3.50 (1.94)	3.66 (1.97)	4.15 (2.13)
Total Pulses	**23.47 (13.86)**	**22.64 (12.53)**	**24.00 (12.90)**	**27.39 (14.08)**
Groundnut	7.23 (4.27)	6.96 (3.85)	5.88 (3.16)	4.83 (2.48)
Rapeseed & Mustard	3.26 (1.93)	5.67 (3.14)	5.65 (3.04)	5.96 (3.06)
Total Oilseeds	**20.45 (12.08)**	**26.82 (14.84)**	**29.15 (15.66)**	**27.79 (14.28)**
Sugarcane	3.12 (1.84)	4.62 (2.56)	4.87 (2.62)	5.31 (2.73)
Cotton	7.28 (4.30)	8.89 (4.92)	10.14 (5.45)	12.67 (6.51)
Total Fibres	8.64 (5.10)	9.98 (5.52)	11.08 (5.95)	13.44 (6.91)
Fruits & Vegetables	**5.32 (3.14)**	**7.65 (4.23)**	**9.89 (5.31)**	**10.72 (5.51)**
Spices	2.21 (1.30)	4.50 (2.49)	3.91 (2.10)	4.48 (2.30)
Others	1.79 (1.06)	2.20 (1.22)	2.80 (1.50)	3.11 (1.60)
Gross cropped area	**169.29**	**180.69**	**186.09**	**194.55**
Irrigation %	**30.98**	**41.40**	**45.19**	**51.94**

Figures in parenthesis indicate percentage of gross cropped area
Source: Author's computation from the secondary data

Table 3.2. Grouping of states of India in different regions

Zone*	States	Geographical area (m ha)	Net sown area (m ha)	Cropping intensity (%)
North-Western Hills	Jammu & Kashmir including Ladakh and Himachal Pradesh	27.79	1.27	160
North Eastern Hills	Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura	26.22	4.47	143
Trans-Gangetic Plains	Punjab and Haryana	9.46	7.68	188
Upper-Gangetic Plains	Uttar Pradesh and Uttarakhand	29.44	17.14	163
Middle-Gangetic Plains	Bihar and Jharkhand	17.39	6.50	143
Lower-Gangetic Plains	West Bengal	8.86	5.25	191
Central Plateau	Madhya Pradesh and Chhattisgarh	44.34	19.96	161
Western Dry Region	Rajasthan, Gujarat, Maharashtra and Goa	84.99	44.55	140
Southern Semi-Arid Tropics	Andhra Pradesh, Karnataka, Kerala, Tamil Nadu and Telangana	63.56	28.15	125

*Note: * Zoning not strictly as per the boundaries defined by ICAR and the erstwhile Planning Commission of India*

Table 3.3 presents a comprehensive analysis of the crop area distribution across various regions over different time periods. The data reveals a consistent increase in rice area across most zones, with notable exceptions in the North Western Hills and Middle-Gangetic Plains. The Trans-Gangetic Plains experienced a remarkable doubling of the rice area, whereas the Central Plateau Region saw a significant 35% increase.

These shifts in cropping patterns were analyzed using the Markov Chain process, as depicted in Figure 3.1, where the arrows indicate transitions from one crop to another. A key finding of this analysis is that the expansion of rice cultivation has primarily occurred at the expense of oilseeds and millets. Approximately 18% of oilseed acreage and 10% of millet acreage has been replaced by rice. This shift towards paddy cultivation is primarily driven by higher returns compared to other crops, as well as assured procurement at the minimum support price (MSP). Despite their potential benefits, these factors discourage the diversification of alternative crops.

While oilseeds have seen a substantial increase in acreage in absolute terms, at the national level, replacing other crops in some areas, this transition has not effectively addressed the issue of rice cultivation, particularly in the groundwater-stressed regions of Punjab and Haryana. In the Central Plateau and Western Dry Region, oilseed cultivation has primarily expanded at the expense of pearl millet, pulses, and sugarcane to some extent (Table 3.3). The increase in *kharif* oilseed cultivation is largely attributable to increased soybean area. Conversely, millet cultivation has experienced a consistent decline across all regions, with notable reductions in the Western Dry Region, Southern Semi-Arid Tropics, Central Plateau, Upper-Gangetic Plains, and Trans-Gangetic Plains. Cotton area increased slightly, particularly due to area increase in the Western Dry Region and Southern Semi-Arid Tropics, by replacing maize while area under maize has also increased replacing cotton and apart from spices in some areas (Figure 3.1 and Table 3.3). Area increase in maize also due to utilizing previously fallow lands and in state like Bihar.

During the *rabi* season, wheat experienced significant expansion and regional shifts. The crop now occupies 17% of the gross cropped area and 40% of the *rabi* area, with half of the total wheat area concentrated in the Trans-Gangetic Plains and Upper-Gangetic regions (Table 3.3). The Central Plateau and Western Dry Regions have also experienced substantial increase, collectively accounting for 40% of the total wheat area. This expansion has been driven by the introduction of wheat in new areas and the substitution of crops, such as rapeseed & mustard, chickpea, and sugarcane (Figure 3.2). The Central Plateau, in particular, has witnessed a doubling of wheat area, while the Western Dry Region has seen a 66% increase (Table 3.3).

Chickpea, another important *rabi* crop, has undergone significant changes in cultivation patterns across different regions. While it remains a crucial crop grown across various regions, over three-fourths of the total chickpea cultivation is concentrated in the Western Dry Region and Central Plateau Region. Notably, the Southern Semi-Arid Tropics Region has experienced a remarkable increase of approximately 1.5 m ha in chickpea cultivation. However, there has been a stark decline in chickpea cultivation in the Indo-Gangetic Plains, particularly in the Trans-Gangetic Plains, where wheat has largely replaced chickpeas as the dominant crop.

The expansion of horticultural crops, particularly fruits and vegetables, represents a significant shift in India's agricultural landscape since 1986-87. This change is most pronounced in arid and semi-arid regions, with the Western Arid Region and Southern Semi-Arid Tropics experiencing the most substantial increases of 2.2 million and 1.4 m ha, respectively. Notably, this growth has primarily occurred through the cultivation of additional land rather than the reallocation of existing cropland, as indicated by the negligible transition probabilities from other crops to fruits and vegetables (Figure 3.1 & 3.2).

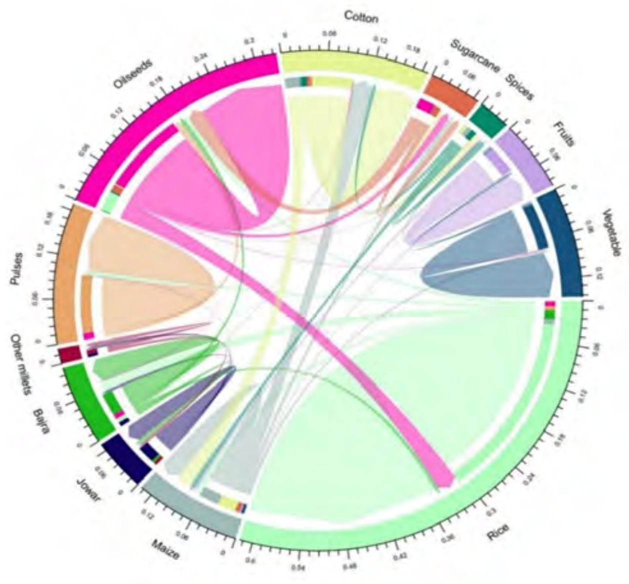
Table 3.3. Region-wise area under different crops in India (in '000 ha)

Year (TE)	Rice	Wheat	Millets	Cereals	Chickpea	Pigeon pea	Pulses	Groundnut	Rapeseed & Mustard	Oilseeds	Sugarcane	Cotton	Fibres	Fruits & Vegetable	Condiments & Spices	Others
North-Western Hills																
1986-87	3.63	6.08	1.03	16.64	0.08	0.00	0.91	0.02	0.59	0.86	0.04	0.00	0.03	1.09	0.11	0.13
2000-01	3.36	6.27	0.74	16.57	0.02	0.00	0.61	0.00	0.77	0.94	0.03	0.00	0.00	1.54	0.09	0.05
2019-20	3.39	5.39	0.50	14.74	0.00	0.03	0.42	0.00	0.44	0.53	0.02	0.00	0.02	2.37	0.22	0.06
North-Eastern Hills																
1986-87	32.03	1.45	0.67	35.52	0.07	0.13	1.53	0.02	3.44	4.09	0.58	0.14	1.63	3.67	1.54	2.72
2000-01	34.19	1.00	1.23	38.02	0.09	0.19	1.88	0.04	3.38	4.80	0.35	0.12	1.08	5.40	2.69	2.66
2019-20	33.81	0.26	0.53	37.10	0.09	0.17	2.76	0.08	3.93	5.20	0.45	0.09	1.00	8.68	3.34	4.93
Trans-Gangetic Plains																
1986-87	23.04	48.60	10.28	85.25	7.73	0.69	9.58	0.52	4.37	5.37	2.00	8.73	8.84	1.51	0.23	0.23
2000-01	36.51	56.65	7.91	102.86	2.03	0.32	3.13	0.06	5.07	6.02	2.46	10.65	10.65	1.98	3.97	0.05
2019-20	45.79	60.56	5.19	112.79	0.42	0.05	0.86	0.05	6.25	6.52	2.01	9.69	9.70	2.58	0.05	0.35
Upper-Gangetic Plains																
1986-87	55.45	83.58	25.31	176.34	14.56	5.20	30.20	1.44	5.14	10.39	15.70	0.23	0.57	8.09	0.56	0.33
2000-01	60.60	94.45	18.20	182.91	8.47	4.16	27.83	1.21	10.25	15.23	20.94	0.07	0.15	10.05	1.13	1.61
2019-20	69.16	104.94	14.47	196.11	3.41	2.60	19.68	1.14	6.87	13.81	23.88	0.10	0.11	13.08	0.81	2.98
Middle-Gangetic Plains																
1986-87	52.91	18.49	4.01	82.08	1.83	0.80	12.31	0.05	0.87	2.39	1.14	0.00	2.06	4.33	0.17	0.85
2000-01	50.75	21.32	1.73	81.00	1.01	0.67	8.71	0.04	1.01	2.46	1.01	0.00	1.74	5.15	0.22	0.20
2019-20	44.84	22.26	0.56	75.49	0.84	0.48	6.26	0.06	1.14	1.87	2.28	0.00	0.88	5.57	0.11	0.11
Lower-Gangetic Plains																
1986-87	52.18	3.46	0.44	56.71	0.67	0.11	3.85	0.00	2.57	4.14	0.13	0.00	6.25	7.09	0.58	1.33
2000-01	58.30	3.86	0.26	62.78	0.35	0.05	2.31	0.33	3.75	6.20	0.24	0.01	6.26	12.69	1.06	1.87
2019-20	55.14	1.39	0.08	59.52	0.34	0.04	4.62	0.69	6.11	9.75	0.19	0.00	5.25	16.74	1.50	2.20
Central Plateau																
1986-87	49.74	35.94	35.80	129.85	21.88	4.67	49.12	2.67	3.38	27.85	0.78	5.25	5.50	1.85	0.81	0.23
2000-01	54.37	42.37	17.56	123.27	25.36	3.61	48.22	2.64	5.96	61.29	0.79	4.90	5.01	3.09	4.82	0.19
2019-20	66.92	77.71	6.84	165.55	29.83	3.62	65.53	2.38	7.13	72.14	1.66	5.64	5.68	5.06	3.51	0.41
Western Dry Region																
1986-87	22.94	31.60	173.67	241.75	22.14	11.35	72.05	28.43	10.91	69.92	5.03	44.32	45.24	5.17	4.59	2.22
2000-01	23.63	40.05	133.65	213.75	24.33	14.19	75.39	26.23	26.23	93.33	9.22	53.98	54.35	10.73	10.29	3.18
2019-20	26.11	52.49	85.60	187.44	40.84	14.94	110.44	26.28	27.60	121.57	11.77	76.68	77.20	27.08	18.09	6.41
Southern Semi-Arid Tropics																
1986-87	75.51	2.98	84.60	168.26	2.76	7.67	36.60	35.97	0.07	69.50	5.37	14.05	15.27	12.24	11.55	9.07
2000-01	81.67	2.79	59.12	154.98	5.26	10.44	43.10	38.29	0.11	74.19	10.82	18.83	19.66	19.70	18.33	12.10
2019-20	77.93	1.74	28.42	134.60	17.23	19.52	59.72	17.29	0.08	45.77	10.76	34.41	34.52	25.96	17.15	13.65

Source: Land Use Statistics of Economics, Statistics and Evaluation Division, Ministry of Agriculture and Farmers Welfare, Government of India.

The driving force behind horticultural expansion in these regions has been the penetration of micro-irrigation, particularly drip system. The Western Arid Region and Southern Semi-Arid Tropics account for approximately 90% of the country's total area under drip irrigation (GoI 2023). This adoption of efficient irrigation methods has enabled farmers to overcome the challenges posed by water scarcity in these areas. Additionally, improvements in marketing, road infrastructure, and storage facilities have facilitated the shift towards high-value horticultural crops, making them more economically viable for farmers in these regions.

Figure 3.1. The transition in the cropping pattern in India in the *kharif* season between 1986/87 and 2019/20 (estimated using Markov Chain)

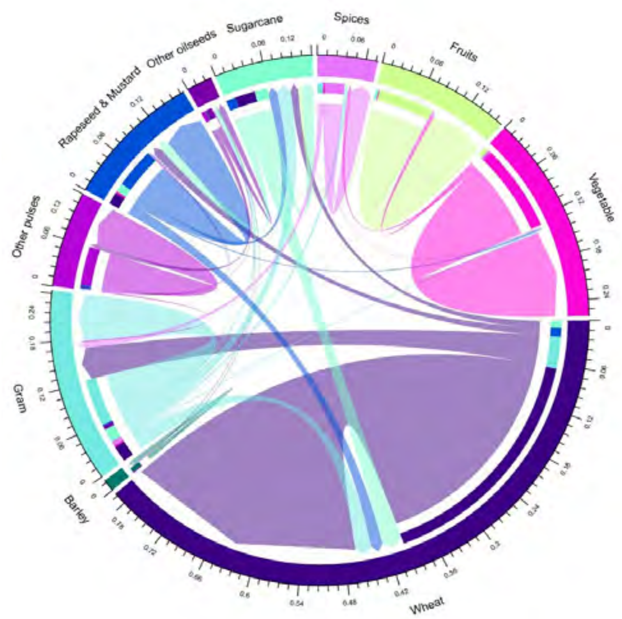


Note: Values are the proportion of the total crop area 2019/20. Arrows returning to the same crop indicate areas planted with that crop.

3.4 Extent of Crop Diversification

The Simpson's Diversification Index, with a small modification, was employed to measure degree of crop diversification. Simpson's index, ranging from 0 to 1, indicates specialization when closer to 0, and higher diversification when approaching 1. This index is though better in capturing evenness of the species, but ignores non-dominant species. Therefore, an additional parameter—the number

Figure 3.2. Transition in cropping pattern in India in the *rabi* season between 1986/87 and 2019/20 (estimated using Markov Chain)



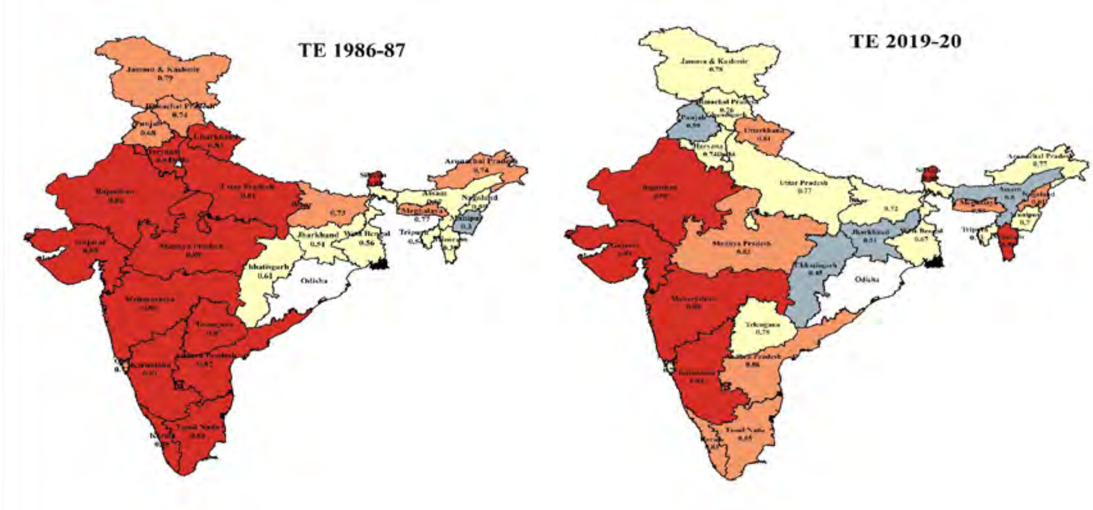
Note: Values are the proportion of the total crop area 2019/20. Arrows returning to the same crop indicate areas planted with that crop.

of crops in the first 50% of the gross cropped area—was incorporated into the index calculation to address the bias towards dominant species.

While crop diversification index at the national level has remained constant at 0.89 since 1986-87, significant variations exist across states. North-Eastern states have shown increased diversification, with Mizoram leading, followed by Manipur, Nagaland, and Tripura. Notably, these states also experienced the highest increase in areas under horticultural crops. Mizoram, for instance, saw a vary high increase, from 7% to 74% in the area share of horticultural crop between TE 1986-87 and TE 2019-20. Similar increases are observed in Sikkim (25% to 61%) and Manipur (4% to 25%). Other states, including Nagaland, Meghalaya, Himachal Pradesh, and Gujarat, also witnessed increases exceeding 10 percentage points.

The trend towards crop specialization in many states, including Chhattisgarh, Telangana, Punjab, Haryana, Madhya Pradesh, and Uttar Pradesh, is evident from the declining diversification index.

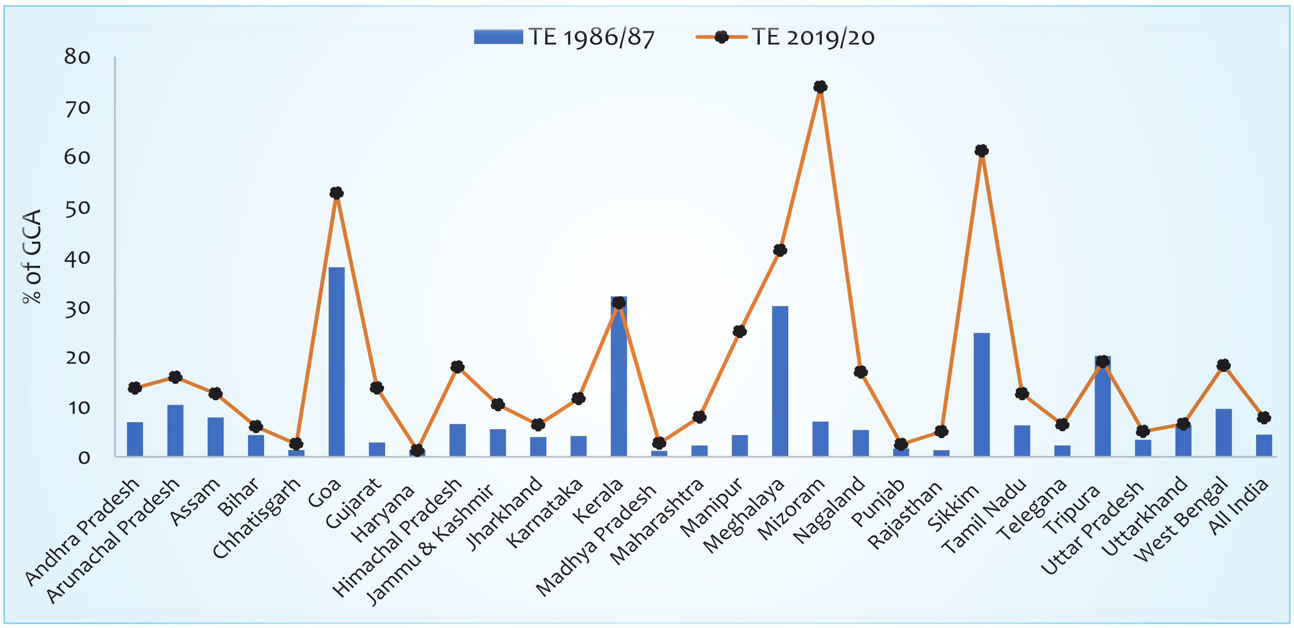
Figure 3.3. State-wise crop diversification index in India



This shift indicates a move away from a diverse range of crops towards focusing on specific, potentially more profitable or easier-to-manage crops. The most significant decrease is observed in Chhattisgarh, with a 26% reduction in the index, followed by Telangana at 13% and Punjab at 12%. This specialization trend could potentially lead to increased vulnerability to crop failures, market fluctuations, and environmental challenges.

Interestingly, these states have shown minimal changes in the percentage area dedicated to horticultural crops, suggesting an opportunity for diversification in this sector (Figure 3.4). Promoting horticulture in these regions could serve as a key strategy to counteract the specialization trend and promote sustainable agriculture. Developing a comprehensive value chain for perishable horticultural commodities would not only foster diversification, but also create employment opportunities, boost exports, and improve nutritional outcomes for the population. This approach would require investments in infrastructure, storage facilities, transportation, and market linkages to ensure successful cultivation and distribution of horticultural products.

Figure 3.4. State-wise area under horticultural crops (fruits, vegetables and spices) as % of gross cropped area



3.5 Strategies for Crop Diversification

Level playing field for alternative crops

The substantial disparity in net returns form rice and alternative crops presents a significant challenge for crop diversification in several Indian states. In Chhattisgarh, the net returns from paddy cultivation are significantly higher than those from soybean, which is the next most profitable crop (Table 3.4). Similarly, in Haryana, paddy cultivation yields significantly higher returns than bajra and cotton, while in Punjab, the difference in net returns between paddy and maize exceeds Rs. 78 thousand/ha. These wider gaps in profitability create a strong economic incentive for farmers to continue rice cultivation despite its potential environmental drawbacks.

The benefits of subsidized inputs, such as electricity, fertilizers, and irrigation infrastructure, have largely been enjoyed by two staple crops, rice and wheat. Rainfed crops such as millet, pulses, and oilseeds have not benefitted equally. The area irrigated in the case of rice and wheat is almost 100% compared to 41.34% for pulses (<30% in gram) and 34.86% for pearl millet in Haryana. The gaps in irrigated area are much wider in other states. For example, less than 3% of the pulse area is irrigated in Andhra Pradesh, compared to 97% of paddy and 92% of wheat. Similarly, there are huge inter-crop differences in the use of subsidized chemical fertilizers. For example, the use of NPK in paddy is four times higher compared to sorghum in Andhra Pradesh and more than six times in Karnataka. The differences are even higher in case of pulses, oilseeds and nutria-cereals.

A multifaceted approach is necessary to address this issue and promote crop diversification. This includes improving the yield of alternative crops through better agricultural practices and technologies, reducing cultivation costs, and ensuring remunerative prices through market interventions or policy measures.

Table 3.4. State-wise net returns from paddy vis-à-vis alternative crop (Rs. /ha; over A2+FL cost, TE 2021-22)

States	Net returns from paddy	Alternative crops
Andhra Pradesh	39610	Maize (56811), sorghum (43692), black gram (39072), Cotton (22201), pigeon pea (20269)
Assam	8232	Jute (43133)
Bihar	12611	Jute (52081), green gram (35579), maize (34121)
Chhattisgarh	41295	Soybean (1055), maize (-10229), black gram (-25861)
Gujarat	26079	Cotton (37099), bajra (29107), groundnut (24487), pigeon pea (17374), sesame (16661), maize (3679)
Haryana	78980	Cotton (27072), bajra (10562)
Himachal Pradesh	32836	Maize (12955)
Jharkhand	6040	Maize (23712)
Karnataka	34255	Cotton (33877), soybean (20562), maize (14546), pigeon pea (12613), groundnut (11966), sorghum (11775), black gram (6018), ragi (2773)
Kerala	59434	-
Madhya Pradesh	33418	Pigeon pea (22114), sesame (20179), sorghum (16131), maize (14520), soybean (4731), green gram (2867), black gram (783), cotton (-9548), groundnut (-9676)
Maharashtra	-25344	Pigeon pea (42030), maize (40252), soybean (18283), cotton (8170), sorghum (7016), bajra (5471), black gram (3403), green gram (548), groundnut (-7935)
Odisha	11105	Cotton (12832), pigeon pea (11243), black gram (8859), sesame (2629), groundnut (2413), maize (-922)
Punjab	82037	Cotton (81582), maize (3446)
Rajasthan	-	Groundnut (63267), cotton (44642), soybean (8653), green gram (5309), bajra (5278), black gram (3219), maize (2387), sesame (147)
Tamil Nadu	22693	Sesame (37607), cotton (20340), maize (19292), groundnut (17253), black gram (13130), green gram (8558), sorghum (8523), ragi (5525)

States	Net returns from paddy	Alternative crops
Telangana	35233	Sesame (57058), maize (32258), black gram (22667), groundnut (19668), soybean (11593), pigeon pea (8254), cotton (6436), green gram (1643), sorghum (-17544)
Uttar Pradesh	8091	Pigeon pea (41787), Groundnut (19091), maize (15605), bajra (12225), sesame (3815), black gram (2450)
Uttarakhand	17854	Ragi (8149)
West Bengal	2357	Jute (54595), green gram (7397), sesame (3416)

Note: Figures in parentheses are net returns per ha.

Source: Computed based on data of Cost of Cultivation.

Agroforestry based integrated farming

Agroforestry systems offer numerous benefits in flood-prone regions, extending beyond their role in mitigating flood impact. These systems contribute to improved soil health by enhancing the organic matter content and nutrient cycling. The deep root systems of trees and shrubs facilitate nutrient uptake from the lower soil layers, making previously inaccessible nutrients available to crops. This process not only improves soil fertility but also increases the overall land productivity. Additionally, agroforestry practices promote biodiversity by creating diverse habitats for various plant and animal species, leading to improved ecosystem services such as pollination and natural pest control.

Furthermore, agroforestry systems can contribute to climate change mitigation by sequestering carbon in both aboveground biomass and soil. This aspect not only helps reduce greenhouse gas emissions but also opens up potential opportunities for farmers to participate in carbon credit markets, providing an additional income stream. Thus, the adoption of agroforestry represents a holistic approach to sustainable agriculture, simultaneously addressing environmental, economic, and social challenges.

Stable market for alternative crops

The procurement of rice, wheat, and sugarcane has incentivized farmers to expand their cultivation. This has been disproportionately concentrated in a few states, primarily Punjab and Haryana, as well as Chhattisgarh, Telangana, and Madhya Pradesh in recent years. Although the government has recently initiated measures to enhance the procurement of millets, oilseeds, and pulses, the levels remain insufficient. Consequently, there is a pressing need to diversify procurement away from rice and wheat. States can benefit from learning from each other's experience. For instance, the *Odisha Millets Mission* demonstrated significant improvements in the cultivation of millets, farmers' income, and biodiversity when issues related to the production, processing, marketing, and consumption of millets were concurrently addressed. This project, implemented in selected districts, included an intervention to supply millets through the Public Distribution System (PDS) and other government nutrition programs to ensure farmers receive better prices.

Paradigm shift in energy and water pricing policies

The interconnectedness of water and electricity policies has had a profound impact on agricultural practices, particularly the expansion of rice cultivation. This expansion, while contributing to increased food production, has led to unintended consequences such as the depletion of groundwater resources and a decrease in crop diversity. The situation in Punjab exemplifies this trend, in which the focus on rice cultivation has resulted in an unsustainable reliance on groundwater extraction. The current irrigation water pricing system, which is based on non-volumetric measures and primarily applies to canal-based systems, fails to incentivize water conservation or efficient usage. Instead, it encourages farmers to maximize water consumption without considering the long-term environmental implications.

To address these challenges, there is a pressing need to implement incentive-driven energy and water policies to promote crop diversification. Such policies could encourage farmers to adopt more sustainable agricultural practices and cultivate a wider variety of crops that are suited to local conditions. This approach would not only help conserve water resources but also enhance soil health, improve biodiversity, and potentially increase farmers' resilience to market fluctuations and climate change. By aligning energy and water policies with sustainable agricultural goals, policymakers can create a more balanced and environmentally responsible farming sector that meets food security needs, while preserving vital natural resources for future generations (Chand et al. 2022).

Risk mitigation and risk transfer

Production of pulses faces significant challenges owing to their vulnerability to various biotic and abiotic stresses. These stresses can lead to substantial yield losses ranging from 30% to 100% (Rana et al. 2016). This high level of risk acts as a deterrent for farmers considering their cultivation. To mitigate these risks and promote widespread cultivation of alternative crops, a two-pronged approach is necessary. First, there is an urgent need to develop multiple stress-tolerant varieties that can withstand various environmental pressures and pest attacks. This would significantly reduce the likelihood of crop failure and increase the overall productivity.

Second, the implementation of risk transfer options is crucial to provide farmers with financial security. These mechanisms could include crop insurance schemes or other financial instruments that protect farmers against potential losses due to crop failure or market fluctuations. Additionally, improved market access and value chain development for these crops could further incentivize their production. These measures, combined with ongoing research and development efforts to enhance crop resilience, could pave the way for a more diverse and sustainable agricultural landscape.

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4

Input Use and Yield Gap

Sant Kumar, Vinayak R Nikam and Prabhat Kishore

Enhancing crop yields is imperative to meet the rising demand for both food and non-food agricultural commodities, without compromising the sustainability of natural resources. Despite significant advancements in agricultural technology and crop production practices, a notable yield gap persists between frontline demonstration plots and actual farm-level yields. This chapter examines the trends in the use of key agricultural inputs—including land, water, seeds, fertilizers, pesticides, and electricity—across Indian states and at the national level over the past three decades. The analysis highlights that while the net sown area has largely stagnated, cropping intensity has increased, driven by the expansion and improvement of irrigation infrastructure.

The increased use of high-quality seeds, chemical fertilizers (NPK), pesticides, and electricity has played a critical role in boosting agricultural output. Technological progress has contributed to yield improvements; however, considerable disparities in productivity continue to exist across regions. Bridging this yield gap requires tailored, context-specific strategies such as expanding access to reliable irrigation, promoting the use of certified seeds, encouraging balanced nutrient management, and adopting integrated pest management practices. Policy interventions should focus on smallholder access to modern technologies and climate-resilient practices, thereby advancing the goal of sustainable agricultural intensification.

4.1 Introduction

In India, inputs have played a significant role in enhancing agricultural production, despite a sustained decline in net sown area (NSA) over the past four decades. Foodgrain production increased markedly from 341.5 million tons (m t) in 1980-81 to 1122.5 m t in 2023-24, and this increase primarily driven by yield gains rather than expansion in cultivated area. Research indicates that modern inputs, such as fertilizers, significantly contribute to yield enhancement, accounting for one-third to one-half of the incremental yield (Randhawa and Tandon 1982; FAO 1998). Furthermore, the foundation of any agricultural revolution lies in farmers' access to modern farm inputs, including seeds, fertilizers, pesticides, machinery, irrigation, and knowledge. These inputs are essential for farmers, particularly smallholders, to achieve improved returns through intensive cultivation. However, persistent challenges related to the availability, accessibility, affordability and quality of farm inputs continue to constrain productivity growth.

Increasing crop yield is an essential and sustainable means of meeting the demand for food and non-food products. Increasing crop yield is the best possible option. Though the adoption of modern technology and management practices has helped raising yield levels, it differs from farmer to farmer, even for the same crop in a region. The yield gap between on-farm demonstration and actual farm yield has failed to show appreciable reduction over the past two decades in India (Basavaraja 2000; Jha et al. 2011). Minimizing the yield gap in major crops by adopting improved management practices leads to increase in production while offering both environmental benefits and economic value. The knowledge of yield gaps also helps in understanding yield variability, yield potential, input use efficiency and indicates appropriate strategies to bridge the yield gap for improving production efficiency and farm income (Fischer et al. 2009; Van Ittersum et al. 2013). The knowledge of factors causing yield gap in crops are important from policy perspective to augment production. Against this backdrop, this chapter presents the progress in input use and examines the prevailing yield gaps in major crops.

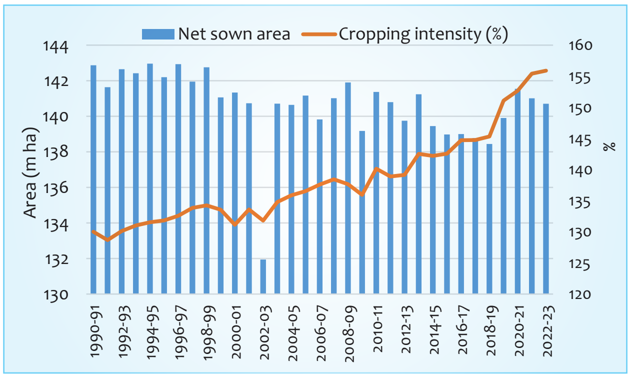
4.2 Progress in Input Use

Increase in farm production has been accompanied by significant rise in use of inputs such as fertilizers, pesticides, farm machinery and improved seeds. Use of these inputs and increased access to energy, which were previously limited or unavailable, have helped in increased food production and thus provides better food and livelihood security. Country like India, which possess less land and water resources, increase in farm production would depend on continuous progress in technological change and sustained and rapid growth in use of agricultural inputs.

4.2.1 Land

Land is the basic input for crop production. In addition to facilitating food production, it serves as a resource for constructing residential buildings, industrial facilities, and various infrastructures such as roads, educational institutions, and hospitals. During the past decade, net sown area (NSA) remained less than 140 million hectares (m ha), and it has been declining over the years due to rising competing demand for other sectors. The marked decline in NSA witnessed in 2002-03 (i.e., 8 m ha) over previous years due to severe drought causing a steep fall in crop production (Figure 4.1). This resulted in a decline in foodgrain production by 14% in 2002-03, compared to 212.02 m t in 2001-02. Despite the decline in NSA, agricultural production increased from 508 million tons (m t) in 1991 to 1122.5 m t in 2023. This is due to a rise in cropping intensity (ratio of gross cropped area to net sown area), from 130% in 1990 to 156% in 2023. The rise in cropping intensity is attributed to an increase in irrigated area by 65%, from 48 to 79 m ha, along with the use of other inputs. However, the per ha yield of major crops is still low in India as compared to many Asian and other developed countries of the world (FAO 2022).

Figure 4.1. Trend in net sown area in India, 1990-91 to 2022-23



State-wise net sown area

As indicated in Table 4.1, the net sown area is largest in Rajasthan, followed by Maharashtra, Uttar Pradesh, Madhya Pradesh, Andhra Pradesh, Karnataka, Gujarat, West Bengal, Bihar, and Tamil Nadu. During the past three decades (1990-2022), NSA has declined in almost all major states, except Gujarat, and Rajasthan. In terms of cropping intensity, Punjab leads the country, followed by West Bengal, Madhya Pradesh, Haryana, and Uttar Pradesh, whereas it is below the national average (156%) in Odisha, Karnataka, Kerala, Jammu & Kashmir, Chhattisgarh, Andhra Pradesh, Jharkhand, Tamil Nadu, Bihar, Maharashtra, and Gujarat.

4.2.2 Water

Presently, about 56% of the cultivated area is irrigated and the remaining area depends on rainfall. In irrigated agriculture, yield per unit of area is more than double that of rainfed agriculture, along with more opportunity for intensification and crop diversification (World Bank, 2022). Net irrigated area (NIA) substantially increased at all-India during 1990-91 to 2022-23 (Figure 4.2). The NIA increased by 65%, from 48 m ha in 1990 to 79 m ha in 2022, while the net sown area irrigated grew 20% during the above period.

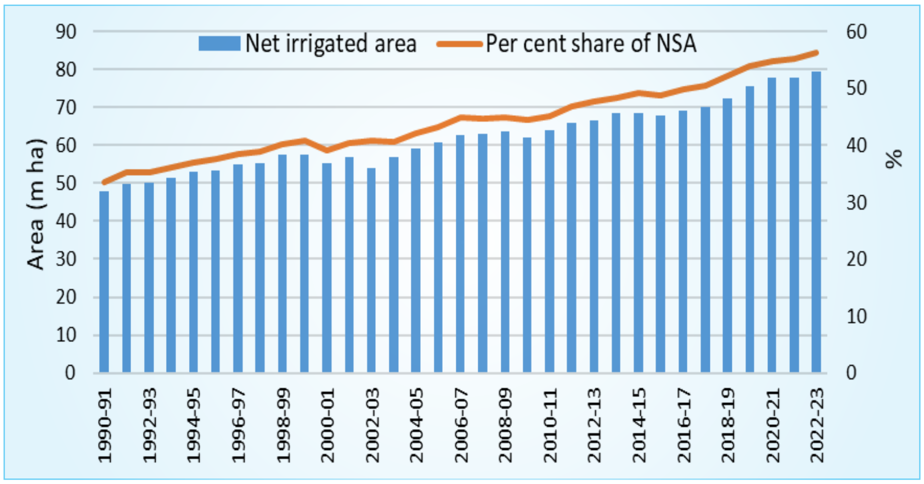
Table 4.1. State-wise net sown area in India

State	Net sown area (m ha)					Cropping intensity (%)
	1990-91	2000-01	2010-11	2015-16	2022-23	2022-23
Andhra Pradesh@	11.02	11.11	11.19	10.38	11.62	137.8
Assam	2.70	2.79	2.81	2.80	2.74	147.0
Bihar	7.70	5.66	5.26	5.20	5.11	142.2
Chhattisgarh	NR	4.76	4.70	4.65	4.59	121.8
Gujarat	9.30	9.43	10.11	9.77	9.75	143.5
Haryana	3.57	3.53	3.52	3.52	3.58	185.5
Himachal Pradesh	0.58	0.56	0.54	0.55	0.53	166.8
Jammu & Kashmir	0.73	0.75	0.73	0.75	0.73	126.5
Jharkhand	NR	1.77	1.08	1.38	1.02	119.9
Karnataka	10.38	10.41	10.52	10.01	11.16	132.1
Kerala	2.25	2.21	2.07	2.02	1.99	126.5
Madhya Pradesh	19.56	14.66	15.12	15.15	15.85	190.0
Maharashtra	18.56	17.84	17.41	17.19	16.49	153.9
Odisha	6.30	5.83	4.68	4.20	4.27	117.4
Punjab	4.22	4.25	4.16	4.14	4.11	202.2
Rajasthan	16.38	15.86	18.35	18.02	18.42	152.7
Tamil Nadu	5.58	5.30	4.95	4.83	4.84	132.7
Uttar Pradesh	17.30	16.82	16.59	16.47	16.12	175.2
West Bengal	5.33	5.41	4.98	5.24	5.22	191.2
All-India	142.87	141.36	141.37	138.97	140.71	155.9

Note: NR refers to not reported; @ indicates Andhra Pradesh (erstwhile).

The increase in NIA is attributed to the scheme on micro irrigation (MI) launched in 2005-06. Following the implementation of micro-irrigation, approximately one million hectare of land was irrigated annually, compared to the previous coverage of approximately 0.7 m ha per year prior to the adoption of micro-irrigation. Between 1990-91 and 2022-23, the area under irrigation experienced a growth rate of 1.42%, whereas the net sown area (NSA) exhibited a negative growth rate of -0.06%. This trend underscores the increasing role of irrigation infrastructure in sustaining agricultural productivity, even amidst stagnating or declining land availability.

Figure 4.2. Trend in net irrigated area in India, 1990-91 to 2022-23



State-wise net irrigated area

The highest area under irrigation is in Uttar Pradesh, followed by Madhya Pradesh, Rajasthan, Andhra Pradesh, Gujarat, Karnataka and Punjab (Table 4.2). During the last decade, an increase in irrigated area has been noticed in all states, while a steep increase is observed in Madhya Pradesh, Uttar Pradesh, and Rajasthan. On the other hand, irrigation intensity is the highest in Punjab (99%), followed by Haryana (93%), Uttar Pradesh (87%) and Madhya Pradesh (82%), while the irrigation level is below country average (56%) in Assam, Jharkhand, Chhattisgarh, Kerala, Maharashtra, Odisha, Rajasthan, Jammu & Kashmir, Himachal Pradesh, and Karnataka (Table 4.2). This reflects regional disparities in irrigation development and highlights the need for targeted interventions to expand irrigation coverage in underperforming states.

Table 4.2. State-wise net irrigated area in India

State	Total net irrigated area (m ha)					Irrigation intensity (%)
	1990-91	2000-01	2010-11	2015-16	2022-23	2022-23
Andhra Pradesh@	4.31	4.53	5.03	4.23	6.72	57.8
Assam	0.57	0.14	0.16	0.30	0.47	17.0
Bihar	3.35	3.43	3.03	2.96	3.12	61.1
Chhattisgarh	NR	0.98	1.36	1.48	1.54	33.4
Gujarat	2.44	2.81	1.4	4.71	6.19	63.5
Haryana	2.60	2.96	2.89	2.96	3.34	93.1
Himachal Pradesh	0.10	0.13	0.11	0.12	0.11	20.5
Jammu & Kashmir	0.30	0.31	0.32	0.36	0.31	42.4
Jharkhand	NR	0.16	0.12	0.21	0.20	19.7
Karnataka	2.11	2.64	3.49	3.24	5.04	45.1
Kerala	0.33	0.38	0.41	0.41	0.42	21.1
Madhya Pradesh	4.31	4.13	7.14	9.28	12.93	81.6
Maharashtra	2.67	3.25	3.26	3.21	3.10	18.8
Odisha	1.93	1.33	1.28	1.23	1.34	31.3
Punjab	3.91	4.04	4.07	4.14	4.08	99.3
Rajasthan	3.90	4.91	6.66	7.94	9.50	51.6
Tamil Nadu	2.37	2.89	2.91	2.83	2.92	60.4
Uttar Pradesh	10.54	12.40	13.44	14.23	14.04	87.1
West Bengal	1.91	3.00	2.96	3.10	3.09	59.2
All-India	48.02	55.13	63.87	67.77	79.31	56.4

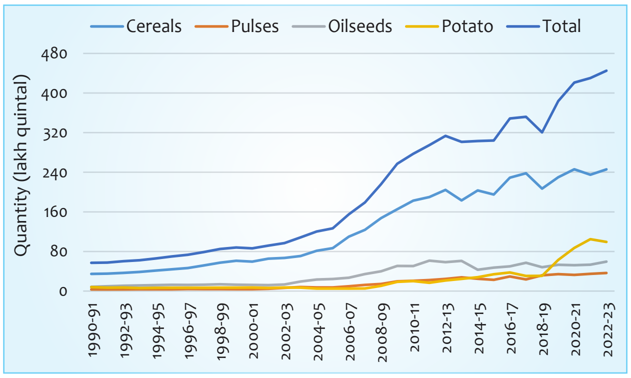
Note: NR refers to not reported; @ indicates Andhra Pradesh (erstwhile).

4.2.3 Seed

Seeds play a pivotal role among agricultural inputs. The use of high-quality seeds, including breeder seed, foundation seed, certified seed, truthfully labeled seed, and planting material, can independently enhance crop yield by 15-20% (GoI 2013). Furthermore, with the effective management of additional inputs, this yield increase can be augmented to as much as 45%, underscoring the essential function of seeds in agricultural productivity (Mistary 2022). Distribution of quality seeds more than doubled, from 57 lakh[1] quintals in 1990-91 to 108 lakh quintals in 2003-04 (Figure 4.3) and further to 445 lakh quintals in 2022-23.

[1] One lakh equals 0.1 million.

Figure 4.3. Trend in quality seeds distribution in India, 1990-91 to 2022-23



Source: GoI (various years).

Share and growth in seed supply

Cereals have the largest share of the total seed supply, accounting for 63%, followed by oilseeds at 16%, potatoes at 12%, and pulses at 8% (Table 4.3). Among these, potatoes have recorded the highest growth in the quality seed supply over the past decade, although their share has fluctuated between 3% and 10% of the total supply.

Table 4.3. Crop group-wise share and growth in distribution of quality seeds in India

Crop group	1990s	2000s	2010s	Overall
	Decadal share (%) during			
Cereals	64.5	68.0	62.3	64.8
Pulses	5.2	6.7	8.2	6.8
Oilseeds	16.8	17.7	15.6	16.6
Potato	9.6	5.5	12.8	9.5
Total	100.0	100.0	100.0	100.0
	Growth (CAGR in %)			
Cereals	6.9	13.4	2.5	7.5
Pulses	2.0	16.9	4.3	9.8
Oilseeds	3.0	17.8	-0.4	7.1
Potato	0.5	12.4	17.6	9.4
Total	5.2	14.0	3.9	7.7

Source: GoI(A) (various years). CAGR- Compound Annual Growth Rate.

Crop-wise seed distribution

(i) Cereals

Between 1990 and 2022, there has been a consistent increase in the availability of high-quality seeds for major cereal crops, as illustrated in Figure 4.4. Among these cereals, wheat accounted for the largest proportion (55%), followed by paddy (37%), with maize representing the smallest share (5%) during the quinquennial ending 2022-23. Over the past two decades (2002-03 to 2022-23), the supply of seeds for wheat and maize has increased more than fourfold, while for paddy, it has expanded by 3.6 times, resulting in an overall 3.7-fold increase in seed supply for cereals.

(ii) Pulses

In India, the primary pulse crops include gram, pigeon pea (arhar), black gram (urad), and green gram (moong). Collectively, these four crops accounted for over 84% of the total pulse production during the triennium ending (TE) 2023-24. In terms of percentage, gram holds the largest share at 47.5%, followed by arhar at 14.1%, moong at 12.8%, and urad at 9.9% during the TE 2021-22 to 2023-24. Over the past two decades (2002-03 to 2022-23), the seed supply for gram has increased more than eightfold, from 2.6 to 22.6 lakh quintals. In contrast, the seed supply for other pulses has increased between two- to threefold, resulting in an average fivefold increase in the seed supply for total pulses (Figure 4.5).

(iii) Oilseeds

In India, the primary edible oilseeds cultivated include rapeseed and mustard (R&M), groundnut, soybean, and sunflower. Collectively, these four oilseeds accounted for approximately 93% of the total production during (TE) 2023-24. Between 2002-03 and 2022-23, the supply of seeds for groundnut and soybean increased fivefold, while the supply for R&M grew threefold, resulting in an overall fourfold increase in the total seed supply for oilseeds (Figure 4.6). In terms of percentage share, soybean held the largest proportion (57%), followed by groundnut (37%), with R&M having the smallest share (4%) during the period from 2018-19 to 2022-23.

Figure 4.4. Trend in quality seed supply for major cereals in India, 1990-91 to 2022-23

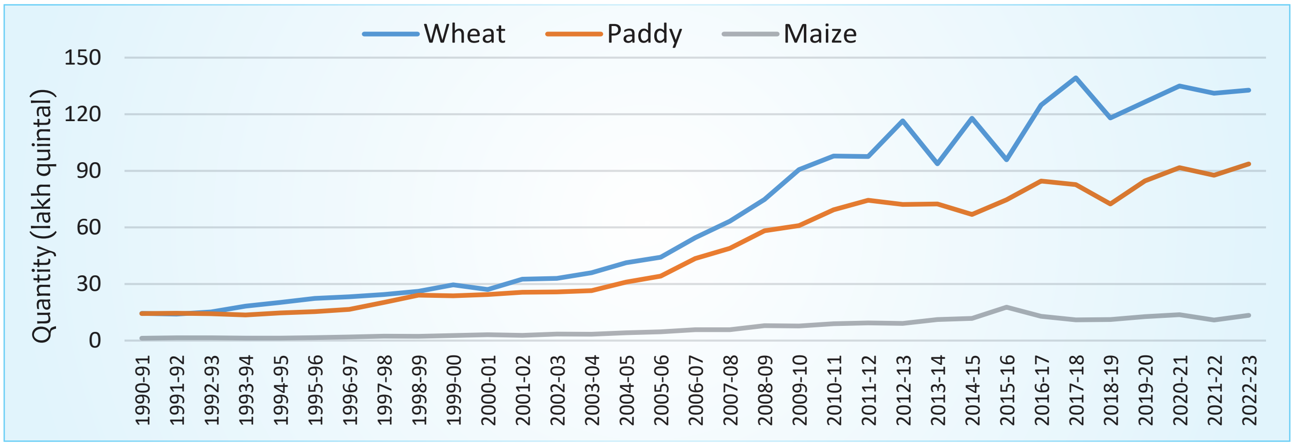


Figure 4.5. Trend in seed supply for major pulses in India, 1990-91 to 2022-23

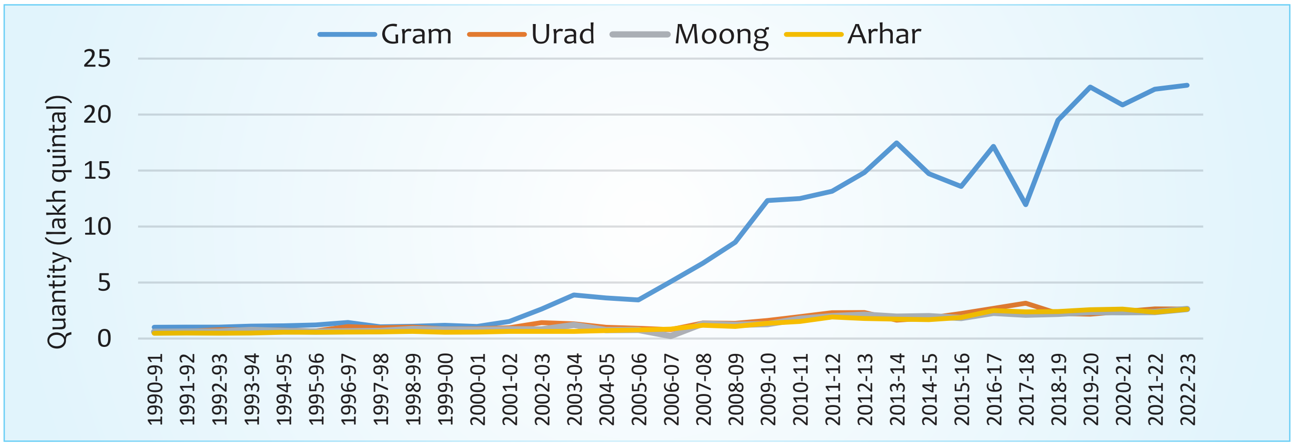
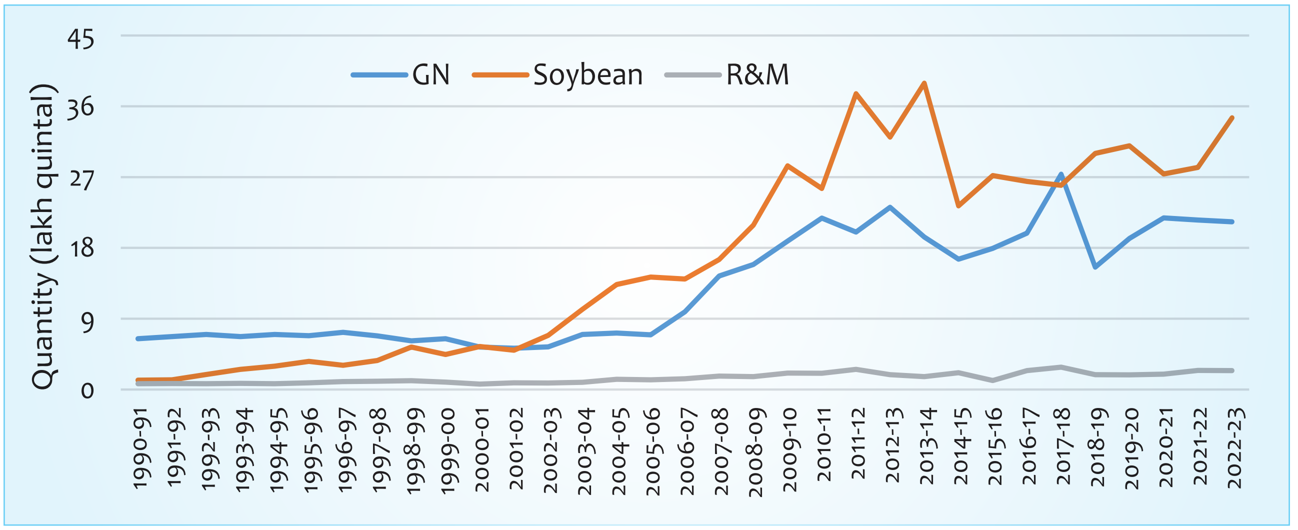


Figure 4.6. Trend in quality seed supply for major oilseeds in India, 1990-91 to 2022-23

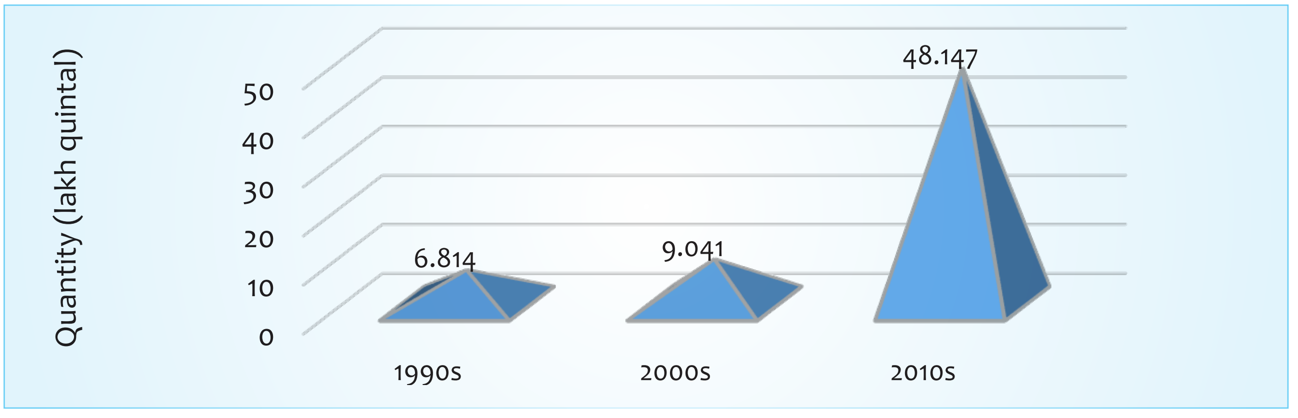


(iv) Commercial crops

Potato

Potato, the dominant tuber crop, is primarily cultivated in the states of Uttar Pradesh, West Bengal, Bihar, Gujarat, Madhya Pradesh, and Punjab. These six states collectively contributed around 90% of the total seed supply during the TE2023-24. Over the past two decades (2002-03 to 2022-23), the seed supply for potatoes has increased fourteen fold at the national level (Figure 4.7).

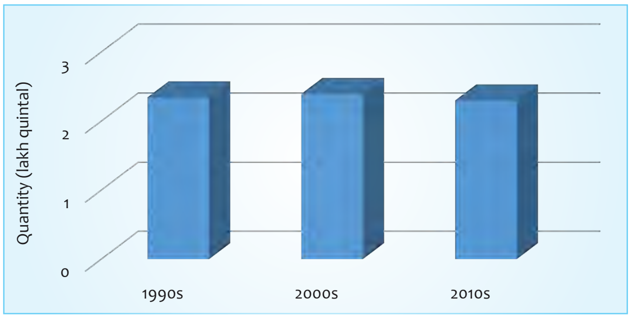
Figure 4.7. Trend in quality seed supply of potato in India, 1990-91 to 2022-23



Fiber crops

Cotton is India's main fibre crop, with production reaching 33.12 million bales during the TE 2020-21. Over the past three decades, the seed supply for fiber crops has consistently remained at approximately 2.3 lakh quintals (Figure 4.8). However, the adoption of hybrids and Bt hybrids varieties, has elevated the importance of quality seed use among cotton cultivators.

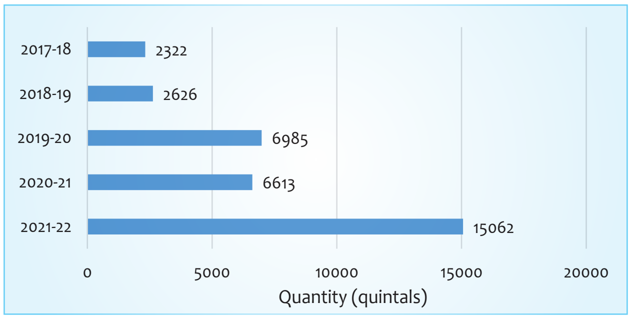
Figure 4.8. Trend in quality seeds distribution of fibre crops in India, 1990-91 to 2022-23



v) *Bio-fortified crops*

In order to enhance nutritional security through the utilization of seeds as carriers, significant emphasis has been placed on the production of high-quality seeds from bio-fortified crop varieties. Data indicate a substantial increase in the supply of seeds from bio-fortified crop varieties over the past five years (Figure 4.9). In the 2021-22 period, a total of 15,062 quintals of quality seeds were produced for 90 bio-fortified varieties. This production includes 7,093 quintals of breeder seed and 7,969 quintals of other seed classes, namely foundation, certified, and truthful seeds.

Figure 4.9. Quality seed supply in bio-fortified crop varieties



4.2.4 Fertilizers

The three primary nutrients—nitrogen, phosphorus, and potash (collectively referred to as NPK)—have witnessed substantial increase in use following the adoption of high-yielding seeds. The consumption of NPK has increased from 12.5 million tons in 1990-91 to 32.53 million tons in 2020-21, although it has experienced a slight decline in recent years (Figure 4.10). Similarly, per hectare usage of NPK (on the gross cropped area basis) has risen significantly, from 67 kg in 1990-91 to 136 kg in 2022-23. The increase in both total and per ha usage of NPK is attributed to the adoption of high-quality seeds, which exhibit greater potential and responsiveness to inputs.

Crop-wise fertilizer use

The intensity of fertilizer use is notably higher in commercial crops such as sugarcane, cotton, fruits, and vegetables. These crops collectively constitute 13.3% of the GCA yet account for 22.5% of the total fertilizer consumption (Kumar et al. 2024). In contrast, rice and wheat, which are staple food crops in India, occupy 47% of the GCA and share 52% of the total NPK. Coarse cereals, pulses, and oilseeds, predominantly cultivated in rainfed conditions, exhibit a relatively low fertilizer consumption share of 20%, despite representing 31% of the GCA.

Among crops, sugarcane registers the highest fertilizer application at 309 kg/ha, while pulses receive the lowest at 61kg/ha. The overall average across all crops stands at 127 kg/ha (Table 4.4). For horticultural crops, fertilizer application is 224 kg/ha for fruits and 186 kg/ha for vegetables. Oilseeds receive about 96 kg/ha. Analysis indicates that the average fertilizer application per ha across all crops increased by 37%, with variations ranging from an 11% increase in vegetables to a 119% increase in maize, when comparing the years 2016-17 to 2001-02.

Figure 4.10. Trend in fertilizers (NPK) use in India, 1990-91 to 2022-23

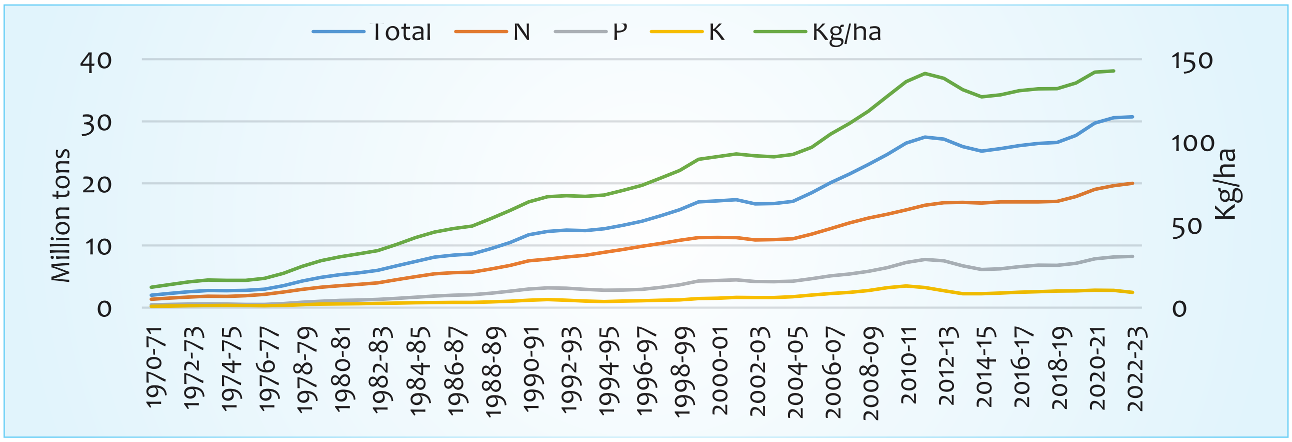


Table 4.4. Crop/ crop-group-wise fertilizer use in India

Crop/ crop group	Fertilizer use (kg/ha)		Change in use (over 2001-02)	
	2001-02	2016-17	Quantity	%
Sugarcane	240.6	309.2	68.6	28.5
Fruits	168.5	224.4	55.9	33.2
Vegetables	166.7	185.5	18.8	11.3
Cotton	110.8	168.5	57.7	52.1
Wheat	130.8	152.3	21.5	16.4
Paddy	119.4	136.0	16.6	13.9
Maize	55.8	122.4	66.6	119.3
Oilseeds	66.2	95.9	29.7	44.9
Pulses	32.0	60.5	28.5	891
Food crops	98.8	128.8	30.0	30.4
Non-food crops	73.3	118.3	45.0	61.3
All crops	92.6	126.7	34.1	36.8

Note: Authors' estimate; Source: GoI(B) (various years)

State-wise fertilizer use

Fertilizer consumption is concentrated in few states, namely, Uttar Pradesh, Andhra Pradesh, Maharashtra, Madhya Pradesh, Gujarat, Karnataka, Punjab, Haryana, Rajasthan, Bihar, and West Bengal, collectively accounting for over 88% of total consumption during the TE 2022-23 period (Table 4.5). Notably, Assam recorded a nine-fold increase in per hectare fertilizer use between 1990 and 2022, compared to a two-fold increase at the national level.

4.2.5 Pesticides

Pesticides play a crucial role in minimizing crop losses due to weeds, insects, pests, and diseases. In their absence, substantial losses are reported: 78% in fruits 54% in vegetables, and a 32% in cereals (Tudi et al. 2021).

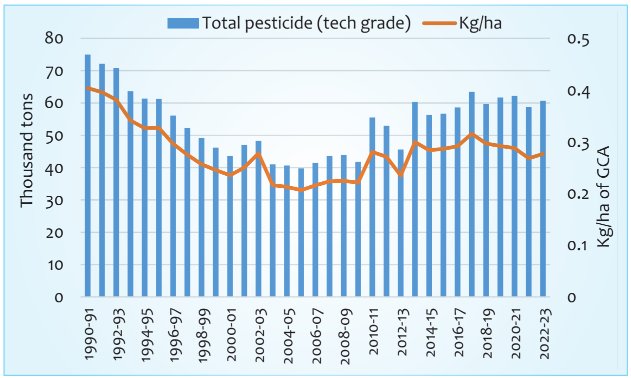
Table 4.5. State-wise fertilizers use by gross cropped area and net sown area

State	Fertilizer use (%), TE 2022-23	Fertilizer use (kg/ha) of NSA during TE				Fertilizer use (kg/ha) of GCA during TE			
		1990-91	2000-01	2010-11	2022-23	1990-91	2000-01	2010-11	2022-23
Andhra Pradesh@	11.54	136.1	200.1	300.5	303.6	113.8	162.2	235.4	263.9
Assam	0.86	10.7	40.2	87.7	97.0	7.7	27.3	60.3	67.6
Bihar	5.60	76.7	127.8	249.0	338.9	56.4	94.8	181.4	236.1
Chhattisgarh	2.54	-	-	109.4	169.0	-	-	91.1	137.5
Gujarat	5.93	73.7	95.0	177.6	186.7	64.8	83.1	153.9	125.8
Haryana	4.55	152.0	246.9	376.0	388.3	92.8	144.4	206.9	212.1
Himachal Pradesh	0.19	55.8	67.1	102.2	109.1	33.2	38.3	58.7	64.7
Jammu & Kashmir	0.45	59.4	81.7	131.9	188.5	40.5	55.5	85.1	122.8
Jharkhand	0.65	-	-	124.0	160.9	-	-	109.8	123.0
Karnataka	7.02	76.3	122.0	192.9	191.7	67.6	104.1	156.7	145.6
Kerala	0.57	100.2	83.6	129.7	86.2	74.5	63.7	101.0	68.6
Madhya Pradesh	9.06	37.4	56.9	110.0	175.9	31.4	43.3	77.2	92.7
Maharashtra	10.17	62.1	98.4	174.8	188.5	54.2	81.4	133.8	123.3
Odisha	1.84	29.0	53.6	105.8	136.3	19.5	38.2	79.6	117.3
Punjab	6.31	274.0	325.4	444.5	470.7	155.2	175.1	234.4	241.6
Rajasthan	5.66	20.0	45.4	65.1	95.6	17.1	35.1	48.8	63.8
Tamil Nadu	3.58	141.8	176.7	247.9	226.1	119.6	150.5	215.2	174.2
Uttarakhand	0.47	-	-	210.0	242.7	-	-	131.7	149.1
Uttar Pradesh	17.42	125.0	179.1	253.5	330.4	85.0	120.0	164.8	192.2
West Bengal	5.31	128.7	207.2	295.6	310.2	80.9	120.8	163.0	160.8
All-India	30725.16# (100.0)	82.4	121.1	188.2	217.8	64.2	90.5	136.5	140.8

Note: @ indicates Andhra Pradesh (erstwhile); # indicates thousand tons.

Total pesticide consumption in India declined significantly from 1990-91 to 2005-06 (Figure 4.11). Subsequently, it increased, reaching 60 thousand tons in 2013-14, over 63 thousand tons in 2017-18, and recently approximately 61 thousand tons. The recent rise in pesticide use is attributed to the increased use of herbicides, driven by the rising cost of manual weeding due to increased agricultural wages (FICCI 2015). A similar trend is noted in per ha pesticide use, which was 0.404 kg/ha in 1990-91, decreased to nearly half (0.206 kg/ha) in 2005-06, and then began to rise, with the current level being less than 0.3 kg/ha. Nonetheless, India's pesticide use remains far below that of countries like, China (13.06 kg/ha), Japan (11.85 kg/ha), Brazil (4.57 kg/ha), and other Latin American countries (FAOSTAT 2022).

Figure 4.11. Trend in pesticides use in India, 1990-91 to 2022-23



State-wise use of pesticides

The highest pesticide consumption is in Uttar Pradesh, followed by Maharashtra, Punjab, Telangana, Haryana, and Jammu & Kashmir (Table 4.6). Over the past decade, total pesticide consumption has increased in Maharashtra and Uttar Pradesh, while it has slightly decreased in Punjab and Haryana. States such as Gujarat and West Bengal have experienced a significant decline in consumption. Conversely, Chhattisgarh, Jharkhand, and Kerala have shown a marked increase. In terms of per ha usage, Jammu & Kashmir leads with 3.69 kg/ha, followed by Punjab and Haryana (0.62 kg/ha each), and Maharashtra (0.55 kg/ha). Madhya Pradesh, Rajasthan, Gujarat, and Karnataka exhibit relatively low usage levels.

4.2.6 Electricity

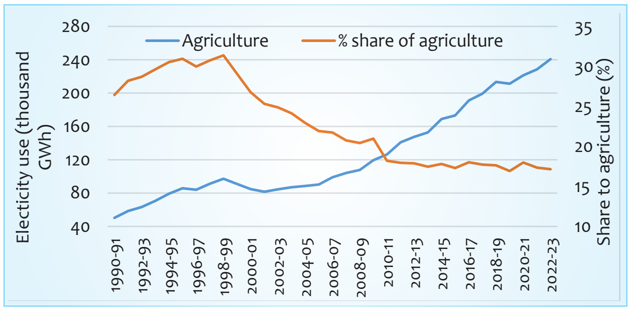
Modern agriculture relies heavily on energy at all stages—from land preparation and irrigation to post-harvest processing, storage, and transport. At present, agriculture accounts for 17% of total electricity consumption in India, down from 30% in the 1990s (Figure 4.12). Yet, in absolute terms, electricity consumption in agriculture has increased over fourfold—from 50 thousand GWh in 1990–91 to 241 thousand GWh in 2022–23.

Table 4.6. State-wise consumption of pesticide (technical grade)

State	Total consumption (tons)					Per ha (kg)
	2003-04	2008-09	2015-16	2018-19	2022-23	2022-23
Andhra Pradesh	2034	1381	2713	1689	2001	0.297
Bihar	860	915	831	850	995	0.137
Chhattisgarh	332	270	1625	1770	1775	0.317
Gujarat	4000	2650	1980	1608	1750	0.125
Haryana	4730	4288	4100	4015	4184	0.621
Jammu & Kashmir	NR	2679	2251	2459	4086	3.688
Jharkhand	150	160	493	646	470	0.382
Karnataka	1692	1675	1434	1524	1669	0.113
Kerala	326	273	1123	995	504	0.200
Madhya Pradesh	62	663	732	540	598	0.020
Maharashtra	3385	2400	11655	11746	6814	0.269
Odisha	682	1156	994	1609	1348	0.269
Punjab	6780	5760	5743	5543	5130	0.617
Rajasthan	2303	3333	2475	2290	1865	0.066
Tamil Nadu	1434	2317	2096	1901	1952	0.304
Telangana	NR	NR	3993	4894	4920	0.530
Uttar Pradesh	6710	8968	10457	11049	11824	0.419
West Bengal	3900	4100	3712	3190	3321	0.333
All-India	41020	43860	58421	59670	60676	0.277

Note: NR refers to not reported.

Figure 4.12. Trends in electricity use in the agriculture sector



State-wise use of electricity

Electricity consumption is highest in Maharashtra, followed by Rajasthan, Madhya Pradesh, Telangana, Karnataka, Uttar Pradesh, and Andhra Pradesh (Table 4.7). Over the past decade, total electricity usage has intensified across Indian states due to the increasing cost of diesel-operated machinery in agriculture. Telangana, Maharashtra, Madhya Pradesh, and Karnataka experienced a significant rise in total electricity consumption, whereas a slight decline was observed in West Bengal. Per unit electricity usage is highest in Telangana (2908 GWh/m ha), followed by Tamil Nadu (2313 GWh/m ha), Andhra Pradesh (1776 GWh/m ha), Karnataka (1591 GWh/m ha), Punjab (1584 GWh/m ha), Haryana (1490 GWh/m ha), and Maharashtra (1390 GWh/m ha). In contrast, consumption levels are lower in Jharkhand, West Bengal, Odisha, Bihar, Kerala, and Jammu & Kashmir.

4.3 Yield Trend in Major Crop

The yield and annual yield changes of major crops from 1991 to 2020 show mixed results, especially for cereals. Despite relatively low yield growth and a decreasing cultivated area, production has generally risen. For instance, rice yields doubled in the period from 2011-2020 compared to 1991-2000, with major rice-producing states mirroring the national trend (Table 4.8). Wheat yields grew at an average rate of 5.0 kg/ha during 2011-2020,

Table 4.7. State-wise consumption of electricity for agricultural purposes

State	Total consumption (GWh)					Per m ha (GWh)
	1999-00	2009-10	2015-16	2018-19	2021-22	2021-22
Andhra Pradesh	11176.0	18798.6	10970.0	9368.7	14114.0	1775.8
Bihar	1526.0	388.6	344.3	1140.9	1074.4	147.2
Chhattisgarh	NR	1940.0	4025.2	5902.8	5933.1	983.3
Gujarat	14935.0	13338.3	11204.5	12663.8	13791.4	927.5
Haryana	4591.0	8295.7	9506.0	10087.5	9123.5	1490.2
Jammu & Kashmir	127.0	198.1	305.0	361.6	375.4	337.9
Jharkhand	NR	70.0	98.0	203.6	178.1	109.0
Karnataka	6388.0	13556.3	19318.5	22237.2	21935.7	1590.5
Kerala	375.0	240.6	288.2	412.0	384.7	149.2
Madhya Pradesh	10105.0	6810.1	18868.2	25645.5	26521.5	886.3
Maharashtra	10543.0	16713.9	28396.6	33912.3	36253.2	1389.7
Odisha	290.0	176.2	265.8	644.7	781.0	143.1
Punjab	8233.0	9957.4	11513.9	13092.9	12572.5	1584.0
Rajasthan	6560.0	13235.9	19968.3	28525.5	28816.6	1005.6
Tamil Nadu	8387.0	12632.9	11548.3	13974.7	13436.2	2313.4
Telangana	NR	NR	11991.5	22260.1	22159.2	2907.7
Uttar Pradesh	5305.0	7689.9	12671.2	18931.3	18956.5	689.7
West Bengal	1308.0	1803.8	1524.3	1332.2	1224.6	130.5
All-India	90,186.0	1,26,377.4	1,73,185.4	2,21,303.4	2,28,451.5	1042.5

Note: NR refers to not reported.

slightly surpassing the growth observed in the 1991-2000 period. The maize yield averaged 3.1 tons/ha during TE 2020-21, with significant variability between states—from 2 tons in Rajasthan to over 6 tons in Andhra Pradesh. The annual yield change for maize doubled in the period 2001-2010 compared to 1991-2000, a trend that persisted in subsequent years, driven by key states like Andhra Pradesh, Bihar, Madhya Pradesh, Rajasthan, and Uttar Pradesh.

In pulses, chickpea, black gram, and green gram constitute the bulk of India's pulse production, accounting for around 69% of total pulse output in 2021-22. Chickpea yields have shown an upward trend, with the annual yield change rising from 0.3 kg during 1991-2000 to 3.0 kg during 2011-2020. Significant contributions to this yield growth have come from states like Gujarat, Madhya Pradesh, Maharashtra, Rajasthan, and Uttar Pradesh. Meanwhile, black gram and green gram have generally seen negative annual yield changes over the past two decades, except for a positive change during 2011-2020.

Among oilseeds, rapeseed and mustard (R&M), groundnut, and soybean are the primary crops. The yield of R&M increased from 0.3 kg/ha in 1991-2000 to 3.4 kg/ha in 2011-2020. Groundnut yields showed a steady increase during the period, but the rate slowed in recent years. For soybean, however, yields have been stagnant or declined in major growing states, except in Gujarat.

For commercial crops like sugarcane, cotton, and potato, yields have varied significantly across regions. Sugarcane yields in India averaged 81 tons/ha in TE 2020-21, with the highest yield in Tamil Nadu at 105 tons/ha and the lowest in Bihar at 68 tons/ha. A notable yield increase in sugarcane was recorded during 2011-2020, attributed to the adoption of improved varieties like Co-238 and Co-86032. Cotton yields showed variability, with Andhra Pradesh achieving the highest yield (502 kg/ha) and Maharashtra the lowest (298 kg/ha), while potato yields ranged from 31 tons/ha in Gujarat to 15 tons/ha in Karnataka.

Table 4.8. State-wise decadal yield change in major cereals in India

State	Rice				Wheat				Maize			
	Yield (t/ha)	Annual yield change (kg/ha)			Yield (t/ha)	Annual yield change (kg/ha)			Yield (t/ha)	Annual yield change (kg/ha)		
	TE 2020-21	1991-00	2001-10	2011-20	TE 2020-21	1991-00	2001-10	2011-20	TE 2020-21	1991-00	2001-10	2011-20
Andhra Pradesh	3.6	5.4	1.0	3.6	-	-	-	-	6.2	9.1	23.2	6.0
Bihar	2.1	1.3	-3.8	11.4	2.8	2.1	-1.8	8.2	3.3	8.5	-1.8	9.8
Chhattisgarh	1.8	-3.1	7.6	2.3	1.4	10.2	4.2	4.1	-	-	-	-
Gujarat	2.3	-6.8	10.4	5.1	3.2	3.4	8.9	0.5	1.8	-6.8	8.8	0.8
Haryana	3.3	-2.2	2.3	5.5	4.8	6.3	5.2	2.1	-	-	-	-
Karnataka	3.1	4.0	1.3	3.5	-	-	-	-	3.0	6.8	2.6	-3.4
Madhya Pradesh	2.1	-3.4	5.3	9.8	3.0	0.4	3.0	12.3	3.0	0.4	-1.8	15.0
Punjab	4.2	2.8	3.2	5.4	5.0	8.5	1.3	1.8	3.6	10.1	9.0	-0.3
Rajasthan	-	-	-		3.6	0.3	5.1	7.7	2.0	-2.8	7.5	4.9
Uttar Pradesh	2.7	1.6	1.4	6.1	3.5	5.2	4.2	4.9	2.3	3.0	-1.4	8.7
West Bengal	2.9	4.9	3.5	3.2	2.9	5.1	2.8	3.2	-	-	-	-
All-India	2.7	1.8	3.2	4.8	3.5	4.3	2.8	5.3	3.1	3.0	7.2	6.6

Table 4.9. State-wise decadal yield change in major pulses of India

State	Chickpea				Black gram				Green gram			
	Yield (t/ha)	Annual yield change (kg/ha)			Yield (t/ha)	Annual yield change (kg/ha)			Yield (t/ha)	Annual yield change (kg/ha)		
	TE 2020-21	1991-00	2001-10	2011-20	TE 2020-21	1991-00	2001-10	2011-20	TE 2020-21	1991-00	2001-10	2011-20
Gujarat	1.5	-1.5	6.1	4.3	0.7	-2.3	1.6	2.2	-	-	-	-
Karnataka	0.6	3.5	0.1	-0.3	0.9	0.3	-2.1	7.5	0.4	0.2	-2.2	2.8
Madhya Pradesh	1.4	0.5	0.4	6.2	0.4	0.4	0.6	-1.0	1.0	0.4	0.3	8.4
Maharashtra	1.0	-0.1	3.8	1.7	0.4	0.4	-1.5	1.1	0.4	0.6	-1.3	0.6
Rajasthan	1.1	-0.2	3.1	1.7	0.4	0.8	-0.2	-0.2	0.5	-1.6	-0.5	5.0
Tamil Nadu	-	-	-	-	0.7	0.8	-0.7	4.0	0.4	0.8	-0.9	0.2
Uttar Pradesh	1.3	-0.4	0.9	3.1	0.5	1.1	-0.2	0.1	-	-	-	-
All-India	1.1	0.3	1.5	3.0	0.5	-0.1	-0.1	0.4	0.6	-0.2	-1.5	3.8

Table 4.10. State-wise decadal yield change in major oilseeds of India

State	Rapeseed & mustard				Groundnut				Soybean			
	Yield (t/ha)	Annual yield change (kg/ha)			Yield (t/ha)	Annual yield change (kg/ha)			Yield (t/ha)	Annual yield change (kg/ha)		
	TE 2020-21	1991-00	2001-10	2011-20	TE 2020-21	1991-00	2001-10	2011-20	TE 2020-21	1991-00	2001-10	2011-20
Andhra Pradesh	-	-	-	-	0.9	2.0	-2.4	-0.1	-	-	-	-
Gujarat	1.9	2.3	3.3	4.1	2.0	-2.2	14.7	0.5	1.3	-3.3	0.0	5.5
Madhya Pradesh	1.6	-1.5	3.7	6.0	1.7	2.8	4.4	2.9	0.9	-2.5	4.3	-5.6
Maharashtra	-	-	-	-	1.1	-1.7	3.3	0.3	1.3	1.6	4.7	-1.2
Rajasthan	1.6	0.7	2.7	4.9	2.2	-0.2	10.4	2.9	0.9	-4.2	7.7	-4.9
Uttar Pradesh	1.4	0.2	1.9	2.5	-	-	-	-	0.7	-7.1	6.9	-5.9
All-India	1.5	0.3	2.5	3.4	1.7	0.7	4.3	2.9	1.0	-1.9	5.0	-3.5

Table 4.11. State-wise decadal yield change in major commercial crops of India

State	Sugarcane				Cotton				Potato			
	Yield (t/ha)	Annual yield change (kg/ha)			Yield (kg/ha)	Annual yield change (kg/ha)			Yield (t/ha)	Annual yield change (kg/ha)		
	TE 2020-21	1991-00	2001-10	2011-20	TE 2020-21	1991-00	2001-10	2011-20	TE 2020-21	1991-00	2001-10	2011-20
Andhra Pradesh	77.6	118.1	-34.3	-26.9	502	-0.11	2.03	-0.30	-	-	-	-
Bihar	68.2	-98.4	88.2	33.0	-	-	-	-	27.9	1.5	89.5	91.9
Gujarat	74.1	-181.6	9.8	49.1	499	-1.22	5.49	-1.31	31.0	-27.2	69.9	21.9
Haryana	81.6	44.3	139.5	151.0	496	0.22	1.81	-1.86	26.0	-2.8	69.0	39.4
Karnataka	97.7	259.2	-91.6	22.5	432	0.67	1.11	1.07	15.1	-51.1	-17.9	59.0
Madhya Pradesh	-	-	-	-	487	-0.27	4.39	-1.36	23.1	-3.4	13.7	108.2
Maharashtra	84.5	-31.6.	15.2	71.3	298	-0.18	2.67	0.11	22.6	-1.0	129.0	46.4
Tamil Nadu	104.9	44.4	31.3	-43.6	377	0.26	3.10	-2.58	-	-	-	-
Uttar Pradesh	81.3	-10.9	20.1	250.8	-	-	-	-	25.0	21.8	31.9	10.9
All-India	81.4	31.8	15.1	134.8	428	-0.35	3.1	-0.48	24.1	23.1	41.6	14.0

India's crop yield in relation rest of the world

Despite India achieving record production levels of wheat and rice in recent years, their yields remain significantly lower than those in developed nations and the global average. For instance, India's paddy yield is 14% below the world average and over 70% lower than that of Japan and China (Table 4.12). This trend is observed across other crops to varying extents. However, the low crop yields cannot be solely attributed to the lack of advanced technologies; they are also influenced by factors such as short growing seasons, diverse agro-climatic conditions, low input usage, and extreme weather events. Nevertheless, the Government has implemented several initiatives to address the issue of low yields, resulting in increased production and yield of most crops. For example, India's rice yield has risen from 2102 kg/ha in 2005-06 to 2717 kg/ha in 2020-21, while wheat yields have increased from 2619 kg/ha to 3521 kg/ha over the same period.

Table 4.12. Yield of principal crops in various countries including India in 2020 (kg/ha)

Country	Paddy	Wheat	Maize	Pulses	Sugarcane	Groundnut
China, mainland	7043	5742	6318	1815	79888	3911
Japan	7161					
Indonesia	5128		5700		69678	
Vietnam	5921					
Bangladesh	4809					
Germany		7819				
France		6680				
Canada		3537		2212		
United States of America		3342	10761	2171	85400	4273
Brazil			5695	1121	75604	
Argentina		2939				3499
Ukraine		3795	5618			
India	4138	3440	3006	885	83566	1703
World	4717	3474	5818	986	70483	1767

Source: GoI(A).

4.4 Yield Gap in Major Crops

The global demand for staple crops is projected to increase by 70-100% by 2050, primarily due to population growth, rising per capita income, changes in dietary diversity, and the use of grains for biofuels (Alexandratos and Bruinsma 2012; Gillard et al. 2009). A recent study estimates that the demand for food grains in India will reach 415-437 m t by 2047-48, representing an increase of approximately 42-49% compared to the levels in 2019-20 (NITI Aayog 2024). To meet this anticipated demand, increasing crop yield is crucial, as the potential for expanding land or irrigation is constrained by competing demands. Consequently, increased production must primarily result from yield improvements on existing farmland (Ramankutty et al. 2002; You et al. 2011). This can be achieved by bridging the 'yield gap' and advancing the yield frontier.

Several concepts of yields are used to measure the yield gaps and these are summarized below:

Table 4.13. Summary of yield and gap measurement

S. No.	Yield	Definition	Estimation method
1	Average farm yield	Average yield achieved by farmers in a defined region and period	Regional or national statistics, ground or satellite survey of fields
2	Economically attainable yield	Yield achieved with best management practices adopted at economical levels of controlling yield-limiting and yield-reducing factors	70-80% of the yield potential for non-water limiting conditions
3	Potential yield	Maximum yield with latest varieties, removing all constraints, including moisture, at generally prevailing solar radiation, temperature and day length	Highly controlled on farm experiments, best farmers, crop models calibrated with latest varieties, well monitored crop contests
4	Water-limited potential yield	Maximum yield under rainfed conditions, removing all constraints as potential yield except for moisture	Highly controlled on farm experiments, best farmers, crop models or crop contests
5	Exploitable yield gap	Difference between economically attainable yield and average farm yield	(2) - (1)
6	Theoretical yield gap	Difference between potential yield and average farm yield	(3) - (1)

Source: Metclfe and Elkins (1980).

The yield gap II for a particular crop is defined as the difference between the yield obtained in Frontline demonstration (FLD) plots and the state average yield, expressed as percentage relative to state average yield.

4.4.1 State-wise yield gap in cereal crops

Data indicate that the eastern states of Odisha, Bihar, Chhattisgarh, and Uttar Pradesh exhibit a significant yield gap in major cereal crops (Table 4.14). Specifically, the yield gap for maize is most pronounced in Uttar Pradesh (96%) and Bihar (78%). In contrast, the yield gap for rice ranges from 50% to 60% in the eastern states, excluding Uttar Pradesh. The eastern region is pivotal for advancing the green revolution, necessitating targeted efforts to enhance rice yields. Regarding wheat, Madhya Pradesh, Rajasthan, and Bihar demonstrate substantial yield gaps. Although Madhya Pradesh is a principal wheat-producing state in India, its full potential remains untapped, warranting specific policy, varietal, and agronomic interventions. For pearl millet, a notably higher yield gap is observed in Punjab and Karnataka, while Rajasthan, a major bajra-producing state, also has considerable potential for yield improvement. In summary, the analysis reveals a significant yield gap across various states and crops, suggesting potential for future yield enhancement. Addressing both technological and socioeconomic factors is essential, with timely provision of technology, quality inputs, and services to farmers being crucial.

4.4.2 State-wise yield gap in pulses, oilseeds and cotton

In the case of chickpea, major states like Karnataka, Rajasthan, Uttar Pradesh and Andhra Pradesh need more efforts to reduce the yield gap (Table 4.15). Similarly, for pigeon pea, Andhra Pradesh and Madhya Pradesh need priority to bridge the higher yield gap existed. In oilseeds, a very high yield gap is noticed in Rajasthan and Karnataka states. Efforts in terms of drought-resistant varieties, quality seeds of high-yielding varieties and best agronomic practices are required to enhance the yield of soybean in above noted states. In the case of R&M, the yield gap is manageable in other states, except for Rajasthan (50%), which is the large producer of R&M, indicating the large potential to increase yield level in the State. For cotton, Tamil Nadu and Haryana showed a higher yield gap to the extent of 91 and 119%, respectively. The yield gap in cotton may be bridged by adopting improved varieties/ hybrids, and improved farm practices. Pest and disease management is equally important to bridge wide yield gaps in cotton, as the yield of this crop is affected by the infestation of pink bollworm, whitefly, cotton leaf curl virus, etc.

4.4.3 Factors affecting yield gap

Yield gap analysis is a crucial instrument in agricultural research, as it identifies the primary factors limiting current farm yields, such as crop selection, soil conditions, and management practices. This analysis facilitates the development of enhanced practices aimed at bridging yield gaps. The factors contributing to yield gaps can be categorized based on their nature and the extent of their impact on these gaps (Metclfe and Elkins 1980).

- *Biophysical:* climate/weather, soils, water, pest pressure, weeds.
- *Technical/management:* tillage, variety/seed selection, post-harvest management.
- *Socio-economic:* socio-economic status, farmer's traditions and knowledge, family size, household income/expenses/investment.
- *Institutional/policy:* government policy, prices, credit, input supply, land tenure, market, research, development, extension.
- *Technology transfer and linkages:* the competence and facilities of extension staff; farmer's ability to adopt new technologies etc.

4.5 Conclusions

The intensification of agriculture, along with improved availability and accessibility of inputs, has significantly boosted crop yields and production in India. However, excessive

Table 4.14. State-wise yield gap in major cereal crops during TE 2022-23

State	Rice			Wheat			Maize			Pearl millet		
	FLD	SA	YG (%)	FLD	SA	YG (%)	FLD	SA	YG (%)	FLD	SA	YG (%)
Andhra Pradesh	65.9	50.9	29.46							18.6	22.8	-18.42
Bihar	54.7	33.5	63.28	42.2	28.3	49.11	57.3	32.1	78.50			
Chhattisgarh	45.8	28.3	61.83									
Haryana				51	46.7	9.20				28.5	23.7	20.25
Karnataka	62	46.1	34.49				28.5	31.1	-8.36	27.1	12.4	118.54
Madhya Pradesh	39.7	31.3	26.83	51.4	29.9	71.90	48.9	27.6	77.17			
Odisha	48.2	32.7	47.40									
Punjab	62.46	43.66	43.06*	52.4	50.9	2.94	36.3	36.7	-1.08	39.6	6.4	518.75
Rajasthan				51.3	34.5	48.69	27.9	22.9	21.83	16	10.5	52.38
Tamil Nadu	55.3	50.7	9.07				69.4	64.1	8.26	27	23.6	14.40
Uttar Pradesh	53.2	41	29.75	46.8	33.8	38.46	46.1	23.5	96.17			
West Bengal	46.6	44.4	4.95									

Note: Yield in qt/ha; FLD refers frontline demonstration, SA indicates state average, and YG denotes yield gap.
*Source: CACP (2023), *2020-21 FLD data from ATARI Ludhiana annual report and SA from UPAg.gov.in.*

Table 4.15. State-wise yield gap in major pulses, oilseeds and cotton crops during TE 2022-23

State	Chickpea			Pigeonpea			Soybean			Rapeseed and mustard			Cotton		
	FLD	SA	YG (%)	FLD	SA	YG (%)	FLD	SA	YG (%)	FLD	SA	YG (%)	FLD	SA	YG (%)
Andhra Pradesh	14.9	9.5	56.84	12.9	8.6	50.0							10.3	13.50	-23.70
Bihar				20.4	16.1	26.70									
Haryana										26.7	19.6	36.22	24.1	12.6	91.26
Karnataka	12.1	6.4	89.06	11.5	7.6	51.31	25.2	12.12	107.92				20.5	14.40	42.36
Madhya Pradesh	14.9	13.3	12.03	19.6	13.1	49.61	11.14	7.1	56.90	18.1	14.4	25.69	16.6	11.70	41.88
Odisha				12.2	11.7	4.27	7.6								
Punjab				12.5	11.6	7.75							23	20.7	11.11
Rajasthan	17.6	11	60	13.6	8.8	54.54	31.71	9.69	227.24	23.4	15.6	50.00	20.9	20.40	2.45
Tamil Nadu				12.5	10.5	19.04							24.3	11.10	118.9
Uttar Pradesh	20.1	12.7	58.26	17.1	10.1	69.30				19.3	13.8	39.85			
West Bengal										13.4	11.8	13.55			

Note: Yield in qt/ha; FLD refers frontline demonstration, SA indicates state average, and YG denotes yield gap.
Source: CACP (2023).

and indiscriminate use of irrigation water and chemical fertilizers has degraded natural resource quality, reducing input-use efficiency, factor productivity, and profitability. With the net sown area stabilizing around 140 million hectares and gradually declining, future production growth must come from vertical yield improvements. The untapped yield potential in the eastern region can be realized through high-yielding varieties and advanced technologies to address genetic ceilings and mitigate biotic and abiotic stresses. Micro-level constraint analysis at the village or block level is vital to guide focused research and development efforts. Moreover, timely crop management—including sowing, irrigation, weeding, plant protection, and harvesting—can raise yields by up to 20% above the current average.

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5

Irrigation Development

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This chapter presents empirical insights into the inter-state disparities in irrigation development, emphasizing the influence of natural resource endowments, investment levels, technological adoption, policy initiatives, and institutional arrangements in shaping outcomes. Achieving sustainable water resource management necessitates a strategic balance between regional supply and demand. Although complete uniformity may be unattainable, considerable potential exists to narrow regional disparities through context specific approaches for sustainable water management. This chapter explores technological, policy, and institutional strategies that are vital for sustaining and enhancing irrigation systems in India.

5.1 Introduction

Irrigation has long been a cornerstone of India's agricultural growth and stability, due to its significant yield-enhancing and risk-mitigating effects. Driven by substantial public investments in canal infrastructure and private investments in groundwater extraction, the gross irrigated area (GIA) expanded 5.34 times, from 22.6 million hectares (m ha) in 1950–51 to 120.3 m ha in 2021–22. This expansion occurred at an annual rate of 2.35%, significantly outpacing the 0.54% growth in the gross cropped area (GCA), thereby raising irrigation coverage from 18% to 55%. With irrigated lands being markedly more productive than rainfed ones, expanding and improving irrigation efficiency is crucial to ensuring food security amidst shrinking land and water availability.

However, stark regional disparities persist in irrigation infrastructure, driven by heterogeneities in water availability, hydrogeological, topographical, and other institutional constraints (Narayanamoorthy 2011; Srivastava et al. 2014). Additionally, utilization of the created irrigation potential differs across states owing to the varying adoption of technologies, performance of institutions, and policies related to irrigation (Gulati and Banerjee 2016). Disparity in access to irrigation translates into inter-state variations in agricultural performance. Therefore, reducing regional disparities in irrigation infrastructure and its efficient utilization can greatly contribute to the equitable growth of the agriculture sector. This chapter provides empirical evidence on inter-state variation in irrigation development and discusses the underlying technologies and institutional and policy-related factors behind inequitable irrigation development. Specifically, following aspects of irrigation development at the sub-national level are detailed in ensuing sections: (1) water resource availability representing resource endowment, (2) irrigation coverage and its sources representing access to irrigation, (3) adoption of micro-irrigation and solar pumps representing water- and energy-efficient technologies, (4) electricity subsidy for irrigation representing policy support, and (5) institutional structure and institutional innovations.

5.2 Water Resources Availability

India water resources base is largely shaped by its annual precipitation of about 4000 billion cubic meters (BCM) including snowfall. The water resource potential available as natural runoff in the rivers is estimated to be 1999 BCM, taking both surface and groundwater into account (CWC 2021). Given the limitations of physiographic conditions, socio-political environment, legal and constitutional constraints, and the technology available at hand, the utilizable water resources in the country have been assessed at 1097 BCM, approximately 690 BCM from surface water and 407 BCM from groundwater sources. Most of this availability is concentrated during the monsoon (June-September) and exhibits substantial spatial variation.

To plan and develop water resources, the Central Water Commission has divided the country into 20 river basins. A river basin is the total area of land drained by a river and its tributaries. The river basin is a basic hydrological unit that usually covers more than one state. Among all river basins, Ganga-Brahmaputra-Meghna is the largest river basin contributing 34.2% to the total catchment area (327.19 m ha), 56.2% to the estimated average water resource potential (1999.20 BCM), and 39.7% to the utilizable surface water potential (690.1 BCM) (Appendix 5.1). As estimates of surface water are not readily available for administrative boundaries, we estimated the surface water availability for Indian states based on the distribution of their drainage/catchment areas in different river basins.

Apart from surface water, groundwater resources are used for various purposes and are assessed and monitored by the Central Groundwater Board (CGWB). The state-wise estimated availability of water resources for various purposes is presented in Table 5.1. The evidence reveals wide inter-state variation in water resource endowments in India. As water is a critical input for agriculture, regional variation in its endowment has become a major source of inequality in agricultural development.

5.3 Irrigation Development and Emerging Challenges

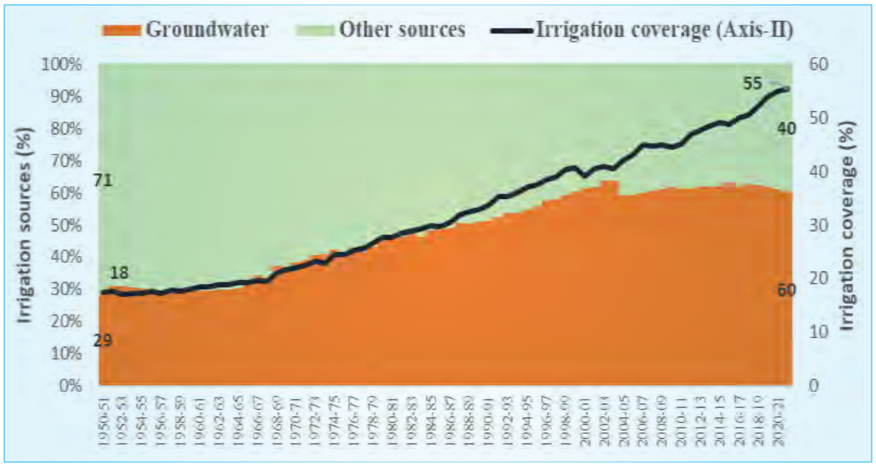
Rainfall uncertainty makes irrigation development a core strategy for agricultural development. Since independence, massive investment has been

Table 5.1. Inter-state variation in utilizable water availability in India

State	Surface water (BCM)	Ground water (BCM)	Total (BCM)	Per capita (m^3/capita)	Per ha catchment area (m^3/ha)
Andhra Pradesh	36	26	63	688	3109
Bihar	29	31	60	473	6375
Chhattisgarh	42	12	54	1802	4143
Gujarat	21	25	47	658	2620
Haryana	12	9	21	695	3303
Himachal Pradesh	9	1	10	1301	1742
Jharkhand	24	6	30	767	3835
Karnataka	45	17	62	916	3266
Kerala	17	5	22	617	5535
Madhya Pradesh	95	33	128	1487	4226
Maharashtra	71	31	102	817	3429
Odisha	47	16	62	1354	4157
Punjab	7	17	24	750	4807
Rajasthan	46	11	58	713	1685
Tamil Nadu	25	20	45	585	3418
Uttar Pradesh	75	66	140	597	5809
Uttarakhand	16	2	18	1558	3442
West Bengal	24	24	48	489	5625
North-east	23	29	52	988	2058
Overall	690	407	1097	794	3427

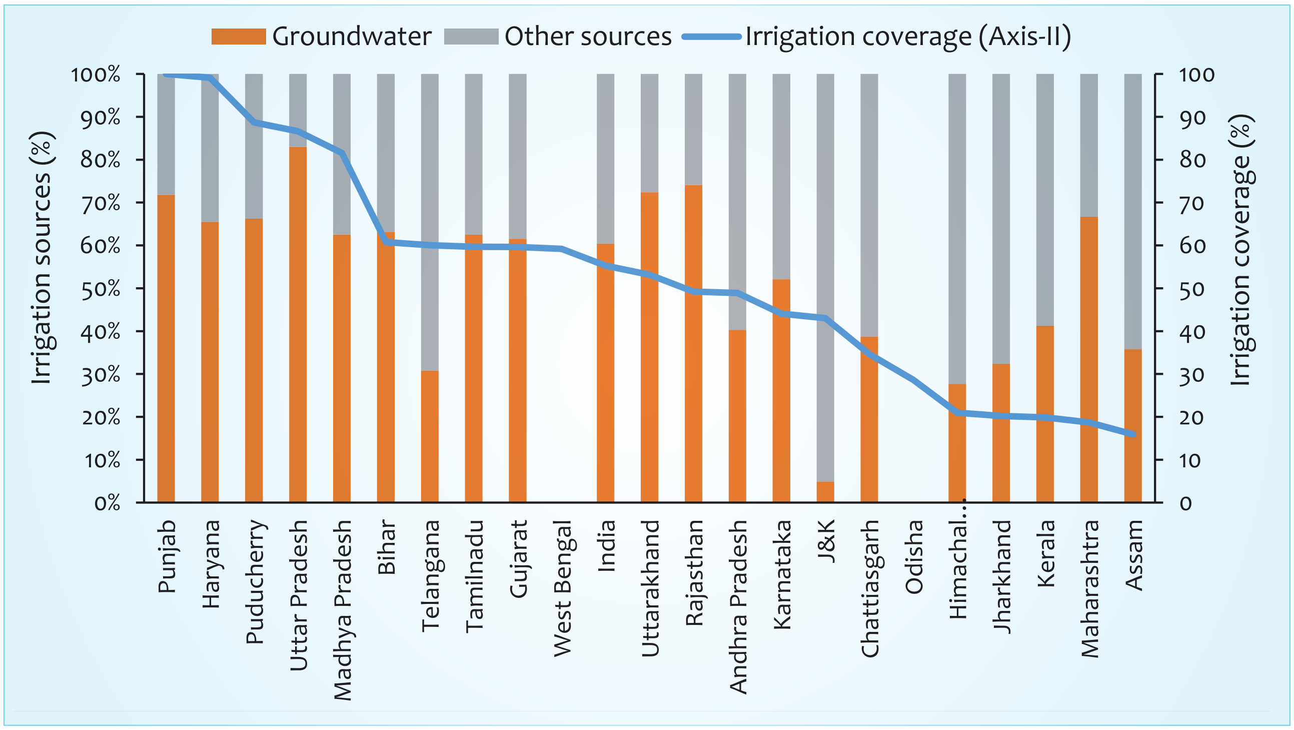
Source: Central Water Commission (CWC) and Central Groundwater Board (CGWB) made in the development of irrigation, which has led to a significant increase in the gross irrigated area in the country, from 22.6 million hectares (m ha) in 1950-51 to 120.3 m ha in 2021-22. Irrigation coverage (share of net irrigated area in net sown area) has increased from 18% in 1950-51 to 55% in 2021-22, contributing significantly to the productivity and stability of agriculture.

Figure 5.1. Trends in irrigation coverage and sources in India



During 1950s and 1960s, canals and tanks were the main sources of irrigation in most parts of the country. Canals were primarily designed for protective irrigation and to meet the water demands of a maximum of one crop per year (Mukherji 2022). With access to irrigation, farmers began cultivating more than one crop and shifted the cropping pattern to more water-intensive crops. Furthermore, canal irrigation suffered from several inefficiencies in the maintenance of the created infrastructure and distribution of water to the farmers' fields. Gradually, the canal became an inadequate and unreliable source to meet irrigation water demand. The period of late 1960s and 1970s witnessed a transition from public to private irrigation and groundwater emerged as a predominant source of irrigation over time. The share of groundwater in the net irrigated area has increased from 34% in 1966-67 to 60% in 2021-22. Thus, the long-term trajectory of irrigation development in India is characterized by a transition from traditional water conservation structures to large canal-based irrigation and, more recently, groundwater-dominant private irrigation.

Figure 5.2. Inter-state variation in irrigation coverage and sources of irrigation in 2021-22



In the Indian Constitution, the responsibility of water conservation and its distribution lies with state governments, except for inter-state water transfer issues, which fall under the purview of the central government. The central government supplements state governments with technical and financial support for water management. State specificity in water policies and various hydrogeological, socio-economic, and climate-related factors have resulted in wide inter-state variation in irrigation coverage and its sources (Figure 5.2). Irrigation coverage varies from 16% in Assam to almost 100% in Punjab and Haryana in 2021-22. Similarly, the share of groundwater in irrigated areas is not uniform across states.

Several studies have established the direct productivity and income enhancing impacts and the indirect poverty-reducing impacts of the improvement in irrigation in India (Saleth 1996; Vaidyanathan 1999; Hasnip et al. 2001; Bhattarai et al. 2002; Saleth et al. 2003; Narayanamoorthy and Bhattarai 2004; Narayanamoorthy 2007; Srivastava et al. 2014). Along with augmenting and stabilizing productivity, access to irrigation improves cropping intensity by ensuring year-round crop production, which in turn raises farm income and creates employment for farm families and hired laborers. Irrigation enhances the use of other inputs, such as fertilizers and high-yielding varieties, thus generating additional employment opportunities. Increased production from irrigated agriculture reduces prices and makes food affordable to poor households. Apart from its positive impacts on food security and economic development, canal irrigation recharges groundwater and provides various other ecosystem services. However, large positive impacts of irrigation development coexist with negative outcomes.

Many studies have pointed out that irrigation development in the country is unsustainable and its benefits are not equally distributed across regions and farming communities. Some of the major challenges faced by India's irrigation sector are as follows:

- Although India has the largest irrigated area in the world, 45% of its cultivated area remains rainfed. Erratic rainfall and water scarcity are the foremost challenges in such areas, leading to a large gap between crop productivity between irrigated and rainfed conditions. Providing supplementary irrigation through water conservation and efficient use can narrow this gap to a large extent.
- A large gap exists between the irrigation potential created (IPC) and utilized (IPU), which requires modernization of the canal irrigation system and improvement of the efficiency of water use through the adoption of technologies such as micro-irrigation.
- Groundwater is unsustainably used for irrigation, leading to its overexploitation in several regions of the country. Approximately 25% of the total assessment units (blocks/ mandals/taluka) have been categorized as over-exploited/critical/semi-critical, where groundwater is depleted at an alarming rate (CGWB 2023). Most of these areas are located in northwestern and southern parts of the country. Apart from disrupting the ecological balance, depleting groundwater resources places a heavy financial burden on farmers and results in socio-economic inequality in its distribution (Sarkar 2011). On the other hand, groundwater resources are under-utilized in most of eastern India, primarily due to poor economic access of farmers to groundwater irrigation. This evidence points towards the dual challenges of reversing the over-exploitation of groundwater in some areas and promoting its sustainable use in others.
- In addition to depleting groundwater, an increasing number of groundwater extraction devices (GEDs) and energy sources contribute to climate change by emitting greenhouse gases (GHG). Later on, climate change reverts

with serious threat to water-security. Thus, addressing the water-energy-climate nexus has become essential for developing sustainable food systems. Groundwater irrigation can increase energy and carbon efficiency by implementing measures such as improving pump efficiency, adopting micro-irrigation, rationing electricity supply, and improving on-farm efficiency (Shah 2009; Nelson et al. 2019; Patle et al. 2016). Introducing new pumps, replacing conventional pumps with highly efficient pumps, and promoting solar-powered irrigation systems can substantially reduce growing carbon emissions (Rajan et al. 2020).

5.4 Technology Adoption

Sustainability of water resources can be achieved by striking a balance between supply and demand. This requires technological and policy-led solutions to augment water resources and improve efficiency in various uses, particularly in agriculture, which is the largest consumer of water resources. The availability of water resources can be augmented through the modernization of existing and creation of new water harvesting and conservation structures. However, various technologies and practices can be adopted to reduce the water demand for crop cultivation. Micro-irrigation (drip & sprinkler) is one among such technologies, leading to a significant saving in water use- 15-20% with sprinkler irrigation and 40-60% with drip irrigation over conventional flood irrigation methods. Along with improving water use efficiency, the adoption of micro-irrigation leads to several other benefits, such as savings in fertilizer use, improvement in productivity, irrigated area, crop diversification, and income.

Energy is closely intertwined with most water management technologies, particularly groundwater irrigation, and thus, plays a critical role in sustainable water management. To sustainably meet energy security, thrust is provided to promote the transition towards renewable sources of energy, particularly solar energy, for energizing irrigation pumps. Solarization of irrigation can significantly contribute to improving economic access to irrigation, reducing subsidy burden, and de-carbonizing the sector. At the same time, unlimited access to solar energy poses the risk of groundwater overuse (Shah and Kishore 2012; FAO 2017). Coupling micro-irrigation with solar pumps can negate such risks to a large extent (Srivastava et al. 2024).

In India, the adoption of micro-irrigation and solar pumps is low, with wide inter-state variation. Until 2023, only 17.6% of the potential area under micro-irrigation and 2.6% of the solar energy potential from irrigation were utilized (Table 5.2). Approximately 80% of the area under micro-irrigation and solar pumps for irrigation is concentrated in a few states. The adoption of micro-irrigation (share of actual area in total estimated potential area) varied from just 1-2% in states such as Punjab, and Uttar Pradesh to 80% in Andhra Pradesh. The adoption of solar pumps (share of installed capacity in the total estimated potential) varied from only 0.1% in Telangana to 37.6% in Chhattisgarh. States with large potential but poor adoption should prioritize promoting micro-irrigation.

Interestingly, states with higher adoption of micro-irrigation lag behind the adoption of solar energy, and vice versa. For instance, Chhattisgarh has the largest share of 23.8% of the total installed solar pumps but shares only 2.6% of the total area under micro-irrigation. Karnataka has the highest share of micro-irrigation (16.6%) but shares only 1.5% of the total installed solar pumps. This indicates that the adoption of these two complementary technologies differs significantly across geographical locations. Currently, these technologies are promoted by proving capital subsidies (up to 90% for micro-irrigation and up to 60% for solar pumps) by the government. Given the limited financial resources of the government and the huge market potential of micro-irrigation, it is essential to build an ecosystem of a self-sustaining market for this technology.

Table 5.2. Potential and adoption of micro-irrigation and solar power in agriculture, 2023

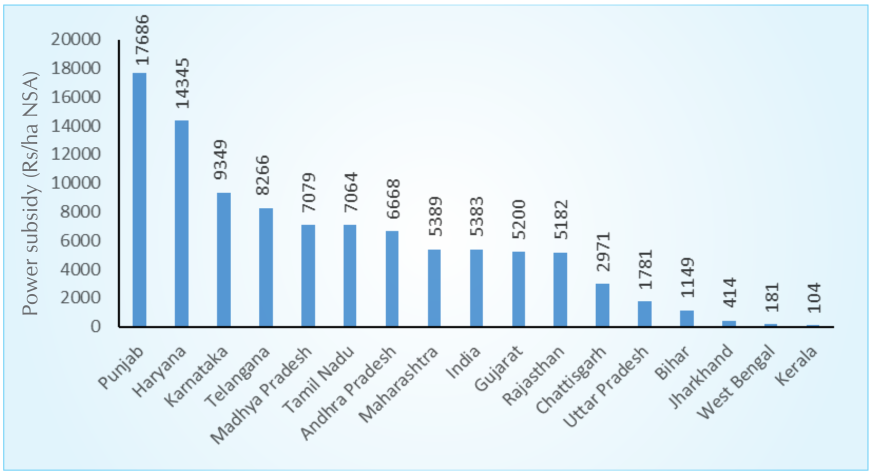
States	Micro-irrigation				Solar power			
	Potential (lakh ha)	Actual (lakh ha)	% exploited	% share in total	Potential for irrigation (Megawatt)	Installed capacity (Megawatt)	% exploited	% share in total *
Uttar Pradesh	201.7	3.7	1.8	2.4	20685	218	1.1	8.3
Madhya Pradesh	118.1	7.1	6.0	4.5	7008	94	1.3	5.0
Rajasthan	92.8	22.9	24.6	14.7	10376	596	5.7	21.7
Gujarat	75.2	18.2	24.1	11.6	7416	54	0.7	2.6
Punjab	65.5	0.6	0.9	0.4	8699	81	0.9	3.3
Haryana	49.2	7.2	14.6	4.6	2484	488	19.7	8.4
Maharashtra	45.1	22.1	49.0	14.2	12011	288	2.4	9.8
Bihar	41.7	1.3	3.0	0.8	2283	21	0.9	0.6
Karnataka	38.6	26.0	67.3	16.6	5789	30	0.5	1.5
West Bengal	35.0	1.4	4.1	0.9	1701	13	0.8	0.1
Tamil Nadu	32.0	13.3	41.4	8.5	8203	66	0.8	1.6
Telangana	30.8	3.5	11.5	2.3	6853	9	0.1	0.1
Andhra Pradesh	25.2	20.1	80.0	12.9	5687	88	1.6	6.8
Chhattisgarh	14.1	4.1	28.8	2.6	1029	387	37.6	23.8
Odisha	7.0	2.0	28.4	1.3	876	28	3.2	2.1
Uttarakhand	4.4	0.3	7.8	0.22	264	14	5.5	0.1
Kerala	3.3	0.4	10.8	0.23	98	23	23.6	0.2
Assam	2.3	0.4	17.9	0.26	526	9	1.8	0.01
Jharkhand	1.9	0.5	28.5	0.35	311	50	15.9	2.7
India	886.7	155.9	17.59	100	102438	2704	2.64	100

Source: *Srivastava* et al. *(2024)*.

5.5 Policy Support

There is wide variation in the policy support provided by different state governments for irrigation. For instance, several states supply electricity for irrigation, either at free or subsidized prices, to provide economic access to energy. Although such provisions improve farmers' welfare, they do not incentivize them to save water. Subsidized/ free electricity coupled with the widespread adoption of flood irrigation methods leads to the injudicious and inefficient use of groundwater. On the other hand, power subsidies place a heavy fiscal burden on the state exchequer and adversely affect the financial viability of power distribution companies (DISCOMS). The agricultural sector consumed approximately 20% of the total electricity consumption and constituted 66% of the total loss incurred by the DISCOMS from supply power at subsidized tariffs than the actual supply cost during TE 2020-21. This loss is borne by the

Figure 5.3. State-wise estimated power subsidy (Rs. /ha NSA) during TE 2020-21



government as a power subsidy, which has been estimated at Rs. 75,017 crore[1] in TE2020-21. There exists a wide inter-state variation in power subsidies (Rs. /ha NSA), which indicates that the benefits of subsidies (such as improved economic access) are inequitably distributed (Figure 5.3). Rationalizing subsidies and incentivizing farmers to use groundwater resources judiciously has become a major challenge in India. Apart from extending the negative consequences on water resources, subsidized availability of electricity also discourages farmers from adopting clean technologies such as solar pumps. Electricity subsidies can be repurposed for the adoption of clean technologies to accelerate transitions towards sustainable food systems.

5.6 Institutional Structure and Innovations

Institutions play a key role in the technological adoption and sustainable management of water. As authority in the power of decision-making related to water differs from state to state, water governance and management also vary. This also generates a considerable degree of variation across the diverse dimensions of water institutions among states. For instance, some states have enacted a legal framework for groundwater regulation, whereas others have not yet passed. Similarly, a few states, such as Punjab and Tamil Nadu, do not charge electricity for agricultural use, while most states charge the same with varying extents of subsidization.

Transferring the distribution and management of water to local communities has been recognized as a major institutional intervention in existing water policies. But wide inter-regional variation in adoption of community led institutions (e.g., water users' associations) and their performance necessitate a deep understanding about the social dynamics and community behaviour. A few recent community-led initiatives by different state governments to effectively manage scarce water resources in agriculture are presented in Table 5.3. Successful models developed in different parts of the country should be evaluated and promoted in other regions with similar agro-ecological and sociocultural conditions.

Table 5.3. Community-based institutional innovations for managing water resources in agriculture in different states

Place	Objective	Interventions	Outcomes
Maharashtra (Initiated in 2017)	Desilting the water-bodies to restore the water storage capacity and improve the percolation potential under scheme" "Gaalmukt Dharan and Gaalyukt Shivar" (GDGS)	- Hired excavation machines by community contributions or by the source of humanitarian funding - Fuel cost for running machine for excavation to be borne by govt. - Farmers can have silt free of cost (Carting on their own expense)	- Till 2021, 5270 waterbodies have been de-silted increasing the water storage capacity of about 32,300 thousand M^3 - Excavated silt was spread across more than 54000 acres benefitting to over 6.4 million farmers by improving the farm productivity by 2-4 times.
Chhattisgarh (Uttar Bastar Kanker district) (2018)	To make water sufficient and poverty free gram panchayat and to ensure women education and participatory planning on watershed management. (NITI Aayog, 2021)	- With the active participation of village organization and SHGs, trainings and visits were done - Social and resource mapping and livelihood focused planning - Communities were linked to government schemes	- Farm ponds were made more deeper to ensure water availability for longer period - Emergence of fishery as a new livelihood activity - Shift in cropping pattern toward vegetable crops - Higher yields and production of paddy

[1] One crore equals 10 million.

Place	Objective	Interventions	Outcomes
Andhra Pradesh and Telangana (2011-13)	To bring farmers together for sustainable model of water sharing and ground water management by using shared networks of borewell pooling	- Identification of farmers with borewell and building a collective of borewell owners and non-owners - Establishment of norms and capacity building for mapping of aquifers, borewell and rainfed areas and hydrogeology training - Formulation of groundwater sharing norms and a system for their enforcement and maintenance - Mapping of agricultural land and connecting borewells for designing a borewell network - Promotion of soil conservation practices	- Rise in groundwater level which reduced pumping time and increased water availability - Soil conservation along with micro irrigation practices improved the crop productivity which reduced assured livelihood and hence, reduced migration
Jharkhand (2017)	Installation of Solar power lift irrigation system (SPLIS) through community led-co-investment (Supported by Syngenta foundation of India) to ensure higher conveyance efficiency by reducing seepage water loss (CGIAR, 2020)	- Farmer collectives bear 40% of total capital cost and provide human resource for installation and rest 60% cost contributed by SFI - Ownership of the pump to all who paid for the pump - SFI provides technical guidance and support in laying pipeline water supply system for pumping and distributing water from nearby river - Aftercare and maintenance managed by community	- Increased area under irrigation - Shift in area under rice cultivation to vegetables and fruits - Increased income of the farmers and their lifestyle - Many children moved to private schools for better education
Madhya Pradesh (Betul district) (2017)	SHGs initiative to increase access to clean, reliable and cheap energy sources through portable solar irrigation pumps (SPIS) via Custom Hiring center (CHCs)	- SPIS owned and managed by CHCs operated by women SHGs with the support of BAIF development research foundation. - 20% of capital cost borne by SHGs and rest by SFI - Renting out of the portable pumps at the rate of Rs. 50 per day for drinking and irrigation pump	- The mean earnings of all the five groups formed for the Rabi season 2018-19 has been Rs. 2,000 and Rs. 1800 for irrigation and drinking purpose, respectively - Increased accessibility and affordability to power to the small farmers

5.6 Conclusions

Amidst increasing food demand and water scarcity, the sustainable management of water resources in agriculture has emerged as a top priority in the development agenda. The evidence reveals a wide regional variation in water resource endowment and irrigation infrastructure in India, which translates to regional disparities in overall agricultural development. Regional variation in irrigation development is due to inequality in water resource endowment, as well as investment, technological adoption, policy, and institutional arrangements for managing the available water for agriculture. It is essential to understand the regional dimensions of water resource management and devise region-level strategies to address the emerging challenges. Although complete elimination of regional disparity in irrigation development may not be feasible, there is a large potential to reduce it by developing and adopting region-specific strategies for sustainable water management. Harnessing the synergies between policy, technology and institutions will be key to building a resilient agricultural sector across diverse agro-ecological conditions.

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Appendix 5.1. River-basin wise water resources availability in India

River basin	Catchment Area (sq. km)	Average water resources potential (BCM)	Utilizable water resources potential (BCM)
Indus (Up to border)	317708	45.53	46
Ganga	838803	509.52	250
Brahmaputra	193252	527.28	24
Barak and others	86335	86.67	
Godavari	312150	117.74	76.3
Krishna	259439	89.04	58
Cauvery	85167	27.67	19
Subernarekha	26804	15.05	6.8
Brahmani and Baitarni	53902	35.65	18.3
Mahanadi	144905	73	50
Pennar	54905	11.02	6.9
Mahi	39566	14.96	3.1
Sabarmati	31901	12.96	1.9
Narmada	96659.8	58.21	34.5
Tapi	65805.8	26.24	14.5
West flowing rivers from Tapi to Tadri	58360	118.35	11.9
West flowing rivers from Tadri to Kanyakumari	54231	119.06	24.3
west flowing river south of Tapi Basin			
East flowing rivers between Mahanadi and Pennar	82073	26.41	13.1
East flowing rivers between Pennar and Kanyakumari	101657	26.74	16.5
West flowing rivers of Kutch and Saurashtra including Luni	192112	26.93	15
Area of inland drainage in Rajasthan	144835	Negligible	
Minor rivers draining into Myanmar & Bangladesh	31382	31.17	
Total	3271953	1999.2	690.1

Source: Central Water Commission (2021).

6

Farm Mechanization

Nalini Ranjan Kumar and S Rohit

The availability of farm power in India has witnessed a substantial rise, primarily driven by a remarkable increase in the number of tractors. Farm mechanization has consistently demonstrated its capacity to save time, labor, and resources, while also enhancing agricultural productivity and operational efficiency. Nevertheless, significant disparities persist in machinery ownership across farm sizes and states, with larger farms and agriculturally advanced states enjoying greater access to mechanized tools. Although the government has launched initiatives such as the Sub-Mission on Agricultural Mechanization (SMAM) and the creation of Custom Hiring Centre's (CHCs), further efforts are required to promote mechanization among small and marginal farmers. Key recommendations include strengthening CHC infrastructure, ensuring easy access to institutional credit for CHCs, consolidating land holdings, promoting equipment designed for small plots, enhancing farmer skills, and setting up localized repair and maintenance workshops for advanced machinery. Tackling these challenges can accelerate agricultural modernization and contribute to sustainable growth in the sector.

6.1 Introduction

Farm mechanization entails the use of machinery and implements for carrying out farm operations. This includes a spectrum of equipment, from simple hand tools and animal driven implements to advanced powered machines. Mechanization addresses labor shortages, particularly during peak seasons, reduces drudgery of manual work and ensures the timely farm operations and optimizes resource use, thereby enhancing agricultural productivity.

Mechanization in Indian agriculture began with the introduction of tractors in 1914 and pump sets in the 1930s. Recognizing that these initiatives not only helped more area under cultivation and raise land and labor productivity but also reduce drudgery the central and state governments laid considerable emphasis on farm mechanization (Pingali 2007; Singh 2009; Tiwari et al. 2012; Kienzele et al. 2013; Basu and Nandi 2014; Singh 2015; Houssou and Chapoto *2015*; Clarke 2000; Singh et al. 2003; Singh et al. 2006; Yadav and Lohan 2006; Verma and Tripathy 2015; Mohapatra 2016). Consequently, the availability of farm power has significantly risen from approximately 0.30 kW/ha in 1960-61 to around 2.761 kW/ha in 2020-21 (Singh and Singh 2023).

Given the critical role of mechanization, ongoing policy and government initiatives, this chapter documents the evolution of farm power, examines mechanization trends across farm sizes and states, and outlines a roadmap for the future.

6.2 Status of Farm Mechanization in India

There are several animate (human and animal) and inanimate (machines) sources of farm power. The availability of farm power in India over different periods is depicted in Table 6.1 and Figure 6.1. Notably, farm power availability in the country has increased from 0.28 kW/ha in 1960-61 to 2.761 kW/ha in 2020-21, reflecting a trend towards increased farm mechanization. The tractors, along with diesel engines and electric motors, serves as the primary source of power driving this trend. Table 6.2 presents data on the number of tractors from 1950 to 2022-23. Their number has increased more than 1200 times over the past seven decades, reaching 9.7 million in 2022-23. Tractor availability has significantly improved, with one tractor per 14 ha of net sown area in 2022-23, compared to one tractor per 14,843 ha in 1950.

Table 6.1. Availability of farm power in India

Periods	Farm power availability in India (kW/ha)
1961-62	0.28
1971-72	0.32
1981-82	0.471
1991-92	0.759
2001-02	1.231
2005-06	1.502
2009-10	1.724
2011-12	1.92
2016-17	2.24
2018-19	2.49
2020-21	2.761

Source: Singh & Singh (2023).

Figure 6.1. Trend in availability of farm power in India

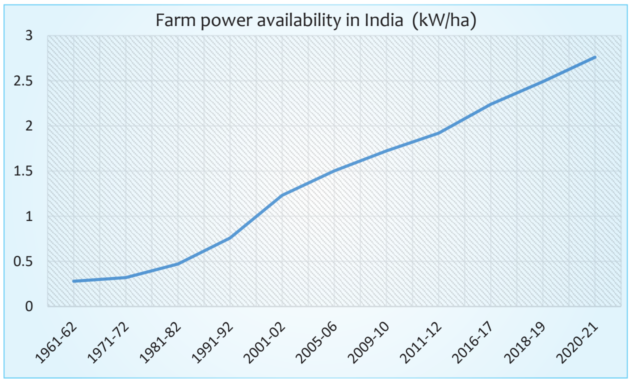

Table 6.2. Availability of tractors in the country during different periods

Period	Tractor Number	Net sown area/tractor (ha)
1950	8,000	14843
1951	8,500	13970
1955	20,000	6393
1960	37,000	3600
1965-66	52,000	2619
1970-71	1,47,000	958
1975-76	2,67,000	531
1980-81	4,83,000	290
1985-86	7,54,000	187
1990-91	11,15,000	128
1995-96	17,38,560	82
2000-01	25,45,770	56
2005-06	31,32,422	45
2010-11	42,07,046	34
2015-16	59,09,833	24
2020-21	85,28,014	16
2022-23	97,33,062	14

Source: Singh & Singh (2023).

6.3 Contribution of Agricultural Mechanization

Mechanization significantly enhances the efficiency and precision of farming operations while simultaneously alleviating the physical burden. It is estimated that mechanization results in a 15-20% reduction in the use of seeds and fertilizers and a 20-30% decrease in the time required for agricultural activities (Table 6.3). Furthermore, it addresses labor shortages in agriculture, reducing labor requirements by 20-30%, and increases cropping intensity by 5-20%, with a corresponding 10-15% improvement in productivity. In India, the highest level of farm mechanization is observed in seedbed preparation (60%), followed by plant protection (50%), irrigation (45%), and seeding and planting (40%) (Table 6.4). Harvesting and threshing operations for rice and wheat exhibit the highest mechanization levels (70-80%), whereas mechanization for other crops remains below 25%. The variability in mechanization levels across different farming operations can be attributed to factors such as topographical conditions, farmer preferences, land size and holdings, and the prevalence of dryland and rainfed conditions.

Table 6.3. Benefits of farm mechanization

Components	Benefits Values (%)
Saving in seed	15-20
Saving in fertilizer	15-20
Saving in time	20-30
Reduction in labour	20-30
Increase in cropping intensity	5-20
Higher productivity	10-15

Source: Singh & Singh (2023).

Table 6.4. Level of farm mechanization in India

Operations	Level of mechanization (%)
Soil working and seedbed preparation	60
Seeding and planting	40
Plant protection	50
Irrigation	45
Harvesting and threshing	
(i) for wheat and rice	70-80
(ii) for other crops	Less than 25%

Source: Singh & Singh (2023).

6.4 Availability of Agricultural Machinery across Farm Classes

The relationship between farm size and the ownership of agricultural machinery is illustrated in Table 6.5. There exists a direct correlation between the size of a farm and the ownership of agricultural equipment. As the size of landholdings increases, the proportion of households possessing various types of agricultural machinery and equipment also rises. Over 65.9% of large farmers own tractors, compared to only 2.15% of marginal farmers. This disparity in ownership between marginal and large-scale farmers is similarly observed in the possession of other types of farm machinery.

6.5 Investment in Agricultural Machinery and Implements

Table 6.6 presents the average value of agricultural machinery and equipment owned per household across different farm size categories in India. Over the past 15 years, India has made notable strides in farm mechanization (Mehta et al., 2019). However, a clear disparity persists in the ownership of agricultural machinery across various farm sizes. There is a positive correlation between farm size and investment in machinery, with larger farms typically possessing higher-value implements. For example, the average value of tractors owned by large farmers stands at ₹2.91 lakh, compared to merely ₹6,200 for marginal farmers. This pattern

Table 6.5. Farmers owning selected farm machinery and equipment across farm size classes (in %)

Land class	Tractors (all types)	Power tiller	Crop harvester/ combined harvester	Thresher	Laser land leveller	Diesel pumps	Electric pumps	Drip & sprinkler	Other machinery for irrigation
Marginal (≤ 1.0 ha)	2.15	1.62	0.33	1.54	0.30	0.33	6.34	1.65	3.43
Small (1-1.99 ha)	9.48	5.50	1.06	3.92	1.32	0.51	19.82	4.61	6.72
Semi medium (2-3.99 ha)	19.62	11.46	2.99	6.94	2.42	1.22	29.46	8.67	10.21
Medium (4-9.99 ha)	37.77	19.91	5.62	12.46	6.00	1.52	38.30	13.75	12.69
Large (≥10 ha)	65.95	34.05	6.90	22.41	10.34	1.72	39.66	15.09	17.67
Total	6.12	3.74	0.85	2.79	0.86	0.48	11.49	3.12	4.85

Source: Authors' calculations from unit-level data of AIDIS 2019, NSS 77th round.

Table 6.6. Investment in agricultural machinery and implements across farm size classes (in Rs. /farm)

Land class	Tractors (all types)	Power tiller	Crop harvester/ combined harvester	Thresher	Laser land leveller	Diesel pumps	Electric pumps	Drip & sprinkler	Other machinery for irrigation
Marginal	6228	650	143	330	23	883	1136	132	282
Small	27850	2896	636	1470	101	3932	5062	586	1258
Semi-medium	60336	5916	1299	3003	207	8034	10342	1198	2570
Medium	1,21,884	15810	3472	8025	554	21470	27638	3202	6868
Large	2,91,903	89679	19692	45524	3142	121787	156772	18161	38960
Total	18975	1643	780	994	151	1201	2800	536	672

Source: Authors' calculations from unit-level data of AIDIS 2019, NSS 77th round.

holds true across all categories of machinery, indicating that the value of equipment consistently increases with farm size.

6.6 Households Owning Selected Agricultural Machinery and Equipment across States

Table 6.7 presents the state-wise distribution of household ownership of farm machinery and implements. Punjab leads in the ownership of major equipment such as tractors, power tillers, harvesters, threshers, laser land levelers, and electric pumps. There is marked variation across states, with higher ownership in agriculturally advanced states like Punjab, Haryana, and Gujarat, and significantly lower levels in states such as Meghalaya, Sikkim, and Kerala. This disparity highlights the potential for expanding custom hiring services in states with low machinery ownership, enabling smallholders to access mechanization without large capital investment.

6.7 Availability of Agriculture Machinery and Implements across States

Table 6.8 illustrates the farm machinery per 100 acres of cultivated land across states. Punjab and Uttarakhand lead with over 9 tractors for every 100 acres, while states such as Kerala, Meghalaya, Sikkim, Nagaland, Arunachal Pradesh, and Tripura have fewer than 1 tractor per 100 acres. This stark contrast underscores the uneven distribution of agricultural machinery across states—while some have adequate resources to support full-scale mechanization, many continue to face serious equipment deficits that constrain agricultural productivity and efficiency.

Table 6.7. Households owning selected farm machinery and equipment across states of India

(%)

S. No.	State	Tractors	Power tiller	Crop harvester	Thresher	Laser land leveler	Diesel pumps	Electric pumps	Drip/ sprinkler	Other machines for irrigation
1	Punjab	48.06	33.6	6.83	27.31	10.98	19.81	62.12	4.42	15.13
2	Haryana	23.89	27.74	4.01	15.58	5.49	16.62	28.64	93.32	13.06
3	Gujarat	14.62	5	0.78	2.39	1.61	9.67	18.84	95	52.58
4	Rajasthan	11.37	5.8	2.65	5.74	3.65	12.33	21.12	165.55	58.29
5	Uttarakhand	10.98	25.96	1.5	7.15	2.66	6.82	12.48	4.16	18.64
6	Madhya Pradesh	10.68	6.05	1.17	3.57	1.06	9.02	31.05	49.22	91.55
7	Uttar Pradesh	8.52	4.86	1.32	4.82	2.1	26.08	6.08	2.01	7.26
8	Telangana	5.69	3.59	0.25	0.87	2.72	3.09	48.39	5.32	9.65
9	Maharashtra	5.62	7.73	1.7	2.83	1.52	5.38	32.09	40.01	49.85
10	Andhra Pradesh	5.62	4.72	0.2	3.61	0.3	5.52	12.85	5.72	8.03
11	Karnataka	5.46	4.95	0.17	0.73	0.06	1.74	17.33	48.9	26.67
12	Tamil Nadu	3.6	1.41	0.62	1.05	0.35	5.36	27.33	9.58	20.91
13	Chhattisgarh	3.28	1.51	0.35	0.27	0.98	2.66	9.23	30.88	24.13
14	Himachal Pradesh	3.17	4.6	0.32	3.65	2.38	4.76	10.95	6.35	5.4
15	Bihar	3.06	2.69	0.45	2.96	0.64	16.82	3.69	0.79	10.16
16	Assam	2	1.55	0	3.55	0.89	3.55	3.49	1.33	4.83
17	Odisha	1.86	2.28	0.14	0.65	1.35	5.78	2.56	2.33	1.02
18	Manipur	1.84	0.41	0	0.41	0.41	2.04	3.06	0.31	0.51
19	Jharkhand	1.8	4.5	0.14	2.42	0.97	11	6.09	0.21	2.07
20	Goa	1.49	1.49	0	1.49	0	10.45	8.96	1.49	0
21	Mizoram	1.45	1.45	0	0	0	4.12	0.24	0	0.48
22	West Bengal	1.13	1.06	0.74	6.24	0.85	8.99	2.61	2.93	3.95
23	Tripura	1.09	2.72	1.22	0.41	0.68	0.41	0.54	0.14	4.21
24	Arunachal Pradesh	0.95	3.47	0.32	0.79	3.31	0	0	5.21	11.67
25	Nagaland	0.45	0	0	0.45	0	3.63	0	0.45	2.49

S. No.	State	Tractors	Power tiller	Crop harvester	Thresher	Laser land leveler	Diesel pumps	Electric pumps	Drip/ sprinkler	Other machines for irrigation
26	Kerala	0.37	0	0.09	0.37	0.09	1.66	9.96	2.58	2.58
27	Sikkim	0	0	0	0	0.54	0	0.27	5.9	2.95
28	Meghalaya	0	0.29	0	0	0	2.29	0.29	1.71	0.43
	Others	2.06	2.6	0.18	1.8	0.81	5.3	4.13	1.17	3.77
	Total	6.44	4.94	0.98	3.63	1.58	10.32	13.52	27.18	22

** Includes the total of all union territories.*

Source: Estimated from unit-level data of AIDIS 2019, NSS 77th round.

Table 6.8. Availability of agriculture machinery and implements across states

(Number per 100 acres of operated land)

S. No.	State	Tractors	Power tiller	Crop harvester	Thresher	Laser land leveler	Diesel pumps	Electric pumps	Drip & sprinkler	Other machines for irrigation
1	Uttarakhand	9.57	22.62	1.31	6.24	2.32	5.95	10.88	3.63	16.24
2	Punjab	9.04	6.32	1.28	5.14	2.07	3.73	11.69	0.83	2.85
3	Haryana	5.54	6.44	0.93	3.61	1.27	3.86	6.64	21.65	3.03
4	Uttar Pradesh	4.95	2.82	0.77	2.79	1.22	15.13	3.53	1.17	4.21
5	Gujarat	4.14	1.42	0.22	0.68	0.46	2.74	5.34	26.91	14.9
6	Himachal Pradesh	3.44	4.98	0.34	3.95	2.58	5.15	11.85	6.87	5.84
7	Madhya Pradesh	2.86	1.62	0.31	0.96	0.28	2.41	8.31	13.17	24.5
8	Rajasthan	2.47	1.26	0.58	1.25	0.79	2.68	4.59	35.95	12.66
9	Bihar	2.42	2.13	0.36	2.35	0.5	13.31	2.92	0.62	8.05
10	Tamil Nadu	1.96	0.76	0.33	0.57	0.19	2.91	14.83	5.2	11.35
11	Goa	1.93	1.93	0	1.93	0	13.53	11.6	1.93	0
12	Andhra Pradesh	1.66	1.4	0.06	1.07	0.09	1.63	3.8	1.69	2.38
13	Karnataka	1.65	1.49	0.05	0.22	0.02	0.53	5.22	14.74	8.04
14	Jharkhand	1.61	4.02	0.12	2.16	0.87	9.83	5.44	0.19	1.86
15	Assam	1.48	1.15	0	2.63	0.66	2.63	2.59	0.99	3.58
16	Maharashtra	1.47	2.02	0.44	0.74	0.4	1.41	8.4	10.47	13.05
17	Manipur	1.39	0.31	0	0.31	0.31	1.54	2.31	0.23	0.38
18	Telangana	1.36	0.86	0.06	0.21	0.65	0.74	11.6	1.28	2.31
19	West Bengal	1.3	1.22	0.85	7.19	0.98	10.36	3.01	3.37	4.55
20	Chhattisgarh	1.15	0.53	0.12	0.09	0.34	0.93	3.23	10.81	8.45
21	Odisha	1.04	1.28	0.08	0.36	0.75	3.23	1.43	1.3	0.57
22	Tripura	0.97	2.42	1.09	0.36	0.61	0.36	0.48	0.12	3.76
23	Mizoram	0.63	0.63	0	0	0	1.78	0.1	0	0.21
24	Arunachal Pradesh	0.59	2.16	0.2	0.49	2.06	0	0	3.24	7.26
25	Kerala	0.5	0	0.12	0.5	0.12	2.23	13.37	3.47	3.47
26	Nagaland	0.42	0	0	0.42	0	3.35	0	0.42	2.3
27	Sikkim	0	0	0	0	0.62	0	0.31	6.87	3.44
28	Meghalaya	0	0.14	0	0	0	1.14	0.14	0.86	0.21
	Others	1.94	2.45	0.17	1.69	0.76	4.98	3.89	1.1	3.55
	Total	2.74	2.1	0.42	1.54	0.67	4.39	5.75	11.55	9.35

** Includes the total of all union territories.*

Source: Estimated from unit-level data of AIDIS 2019, NSS 77th round.

6.8 Operational Holdings Owning and Using Agricultural Machinery

The distribution of households owning and utilizing farm machinery, categorized by farm size, is detailed in Table 6.9. Overall, electric pump sets, followed by agricultural tractors, power sprayers, and diesel pump sets, are the most prevalent types of farm machinery, owned and utilized by over 7% of operational holdings. In contrast, self-propelled rice transplanters, tractor-driven pneumatic planters, vegetable planters, and sugarcane cutters and planters are the least owned and utilized. The data clearly indicate a positive correlation between farm size and both ownership and usage of machinery, with larger farms demonstrating significantly higher levels of mechanization. This trend underscores the need to expand custom hiring services, particularly to support small and marginal farmers who lack the scale or resources for individual ownership of such equipment.

6.9 Holdings Hiring Agricultural Machinery

Table 6.10 presents the proportion of farm households that hire various types of farm machinery, categorized by farm size. The data indicate that agricultural tractors are the most frequently hired machinery, utilized by approximately 41% of households. Interestingly, the hiring rate is highest among small farms at 43% and lowest among large farms at 32.4%. However, there is no uniform trend across machinery types—while some equipment is predominantly hired by smaller farms, others see greater use among larger holdings. This variation highlights the broad relevance and growing importance of custom hiring services across all farm sizes. Even large farms may prefer hiring over ownership, particularly for high-cost or infrequently used machinery, making custom hiring an economically rational choice across the spectrum of farm sizes.

6.10 Way Forward

In its ongoing efforts to promote farm mechanization, especially among small farmers and in underdeveloped regions, the Government of India initiated the "*Sub Mission on Agricultural Mechanization* (SMAM)" during the 2014-15 period. This initiative aims to extend the reach of mechanization to underserved areas, fostering sustainable agricultural development. As part of this scheme, the Government, in collaboration with state governments, has actively supported the establishment of Custom Hiring Centres (CHCs) across the country. These Centre's enable farmers, particularly those without sufficient capital, to access modern and high farm machinery for various agricultural operations. A significant number of CHCs have already been established nationwide, contributing to increased mechanization. On November 30, 2023, Prime Minister Narendra Modi further bolstered this agenda by launching the '*NAMO Drone Didi*' scheme, which seeks to equip 15,000 Women Self-Help Groups (SHGs) with drones for rental services, facilitating tasks like pesticide and fertilizer application. Despite these initiatives, there is a need for further measures to strengthen farm mechanization, particularly for small and marginal farmers. The following recommendations can help amplify the impact of these schemes and drive broader mechanization adoption.

Strengthening of CHC Institutions

To ensure that CHCs remain sustainable and effective, it is crucial to revise the allocation criteria. The government should prioritize individuals who own agricultural land and have been engaged in farming for a minimum of two to three years after completing their formal education. This will ensure that CHC operators are committed to long-term involvement in agriculture and are more likely to maintain their operations effectively.

Furthermore, many farmers and educated youth lack the necessary skills to operate and maintain modern agricultural machinery, often relying on external operators. Therefore, it is essential to incorporate skill development training into the CHC allocation process. Prospective operators must undergo training in machinery operation,

Table 6.9. % share of operational holdings that owned and used agricultural machinery by farm size

Farm machines & implements	Farm size group (ha)					
	Marginal (< 1.0 ha)	Small (1-1.99)	Semi-medium (2 -3.99)	Medium (4-.9.99)	Large (> 10 ha)	Overall
Electric pump set	10.1	20.5	24.6	29.5	27.8	14.1
Agricultural tractors	5.3	10.2	16.9	29.6	39.3	8.4
Power sprayer	6.6	10	10.5	10.8	11.5	7.7
Diesel engine pump set	6.2	9.9	11.3	13.1	13.7	7.6
Moldboard plough (TD)	1.9	5.1	9.4	17.6	27.1	3.9
Disc harrow (TD)	1.8	4.7	9.1	16.9	24.2	3.7
Cultivator (TD)	1.5	4.5	7.7	13.5	23.4	3.2
Power threshers – Multi-crop	1.9	3.8	5.9	10.2	14.4	3
Power chaff cutter	1.8	3.9	6.1	9.5	13.4	3
Seed drill/seed-cum-fertilizer drill(TD)	1.3	3.7	7.3	15.6	22.4	2.9
Land leveller (TD)	1.5	3.9	6.6	11.7	19.1	2.9
Power tiller	2	3.5	5	6.5	6.7	2.8
Sprinkler irrigation set	1.3	4.6	5.8	8.6	12.5	2.6
Rotavator	1.2	3.2	5.2	9.3	12	2.3
Drip irrigation set	1.2	4	5.5	5.1	5.8	2.3
Reaper binder	1.2	2.4	3	3.7	2.6	1.7
Tractor drawn planter	0.9	2.1	3.1	4.3	5.4	1.4
Tractor-drawn potato digger	0.4	1	1.9	2.9	3	0.8
Cage wheels used for puddling	0.5	0.9	1.1	1.4	1.9	0.7
Disc plough (TD)	0.2	0.6	1.6	4	7.5	0.6
Self-propelled reaper	0.4	0.5	0.6	1	1.7	0.5
Brush cutter	0.5	0.4	0.9	0.5	0.8	0.5
Combine harvester (TD)	0.2	0.4	0.7	1.6	2.8	0.4
Tractor-mounted spray pump	0.1	0.5	0.9	2.4	4.3	0.4
Power cane crusher	0.2	0.4	0.6	1.6	2.1	0.3
Combine harvester (self-propelled)	0.2	0.3	0.6	1.4	3.3	0.3
Zero-till seed-cum-fertilizer drill (TD)	0.1	0.2	0.7	2.1	3.8	0.3
Laser land leveler	0.1	0.3	0.6	1.6	2.8	0.3
Chain saw	0.3	0.3	0.3	0.3	0.4	0.3
Hedge trimmers	0.3	0.4	0.5	0.5	0.6	0.3
Solar pump set	0.2	0.4	0.6	1	1.9	0.3
Power Maize Sheller	0.1	0.3	0.4	0.9	1.3	0.2
Tractor mounted reaper	0.1	0.1	0.4	1.2	2.3	0.2
Aero-blast sprayer	0.2	0.2	0.3	0.4	0.8	0.2
Power Weeder (self-propelled)	0.1	0.2	0.2	0.7	0.3	0.2
Tractor-mounted post-hole digger	0.2	0.3	0.1	0.2	0.4	0.2
Happy seeder	0.1	0.2	0.3	0.9	1.5	0.2
Ground nut decorticator	0.1	0.1	0.2	0.4	0.7	0.1
Raised-bed planter (TD)	0.1	0.2	0.3	0.7	1.5	0.1
Strip-till-drill (tractor-drawn)	0	0.1	0.1	0.3	0.5	0.1
Straw combines (TD)	0.1	0.1	0.4	1	2.3	0.1
Straw baler	0.1	0.1	0.2	0.3	0.6	0.1
Sugarcane harvester	0.1	0.1	0.1	0.2	0.3	0.1
Portable augur digger	0.1	0.1	0.1	0.2	0.3	0.1
Sugarcane cutter planter (TD)	0	0	0.1	0.2	0.3	0
Vegetable transplanter (TD)	0	0	0.1	0.2	0.4	0
Pneumatic planter (TD)	0	0	0.1	0.2	0.4	0
Self-propelled rice transplanter	0	0	0	0.1	0.1	0
Others	3.4	5.4	6.2	6.9	7.3	4.1

Source: Input survey 2016-17.
Note: TD indicates Tractor drawn/Tractor driven.

Table 6.10. % operational holdings hiring farm machinery by farm size

Farm Machinery/implements	Marginal (< 1.0 ha)	Small (1.0 - 1.99)	Semi-medium (2.0 - 3.99)	Medium (4.0 - 9.99)	Large (> 10 ha)	Overall
Agricultural Tractors	41.6	43	37.3	32.6	32.4	41
Moldboard Plough (TD)	13	20.3	19.8	17.6	15.8	15.1
Power Threshers – Multi-crop	11.4	14.7	15.8	18.7	25.9	12.8
Cultivator (TD)	10	16.2	16.1	18.3	21.4	12
Disc Harrow (TD)	10	14.8	15.2	16.1	18.7	11.6
Power Tiller	10.4	10.8	8.3	7.4	5.3	10.1
Land Leveller (TD)	7.9	11.1	10.8	10.7	10.1	8.8
Rotavator	7.4	10.9	11.1	9	7.3	8.4
Seed Drill/Seed-Cum-Fertilizer Drill (TD)	5.7	12.3	14.4	14.8	14.8	8.1
Power Sprayer	7.5	9.3	8.4	6	5.1	7.8
Diesel Engine Pump set	6.1	4	3.3	2	1.2	5.3
Combine Harvester (TD)	3.8	5.6	6.1	6.4	6.5	4.4
Electric Pump Set	4.9	3.9	2.7	2.1	1.2	4.4
Combine Harvester (Self Propelled)	2.2	3.5	4.4	6.1	7.1	2.8
Tractor Drawn Planter	2	3.1	3.2	3.3	3.3	2.4
Cage Wheels Used For Puddling	2.2	2.9	2.6	2.1	1.3	2.4
Power Chaff Cutter	1.9	2.8	3.4	4.1	5.5	2.3
Disc Plough (TD)	1.5	2.3	3	4.6	10.6	2
Power Maize Sheller	1.1	2.3	2.3	2.3	1.7	1.5
Potato Digger (TD)	1	1.6	1.8	2.1	1.5	1.2
Self-Propelled Reaper	1	1.3	1.6	1.8	2	1.1
Tractor Mounted Reaper	0.8	1.2	1.4	2	3.5	1
Laser Land Leveler	0.7	1.1	2	3.3	4.6	1
Power Cane-crusher	0.7	1.1	1.2	1.5	1.5	0.9
Spray Pump (TD)	0.5	1.1	1.7	2.5	5.3	0.8
Zero-Till Seed-Cum-Fertilizer Drill (TD)	0.5	0.9	1.1	1.6	2.2	0.7
Straw Combines (TD)	0.5	0.8	1.3	2.4	3.1	0.7
Raised-Bed Planter (TD)	0.4	0.8	1.1	1.4	2.4	0.6
Straw Baler	0.4	0.6	0.7	0.8	0.5	0.5
Ground Nut Decorticator	0.3	0.6	0.8	0.8	0.7	0.4
Sugarcane Harvester	0.2	0.4	0.6	1	3.2	0.4
Happy Seeder	0.2	0.5	0.8	1.4	1.7	0.4
Brush Cutter	0.3	0.4	0.4	0.5	0.4	0.4
Sprinkler Irrigation Set	0.3	0.4	0.5	0.5	0.5	0.4
Strip-Till-Drill (TD)	0.3	0.5	0.5	0.5	0.4	0.3
Aero-Blast Sprayer	0.2	0.3	0.4	0.5	1.1	0.3
Power Weeder (Self Propelled)	0.3	0.4	0.5	0.5	0.4	0.3
Pneumatic Planter (TD)	0.2	0.3	0.4	0.7	2.2	0.3
Reaper Binder	0.3	0.4	0.4	0.5	0.4	0.3
Sugarcane Cutter Planter (TD)	0.2	0.3	0.3	0.4	0.4	0.2
Vegetable Transplanter (TD)	0.2	0.2	0.3	0.3	0.2	0.2
Self-Propelled Rice Transplanter	0.2	0.2	0.3	0.5	0.2	0.2
Post Hole Digger (TD)	0.2	0.3	0.4	0.5	0.6	0.2
Chain Saw	0.2	0.2	0.3	0.3	0.1	0.2
Hedge Trimmers	0.2	0.2	0.2	0.2	0.1	0.2
Drip Irrigation Set	0.2	0.3	0.3	0.3	0.1	0.2
Portable Augur Digger	0.1	0.1	0.2	0.2	0.1	0.1
Solar Pump Set	0.1	0.1	0.2	0.2	0.1	0.1
Others	1	1.4	1.4	1.2	1.3	1.2

Source: *Input survey 2016-17.*
Note: *TD indicates Tractor drawn/Tractor driven.*

maintenance, and the application of modern farming practices. This would enable them to operate equipment independently, offer technical guidance to fellow farmers, and contribute to improved mechanization practices at the local level.

Ensuring easy availability of institutional credit for CHC

One of the key barriers to the establishment and expansion of CHCs is limited access to institutional credit. To address this, facilitating easy and affordable credit for CHC operators is vital. Such access will not only enable existing operators to scale up but also support the establishment of additional CHCs, enhancing the availability of machinery for small and marginal farmers. Increased access to credit will promote mechanization, which will ultimately improve agricultural productivity and sustainability.

Consolidations of land holdings

In many regions, particularly in the eastern states, land holdings are fragmented and scattered, making mechanization costly and inefficient. Consolidating fragmented landholdings would significantly reduce operational costs, making it easier and more economical to deploy mechanized farming practices. The government could support land consolidation initiatives, or alternatively, promote land leasing arrangements, which would help solve issues of absentee landlordism and enable more efficient use of land. This would increase the size of operational holdings, thus supporting the economics of mechanization and improving productivity.

Promoting farm machinery suitable for small plot size

In India, approximately 86% of farmers are classified as marginal and small, with insufficient plot sizes to justify the purchase of large-scale agricultural machinery. To address this, it is essential to develop and promote machinery that is specifically designed for small landholdings. Such equipment would be more affordable, efficient, and compatible with the needs of small farmers. Increased availability of compact machinery would allow small farmers to adopt mechanization, leading to improved efficiency and productivity at the farm level.

Skill development of farmers

The successful adoption of modern agricultural machinery requires farmers to be well-versed in its operation and maintenance. A focused, mission-oriented skill development programme is essential to equip farmers with the knowledge required to use contemporary machinery effectively. Training programmes should cover a wide range of equipment, including paddy transplanters, zero-till seed drills, combine harvesters, and sugarcane harvesters. Furthermore, encouraging sugar mill owners to adopt and operate sugarcane harvesters independently could improve recovery rates. The mechanization of horticultural crops, especially fruits, also warrants increased attention to improve post-harvest quality and reduce losses.

Workshop for repair and maintenance of sophisticated machinery

Currently, the majority of repair and maintenance facilities for sophisticated agricultural machinery, such as combine harvesters and laser land levelers, are located primarily in Punjab. Farmers in other states must often transport their machinery to Punjab for servicing, leading to high costs and significant downtime. To mitigate this issue, the government, in collaboration with machinery manufacturers, should establish repair and maintenance centres in major agricultural states. These facilities would provide much-needed local support for farmers, encouraging greater adoption of advanced machinery and improving its operational lifespan.

These recommendations offer a comprehensive strategy to accelerate farm mechanization, especially for small and marginal farmers. By addressing the structural, financial, and operational barriers, the government can further enhance mechanization's role in Indian agriculture, improving productivity, sustainability, and farmer incomes across the country.

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7

Institutional Credit

Pavithra S and Shyam Mani Tripathi

This chapter presents the temporal and spatial patterns in the flow of institutional credit to the agricultural sector in India and assesses the progress and regional coverage of the Kisan Credit Card (KCC) scheme. Over the years, institutional credit to agriculture has exhibited consistent growth, with Scheduled Commercial Banks (SCBs) emerging as the dominant source, followed by Regional Rural Banks (RRBs) and Cooperative Banks. However, the contribution of cooperative banks has seen a marked decline over time. SCBs currently account for nearly 64% of short-term (ST) or production credit and more than 90% of medium-term (MT) and long-term (LT) credit. The share of MT/LT credit in the overall credit flow has also increased over the years. However, notable regional disparities persist in the outreach and effectiveness of the KCC scheme. The Southern, Central, and Northern regions report a higher number of active KCCs and associated outstanding amounts, whereas the Eastern, Western, and North-Eastern regions lag behind. This calls for targeted efforts to strengthen the KCC coverage, particularly in underserved regions.

7.1 Introduction

Financial inclusion has emerged as a cornerstone of rural development policy, aiming to extend access to a broad range of financial services to marginalized groups, including rural households. A flagship initiative in this direction is the *Pradhan Mantri Jan Dhan Yojana (PMJDY)*, initiated in 2014, which seeks to bring unbanked populations into the formal financial system. The primary aim of this scheme is to ensure access to financial services encompassing basic savings bank accounts, need-based credit, remittance facilities, insurance, and pensions (PMJDY-GoI 2023). D'Souza (2020) observes an increase in financial inclusion index from 50.1 in 2013 to 58 in 2016. The proportion of bank account holders rose from 53% in 2014 to 80% in 2017, largely driven by massive expansion of Jan Dhan accounts, which reached approximately 281.7 million. According to NABARD (2016-17), over 55% of the new bank accounts opened between 2011 and 2017 were attributed to PMJDY.

Access to affordable and timely credit remains a critical determinant of performance in agriculture based economies. Capital availability directly influences technology adoption, input usage, resource efficiency and household income stability (Banerjee and Newman 1993; Carter and Weibe 1990). It also plays a role in adoption of improved technology and thus improving resource use efficiency and also helping in consumption smoothing. Thus, it aids in improving household income and reducing poverty (Binswanger 1989; Zeller et al. 1997; Das et al. 2009; Swain et al. 2008; Conning and Udry 2005; Rosenzweig and Binswanger 1993; Simtowe et al. 2006; Shivaswamy et al. 2020).

India has seen a substantial increase in the flow of institutional credit to the agricultural sector (GoI 2023). A significant early milestone was the establishment of the Agriculture Credit Department (ACD) in the Reserve Bank of India (RBI) in 1935. The outreach of institutional credit to the rural sector accelerated after the nationalization of commercial banks in 1969 (Binswanger 1989; NABARD 2013). Other key initiatives include the launch of the Kisan Credit Cards (KCC) Scheme in 1998-1999 with the aim of enabling farmers to purchase inputs and meet credit demand for production needs. The KCC scheme was further extended to the livestock and fishery sectors in 2018. Special initiatives such as the KCC Saturation Drive for farmers enrolled under *Pradhan Mantri Kisan Samman Nidhi* (PM-KISAN) scheme have also simplified the process and documentation involved for getting the KCC sanctioned. To provide short-term production loans to farmers at cheaper interest rates, the Interest Subvention Scheme (ISS) was announced in 2006-07.

The Modified Interest Subvention Scheme (MISS) offers 7% interest for short-term loans up to Rupees three lakhs through the KCC (PIB 2023; NABARD 2024).

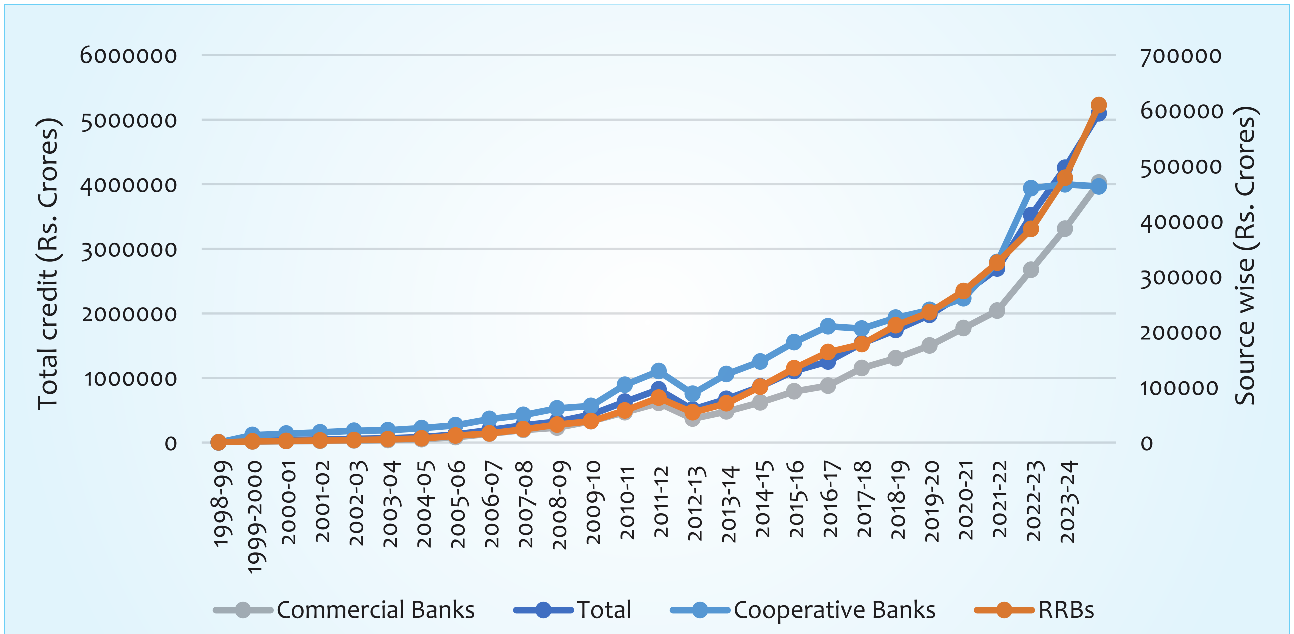
In September 2023, the Ministry of Agriculture and Farmers Welfare launched two initiatives related to KCC and the Modified Interest Subvention Scheme (MISS), namely, the *Kisan Rin Portal* (KRP) and KCC *Ghar Ghar Abhiyaan*, to further expand the reach of KCC scheme (PIB 2023). These sustained policy efforts have resulted in a significant and sustained rise in institutional credit flow. Notably, the actual flow of credit has consistently exceeded the set targets. In 2021-22 the flow was 13% higher than the target of Rs. 16.50 lakh crore. Nevertheless, the issues of disparities in the outreach of institutional credit across different socio-economic groups and regions have often been highlighted by researchers, including the limitations in the outreach of innovative financial inclusion schemes such as the KCC (Jumrani and Agarwal 2012; Jain et al. 2019; Kumar et al. 2020; Kumar et al. 2021; Sathyasai and Tiwari 2021). Against this backdrop, the present chapter explores the trends in the flow of institutional credit and the outreach and progress of the KCC scheme across states in India.

7.2 Trends in Flow of Institutional Credit to Agriculture and Allied Sectors

The flow of institutional credit to the agricultural sector has shown positive growth over the years owing to various targeted programs and policies, as briefly discussed in the previous section.

The flow of total institutional credit exhibited a positive trajectory from 2001-02 to 2022-03 (Figure 7.1). In the fiscal year 2022-23, a sum of Rs. 29.35 lakh crores were allocated to address the short-term, long-term, and medium-term financial needs of the agricultural sector. Of this, approximately 73% was through commercial banks, 11% through cooperative banks, and 15.58% through Regional Rural Banks (RRBs).

Figure 7.1. Flow of institutional credit to agriculture sector



Source: Directorate of Economics and Statistics (DES), Government of India. Note: Throughout, the amount is presented in real terms at 2011-12 prices, deflated using agriculture and allied sector GDP deflator.

Scheduled commercial banks play a pivotal role in the agricultural credit system, accounting for over 78% of the total institutional credit to the agricultural sector. This is followed by Regional Rural Banks (RRBs), whose contributions have been increasing over the years, and finally, cooperative banks (Figure 7.2).

Regarding the composition of the total institutional credit flow to the agricultural sector, approximately 64% of the total credit was allocated for short-term purposes, addressing the production needs of the sector. Between the period 2001-02 and 2022-23, there was a gradual increase in the proportion of MT/LT credit within the total institutional credit flow to the agricultural sector, particularly noticeable after 2013 (Figure 7.3).

The distribution of production credit through Commercial Banks, Cooperative Banks, Regional Rural Banks (RRBs), and other agencies increased from Rs. 36,458 crores in 2001 to 25.14 lakh

Figure 7.2. Share of different agencies in total institutional credit flow to agriculture sector

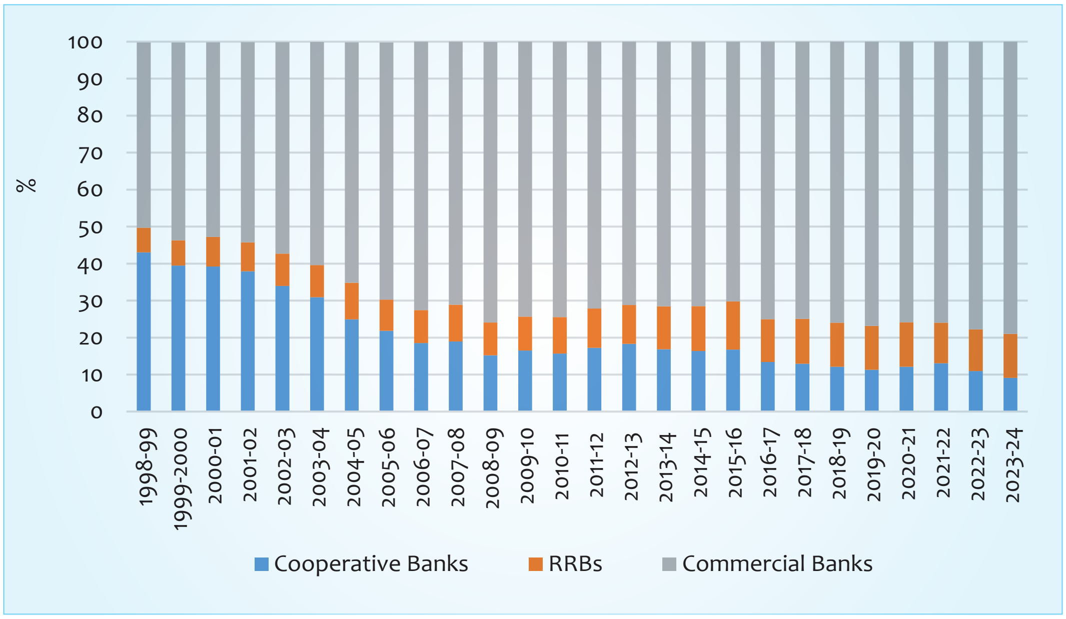
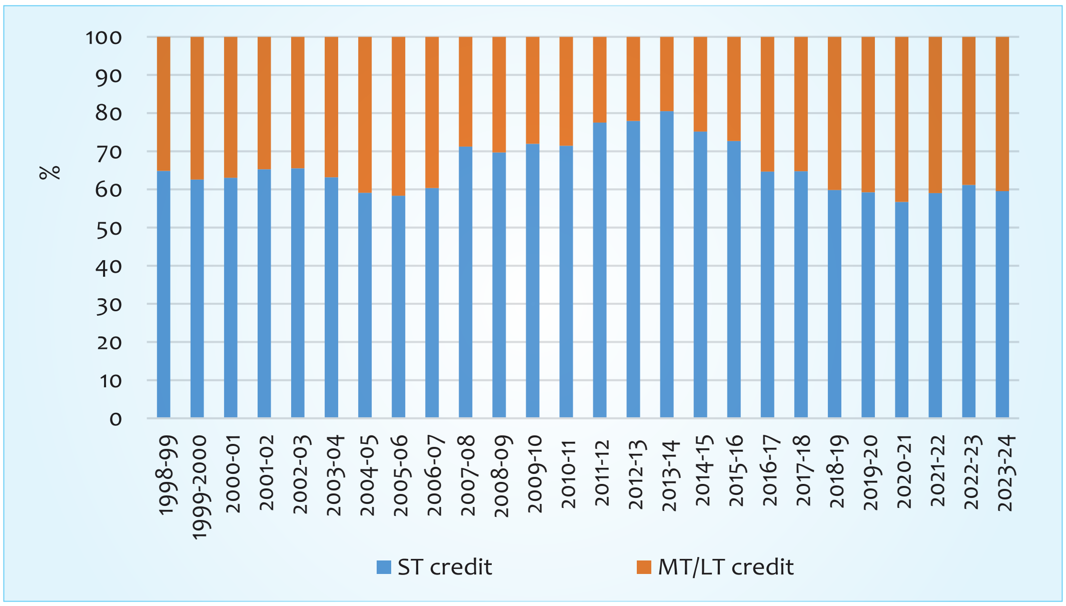


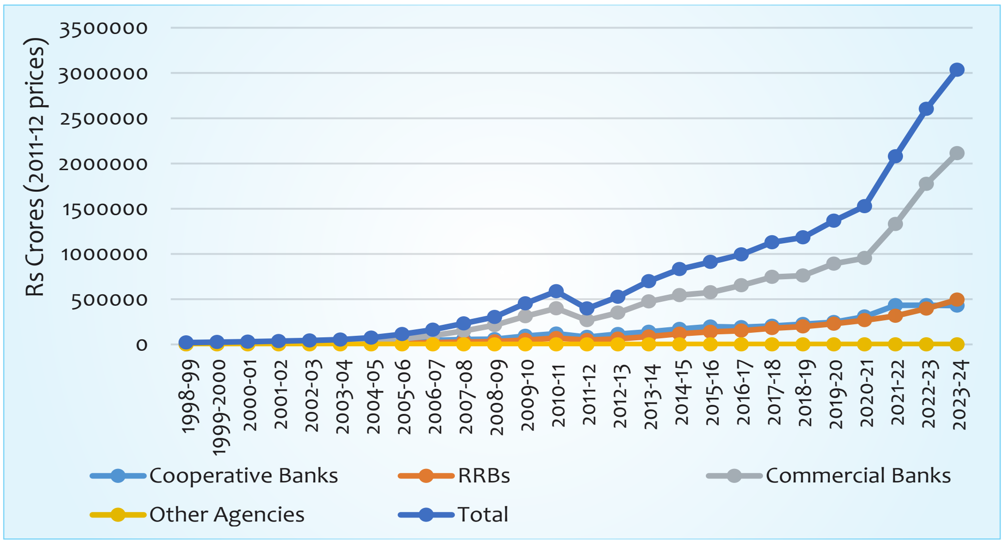
Figure 7.3. Share of ST, MT/LT institutional credit in total agricultural credit



crores in 2023-24 (Figure 7.4). Commercial banks provided a significant portion of short-term institutional credit, followed by cooperative banks and RRBs. Notably, the proportion of production credit advances by commercial banks to the agricultural sector has steadily increased from 44% in 2001-02 to approximately 69.61% in 2023-24. Conversely, the share of short-term credit flow through RRBs increased from about 9% in 2001 to 16% in 2023-24, while the share of cooperative banks has markedly declined from approximately 46% in 2001 to 14% in 2023-24. Aligned with the overall pattern of production credit flow, medium-term/long-term (MT/LT) credit also exhibited positive growth from 2001 to 2023 (Figure 7.5). Commercial banks predominantly contributed to MT/LT credit flow to the agricultural sector, accounting for over 90% of MT/LT credit, followed by RRBs at 5.6%, and cooperative banks at 1.64% as of 2023-24 (Figure 7.6). Additionally, the trends in institutional credit flow per ha of net sown area are illustrated in Figure 7.7.

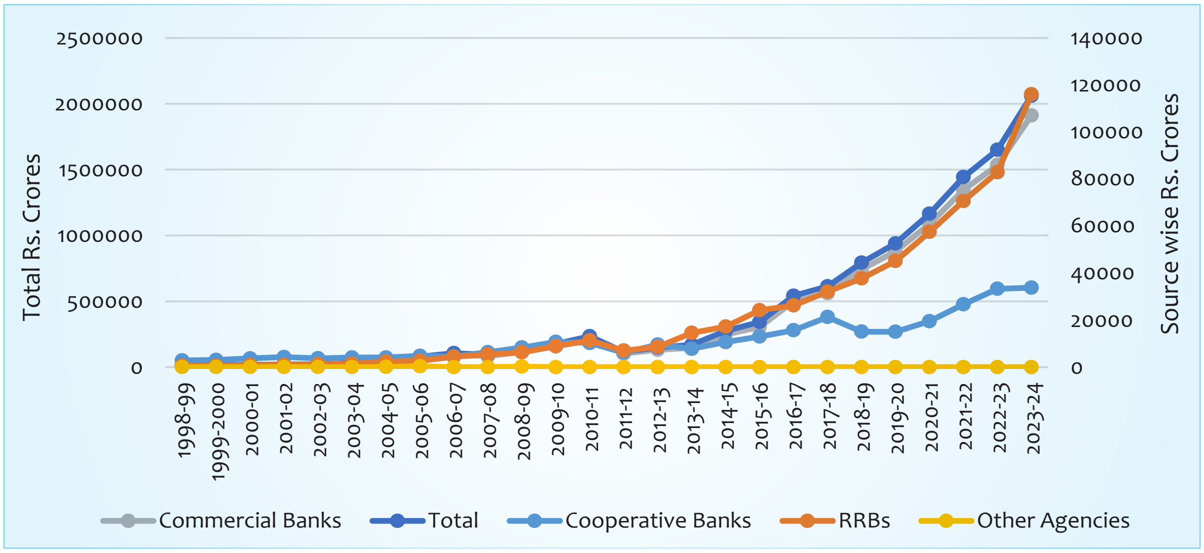
The total outstanding loan amount advanced through SCBs to the agricultural sector and their shares are presented in Table 7.1 and Table

Figure 7.4. Flow of production or short-term institutional credit to agriculture sector



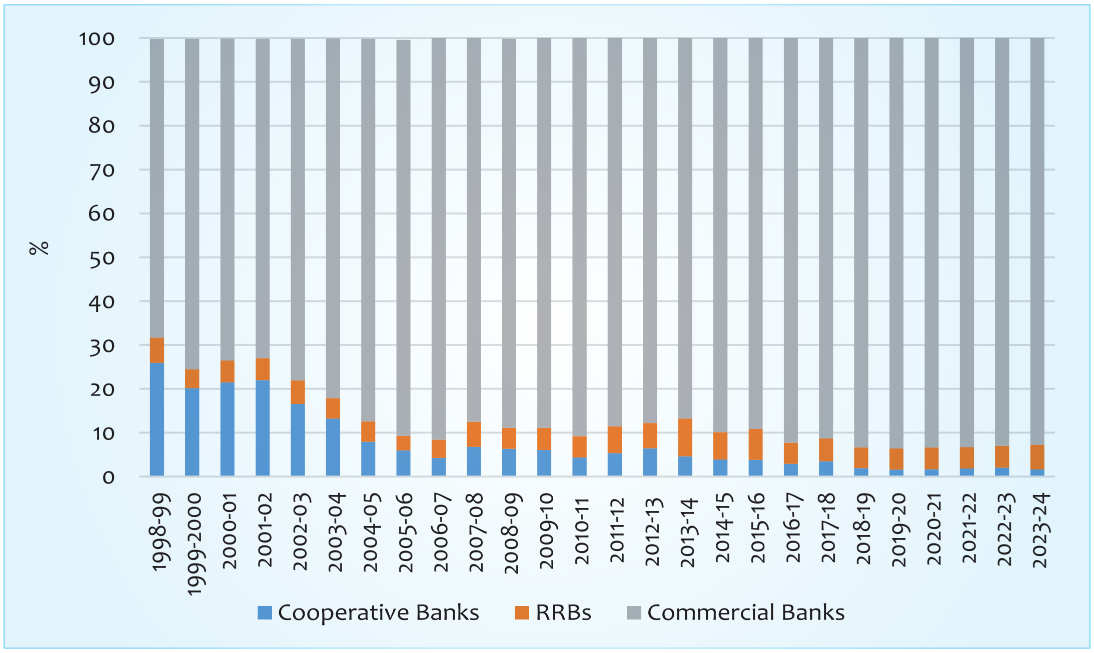
Source: Directorate of Economics and Statistics (DES), Government of India

Figure 7.5. Flow of Medium Term (MT)/Long Term (LT) institutional credit to agriculture sector



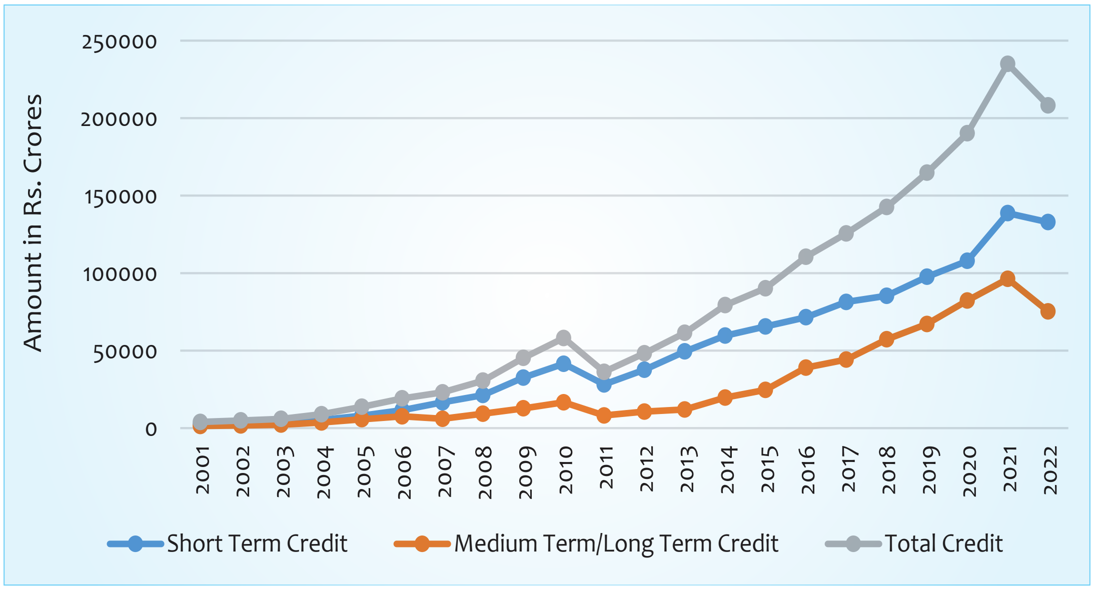
Source: Directorate of Economics and Statistics (DES), Government of India

Figure 7.6. Share of different financial institutions in the flow of MT/LT credit to agriculture sector



Source: Directorate of Economics and Statistics (DES), Government of India

Figure 7.7. Flow of institutional credit per hectare of net sown area



Source: Directorate of Economics and Statistics (DES), Government of India

7.2. The flow of institutional credit increased significantly over the years. In addition, while the share of commercial banks has been increasing, the share of RRBs has been almost stagnant at around 10% since 2020-21, while the share of cooperative banks has been declining.

Table 7.1. Flow of institutional credit to agriculture and allied activities (Outstanding loan amount in Crores at 2011-12 prices)

Year	Co-operatives	Scheduled Commercial Banks	Regional Rural Banks	Total
1981-82	882	648	50	1580
1991-92	5625	7845	917	14388
2001-02	46899	40595	7457	94952
2002-03	55343	50414	9615	115372
2003-04	68904	65719	11311	145935
2004-05	78822	95519	16709	191050
2005-06	88337	145502	23080	256918
2006-07	104469	197413	32064	333946
2007-08	83855	258970	42417	385243
2008-09	92097	368299	53734	514130
2009-10	97997	517000	75856	690853
2010-11	140927	657239	101213	899379
2011-12	92458	443298	70385	606141
2012-13	133070	580473	88325	801868
2013-14	164864	613806	119714	898383
2014-15	201807	894631	147286	1243725
2015-16	213730	1115517	182626	1511873
2016-17	326672	962745	221072	1510489
2017-18	276410	1385202	256780	1918392
2018-19	280926	1563324	310166	2154416
2019-20	309919	1676280	345518	2331716
2020-21	340872	3148026	401249	3890147
2021-22	410014	3601732	457255	4469001
2022-23	466460	4338556	529439	5334455
2023-24	451152	4703882	543728	5698762

Source: Authors' estimates based on data from the Reserve Bank of India, Basic Statistical Returns of Scheduled Commercial Banks in India (for various years).

Note: Agriculture and allied GDP deflator was used[3].

Scheduled commercial banks play a pivotal role in addressing the agricultural sector's institutional credit requirements. An examination of the SCB accounts associated with agriculture relative to the total number of bank accounts reveals that from 2001-02 to 2021-22, the share of agricultural bank accounts fluctuated between 10% and 14%. In contrast, the proportion of agricultural

[1] For the years 2021 and 2022, the GDP deflator was adjusted using the average difference in the deflator value of the previous two years.

Table 7.2. Share of different agencies in institutional credit provided for agriculture and allied activities (%)

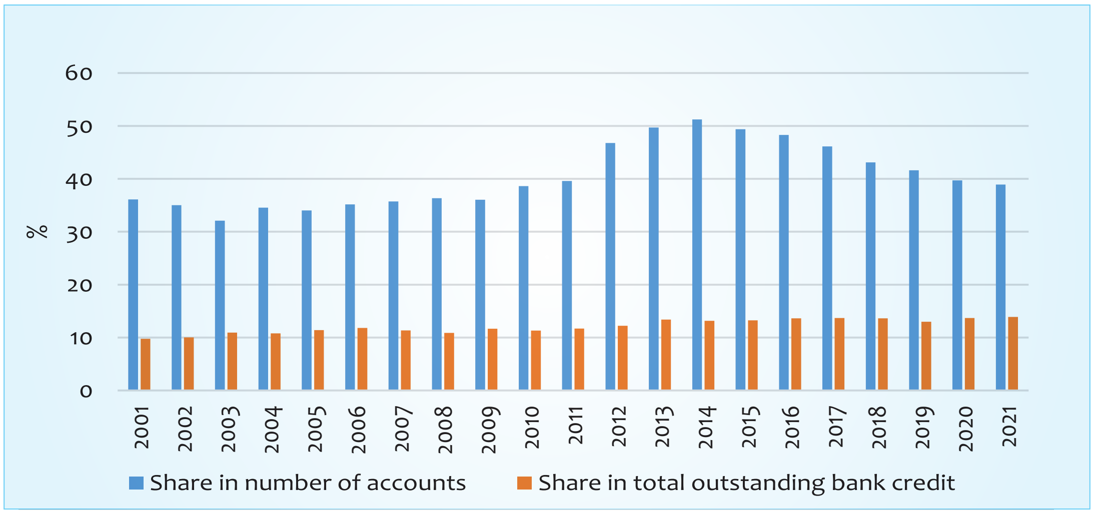
Year	Co-operatives	Scheduled Commercial Banks	Regional Rural Banks
1981-82	55.83	41.01	3.16
1986-87	41.75	52.32	5.93
1991-92	39.10	54.53	6.37
1996-97	40.37	51.70	7.93
2001-02	49.39	42.75	7.85
2006-07	31.28	59.12	9.60
2011-12	15.25	73.13	11.61
2016-17	21.63	63.74	14.64
2021-22	9.17	80.59	10.23
2022-23	8.74	81.33	9.92
2023-24	7.92	82.54	9.54

credit in total bank credit was approximately 39 % in the year 2021-22 (Figure 7.8). The total number of SCB accounts linked to agriculture has exhibited consistent positive growth over the past two decades (Figure 7.9). As of 2021-22, there were 124.83 million agriculture-linked SCB accounts, with approximately 93%, or 116.70 million, associated with direct finance, and 8.13 million accounts related to indirect finance. The outstanding loan amounts were 26.71 lakh crore and 3.32 lakh crore, respectively. The total agricultural loan outstanding, advanced through SCBs in the form of direct and indirect finance, amounted to 30.03 lakh crore in 2021-22 (Figure 7.10).

7.3 State-Wise Credit Flow through the Scheduled Commercial Banks

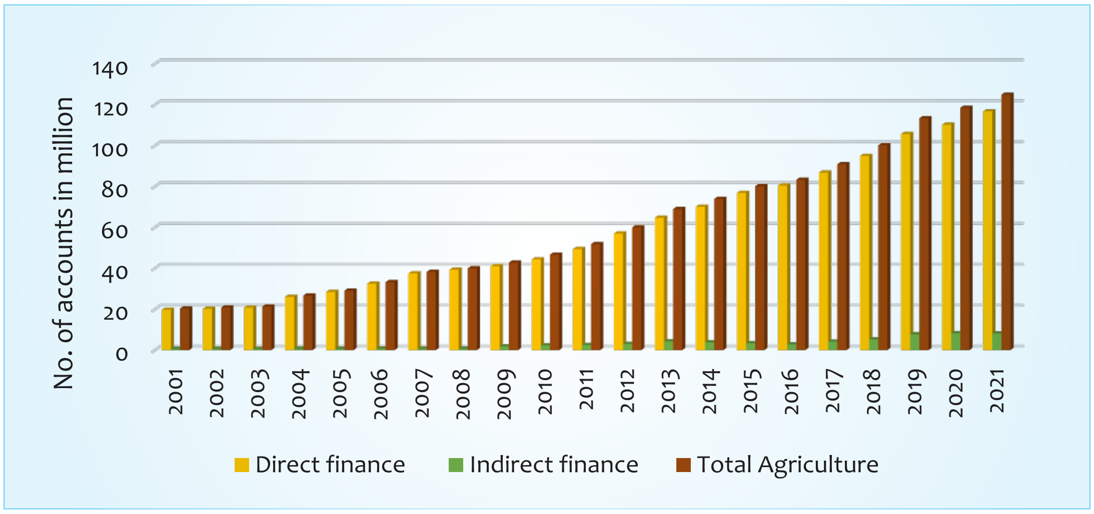
The outstanding amount of credit across the different states estimated per ha of net sown area is provided in Table 7.3. Following the trends in the overall flow of institutional credit to the agriculture sector through the SCBs, we observe that per ha outstanding amount from credit advanced through the SCBs has increased during the period 2001-02 to 2021-22, the latest estimate being Rs. 1,21, 520 per ha of NSA at the national level for the year 2021-22. Across the different regions,

Figure 7.8. Share of agricultural accounts and outstanding credit in total number of bank accounts and total bank credit.



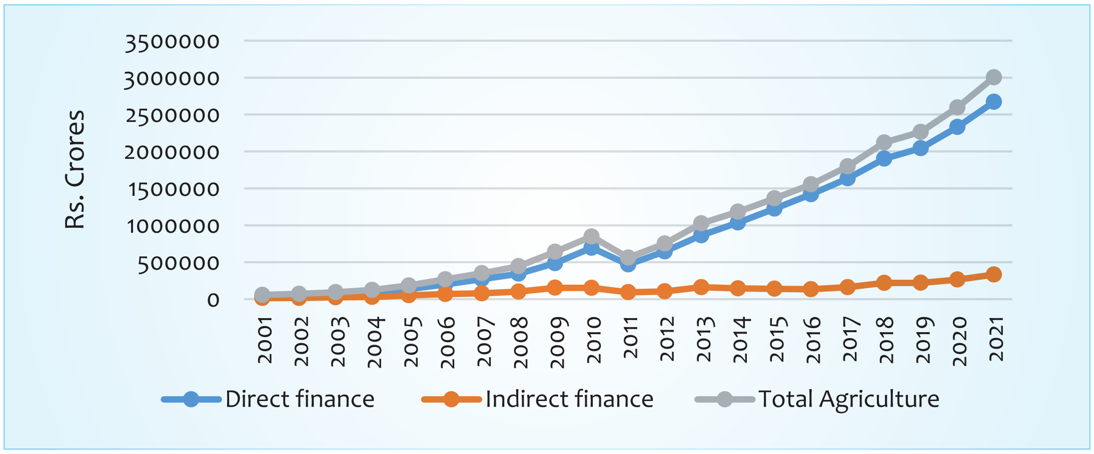
Source: Reserve Bank of India, Basic Statistical Returns of Scheduled Commercial Banks in India (various years).

Figure 7.9. Number of direct and indirect finance accounts in SCBs related to agriculture



Source: Reserve Bank of India, Basic Statistical Returns of Scheduled Commercial Banks in India (various years)

Figure 7.10. Outstanding credit of SCBs to agriculture sector



Source: Reserve Bank of India, Basic Statistical Returns of Scheduled Commercial Banks in India (various years) states of the Southern region showed the highest outstanding amount at Rs. 459841 per ha of NSA, followed by the Eastern region (Rs. 175266 per ha), Northern region (Rs. 149429 per ha), Western region (Rs. 100096 per ha), North-Eastern region (Rs. 76145 per ha), and Central region (Rs. 55755 per ha) during the year 2021-22. States reporting the highest outstanding amount during the same period were Tamil Nadu (Rs. 947357 per ha), Kerala (Rs. 635232 per ha), Andhra Pradesh (Rs. 526220 per ha), Telangana (Rs. 343967 per ha), Punjab (Rs. 261062 per ha), Haryana (Rs. 239447 per ha) and Bihar (Rs. 214767 per ha).

7.4 State Wise Progress of Kisan Credit Scheme

Kisan Credit Card is an ambitious scheme to provide institutional credit to agricultural sector. An examination of the progress of this scheme shows that the Central region states again fared well in terms of the number of KCC issued (1.97 crore), followed by the Southern region (1.58 crore), Eastern region (1.06 crore), and Northern region (1.05 crore) (Table 7.4). According to the estimates of the outstanding credit amount per KCC, Tamil Nadu reported the highest amount at Rs. 947,375 (Table 7.5). Other states with significant outstanding amounts per KCC include Karnataka (Rs. 689,273), Andhra Pradesh (Rs. 526,220), Punjab (Rs. 273,065), Haryana (Rs. 239,447), and Bihar (Rs. 214,767). Clearly, the Southern and Northern regions dominate in terms of the number of cards issued and the outstanding credit amount. Furthermore, in Tables 7.6, 7.7, and 7.8, we present the agency wise number of KCC issued, amount of outstanding, as well as outstanding amount per KCC across the regions for the latest year, that is, 2022. Cooperative and commercial banks play a major role in the outreach of the KCC. However, in the North-Eastern states, RRBs appear to be active in the outreach of the KCC. The share of the total number of KCC issued was highest in the Southern and Central regions at approximately 26 % each, followed by the northern region at 17%.

The Southern states accounted for 28.31% of the outstanding amount against the KCCs, compared to 20.50% in the Central region and 24.20% in the Northern region. The lowest share of outstanding amounts against KCCs was observed for states in the Eastern (7.70%), Western (15.23%), and North-Eastern regions (0.68%). At Rs. 63,029 and Rs. 62,148 of outstanding amount per KCC, respectively the North-Eastern and Eastern states reported the lowest outstanding amount.

7.5 Conclusions

Institutional credit to the agricultural sector has grown substantially over the past two decades, reflecting deeper formal financial engagement in farming. Particularly, medium- and long-term (MT/LT) credit expanded more rapidly than short-term production credit during 2011–2020, signaling a shift toward financing agricultural infrastructure, mechanization, and allied activities. Commercial banks have become the dominant lenders to agriculture, replacing cooperative banks, whose role has steadily declined. This is evident in the sharp rise in agricultural loan accounts with Scheduled Commercial Banks (SCBs). Direct finance to farmers comprises the bulk of SCB lending, while indirect finance—though smaller in share—has shown consistent growth, indicating expanding support for agri-service providers, input dealers, and infrastructure investments.

Despite this overall progress, regional disparities persist. The southern and northern regions lead in outstanding agricultural loans via SCBs, followed by the western and eastern regions. In contrast, the central and northeastern regions report lower credit access and coverage. A similar pattern emerges in the performance of the Kisan Credit Card (KCC) scheme. Southern and northern states show stronger coverage and higher outstanding credit through KCCs. However, implementation remains weak in the eastern and northeastern states, highlighting the need for focused efforts to improve KCC outreach and ensure equitable access to institutional credit across all agricultural regions.

Table 7.3. State wise estimates of outstanding amount by the Scheduled Commercial Banks to agriculture (Rs. /ha of Net Sown Area as on March end):

Region/Year	2001	2006	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Northern Region	3272	13182	37167	41111	41629	55331	73400	76055	83201	107341	110572	114951	134118	149429
Haryana	5919	23061	84212	83072	77875	108072	136010	141479	142969	176030	192141	205762	211801	239447
Himachal Pradesh	4252	23639	47538	61954	54653	69971	97427	99238	129404	144778	165727	144168	227639	197414
Jammu and Kashmir	2076	12424	19200	30046	40770	74105	142320	80157	123903	153313	165298	195277	256039	261062
Punjab	7488	29861	97341	95379	88320	123897	165809	178645	186425	215987	227944	239208	235524	273065
Rajasthan	1660	6620	14921	20319	22889	28478	35362	38846	45142	65763	62989	64568	87451	97556
North-Eastern Region	1020	4638	12076	14777	14600	20370	24048	34198	41537	48369	54095	63705	64281	76145
Arunachal Pradesh		3818	6893	4062	4214	4989	10524	6709	16400	25279	12268	16609	16647	14622
Assam	1103	4259	14272	16947	15874	23514	29147	38570	46283	53298	56234	68088	71507	76759
Manipur	0	4402	8379	10323	8389	10691	9099	14876	17709	9422	18231	31436	24024	56847
Meghalaya	0	8524	8565	11872	8825	24546	17516	38940	32796	39241	65996	34826	35234	44920
Mizoram	0	9670	14557	25393	26899	26639	32154	28743	30894	46009	48321	50080	57315	72747
Nagaland	0	2825	2756	6196	9128	4993	6095	6819	10714	11932	12315	11044	12137	27775
Tripura	2834	6858	13203	18231	25929	28928	31637	83404	117679	150147	185903	218136	208605	242524
Eastern Region	2693	9686	34683	33938	31553	56217	58423	75304	69668	90187	110534	122323	148675	175266
Bihar	2115	9504	27983	31760	34209	69823	68535	75659	80511	94057	125626	145894	176050	214767
Jharkhand	2501	5603	25835	28858	29312	45605	52097	80704	53667	72735	123605	120874	132813	158198
Odisha	1427	6166	31437	28135	20873	41364	45534	77510	51974	90724	82053	81685	117657	150687
Sikkim					12409	14715	15975	17726	17000	18311	29084	35698	46049	106657
West Bengal	17291	14992	47272	42828	38773	58726	61513	72817	77642	91810	115232	132759	152508	162094
Central Region	940	3574	11387	10738	10660	17231	22754	25312	27166	33663	39992	42973	51349	55755
Chhattisgarh	783	3677	18393	17044	20611	20510	26876	30177	26733	37795	36068	52203	48807	53171
Madhya Pradesh	1575	4934	18398	14303	14846	29449	40348	48773	42689	71309	85987	81348	106492	129946
Uttar Pradesh	3161	13190	38669	39264	37074	58344	75690	80848	96652	102950	120766	138245	159800	158909
Uttarakhand	4102	16641	69996	66072	67238	113457	115473	138170	139634	149782	177988	186900	207686	267578
Western Region	2826	11396	24844	28118	37155	33753	54560	61306	58015	74004	106131	73867	93998	100096
Goa		16904	51564	30747	52823	76312	73402	72337	76730	91640	110580	133531	178089	202151
Region/Year	2001	2006	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Gujarat	2809	11665	24877	30645	38921	26378	45069	56889	57448	67624	103958	79909	116309	125802
Maharashtra	2858	11201	24623	26600	36006	37731	59682	63732	58202	77593	107310	69879	80199	84256
Southern Region	6119	25945	92466	106083	111453	121910	158477	208298	236615	223768	317011	285717	368272	459841
Andhra Pradesh	5637	21733	84056	102246	85754	185145	223566	178468	193192	228202	340847	309934	458216	526220
Karnataka	5396	20906	37272	53171	60180	78784	93935	142587	151470	131080	176298	152151	169420	229024
Kerala	8240	41482	173821	165890	174971	202494	305348	339182	297942	399604	517278	541919	553619	635232
Tamil Nadu	7454	37654	193229	191624	254070	215488	286546	346790	572162	390100	597144	620549	803541	947357
Telangana								179684	129125	167022	236861	129644	229671	343967
All India	1911	7830	25235	27961	29643	35029	45744	55720	59857	65848	86974	80537	102123	121520

Source: Reserve Bank of India, Basic Statistical Returns of Scheduled Commercial Banks in India (various years) Note: '- 'estimates not available. Estimates at 2011-12 prices. State agriculture GDP was used. May not match All-India level totals as only major states are presented.

Table 7.4. State-wise number of KCCs (Number in thousands)

State/region	2006	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Northern Region	825	525	595	9763	10733	1283	1122	1586	15056	10820	17348	10814	10924	10549
Haryana	254	111	155	2348	2492	148	191	200	2588	2101	3641	2117	2114	2107
Himachal Pradesh	35	29	26	325	503	57	63	57	432	416	772	336	346	357
Jammu and Kashmir	9	5	6	78	93	16	14	225	69	265	710	346	376	394
Punjab	179	114	121	2230	2398	213	214	282	2747	1861	3812	1981	1962	1957
Rajasthan	347	265	277	4757	5220	843	633	749	6923	6172	8381	6018	6118	5727
North-Eastern Region	103	80	79	732	889	165	395	322	1480	1591	2898	1199	1327	1267
Arunachal Pradesh	2	1	2	19	23	2	7	4	32	14	37	12	13	12
Assam	65	34	48	463	568	117	251	221	991	1074	1826	789	871	840
Manipur	6	15	2	40	44	2	3	6	37	26	50	22	24	24
Meghalaya	10	12	8	68	79	4	25	22	105	102	155	92	90	88
Mizoram	4	4	5	23	26	4	6	7	31	33	101	20	25	21
Nagaland	4	4	2	22	28	3	11	9	39	35	72	38	33	31
Tripura	11	10	13	97	121	32	92	53	245	306	657	226	271	238
Eastern Region	1312	1012	1173	12177	13989	1743	2429	2157	15016	13992	24823	12211	10803	10690
Bihar	209	279	239	3128	3805	567	584	615	4297	3653	6824	3247	2824	2883
Jharkhand	127	201	84	992	1168	155	222	331	1135	1108	1908	1029	989	996
Odisha	494	349	462	4934	5553	571	1008	488	5218	5717	7895	4736	4109	3940
Sikkim	2	1	1	9	11	1	2	3	17	12	36	13	13	13
West Bengal	480	182	386	3108	3445	449	611	719	4339	3495	8149	3192	2876	2866
Central Region	2129	1939	2016	22607	25221	2320	3223	3140	23910	21411	41275	22226	21826	19754
Chhattisgarh	239	176	139	1430	1663	272	303	282	9	2392	786	1844	1396	1396
Madhya Pradesh	498	374	403	5151	5777	627	841	725	7465	7159	9201	7559	7918	6733
Uttar Pradesh	1333	1358	1426	15423	17113	1348	1943	2027	15611	11222	29306	12035	11960	11144
Uttarakhand	60	32	47	603	668	73	136	106	824	638	1982	788	552	482
Western Region	1020	1305	1028	10740	11716	971	1311	1499	12759	10196	14794	9788	8723	8225
Goa	3	1	1	15	17	2	2	4	21	5	21	10	9	10
Gujarat	239	217	145	2801	2997	243	363	422	3624	2729	4353	2770	2457	2420
Maharashtra	778	1088	881	7919	8697	726	946	1072	9108	7461	10417	7007	6256	5795
Southern Region	2624	2608	2409	28463	31125	3686	3280	4278	32872	16085	49323	11157	11338	15837
Andhra Pradesh	1346	1378	1215	14432	15582	1898	1414	2325	16687	8167	14568	4114	4263	4543
Karnataka	505	387	371	5041	5665	650	629	560	6226	4127	9477	4178	4060	3992
Kerala	240	318	353	3124	3466	301	342	366	2726	1249	5235	1276	1088	1296
Tamil Nadu	528	518	467	5809	6156	828	881	1008	6956	2514	9937	2121	2340	2065
Puducherry	5	7	5	56	67	10	13	18	89	26	134	23	12	12
Telangana											9969	3559	3838	3930
All India	8012	7470	7299	84482	93861	10169	11760	12982	101282	74094	150461	67395	64941	66323

Note: Data as on March 2022. Source: Directorate of Economics and Statistics and Reserve Bank of India

Table 7.5. State average wise amount of outstanding per KCC in real terms (Rs. /KCC)

Year/region	2005-06	2010-11	2011-12	2012-13	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Northern	77605	172351	190753	197570	189213	91457	212848	14259	246051	249428	255758	266410
Haryana	109792	253229	222905	256692	194008	118324	211432	12925	281606	302652	298796	330425
Himachal Pradesh	80163	117981	139080	145407	108553	50183	189422	13550	221601	192153	294171	238085
Jammu and Kashmir	23199	67210	90059	51547	246070	55735	197025	18309	205655	213109	134606	133552
Punjab	77077	149252	155126	153325	108485	83833	137385	12527	184807	199051	187304	241696
Rajasthan	97795	274082	346594	380877	288948	149210	328978	13983	336587	340174	363915	388291
North-eastern	12875	47113	36261	42322	84542	26140	79578	13964	88904	85607	85746	119902
Arunachal Pradesh	6366	66313	24952	43855	60812	31945	110975	14719	117774	105316	1366	120719
Assam	12333	53302	37009	35789	47449	27697	64001	12841	69101	73972	62545	93264
Manipur	11589	64122	41866	57614	60681	43066	105784	8406	99832	105846	34859	136963
Meghalaya	13415	61611	31580	38230	299631	21057	55256	12401	74030	76028	184724	93892
Mizoram	13833	36590	61579	59237	56269	20869	126663	16644	117561	111752	185670	187360
Nagaland	16351	26620	42695	40058	49482	29072	61457	15304	94122	85292	87614	156155
Tripura	16234	21233	14148	21473	17472	9273	32908	17437	49910	41042	43443	50961
Eastern	24682	63129	40618	45446	40005	26564	53978	15251	73751	86083	90377	109397
Bihar	31858	70004	70694	54135	60907	31280	75807	13850	107043	115353	112340	132501
Jharkhand	20000	43274	31020	26004	34078	30606	44746	14585	88735	78944	82402	89954
Orissa	38704	37103	21954	35166	26591	31043	38354	19471	71926	71876	91335	106674
Sikkim	18410	99135	36169	59390	39498	23001	60573	14136	41822	98126	101960	141489
West Bengal	14441	66127	43255	52533	38953	16891	50408	14211	59230	66118	63848	76369
Central	37727	103262	75838	87642	72904	60737	85518	14842	133157	145555	165396	182091
Chhattisgarh	11351	44288	46319	50707	31324	91204	37218	16912	69756	60775	81130	94272
Madhya Pradesh	57713	120766	81003	99164	81659	71238	80200	16437	168922	193643	224484	252518
Uttar Pradesh	42958	105840	88484	72329	86735	33175	107027	13723	137556	164376	171885	173163
Uttaranchal	38887	142153	87546	128369	91899	47330	117627	12296	156392	163427	184086	208412
Western	90328	91331	98027	146029	151935	57328	174994	14267	241270	180278	185606	240435
Goa	95428	85850	101467	155886	247944	31154	285301	16905	330627	212686	160572	282474
Gujrat	122840	119673	111728	166831	124871	85625	154299	11715	272420	233216	291125	326228
Maharashtra	52715	68469	80886	115370	82991	55204	85381	14182	120764	94931	105121	112603
Southern	49054	109596	128894	122549	106526	190952	32707	118447	163856	154741	183268	296855
Andhra Pradesh	30923	70317	89348	64929	78495	28388	117678	13019	160492	146920	194275	215732
Karnataka	126402	91533	111178	160125	119510	187316	16190	133254	109639	151087	153000	689273
Kerala	32262	136754	121208	124027	110721	167935	11288	136865	207086	196314	197504	201951
Tamil Nadu	29000	134315	134691	135110	80583	131852	20042	117495	181304	107364	116364	190586
Pondicherry	26683	115062	188045	128557	143319	489230	18123	200536	187403	227749	278789	300874
Telangana						140993	12924	109514	137212	99012	159674	182716

Source: Directorate of Economics and Statistics and Reserve Bank of India Note: Amount in 2011-12 base price series. '-' . Data not available. Data on outstanding amount was not available for 2013-14.

Table 7.6. Region wise progress of KCC: No of active KCC Cards (in 000's) (as on 31st March 2024)

Region	Co-operative Banks		Regional Rural Banks		Commercial Banks		Region Total	Share of regions
	Number	Share	Number	Share	Number	Share		
Northern	5,564	42.65	1,556	11.93	5925	45.42	13045	16.89
North-Eastern	63	6.00	445	42.38	542	51.62	1050	1.36
Western	4,600	44.37	1,264	12.19	4505	43.45	10368	13.42
Central	8,685	43.16	4,519	22.46	6917	34.38	20121	26.05
Southern	8,939	41.56	4,082	18.98	8488	39.46	21509	27.84
Eastern	5,067	45.42	2652	23.77	3438	30.81	11157	14.44
All India	32,917	42.61	14,517	18.79	29814	38.59	77249	100.00

Table 7.7. Region wise progress of KCC: outstanding amount against active KCCs (Rs. crore) (as on 31st March 2024)

Region	Co-operative Banks		Regional Rural Banks		Commercial Banks		Region Total	Share of region in All India
	Amount	Share	Amount	Share	Amount	Share		
Northern Region	37,387	15.76	40101	16.90	159797	67.34	2,37,286	24.20
North-Eastern Region	212	3.20	2350	35.51	4056	61.29	6,618	0.68
Western Region	43,810	29.33	17834	11.94	87715	58.73	1,49,359	15.23
Central Region	36,877	15.35	62662	26.09	140667	58.56	2,40,206	24.50
Southern Region	64,540	23.25	56259	20.27	156799	56.48	2,77,598	28.31
Eastern Region	24,852	35.84	18546	26.75	25940	37.41	69,338	7.07
Total	2,07,678	21.18	197753	20.17	574974	58.65	9,80,404	100.00

Table 7.8. Region wise and source wise outstanding amount per KCC (Rs. /KCC) (as on 31st March 2024)

Region	Co-operative Banks	Regional Rural Banks	Commercial Banks	Total
Northern Region	67,194	2,57,719	2,69,700	1,81,898
North-Eastern Region	33,651	52,809	74,834	63,029
Western Region	95,239	1,41,092	1,94,706	1,44,058
Central Region	42,461	1,38,663	2,03,364	1,19,381
Southern Region	72,200	1,37,822	1,84,730	1,29,061
Eastern Region	49,047	69,932	75,451	62,148
Total	63,091	1,36,222	1,92,854	1,26,915

Source: Estimates based on the data from the Directorate of Economics and Statistics (DES). Note: Amount in nominal terms.

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8

Market Infrastructure and Institutions

Purushottam Sharma, Vinayak R Nikam and Dinesh C Meena

Despite substantial investments, significant disparities persist in market infrastructure across states—particularly in regulated markets, storage facilities, cold chains, and the presence of Farmer Producer Organizations (FPOs) and cooperatives. States like Maharashtra, Uttar Pradesh, Madhya Pradesh, Gujarat, West Bengal, and Rajasthan exhibit relatively better-developed marketing infrastructure, whereas North-Eastern states continue to lag. Cold storage capacity is largely concentrated in West Bengal, Uttar Pradesh, Punjab, and Gujarat, while Maharashtra, Gujarat, and Andhra Pradesh lead in the number of active FPOs and cooperatives. There remains considerable untapped potential for expanding cold storage facilities beyond potatoes to cater to a wider range of agricultural and horticultural produce. Additionally, expanding the coverage of regulated warehouses and enabling them to issue electronically Negotiable Warehouse Receipts (eNWRs) can further strengthen post-harvest management. This chapter underscores the critical importance of bolstering agricultural marketing infrastructure and institutions to improve market access, reduce post-harvest losses, and enhance farmer incomes.

8.1 Introduction

An organized marketing system is essential for the efficient use of scarce resources, promoting sustainable production, food security, inclusive growth, and farmers' welfare. Effective marketing ensures a balance between the affordability and availability of food for consumers and the sustained improvement of farmers' incomes. Furthermore, an efficient price discovery mechanism in the market can stimulate farmers' investments, leading to enhanced productivity and production. Well-structured agricultural marketing infrastructure and institutions enhance farmers' market access and significantly contribute to the monetization of agricultural produce, thereby reducing transaction costs for supply chain participants, including farmers.

Promoting balanced regional development has been a key pillar of India's agricultural strategy, with sustained focus on investments and reforms in agricultural marketing systems. This chapter explores the status of agricultural marketing infrastructure and institutions across different states.

8.2 Infrastructure for Agricultural Marketing

Maharashtra leads in number of regulated markets, both principal markets and sub-yards, followed by Uttar Pradesh, Madhya Pradesh, Karnataka, West Bengal, and Rajasthan (Table 8.1). The states in the North-Eastern region have fewer number of regulated markets. There are no regulated markets in states that do not have the APMC Act in place, for example, Bihar and Kerala, although there are markets in operation. Current coverage by a regulated market ranges from 70 sq. km. in Puducherry to 11,215 sq. km. in Meghalaya with an average of 406 sq. km. (Figure 8.1a). To meet the recommended parameters by the National Commission on Farmers, the country would need approximately 41,000 regulated markets compared to the current 7085. There is also a wide disparity in terms of the net sown area served by each regulated market, from less than 2 thousand hectares (ha) in UTs to 38 thousand ha in Rajasthan and 137 thousand ha in Meghalaya (Figure 8.1b), highlighting the inadequacy of market coverage, particularly in larger states.

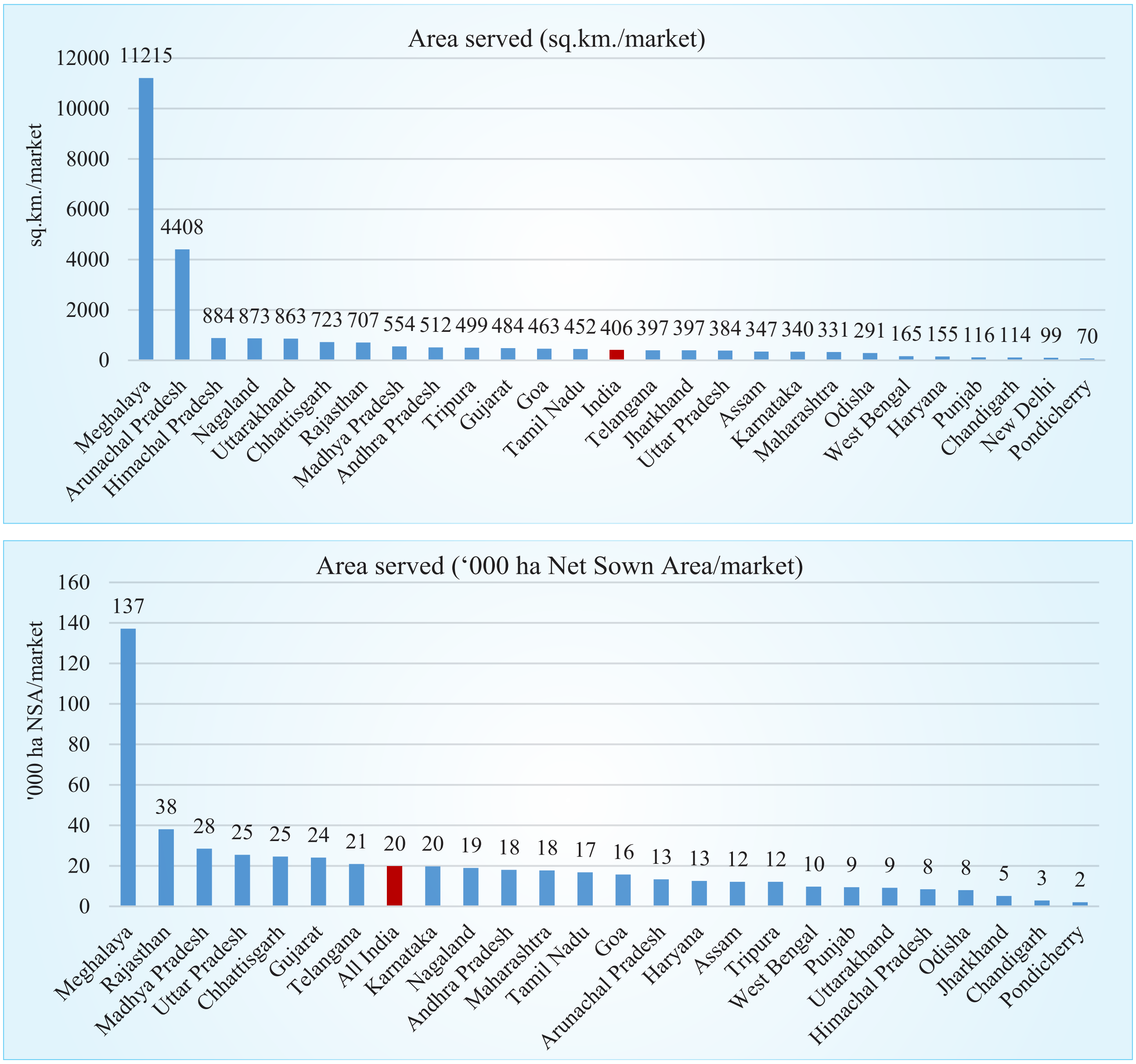
Table 8.1. Status of agricultural marketing infrastructure in India in 2022-23

State	Regulated markets (No.)[1]	Storage capacity (Lakh Tons)[2]	Cold storage capacity ('000 Tons)[2]	Markets integrated with E-NAM[3]	Unified license issued by states[3]
Andhra Pradesh	318	39.24	1703.3	33	3749
A&N Islands	-	0.10	2.2	1	0
Arunachal Pradesh	19	0.42	8.3	-	-
Assam	226	5.41	202.1	3	0
Bihar	No APMC Act	15.04	1475.7	20	0
Chandigarh	1	0.07	12.5	1	0
Chhattisgarh	187	29.94	487.3	20	57
Goa	8	0.19	7.7	7	875
Gujarat	405	8.50	3888.4	144	10140
Haryana	285	83.80	853.3	108	33
Himachal Pradesh	63	0.92	168.5	38	6
J&K, & Ladakh	-	2.26	282853	17	2066
Jharkhand	201	5.66	236.7	19	99
Karnataka	564	9.93	710.0	5	743
Kerala	No APMC Act	8.13	96.4	6	61
Madhya Pradesh	557	199.50	1331.5	139	1079
Maharashtra	929	16.72	1047.7	133	0
Manipur	No APMC Act	0.65	7.8	-	-
Meghalaya	2	0.31	8.2	-	-
Mizoram	No APMC Act	0.32	4.1	-	-
Nagaland	19	1.35	8.2	19	94
New Delhi	15	3.27	129.9	-	-
Odisha	535	11.60	576.7	66	9052
Puducherry	8	0.46	0.1	2	0
Punjab	436	148.51	2451.5	79	1
Rajasthan	484	10.81	631.6	145	84630
Sikkim	No APMC Act	0.23	2.1	-	-
Tamil Nadu	288	27.36	395.9	157	7285
Telangana	282	12.44	411.5	57	6221
Tripura	21	0.48	51.1	7	0
Uttar Pradesh	633	44.85	14876.0	125	39268
Uttarakhand	62	3.50	206.6	20	5807
West Bengal	537	19.26	5948.3	18	46
India	7085	711.59	38224.0	1389	171312

Source: 1. Lok Sabha Unstarred Question No. 588, 2. RBI, 3. Website of e-NAM (as on 31.01.2024).

Agricultural marketing falls under the purview of individual states, making them primarily responsible for investing in infrastructure to ensure market access. However, the revenue generated by the Agricultural Produce Market Committee (APMC) from market fees and licensing fees are rarely reinvested into the development of markets and their infrastructure. Additionally, there exists significant variation in the rates of market fees and commission charges across different states (GoI 2015). To complement state efforts, the central government supports agricultural marketing infrastructure through schemes such as the Integrated Scheme for Agricultural Marketing (ISAM), the Agricultural Infrastructure Fund (AIF), and the *Pradhan Mantri Kisan Sampda Yojna* (PMKSY).

Figure 8.1. Area served per regulated market



Launched in 2016, the e-NAM platform aims to digitally link Agricultural Produce Market Committees (APMC) and other market yards to improve transparency, enable better price discovery, and widen market access for farmer's. As of January 2024, 1,389 markets across 27 states and Union Territories had been integrated into the e-NAM platform, facilitating the trading of 219 commodities. Approximately 83% of these markets have been incorporated into e-NAM in ten states: Tamil Nadu, Rajasthan, Gujarat, Madhya Pradesh, Maharashtra, Uttar Pradesh, Haryana, Punjab, Odisha, and Telangana. A total of 17.705 million farmers have registered on the e-NAM platform for trading purposes, and 3,510 Farmer Producer Organizations (FPOs) have also joined the platform. The majority of these farmers are from Uttar Pradesh, Madhya Pradesh, Haryana, Telangana, Rajasthan, Andhra Pradesh, and Maharashtra. Several states have issued unified licenses to enable trading across state boundaries, with Rajasthan leading in the issuance of such licenses, followed by Uttar Pradesh, Gujarat, and Odisha.

Storage infrastructure is critical for agricultural marketing, offering time utility and reducing post-harvest losses. It helps farmers avoid distress sales. The storage capacity established in the country has expanded to 1086.2 lakh tons, encompassing cover and plinth (CAP) storage capacity managed by the Food Corporation of India (FCI), Central Warehousing Corporation (CWC), State Warehousing Corporations (SWCs), cooperatives, and private enterprises. The majority of this storage capacity has been developed in Madhya Pradesh, Punjab, Uttar Pradesh, Haryana, Maharashtra, Telangana, Rajasthan, Andhra Pradesh, and Karnataka, which collectively account for approximately 80% of the nation's total storage capacity.

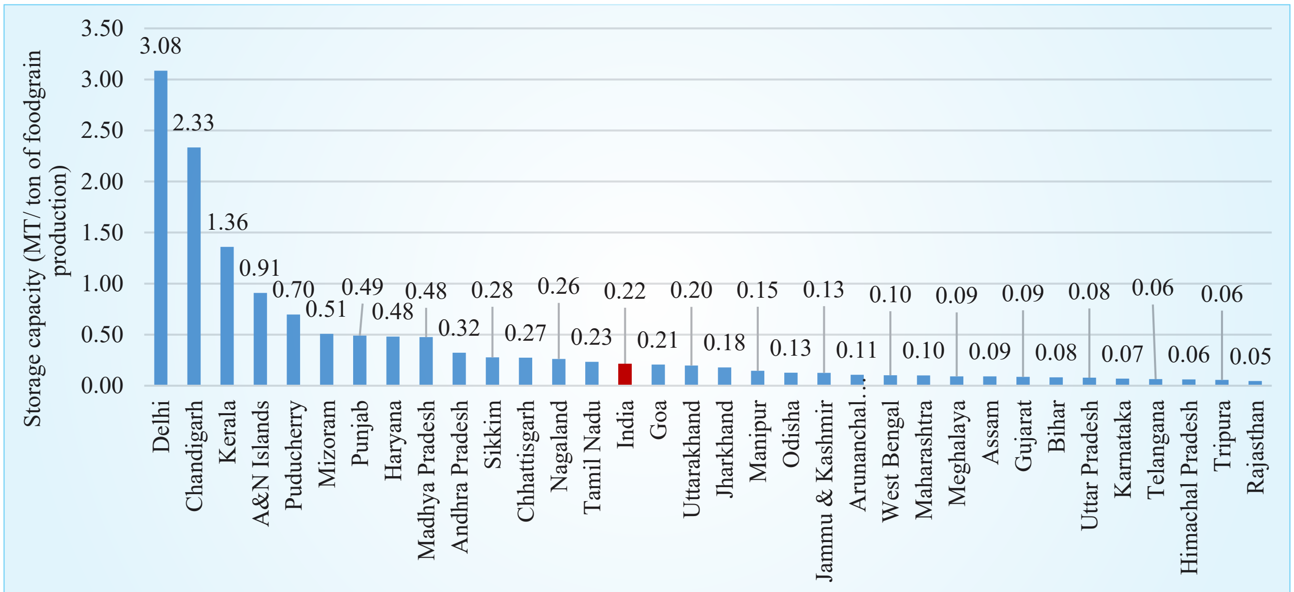
There exists a significant disparity in storage capacity per ton of foodgrain production across various states, with figures ranging from less than 0.1 tons in larger states such as Rajasthan, Uttar Pradesh, Telangana, Karnataka, Bihar, Himachal Pradesh, and Gujarat, to over one ton in regions like Kerala, Chandigarh, and Delhi. As of the 2022-23 period, the national average storage capacity stands at 0.22 tons per ton of foodgrain production (Figure 8.2).

Adequate storage and cold chain infrastructures are essential to minimize post-harvest losses, reducing market glut during harvest, and avoid distress sales. A typical cold chain infrastructure consists of four main components: pack houses, reefer transport, cold storage, and ripening chambers. These components ensure a continuously monitored atmosphere until a product reaches the retail market.

By 2022, India's cold storage capacity had reached 382.24 lakh tons, increase of 244.5 lakh tons since 2009 (Table 8.1). Nevertheless, the distribution of this capacity is uneven, with 83% concentrated in the states of Uttar Pradesh, West Bengal, Gujarat, Punjab, Andhra Pradesh, Bihar, and Madhya Pradesh, predominantly in regions known for potato production. Approximately 68% of the current cold storage capacity is dedicated solely to potato storage, while the remaining 30% accommodates other commodities, including meat and poultry, seafood, dairy products, fruits and vegetables, and pharmaceuticals (GoI 2020).

Figure 8.3 illustrates the significant disparity in cold storage capacity. Specifically, West Bengal possesses 1126 tons of cold storage capacity per thousand hectares of net sown area, followed by Uttar Pradesh with 924 tons, and Punjab with 596 tons, while the North-Eastern states exhibit the lowest capacity (Figure 8.3a). Furthermore, when considering cold storage capacity per ton of

Figure 8.2. Storage capacity per tones of foodgrain and oilseeds production



perishable production, substantial variations are evident among states. This capacity ranges from less than 20 tons in Rajasthan, Tamil Nadu, Kerala, and the northeastern states, to over 100 tons in Delhi, Chandigarh, Uttar Pradesh, West Bengal, and Punjab (Figure 8.3b).

The NCCD (2015) highlighted a significant gap between the availability and the need for cold chain infrastructure in India, especially in pack houses, refrigerated transport, and ripening chambers, with discrepancies ranging from 85% to 99%. Data from the National Horticulture Board's Integrated Cold Chain Availability Platform further reveal uneven distribution of cold chain infrastructure across states (Table 8.2).

Between 2011-12 and 2021-22, a total of 4,256 warehouses were registered with the Warehousing Development and Regulatory Authority (WDRA), with the majority located in Tamil Nadu, Madhya Pradesh, Rajasthan, Gujarat, and Maharashtra. Over 75% of these registered warehouses are operated by private entities and cooperatives. In the fiscal year 2021-22, 42,537 electronic Negotiable Warehouse Receipts (eNWRs) were issued by 425 warehouses, as reported in the WDRA annual report for 2021-22. This data underscores the potential for greater warehouse regulation through WDRA registration, facilitating eNWR issuance and benefitting all stakeholders in the value chain.

Figure 8.3. Cold storage capacity created

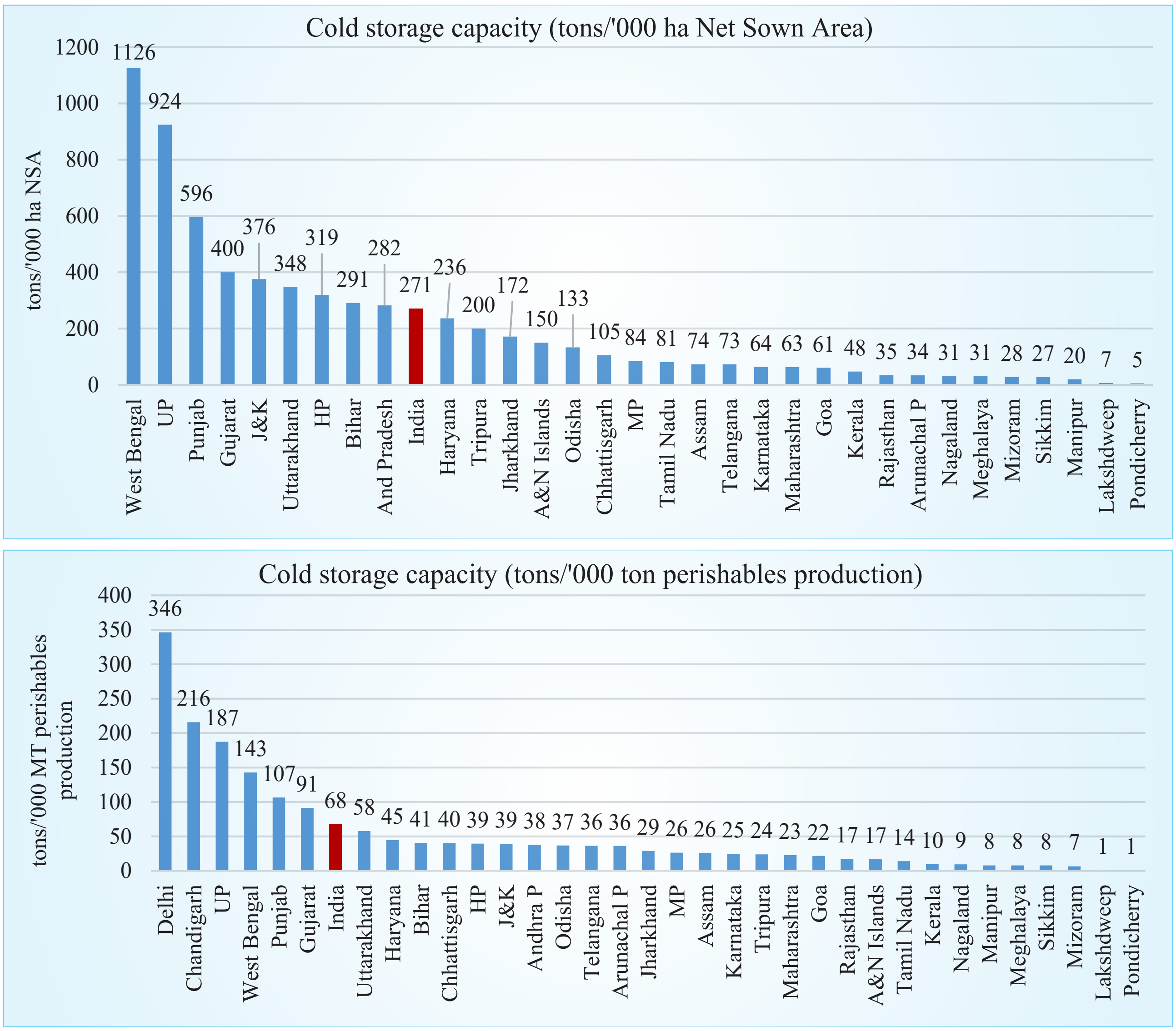


Table 8.2. Cold chain infrastructure

States	Pack house (No)	Collection centre/ grading packing unit		Integrated cold chain	Pre-cooling unit		Ripening chamber		Refrigerated & spl. transport vehicle	
		No.	Capacity (tons)	No.	No.	Capacity (tons)	No.	Capacity (tons)	No.	Capacity (tons)
A&N Islands		1	1.0				37	2333.0	3	36.0
Andhra Pradesh	3	1	100.0						2	6.0
Arunachal Pradesh									2	30.0
Assam	2	1	540.0						2	19.0
Bihar		4	15.0		11	103.0			11	98.0
Chhattisgarh		2	21.0		3	28.0	2	45.6	1	2.0
Delhi									99	859.0
Goa		1	5.0							
Gujarat	2	9	3279.0	4	20	1028.2	54	3180.5	16	63.0
Haryana		5	30.0		1	6.0	11	1536.9	40	542.5
Himachal Pradesh	17	231	215847.3		6	29.0	1	20.4	19	161.0
J&K	5	40	3435.1		6	20.0	1	82.2	50	232.7
Jharkhand					1				1	
Karnataka	3	7	9451.0	4	2	11.0	11	4584.4	47	262.4
Kerala	3	3	9200.0						1	
Madhya Pradesh	2				1	3.0	19	754.3	3	10.0
Maharashtra	17	68	23291.3	1	90	620.9	71	4353.1	42	359.0
Manipur		1	1.0		1	2.0			4	20.0
Mizoram	1	1	2.0		1	1000.0			4	51.0
Nagaland		2	7.0						11	131.0
Odisha	3	1	3.0		10	95.0	4	230.0	31	149.0
Punjab	2	42	290.4		9	117.0	16	1335.4	54	300.0
Rajasthan	4	19	30004.1		6	138.0	27	4345.9	61	324.5
Sikkim	1	10							4	5.0
Tamil Nadu	1	6	9000.5		5	29.0	108	32908.3	4	11.7
Telangana	4	4	46205.0				16	863.6	28	299.7
Uttar Pradesh	2	11	572.0	1	4	25.0	34	2234.9	49	447.0
Uttarakhand		8	30.0		4	8.0	1	60.0	9	43.0
West Bengal	3	3	13.0		6	124.0	2	30.0	14	125.0
Grand Total	75	481	351343.6	10	187	3387.1	415	58898.4	612	4587.6

Note: No. indicates number of projects.

Source: Website of the National Horticulture Board.

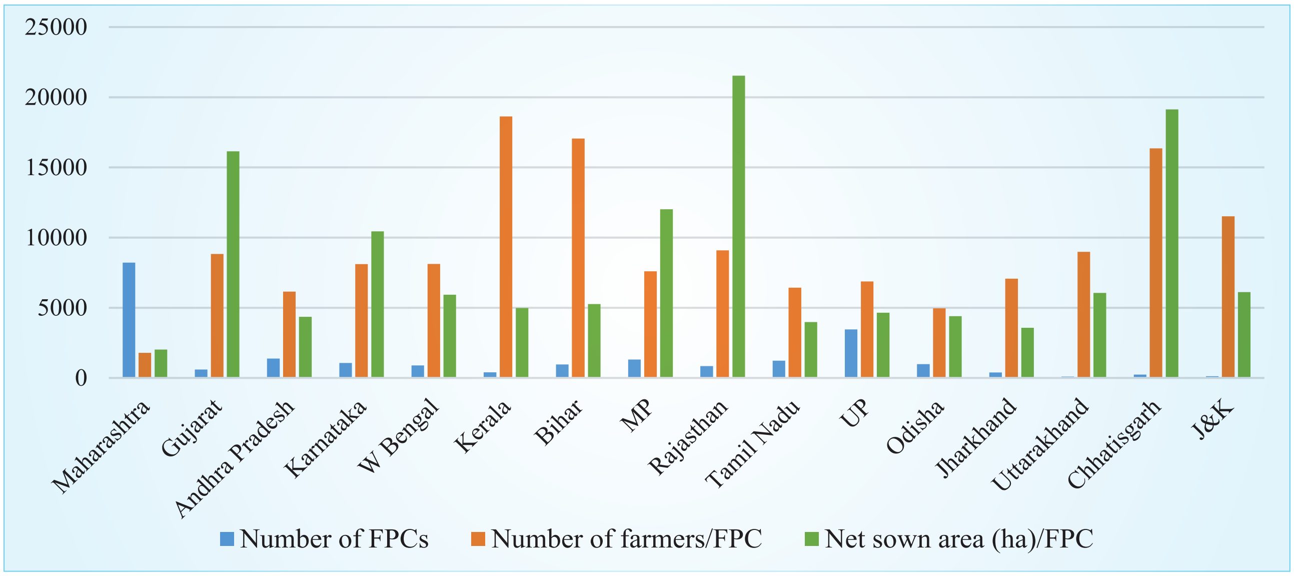
8.3 Institutions for Agricultural Marketing

Farmer producer companies (FPCs)

Introduced by the Government of India in 2003 through an amendment to the Companies Act of 1956, Farmer Producer Companies (FPCs) blend elements of cooperatives and corporations. These entities primarily consist of small and marginal farmers. Currently, over 24,000 FPCs are registered nationwide, engaging in activities like providing inputs, credit, aggregation, procurement, value addition, and marketing.

Maharashtra has the highest number of FPCs, accounting for 34% of the total (figure 8.4). In comparison, Gujarat leads in cooperatives (Table 8.3). The ratio of cooperatives to the number of farmers and net sown area is disproportionately distributed in Kerala, Bihar, Madhya Pradesh, Rajasthan, Chhattisgarh, and Jammu and Kashmir.

Figure 8.4. State-wise distribution of FPCs

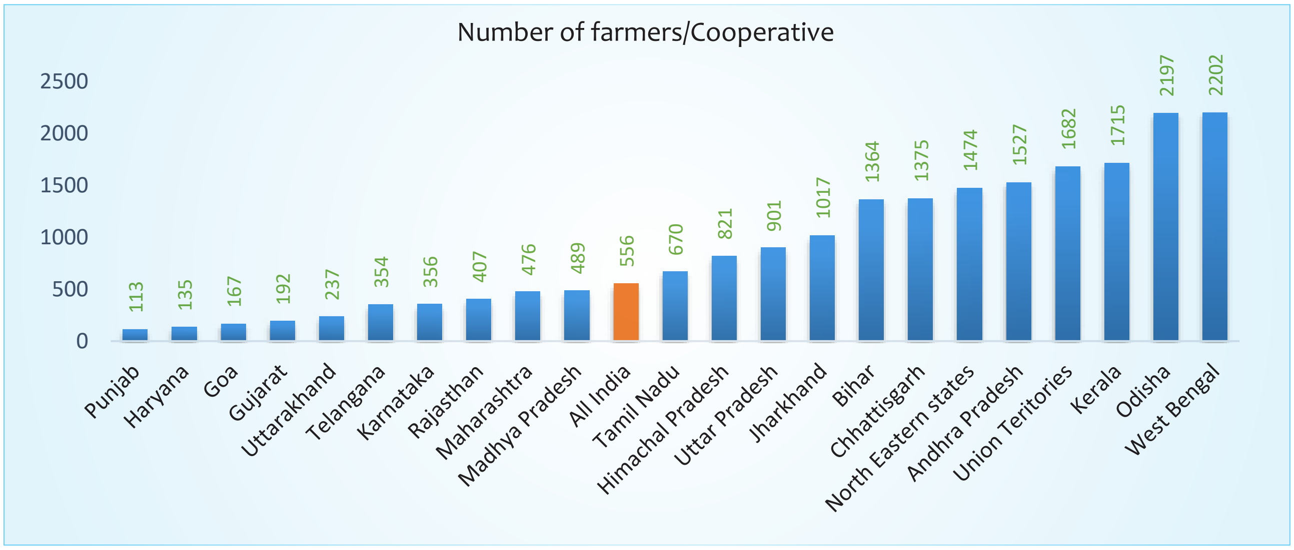


Source: Authors' calculation from data of NAFPO (2023), GoI (2019).

Co-operatives

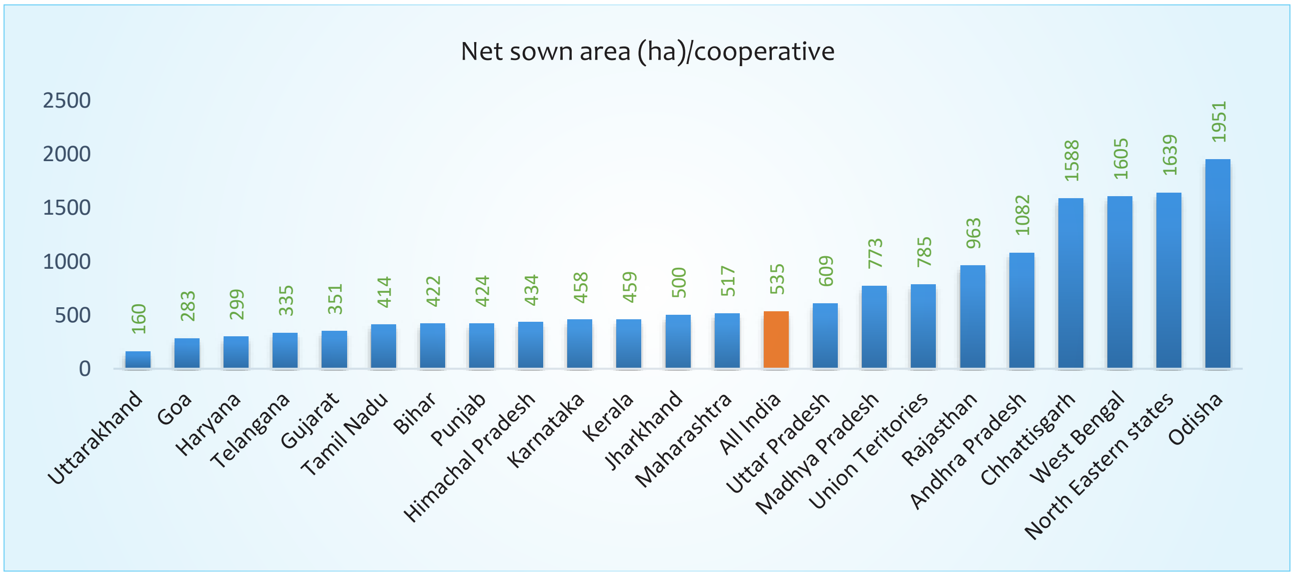
Cooperatives provide a significant opportunity to engage with a large number of people. They encompass a wide range of sectors, including agriculture, dairy, forestry, fisheries, credit and banking, housing, and construction. In the country, there are over eight lakh cooperatives, with approximately 2.63 lakh non-credit cooperatives operating within agriculture and related sectors (GoI 2024). Figure 8.5 illustrates the state-wise distribution of these institutions, detailing the number of farmers and the net sown area per institution. The five leading states—Maharashtra, Gujarat, Uttar Pradesh, Karnataka, and Madhya Pradesh—account for half of the cooperatives associated with agriculture (Table 8.3). Except for Uttar Pradesh, these states exhibit a balanced distribution of cooperatives in relation to the number of farmers and net sown area. In contrast, cooperatives in West Bengal, Odisha, and Kerala serve significantly more farmers and larger net sown areas.

Figure 8.5. State-wise distribution of cooperatives



Note: Cooperatives include non-credit cooperatives working in agriculture and allied sectors.

Source: Authors' calculation from data of GoI (2024), GoI (2019).



Non-credit cooperatives in agricultural sector

Agro-allied/Agro-processing Cooperatives: Gujarat, Maharashtra, and Madhya Pradesh have a significant presence of agro-allied and agro-processing cooperative societies. In contrast, Uttar Pradesh, Madhya Pradesh, and Punjab are notable for their substantial food grain production. Andhra Pradesh, Maharashtra, Uttar Pradesh, Madhya

Table 8.3. State wise distribution of non-credit cooperative societies

	Agriculture & Allied	Agro Processing / Industrial	Dairy	Fishery	Livestock & Poultry	Others
Andhra Pradesh	695	156	812	2135	1627	156
Bihar	1719	1218	7662	514	66	850
Chhattisgarh	54	42	833	1689	1	298
Goa	109	33	185	26	2	93
Gujarat	6644	1408	16344	667	729	1918
Haryana	499	847	7299	131	213	3088
Himachal Pradesh	72	108	488	72	61	414
Jharkhand	895	493	200	769	196	204
Karnataka	418	942	17526	734	878	3892
Kerala	0	0	3432	990	0	0
Madhya Pradesh	3742	1785	10184	2798	96	1870
Maharashtra	3474	5288	13532	3403	654	5757
Odisha	116	33	1045	769	16	236
Punjab	359	1987	7069	8	169	112
Rajasthan	877	1363	15768	175	52	591
Tamil Nadu	18	432	9729	1428	92	155
Telangana	814	236	2102	4985	7974	698
Uttar Pradesh	1274	4030	17959	1105	43	2019
Uttarakhand	196	88	2752	194	174	317
West Bengal	106	142	2145	391	27	479
Union Territories	752	906	1389	239	276	565
North Eastern states	3964	1150	3079	2387	3323	6507
Total	26797	22687	141534	25609	16669	30219

Source: GoI (2024).

Pradesh, and Tamil Nadu are recognized as the leading states in fruit production. Conversely, Uttar Pradesh, West Bengal, Madhya Pradesh, Bihar, and Odisha are prominent in vegetable production. It is imperative to focus on enhancing the number of cooperatives in the agriculture and processing industries in Kerala, Chhattisgarh, West Bengal, and Tamil Nadu.

Dairy Cooperatives: A substantial number of dairy cooperatives are operational in the states of Uttar Pradesh, Gujarat, Karnataka, Maharashtra, and Rajasthan. States like Andhra Pradesh, Bihar, Haryana, Punjab, and Madhya Pradesh are also notable for high milk production.

Livestock/Poultry Cooperatives: A substantial number of livestock and poultry cooperatives are operational in the states of Telangana, Andhra Pradesh, Gujarat, and Maharashtra. In contrast, states such as Bihar, Madhya Pradesh, Rajasthan, Uttar Pradesh, and West Bengal exhibit a significant livestock population, indicating considerable potential for the expansion of cooperatives in these regions. Haryana, Karnataka, and West Bengal also show favorable conditions for poultry cooperatives.

Fishery Cooperatives: Telangana, Maharashtra, Andhra Pradesh, and Madhya Pradesh have a notable presence of fisheries cooperatives. Similarly, states such as Bihar, Gujarat, Karnataka, Odisha, Tamil Nadu, Uttar Pradesh, and West Bengal demonstrate high levels of fish production, suggesting conducive conditions for cooperative initiatives.

8.4 Summing Up

Improving agricultural marketing infrastructure and institutions is essential for improving market access and efficiency, minimizing postharvest losses, and strengthening supply chains. This, in turn, results in increased income for producers and makes production more affordable for consumers. In India, there is a notable disparity in agricultural marketing infrastructure among states. Uttar Pradesh, Maharashtra, Madhya Pradesh, Gujarat, West Bengal, and Rajasthan possess the most advanced marketing infrastructure, whereas the Northern states exhibit significantly poorer infrastructure. Regarding cold storage capacity, West Bengal, Uttar Pradesh, Punjab, and Gujarat account for the largest percentage of the total capacity. Maharashtra, Gujarat, and Andhra Pradesh are leaders in Farmer Producer Companies (FPCs) and cooperatives. This indicates a substantial disparity in the availability of agricultural infrastructure and institutions across the country. Consequently, state-specific policy interventions are necessary to promote agricultural marketing infrastructure and institutions, based on requirements and gap estimations. Targeted investments and scientific planning of especially in expanding cold storage facilities, refrigerated transport, and strengthening Farmer Producer Organizations (FPOs) and cooperatives are critical for an inclusive and resilient agricultural marketing ecosystem.

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9

Livestock and Fisheries

Arathy Ashok and Khem Chand

Livestock and fisheries have emerged as vibrant and dynamic subsectors within the agricultural economy, contributing substantially to national income and rural livelihoods. The livestock sector has witnessed significant expansion, albeit with pronounced inter-state disparities in productivity, infrastructure, and investment. States such as Uttar Pradesh, Rajasthan, Maharashtra, and Madhya Pradesh benefit from well-established dairy cooperative networks, which, if further strengthened, could enhance the efficiency of the dairy value chain. Conversely, the North-Eastern region, where dairy development is constrained, offers greater potential in piggery and egg production. There is an urgent need for targeted investments in strengthening veterinary infrastructure, improving breeding services, ensuring adequate availability of feed and fodder, and reinforcing cooperative institutions to sustain the growth momentum in this sector.

In the fisheries sector, Andhra Pradesh is the largest contributor to total fish production, followed by West Bengal. Despite this, public investment continues to be skewed towards marine fisheries, while inland fish-producing states such as Andhra Pradesh, West Bengal, Odisha, Uttar Pradesh, Bihar, and Chhattisgarh remain underserved. Realizing the potential of the fisheries sector requires focused public investment in inland fisheries development.

9.1 Introduction

The livestock and fisheries subsectors have demonstrated significant growth, becoming increasingly important contributors to the country's economy and rural livelihoods. The livestock's share of agricultural Gross Value Added (GVA) has shown remarkable growth, increasing from 21.79% in 2011-12 to 30.38% in 2022-23, outpacing the crop subsector (GoI 2024). This growth is primarily driven by the milk, which accounts for approximately 66% of the livestock sector's output value. The fisheries sector, while smaller in comparison, has also shown promise, with both inland and marine fish contributing equally to its GVA.

These sectors play a crucial role in advancing India's progress towards Sustainable Development Goals (SDGs), particularly in areas of poverty reduction and zero hunger (Birthal et al. 2023). They are essential for ensuring food and nutritional security, as evidenced by the significant portion of household expenditure being allocated to milk, eggs, meat, and fish. India's global rankings in milk, egg, and fish production further underscore the importance of these subsectors. However, the diversity in livestock and fisheries landscapes across different states necessitates tailored strategies for promoting sectoral development, highlighting the need for state-specific approaches to maximize the potential of these emerging sectors.

9.2 Livestock Sector in India

9.2.1 Contribution of livestock sector to state economy

The analysis of the livestock sector's contribution to Gross Value Added (GVA) at constant prices across various Indian states reveals significant regional variations. Rajasthan has emerged as the leader, where livestock contributed 11.92% to its Gross State Value Added (GSVA) in 2022-23, followed closely by Andhra Pradesh, Punjab, and Haryana. Several other states, including Bihar, Telangana, Madhya Pradesh, Uttar Pradesh, Tamil

Nadu, Jammu & Kashmir, and West Bengal, also derive substantial contributions from exceeding 4% of their respective GSVAs.

When examining the livestock's share in agricultural GVA, Tamil Nadu stood out with the highest contribution, surpassing 50% of the state's agricultural GVA. Other states such as Haryana, Rajasthan, Telangana, Bihar, Punjab, and Jammu & Kashmir also showed significant contributions, with the livestock sector accounting for over 30% of their agricultural GVA. The period from 2011-12 to 2022-23 witnessed notable growth in livestock's contribution, particularly in Tamil Nadu, Bihar, Rajasthan, Haryana, Karnataka, and Punjab. In these states, the livestock role has become increasingly comparable to that of the crops, indicating a shift in the agricultural landscape and highlighting the growing economic significance of livestock-related activities in rural economy.

Table 9.1. Contribution of livestock sector towards GSVA

S No.	States/ Union Territories	% share of livestock sector GVA out of agricultural GVA		% share of livestock sector GVA out of total GVA	
		2011-12	2022-23	2011-12	2022-23
1	A&N Islands	22.86	20.04	3.38	2.23
2	Andhra Pradesh	29.35	28.52	7.89	8.76
3	Arunachal Pradesh	6.51	11.70	2.73	2.76
4	Assam	5.59	12.74	1.18	2.02
5	Bihar	19.38	37.27	4.98	6.40
6	Chandigarh	86.1	81.70	0.58	0.40
7	Chhattisgarh	8.44	10.29	1.53	1.62
8	Delhi	76.27	84.11	0.72	0.22
9	Goa	11.52	10.60	0.60	0.61
10	Gujarat	17.24	20.87	3.35	2.81
11	Haryana	29.28	45.61	6.90	7.63
12	Himachal Pradesh	9.92	14.55	1.66	1.97
13	Jammu &Kashmir	26.34	32.34	4.60	5.01
14	Jharkhand	21.38	27.09	3.43	3.12
15	Karnataka	17.86	29.38	2.44	3.18
16	Kerala	23.26	24.31	3.35	2.07
17	Madhya Pradesh	9.86	17.46	2.96	6.02
18	Maharashtra	19.03	24.02	2.50	2.65
19	Manipur	20.9	15.00	4.13	2.70
20	Meghalaya	21.07	8.78	3.15	1.43
21	Mizoram	20.3	10.66	4.08	1.63
22	Nagaland	22.27	5.73	6.89	1.36
23	Odisha	13.7	14.50	2.45	2.16
24	Puducherry	42.74	38.89	2.17	1.57
25	Punjab	26.03	35.08	8.02	8.07
26	Rajasthan	26.14	43.43	7.47	11.92
27	Sikkim	8.46	10.47	0.70	0.67
28	Tamil Nadu	29.84	51.03	3.78	5.69
29	Telangana	34.51	41.55	5.61	6.40
30	Tripura	6.59	12.54	1.79	3.22
31	Uttar Pradesh	23.92	26.58	6.43	5.96
32	Uttarakhand	21.63	27.76	2.66	2.17
33	West Bengal	19.06	23.78	4.48	4.47
	All India	21.79	30.38	4.04	4.66

Source: GoI (2023).

9.2.2 Population changes across states

Population changes in cattle and buffalo

According to the 20th Livestock Census, there has been a notable increase in the population of exotic and crossbred cattle in several major milk-producing states compared to the 19th Livestock Census. Between 2012 and 2019, the population of exotic and crossbred cows increased by 33.89%, while the buffalo population in India grew by 5.53%. The states of West Bengal, Uttar Pradesh, Madhya Pradesh, Bihar, Maharashtra, and Rajasthan accounted for a substantial portion of the cattle population. In case of buffalo, Uttar Pradesh, Rajasthan, Gujarat, Madhya Pradesh, Bihar, and Andhra Pradesh collectively account for 75% of the population.

Madhya Pradesh, Gujarat, and Uttar Pradesh shows the highest increase in the population of exotic/crossbred cattle, coinciding with a decline in the indigenous cattle population. Conversely, Bihar, Haryana, Punjab, and West Bengal demonstrate positive growth in the population of Indigenous/Non-descript cattle (Figure 9.1). Moreover, there is a positive growth in the buffalo population reported in Madhya Pradesh, Uttar Pradesh, Rajasthan, West Bengal, Bihar, Gujarat, and Telangana (Figure 9.2). Uttar Pradesh and Rajasthan with high milk production witnessed a significant rise in the population of crossbred/exotic cows, with positive growth in buffalo population. In Madhya Pradesh, the population of crossbred/exotic cows nearly doubled. In many southern states also, there was a notable increase in the population of exotic/crossbred cows.

Population changes in goat, sheep, pig and poultry

Between 2012 and 2019, India experienced an increase in the populations of sheep, goats, and poultry, whereas the pig population declined during the same period. The states of Telangana, Andhra Pradesh, Karnataka, Rajasthan, and Tamil Nadu collectively accounted for over 80% of the nation's sheep population. Notably, Telangana, Andhra Pradesh, and Karnataka exhibited positive population growth, accompanied by a significant increase in the crossbred sheep population. The states of Rajasthan, West Bengal, Uttar Pradesh, Bihar, and Madhya Pradesh were predominant in terms of the goat population in India. Positive

Figure 9.1. Population growth (%) in cattle during 2012-2019

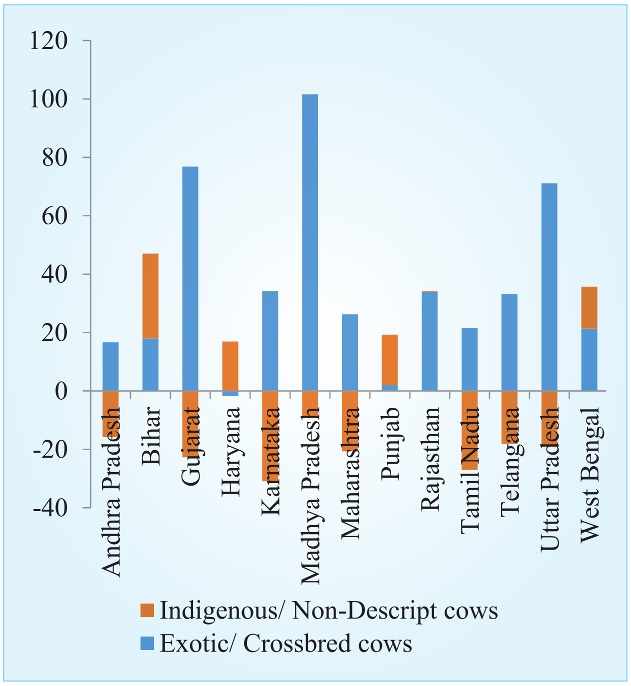
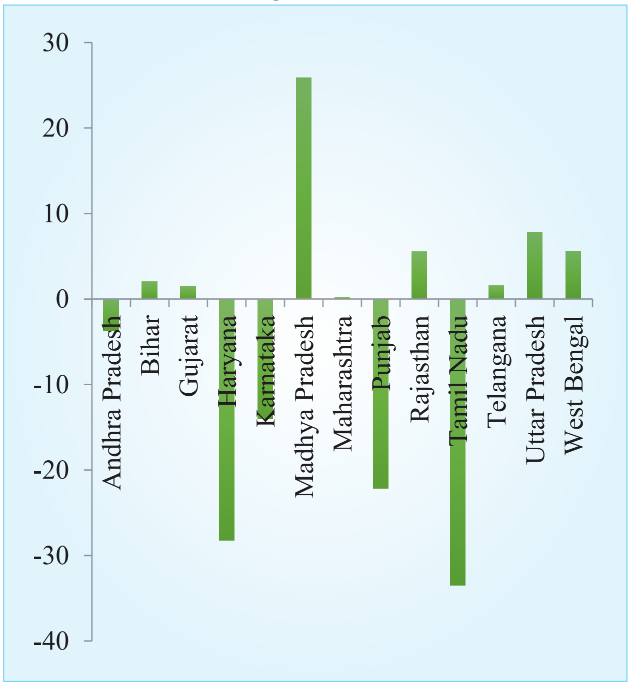


Figure 9.2. Population growth (%) in buffalo during 2012-2019



Source: 20th Livestock Census.

Table 9.2. Population growth in other livestock species during 2012-2019

Sl No.	States/ Union Territories	Population growth (%)			
		Sheep	Goat	Pig	Poultry
1.	A&N Islands	66.67	-0.86	12.71	-0.78
2.	Andhra Pradesh	29.99	22.84	-41.54	31.5
3.	Arunachal Pradesh	-45.79	-47.72	-23.82	14.27
4.	Assam	-35.9	-30.05	28.3	24.85
5.	Bihar	-8.21	5.49	-47.14	24.46
6.	Chandigarh	-100	23.98	2.22	-59.77
7.	Chhattisgarh	7.14	24.19	20.01	-4.08
8.	D&N Haveli	-32.26	80.88	-	2.45
9.	Daman & Diu	6700	-51.97	-100	-35.16
10.	Delhi	0	0	0	-3.04
11.	Goa	-66.67	-27.1	-18.56	19.19
12.	Gujarat	4.66	-1.84	-84.62	57.24
13.	Haryana	-20.48	-9.34	-14.73	8.31
14.	Himachal Pradesh	-1.68	-0.99	-50.78	34.32
15.	Jammu & Kashmir	-4.19	-14.26	-49.81	-11.73
16.	Jharkhand	9.99	38.59	32.69	71.64
17.	Karnataka	15.31	28.63	6.25	11.82
18.	Kerala	2.49	9.08	86.19	15.99
19.	Lakshadweep	-	-7.12	-	29.37
20.	Madhya Pradesh	5.06	38.07	-6.07	39.46
21.	Maharashtra	3.87	25.72	-50.58	-6.39
22.	Manipur	-48.35	-40.61	-15.14	66.52
23.	Meghalaya	-21.98	-15.97	29.99	57.28
24.	Mizoram	-25.38	-33.26	19.26	60.58
25.	Nagaland	-90.59	-68.19	-19.65	22.78
26.	Odisha	-19.1	-1.84	-51.78	36.31
27.	Puducherry	52.72	33.99	-12.87	18.27
28.	Punjab	-33.43	6.32	64.37	9.14
29.	Rajasthan	-12.95	-3.81	-34.87	80.27
30.	Sikkim	-23.46	-20.16	-8.65	27.89
31.	Tamil Nadu	-5.98	21.43	-63.71	3.28
32.	Telangana	48.52	7.85	-24.92	-1.34
33.	Tripura	75.56	-41.04	-43.17	-22.31
34.	Uttar Pradesh	-27.25	-7.09	-69.37	-35.72
35.	Uttarakhand	-22.82	0.33	-11.29	5.18
36.	West Bengal	-11.45	41.49	-16.63	21.59
	All India	14.13	10.14	-12.03	12.81

Source: 20th Livestock Census.

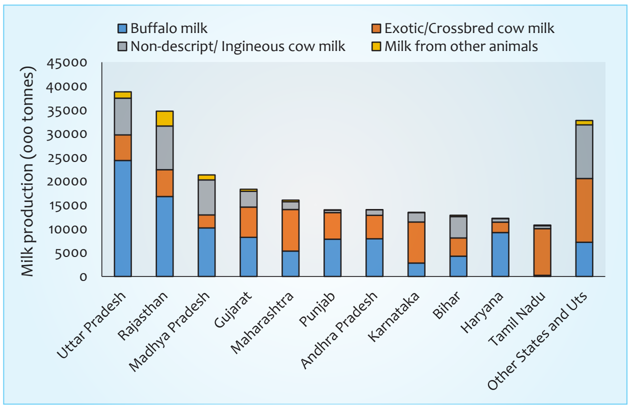
growth in the goat population was observed in West Bengal, Bihar, and Madhya Pradesh, while Rajasthan and Uttar Pradesh experienced a declining trend. Regarding pig rearing activities, Assam, Jharkhand, Meghalaya, West Bengal, and Chhattisgarh emerged as the leading states. In the context of poultry population, Tamil Nadu, Andhra Pradesh, Telangana, Maharashtra, and West Bengal secured the top five positions, demonstrating positive growth (Table 9.2).

9.2.3 Livestock production and productivity across states

Milk production and productivity

Uttar Pradesh is the leading state in milk production, followed by Rajasthan, Madhya Pradesh, Gujarat, and Maharashtra (Figure 9.3). Collectively, these states account for approximately 54% of the nation's total milk production. Buffalo milk constitutes the largest share at 43.62%, with exotic/crossbred cow milk contributing 32.26%. It is noteworthy that buffalo milk production is also predominant in the major milk-producing states. In states such as Maharashtra, Karnataka, and Tamil Nadu, a significant proportion of milk is obtained from exotic/crossbred cows.

Figure 9.3. Milk production and its composition across states, 2023-24



Source: GoI (2024a).

While Uttar Pradesh is the leading contributor to milk production, the productivity of dairy animals in this state is lower compared to states such as Punjab and Haryana. In Punjab, milk yield of cows is the highest, whereas Haryana

Table 9.3. Milk yield of dairy animals across states, 2023-24

	Milk productivity (Litres/ day)		
	Buffalo	Exotic/ Crossbred cow	Non-descript/ Indigenous cow
Punjab	8.82	13.29	8.13
Haryana	10.83	10.56	6.79
Gujarat	5.33	9.93	5.01
Andhra Pradesh	6.7	9.35	3.58
Rajasthan	6.91	7.23	5.36
Uttar Pradesh	5.32	8.53	4.18
Maharashtra	5.53	9.85	2.37
Karnataka	4.22	9.57	3.38
Madhya Pradesh	4.78	7.92	3.4
Bihar	4.59	6.38	3.31
Tamil Nadu	3.59	7.03	3.14
All India	5.92	8.43	3.54

Source: GoI (2024a).

exhibits high yield of buffaloes. Additionally, the productivity levels of exotic or crossbred cows in Gujarat, Maharashtra, Andhra Pradesh, and Karnataka surpass the national average. Conversely, the productivity levels of indigenous or non-descript cows are generally lower across states, although states like Punjab, Haryana, Gujarat, and Rajasthan demonstrate relatively better productivity (Table 9.3).

In the year 2023-24, India produced approximately 7.8 million tons of goat milk. The states of Rajasthan, Uttar Pradesh, Madhya Pradesh, Gujarat, and Maharashtra collectively accounted for approximately 80% of the nation's goat milk production.

Meat, egg and wool production

West Bengal and Uttar Pradesh lead in meat production in India, collectively accounting for approximately 25% of the nation's total meat output. Additionally, states such as Maharashtra, Andhra Pradesh, and Telangana make significant contributions to the country's meat production (Figure 9.4). In terms of egg production, Andhra Pradesh (17.85%), Tamil Nadu (15.64%), Telangana (12.88%), and West Bengal (11.37%) are the primary contributors (Figure 9.5). Rajasthan is the predominant state in wool production, contributing 48% of the national total, followed by Jammu & Kashmir at 23.06%. Other states, including Gujarat, Maharashtra, and Himachal Pradesh, collectively contribute around 15% to India's wool production (Figure 9.6).

Figure 9.4. Meat production across states

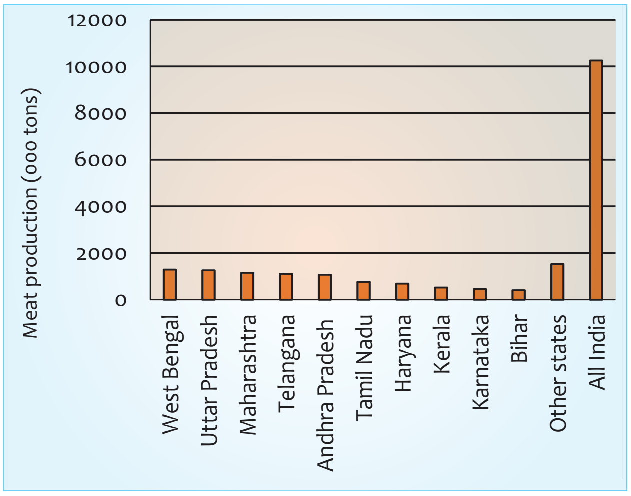
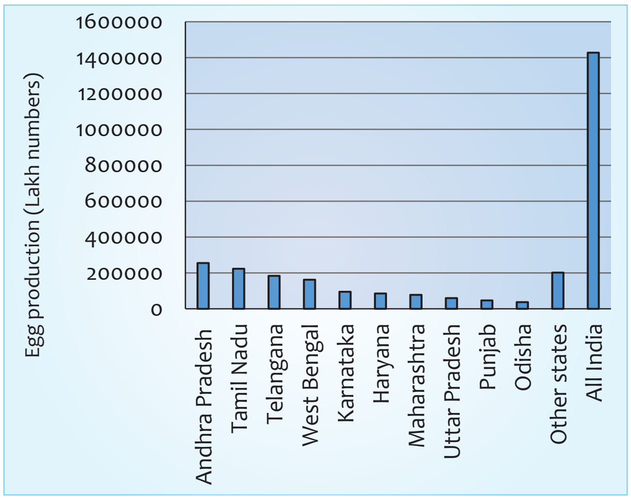
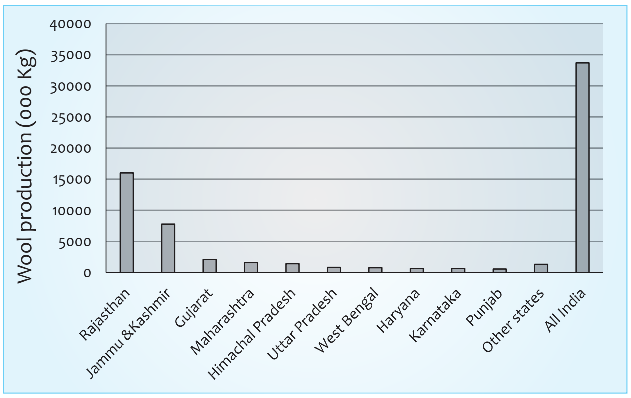


Figure 9.5. Egg production across states



Source: GoI (2024a).

Figure 9.6. Wool production across states



Source: GoI (2024a).

9.2.4 Major drivers of growth in livestock sector

The primary factors driving the growth of the Indian livestock sector encompass technologies, institutions, infrastructure, and investment (Birthal et al. 2019). Technologies pertaining to animal breeding, feed management, and healthcare significantly enhance livestock productivity in India (Birthal and Negi 2012; Gowane et al. 2019). The development of appropriate infrastructure and the effective and efficient delivery of services are essential for achieving sustainable production within the livestock sector (Saxena et al. 2019). This section examines the availability and adequacy of these components across various states in India.

Feed and fodder resources for livestock across states

Although India ranks first globally in both livestock population and milk production, its productivity remains significantly lower compared to other leading countries. In addition to inadequate management and the lack of purebred animals, the scarcity of feed and fodder also adversely impacts livestock productivity. The cultivation of fodder crops enables farmers to fully exploit the potential of their animals. Traditionally, farmers cultivate annual fodder crops such as sorghum, pearl millet, cluster bean, cowpea, oat, berseem, and Lucerne. Data on the area under fodder crops across various states during 2022-23 indicates that Rajasthan has the largest area under cultivated fodder in India, followed by Gujarat and Maharashtra. Furthermore, Rajasthan, Himachal Pradesh, Maharashtra, and Madhya Pradesh possess extensive areas of permanent pastures and grazing lands (Table 9.4).

Roy et al. (2019) assessed the availability and demand for green and dry fodder across various regions (Tables 9.5 and 9.6). It is estimated that the country experiences deficits in green fodder, dry fodder, and concentrate of 35.6%, 10.95%, and 44%, respectively (IGFRI, 2021). Table 9.5 offers a comprehensive overview of the green

Table 9.4. State-wise area under fodder crops, permanent pastures and grazing lands

Sl No.	States/ Union Territories	Area under fodder crops (000 ha)	Area under permanent pastures and grazing lands (000 ha)
1.	Andhra Pradesh	33	204
2.	Arunachal Pradesh	0	18
3.	Assam	10	173
4.	Bihar	28	15
5.	Chhattisgarh	0	898
6.	Goa	0	1
7.	Gujarat	1821	787
8.	Haryana	280	81
9.	Himachal Pradesh	13	1458
10.	Jammu & Kashmir	60	108
11.	Jharkhand	0	131
12.	Karnataka	80	872
13.	Kerala	7	0
14.	Madhya Pradesh	29	1242
15.	Maharashtra	968	1412
16.	Manipur	0	1
17.	Meghalaya	0	0
18.	Mizoram	0	11
19.	Nagaland	0	0
20.	Odisha	0	534
21.	Punjab	480	3
22.	Rajasthan	3253	1654
23.	Sikkim	0	9
24.	Tamil Nadu	35	108
25.	Telangana	37	243
26.	Tripura	0	1
27.	Uttarakhand	30	208
28.	Uttar Pradesh	511	70
29.	West Bengal	2	2
30.	A&N Island	0	4
31.	Chandigarh	0	1
32.	Ladakh	3	0
33.	Dadra & Nagar Haveli and Daman & Diu	0	0
34.	Delhi	1	0
35.	Lakshadweep	0	0
36.	Puducherry	0	0
	All India	7683	10248

Note: Value "0" indicates area below 500 ha.

Source: GoI (2024a).

Table 9.5. Green fodder availability, requirement and deficit/ surplus status

Zones/ States	Total green fodder availability (000 Tons)	Total green fodder requirement (000 Tons)	% Availability	% Deficit(-)/ Surplus (+)
East Zone (Bihar, Jharkhand, Odisha, West Bengal)	80745.4	137381.6	58.8	-41.20
West Zone (Gujarat, Rajasthan, Goa, Maharashtra)	185087.8	197592.3	93.67	-6.33
North Zone (Haryana, Punjab)	114075.2	48947.8	233.05	133.05
Central Zone (Chhatisgarh, Madhya Pradesh, Uttar Pradesh)	230023	241654.6	95.2	-4.80
Southern Zone (Andhra Pradesh, Kerala, Karnataka, Tamil Nadu)	79835.7	142219.9	56.14	-43.86
NEH Zone (Arunachal Pradesh, Manipur, Meghalaya, Assam, Mizoram, Nagaland, Tripura)	22951.6	29832.2	76.9	-23.10
Hill Zone (Himachal Pradesh, Jammu & Kashmir and Uttarakhand)	21141	28157.9	75.1	-24.90
Others including UT (A&N Islands, Chandigarh, Pudducherry, Dadar & Nagar Haveli, Daman & Diu, Lakshadweep and NCT of Delhi	334.4	1402.8	23.8	-76.20
All India	734193.8	827189.3	88.75765	-11.24

Source: Roy et al. (2019).

Table 9.6. Dry fodder availability requirement and deficit/ surplus status

Zones/ States	Total dry fodder availability (000 Tons)	Total dry fodder requirement (000 Tons)	% Availability	% Deficit(-)/ Surplus (+)
East Zone (Bihar, Jharkhand, Odisha, West Bengal	43481.3	77480.5	56.1	-43.90
West Zone (Gujarat, Rajasthan, Goa, Maharashtra)	56739.2	100361.3	56.53	-43.47
North Zone (Haryana, Punjab)	31559.1	23955.4	131.74	31.74
Central Zone (Chhatisgarh, Madhya Pradesh, Uttar Pradesh)	105183.9	125770.7	83.6	-16.4
Southern Zone (Andhra Pradesh, Kerala, Karnataka, Tamil Nadu)	71498	97966.4	73	-27.00
NEH Zone (Arunachal Pradesh, Manipur, Meghalaya, Assam, Mizoram, Nagaland, Tripura)	19772.2	17337.3	114	14.00
Hill Zone (Himachal Pradesh, Jammu & Kashmir and Uttarakhand)	20876.7	13389	155.9	55.9
Others including UT (A&N Islands, Chandigarh, Pudducherry, Dadar & Nagar Haveli, Daman & Diu, Lakshadweep and NCT of Delhi	256.9	627.6	40.93	-59.07
All India	326399.2	426105.3	76.6	-23.4

Source: Roy et al. (2019).

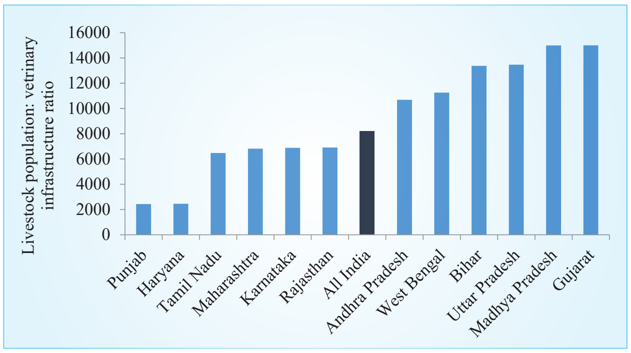
fodder status across different zones, revealing a deficit in all zones except the northern zone of India. Additionally, the country also faces a deficit in dry fodder across all zones, with the exception of the northern, hill, and North-Eastern regions (Table 9.6).

Livestock infrastructure and services

Genetic enhancement of livestock through advanced technologies is crucial for increasing productivity. Artificial insemination (AI) plays a vital role in this process, necessitating the establishment of adequate infrastructure to ensure effective service delivery. Equally important is the management of diseases in dairy animals, given the significant economic losses associated with these. Figures 9.7, 9.8, and 9.9 illustrate the availability of infrastructure for both genetic improvement and disease management across states. As livestock census data is available for 2019, the number of veterinary infrastructure facilities and details regarding AI have been considered for the period 2019-20. Veterinary infrastructure primarily comprises government veterinary hospitals, polyclinics, dispensaries, and veterinary aid centers. In comparison to the livestock population, infrastructure facilities are better in Punjab, Haryana, Tamil Nadu, Maharashtra, and Karnataka, whereas they are less developed in Bihar, Uttar Pradesh, Madhya Pradesh, and Gujarat (Figure 9.7).

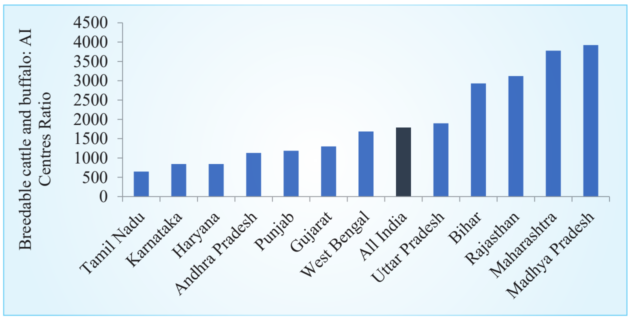
Punjab and Haryana, are relatively better equipped with artificial insemination (AI) centers (Figure 9.8). Conversely, major milk-producing states such as Uttar Pradesh, Rajasthan, Madhya Pradesh, Maharashtra, and Bihar require significant improvement in AI infrastructure. Furthermore, AI coverage among the adult female cattle and buffalo population is notably lower in Madhya Pradesh, Maharashtra, and Rajasthan (Figure 9.9). Given the conception rate of 35% in AI, the number of AI services was divided by three across states for analytical purposes.

Figure 9.7. Livestock population to veterinary infrastructure ratio



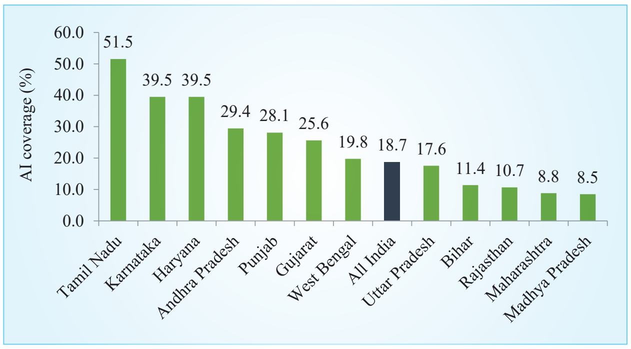
Source: Author' compilation.

Figure 9.8. Breedable bovine to AI centres ratio



Source: Author' compilation.

Figure 9.9. AI coverage among breedable cattle and buffaloes



Access to information among livestock farmers

Access to information is a crucial determinant in facilitating the adoption of technology and enhancing productivity and income within the domain of livestock farming. Among the principal livestock-producing states, farmers in Punjab, Haryana, Gujarat, Tamil Nadu, Andhra Pradesh, and Karnataka have better access to livestock-related information, particularly in the area of health (Table 9.7).

Table 9.7. Access to information among livestock farming households

SI No.	States/ Union Territories	% of households with access to information				
		Livestock information	Breeding information	Feed information	Health information	Management information
1.	A&N Islands	13.59	1.94	0.97	11.65	0
2.	Andhra Pradesh	54.02	10.27	17.9	39.02	1.16
3.	Arunachal Pradesh	3.9	0	0.18	3.19	0.18
4.	Assam	6.5	2.36	0.53	3.61	0.18
5.	Bihar	6.24	0.77	1.24	4.51	0.13
6.	Chhattisgarh	0.39	0.13	0	0.26	0
7.	Delhi	28.57	10.71	0	17.86	0
8.	Goa	4.35	0	0	4.35	0
9.	Gujarat	35.3	12.02	13.62	24.04	1.25
10.	Haryana	43.41	10.68	8.32	34.67	0.55
11.	Himachal Pradesh	34.08	19.15	4.23	18.93	0.22
12.	Jammu & Kashmir	7.87	0.5	3.85	3.69	0.5
13.	Jharkhand	3.12	0.51	0.08	2.45	0.08
14.	Karnataka	32.67	15.1	9.7	21.78	1.83
15.	Kerala	39.36	12.06	10.22	28.64	9.88
16.	Madhya Pradesh	5.08	1.71	0.53	2.93	0.22
17.	Maharashtra	19.9	5.06	5.15	13.07	0.82
18.	Manipur	3.54	0.17	0.51	3.2	0.17
19.	Meghalaya	6.37	0.71	0	0.53	0
20.	Mizoram	14.79	1.41	2.11	5.99	0.35
21.	Nagaland	4.9	0.23	0.23	3.5	0.93
22.	Odisha	16.63	3.7	1.56	12.35	0.39
23.	Punjab	36.93	11.99	6	26.98	4.08
24.	Rajasthan	4.81	1.44	0.62	3.18	0.19
25.	Sikkim	21.99	5.84	6.53	15.81	1.03
26.	Tamil Nadu	58.09	17.15	14.35	47.28	3.95
27.	Telangana	23.22	5.5	8.15	16.5	0.61
28.	Tripura	17.03	1.37	0.46	15.89	0
29.	Uttar Pradesh	12.1	3.79	1.9	7.59	0.63
30.	Uttarakhand	4.74	0.82	1.24	2.47	0
31.	West Bengal	3.77	0.47	1.07	2.14	0.09
	All India	16.93	4.74	3.9	11.94	0.87

Source: Authors' compilation from SAS-LHS Survey 2019.

Disposal pattern of milk across states

The 2019 Situation Assessment of Agricultural Households (SAS) and Land and Livestock Holdings (LHS) of Households in Rural India, conducted by the NSO, reveals that among households with excess milk production, 39.44% sell their milk directly to other households, 26.25% to dairy cooperatives, and 36.65% to private processing entities. Gujarat, where a well-established network of dairy cooperatives exists, approximately 75% of households choose to sell their milk to cooperatives. Similarly, in Karnataka, Kerala, and Goa, a significant proportion of households participate in milk sales via cooperative societies. Conversely, private processors are notably influential in the procurement of milk in Uttar Pradesh, Tamil Nadu, Andhra Pradesh, Maharashtra, Rajasthan, Punjab, and Uttarakhand (Table 9.8).

Table 9.8. Distribution of households based on milk disposal channels across States

Sl No.	States/ Union Territories	Milk disposal channels (% of households)			
		Other households	Dairy Cooperatives	Private milk processors	Other channels
1.	Andaman & Nicobar Islands	100.00	15.38	15.38	0.00
2.	Andhra Pradesh	26.56	38.35	47.29	3.79
3.	Arunachal Pradesh	95.00	0.00	0.00	5.00
4.	Assam	80.39	2.25	13.18	15.11
5.	Bihar	67.63	13.32	23.36	5.28
6.	Chhattisgarh	51.35	10.81	27.03	21.62
7.	Delhi	54.55	0.00	9.09	36.36
8.	Goa	75.00	50.00	25.00	0.00
9.	Gujarat	16.15	74.95	19.34	3.41
10.	Haryana	69.53	8.31	29.92	2.22
11.	Himachal Pradesh	66.67	8.64	29.63	6.17
12.	Jammu & Kashmir	55.69	3.59	31.74	20.96
13.	Jharkhand	72.55	0.00	15.69	15.69
14.	Karnataka	23.34	63.91	17.55	5.13
15.	Kerala	67.39	62.50	6.52	3.80
16.	Madhya Pradesh	53.78	4.76	26.89	26.05
17.	Maharashtra	32.84	33.24	44.68	5.11
18.	Manipur	52.63	0.00	5.26	47.37
19.	Meghalaya	86.67	0.00	13.33	0.00
20.	Mizoram	100.00	0.00	0.00	18.18
21.	Nagaland	100.00	0.00	0.00	0.00
22.	Odisha	55.45	22.28	31.19	6.44
23.	Punjab	41.27	16.47	43.85	13.69
24.	Rajasthan	25.24	23.43	43.93	14.23
25.	Sikkim	81.73	15.38	2.88	8.65
26.	Tamil Nadu	13.39	38.78	55.49	10.62
27.	Telangana	43.15	33.5	39.59	3.55
28.	Tripura	62.16	5.41	19.82	18.92
29.	Uttar Pradesh	28.82	4.34	58.51	18.61
30.	Uttarakhand	31.39	30.94	40.36	8.07
31.	West Bengal	53.75	1.88	33.96	20.42
	All India	39.44	26.25	36.65	10.42

Source: Authors compilation from SAS-LHS Survey 2019.

Table 9.9 provides a comprehensive overview of the distribution of dairy cooperatives across states. It is noteworthy that a substantial number of these cooperatives are situated in Uttar Pradesh, Rajasthan, Karnataka, Gujarat, Maharashtra, Madhya Pradesh, and Tamil Nadu. Nonetheless, despite their presence, the volume of milk procurement through these cooperatives remains low in Uttar Pradesh, Rajasthan, and Madhya Pradesh.

Table 9.9. Number of dairy cooperatives across States

Sl No.	States/ Union Territories	Number of dairy cooperatives
1	Andaman and Nicobar islands	49
2	Andhra Pradesh	956
3	Arunachal Pradesh	34
4	Assam	1284
5	Bihar	9407
6	Chandigarh	11
7	Chhattisgarh	1002
8	Delhi	27
9	Goa	187
10	Gujarat	16855
11	Haryana	7377
12	Himachal Pradesh	831
13	Jammu and Kashmir	2108
14	Jharkhand	310
15	Karnataka	17796
16	Kerala	3435
17	Ladakh	78
18	Madhya Pradesh	10517
19	Maharashtra	12834
20	Manipur	897
21	Meghalaya	190
22	Mizoram	74
23	Nagaland	136
24	Odisha	1042
25	Puducherry	121
26	Punjab	7274
27	Rajasthan	18754
28	Sikkim	443
29	Tamil Nadu	10274
30	Telangana	2146
31	The Dadra and Nagar Haveli and Daman and Diu	33
32	Tripura	375
33	Uttar Pradesh	19470
34	Uttarakhand	2833
35	West Bengal	2220
	All India	151380

Source: GoI (2024b).

Table 9.10. State-wise public investment on livestock

Sl No.	States/ Union Territories	Expenditure on livestock sector (Rs. lakhs)	Proportion of expenditure out of total expenditure in agriculture and allied activities (%)	Proportion of expenditure out of livestock sector GVA of the state (%)
1.	Andhra Pradesh	82521.7	7.32	0.56
2.	Arunachal Pradesh	18716.4	11.01	14.89
3.	Assam	41667.5	10.07	4.01
4.	Bihar	51052.5	9.79	0.75
5.	Chhattisgarh	38864.6	2.22	3.77
6.	Goa	12339.7	26.18	21.59
7.	Gujarat	106142	13.63	1.62
8.	Haryana	89924.9	19.06	1.24
9.	Himachal Pradesh	50060.9	16.47	22.22
10.	Jammu & Kashmir	106480.1	15.20	9.44
11.	Jharkhand	30139.9	8.83	1.48
12.	Karnataka	244859.2	14.36	3.12
13.	Kerala	84370.6	13.27	3.34
14.	Madhya Pradesh	110659.3	7.62	1.26
15.	Maharashtra	192164	5.64	2.15
16.	Manipur	9382.2	18.44	7.64
17.	Meghalaya	18857.7	21.10	11.15
18.	Mizoram	9492.7	13.22	15.42
19.	Nagaland	10257.5	11.74	15.45
20.	Odisha	76081.2	6.80	3.53
21.	Punjab	51682.9	4.10	0.84
22.	Rajasthan	276191.1	26.49	1.73
23.	Sikkim	8331.7	14.69	17.88
24.	Tamil Nadu	107629.6	4.55	0.88
25.	Telangana	55964.6	2.97	0.62
26.	Tripura	14280.7	14.42	4.82
27.	Uttarakhand	41496.6	12.59	5.74
28.	Uttar Pradesh	200416.7	13.98	1.40
29.	West Bengal	87117	8.90	1.38
30.	Delhi	4828.3	19.45	2.50
31.	Puducherry	6960.8	14.16	9.62

Source: RBI (2024).

Public Investment in livestock sector

In the realm of technology generation, infrastructure development, and institution building within the livestock sector, it is crucial to ensure adequate investment. An assessment of public expenditure on the livestock sector and its sufficiency has been conducted across various states, as detailed in Table 9.10. During the 2022-23 period, Rajasthan, Karnataka, Uttar Pradesh, Maharashtra, and Madhya Pradesh were identified as the top five states in terms of total public expenditure on the livestock sector. Among the total expenditure on agriculture and allied sectors, states such as Rajasthan, Goa, Meghalaya, Haryana, and Manipur allocate a relatively higher proportion of their budgets to the livestock sector. Furthermore, states like Himachal Pradesh, Goa, and the North Eastern states allocate a comparatively higher proportion of their expenditure relative to the Gross State Value Added (GSVA) from the livestock sector.

9.2.5 Developments strategies

In the Northern region, encompassing prominent milk-producing states such as Rajasthan, Punjab, and Haryana, significant variations are evident. Punjab and Haryana excel in milk productivity, whereas Rajasthan demonstrates potential for enhancement. In Punjab and Haryana, there is an increase in the population of indigenous cows and a decrease in the buffalo population. These states benefit from surplus feed and fodder production, a robust veterinary infrastructure, and extensive coverage of artificial insemination. In contrast, Rajasthan necessitates improved breeding infrastructure, increased public investment, and enhanced access to information. Private milk processors play a crucial role in milk marketing in these states, although numerous dairy cooperatives are present in states like Rajasthan. Additionally, there is potential for increased investment in non-bovine milk production and wool production in Rajasthan. Punjab and Haryana could focus on strengthening their milk and fodder supply chains to meet demand in other states.

Major milk-producing states such as Uttar Pradesh and Madhya Pradesh, despite their high production levels, exhibit lower productivity compared to Punjab and Haryana. These states have experienced significant increases in the populations of crossbred cows and buffaloes. Additionally, Uttar Pradesh is a leading state in meat production within India. However, there is a noted inadequacy in veterinary infrastructure and artificial insemination centers in these regions. The numerous dairy cooperatives present could potentially play a more substantial role in milk marketing. It may be beneficial to prioritize the allocation of funds towards enhancing veterinary infrastructure, improving breeding services, and strengthening cooperative structures for milk marketing.

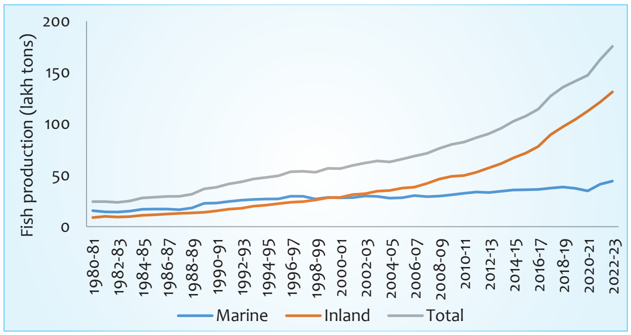
In the Western region of India, Maharashtra and Gujarat are prominent states in terms of livestock production. This area has witnessed an increase in the population of crossbred cows and buffaloes, while the number of indigenous cows has declined. Milk production is predominantly derived from cows, with potential for productivity improvements in crossbred varieties. The region is also challenged by a shortage of fodder, particularly dry fodder. There is a need to enhance veterinary health and breeding infrastructure facilities, although Gujarat benefits from a robust information service and institutional network. It is recommended that additional public investment be directed towards infrastructure development and the enhancement of service provision in this region.

The Eastern region, particularly Bihar, faces low productivity in dairy livestock, primarily due to inadequate feed, fodder availability, and veterinary services. Strengthening institutional mechanisms such as cooperatives and Farmer Producer Organizations could enhance milk distribution efficiency. In contrast, the southern states—including Andhra Pradesh, Karnataka, and Tamil Nadu—are known for high levels of milk production. These states have achieved notable gains in the productivity of crossbred cows through focused breed improvement programmes. Andhra Pradesh also ranks among the leading egg producers in the country. Nevertheless, the region grapples with acute shortages of both green and dry fodder, highlighting the need for increased public investment in feed and fodder development. In the North-Eastern region, the potential for dairy development is limited. Hence, promoting alternative sectors such as piggery and egg production may yield better outcomes for the region's livestock economy.

9.3 Fisheries

India is the third largest fish producing country, contributing around 16% of inland fish production and 5% of marine fish production across the globe. In the past decades, fish production in India had shown an increasing trend mainly achieved through expansion in inland fish production. During 2022-23 India had 175.45 lakh ton fish production with 75% contribution from inland fisheries (Figure 9.10). In addition to domestic food security and livelihood provision, Indian fisheries sector play crucial role in foreign exchange earnings.

Figure 9.10. Fish production trend in India



Source: GoI (2022).

9.3.1 Contribution of fisheries to state economy

The contribution of the fisheries sector to the Gross State Value Added (GSVA) is most significant in Andhra Pradesh, where it accounted for 9.82% in 2022-23, up from 3.40% in 2011-12 (Table 9.11). In Tripura, the fisheries sector contributes approximately 3.81% to the GSVA. In other states, including Chhattisgarh, West Bengal, Assam, and the Andaman & Nicobar Islands, it exceeds 2%. In Andhra Pradesh, Puducherry, Goa, and the Andaman & Nicobar Islands, the fisheries sector's contribution to agricultural Gross Value Added (GVA) exceeds 20%.

Table 9.11. Contribution of fisheries sector towards GSVA

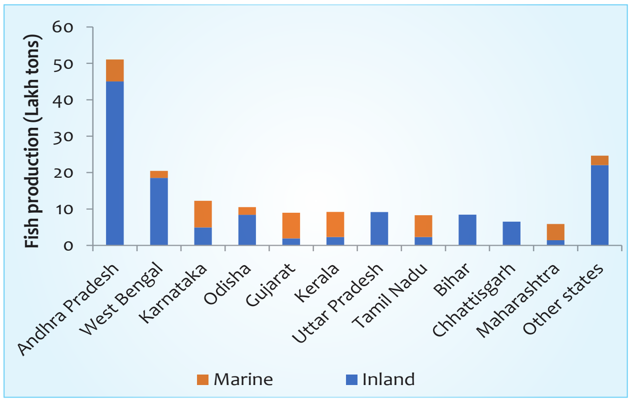
SI No	States/ Union Territories	% share of fisheries GVA out of agricultural GVA		% share of fisheries GVA out of total GVA	
		2011-12	2022-23	2011-12	2022-23
1.	Andaman & Nicobar Islands	25.88	25.22	3.83	2.80
2.	Andhra Pradesh	12.63	31.97	3.40	9.82
3.	Arunachal Pradesh	0.99	1.81	0.42	0.43
4.	Assam	13.90	17.41	2.93	2.77
5.	Bihar	5.23	8.15	1.34	1.88
6.	Chandigarh	1.86	0.82	0.01	0.00
7.	Chhattisgarh	8.74	13.61	1.58	2.14
8.	Delhi	0.29	0.27	0.00	0.00
9.	Goa	32.58	30.49	1.69	1.75
10.	Gujarat	3.01	3.42	0.59	0.46
11.	Haryana	1.33	2.04	0.31	0.34
12.	Himachal Pradesh	0.45	0.74	0.07	0.10
13.	Jammu &Kashmir	2.48	2.42	0.43	0.37
14.	Jharkhand	2.52	6.18	0.40	0.71
15.	Karnataka	3.60	4.83	0.49	0.52
16.	Kerala	7.80	11.23	1.12	0.96
17.	Madhya Pradesh	0.71	1.46	0.21	0.50
18.	Maharashtra	1.96	1.59	0.26	0.17
19.	Manipur	7.58	8.58	1.50	1.54
20.	Meghalaya	1.44	4.85	0.22	0.79
21.	Mizoram	3.25	1.68	0.65	0.26
22.	Nagaland	1.70	1.88	0.53	0.45
23.	Odisha	6.82	12.35	1.22	1.84
24.	Puducherry	25.73	30.63	1.31	1.24
25.	Punjab	0.75	1.20	0.23	0.28
26.	Rajasthan	0.28	0.43	0.08	0.12
27.	Sikkim	0.32	0.71	0.03	0.05
28.	Tamil Nadu	4.83	4.14	0.61	0.46
29.	Telangana	2.71	3.28	0.44	0.51
30.	Tripura	9.55	14.87	2.60	3.81
31.	Uttar Pradesh	1.51	2.09	0.41	0.47
32.	Uttarakhand	0.27	0.47	0.03	0.04
33.	West Bengal	14.69	15.78	3.45	2.97

Source: GoI (2023).

9.3.2 Fish production across states

Top five fish producing states in India are Andhra Pradesh, West Bengal, Karnataka, Odisha and Gujarat (Figure 9.11). Inland fish production is prominent in Andhra Pradesh, West Bengal and Odisha. Marine fish production is highest in Gujarat, followed by Kerala, Tamil Nadu, Karnataka and Maharashtra. Non-coastal states like Uttar Pradesh, Bihar and Chhattisgarh also play a major role in inland fish production in India. Andhra Pradesh with highest fish production in India has large area under shrimp culture. Introduction of Pacific white shrimp (*Litopenaues vannamei*) played a major role in increasing the inland fish production in the state.

Figure 9.11. Fish production across major states in India



Source: Ministry of Fisheries, Animal Husbandry and Dairying, 2022.

9.3.3 Infrastructure, institutions and investment

Fisheries infrastructure

Infrastructure for harvesting and post-harvest operations is pivotal in the development of the fisheries sector. Essential infrastructure for the marine fisheries sector includes fishing vessels for marine fish harvesting and landing centers. Additionally, fish processing infrastructure is crucial for both marine and inland fisheries, particularly given its export potential. The current availability of fishing vessels and landing centers across various coastal states is detailed in Table 9.12, which encompasses deep-sea fishing vessels, motorized and non-motorized fishing vessels, and landing centers. Most states are progressing towards the motorization of fishing crafts, with Tamil Nadu possessing the highest number of motorized crafts, followed by Kerala, Gujarat, and Andhra Pradesh. Andhra Pradesh, Tamil Nadu, Kerala, and Maharashtra have a greater number of landing centers. The Gujarat coast is notable for its substantial number of deep-sea fishing vessels.

Table 9.12. Marine fisheries infrastructure

SI No.	States/ Union Territories	Deep Sea Fishing Vessels	Motorized non-Mechanical Fishing Vessels	Motorized Mechanical Fishing Vessels	Non-motorized Fishing Vessels	Landing centres
1.	A&N Islands	0	1868	117	1365	51
2.	Andhra Pradesh	0	19896	1860	10557	350
3.	Daman & Diu	2	320	2070	0	8
4.	Goa	0	0	2528	270	32
5.	Gujarat	51	11770	16607	76	107
6.	Karnataka	0	9670	4576	7224	115
7.	Kerala	10	30881	5979	2676	174
8.	Lakshadweep	0	1530	52	408	20
9.	Maharashtra	0	0	21075	7790	173
10.	Orissa	0	12962	1876	13640	55
11.	Puducherry	0	1848	646	813	22
12.	Tamil Nadu	0	36301	5796	3351	301
13.	West Bengal	0	6151	3335	6510	49
	Total	63	133197	66517	54680	1457

Source: MPEDA, 2024.

Given the significant contribution of the Indian fisheries sector to export revenues, the establishment of fish processing plants is crucial. In India, there are approximately 426 fish processing facilities that adhere to European Union standards, alongside 202 facilities that comply with Non-European Union standards. These facilities are distributed across various coastal states (Table 9.13).

Table 9.13. Region-wise fish processing plants and their processing capacities

Sl No.	Office	State	European		Non-European	
			Number	Capacity (Tons)	Number	Capacity (Tons)
1.	Bhubaneswar	Odisha	22	1162.86	18	906.42
2.	Chennai	Tamil Nadu	10	318.85	7	946.5
3.	Kochi	Kerala	100	4459.87	17	433.87
4.	Kolkata	West Bengal	30	1645.80	18	511.14
5.	Mumbai	Maharashtra	43	3578.84	19	1559.50
6.	Veraval	Gujarat	54	3310.76	41	1678.62
7.	Vijayawada	Andhra Pradesh	35	1949.29	6	497
8.	Vizag	Andhra Pradesh	13	639.9	5	135.7
9.	Bhimavaram	Andhra Pradesh	41	2425.65	6	316.5
10.	Mangalore	Karnataka	33	3273.82	35	3106.10
11.	Porbandar	Gujarat	19	1189.68	14	738.2
12.	Tuticorin	Tamil Nadu	26	920.2	15	544.88
13.	Hyderabad	Telangana	0	0	1	81.4
	Total		426	24875.52	202	11455.83

Source: MPEDA, 2024.

Fishery cooperatives

A large number of fisheries cooperatives are located in Telangana, Maharashtra, Madhya Pradesh, and Andhra Pradesh. These cooperatives primarily engage in the provision of input services for marine fisheries (Table 9.14).

Table 9.14. Number of fishery cooperatives across states

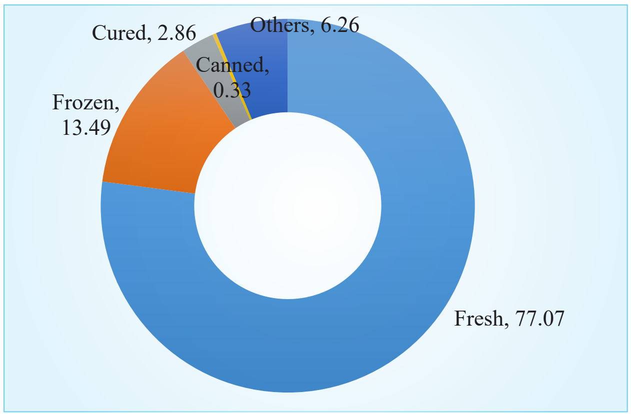
Sl No.	States/ Union Territories	Number of cooperatives
1.	Andaman and Nicobar Islands	136
2.	Andhra Pradesh	2064
3.	Arunachal Pradesh	32
4.	Assam	614
5.	Bihar	501
6.	Chhattisgarh	1949
7.	Goa	28
8.	Gujarat	692
9.	Haryana	136
10.	Himachal Pradesh	78
11.	Jammu and Kashmir	45
12.	Jharkhand	847
13.	Karnataka	767
14.	Kerala	993
15.	Ladakh	2
16.	Lakshadweep	10
17.	Madhya Pradesh	2969
18.	Maharashtra	3173
19.	Manipur	911
20.	Meghalaya	129
21.	Mizoram	49
22.	Nagaland	406
23.	Odisha	777
24.	Puducherry	70
25.	Punjab	22
26.	Rajasthan	197
27.	Sikkim	11
28.	Tamil Nadu	1478
29.	Telangana	4928
30.	The Dadra & Nagar Haveli and Daman & Diu	22
31.	Tripura	324
32.	Uttar Pradesh	1403
33.	Uttarakhand	309
34.	West Bengal	393
	Total	26465

Source: GoI (2024b).

Marketing and trade of fish and fish products

Fish is predominantly distributed in fresh form, followed by frozen form. To a lesser extent, it is also distributed in cured and canned forms (Figure 9.12).

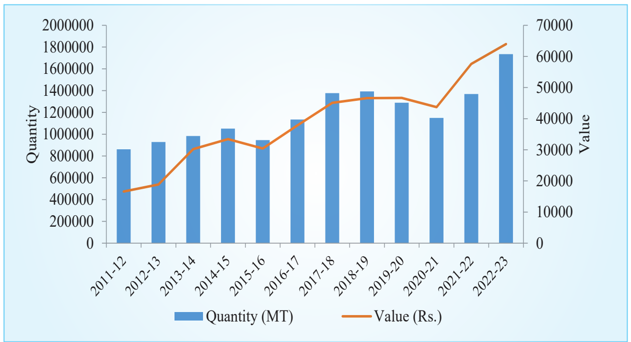
Figure 9.12. Major disposal pattern of fish



Source: MPEDA, 2024.

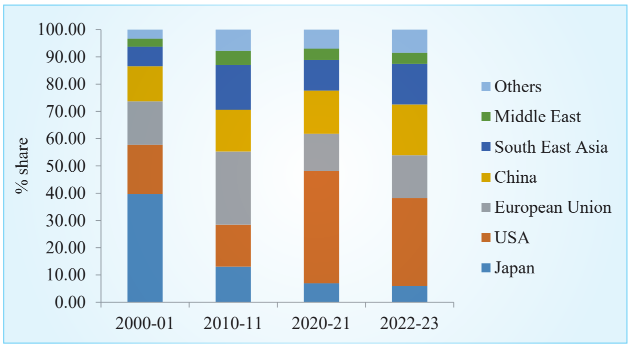
The export of fish has exhibited an upward trend over time, with the exception of a decline during the COVID-19 pandemic (Figure 9.13). Currently, the primary export destinations are the United States, China, and the European Union. In the early 2000s, Japan was the predominant importer of Indian fish; however, its share has gradually decreased over time. Concurrently, India's fish exports to the United States have increased (Figure 9.14). In terms of value, frozen shrimp constitutes the major export commodity, followed by frozen fish.

Figure 9.13. Export quantity and value of fish from India



Source: MPEDA, 2024.

Figure 9.14. Market-wise export of fish from India



Source: MPEDA, 2024.

Public investment in fisheries

Andhra Pradesh holds the leading position in fish and aquaculture production in India, with the majority of production derived from aquaculture. The state's investment in the fisheries sector is relatively low compared to the crop and livestock sectors, potentially due to the predominance of private sector investment in aquaculture. In contrast, other coastal states such as Puducherry, Goa, and Kerala exhibit higher public investment, as fish production in these regions primarily originates from marine sources. Additionally, states like Uttar Pradesh, Bihar, and Chhattisgarh possess significant potential for the development of inland fisheries, and investment in these resources may be further increased in these states (Table 9.15).

9.3.4 Development strategies

The fisheries sector in India plays a multifaceted role in the country's economy and food security. While its contributions to livelihoods and nutrition are well-recognized, its significance in generating export earnings is equally important. The sector's recent expansion has been driven largely by the growth of inland fisheries, reflecting the increasing relevance of freshwater aquaculture and riverine systems in addressing both domestic consumption and export demand.

Despite the growing prominence of inland fisheries, there is a noticeable disparity in the allocation of resources and support between marine and inland sectors. The concentration of

Table 9.15. State-wise public investment in fisheries sector

Sl No.	States/ Union Territories	Expenditure on fisheries (Rs. Lakhs)	Proportion of expenditure out of total agriculture and allied activities expenditure (%)	Proportion of expenditure out of fisheries sector GVA of the state (%)
1.	Andhra Pradesh	29467.2	2.61	0.30
2.	Arunachal Pradesh	8628.2	5.08	45.54
3.	Assam	12324.4	2.98	0.79
4.	Bihar	16606.4	3.19	1.11
5.	Chhattisgarh	10385.6	0.59	0.95
6.	Goa	4819.7	10.23	2.19
7.	Gujarat	38457	4.94	2.70
8.	Haryana	10045.5	2.13	5.66
9.	Himachal Pradesh	3755.8	1.24	14.03
10.	Jammu & Kashmir	26115.6	3.73	35.45
11.	Jharkhand	12969.2	3.80	3.41
12.	Karnataka	23167.2	1.36	1.96
13.	Kerala	69167.9	10.88	4.29
14.	Madhya Pradesh	12104.6	0.83	2.06
15.	Maharashtra	37556.5	1.10	4.80
16.	Manipur	3094.1	6.08	4.79
17.	Meghalaya	3372.5	3.77	6.19
18.	Mizoram	2640.5	3.68	32.46
19.	Nagaland	4372.1	5.00	35.38
20.	Odisha	37272.6	3.33	2.48
21.	Punjab	3081.9	0.24	1.42
22.	Rajasthan	1735.2	0.17	1.20
23.	Sikkim	912.9	1.61	46.02
24.	Tamil Nadu	138006.5	5.84	7.38
25.	Telangana	8088	0.43	1.21
26.	Tripura	7698.5	7.78	2.66
27.	Uttarakhand	3035.3	0.92	28.64
28.	Uttar Pradesh	22489.1	1.57	1.58
29.	West Bengal	17723.8	1.81	0.31
30.	Delhi	54.8	0.22	8.52
31.	Puducherry	7311.9	14.87	18.67

Source: RBI, 2024.

infrastructure, institutions, and public investment in marine fisheries overlooks the potential of inland fisheries, particularly in states that are already leading producers. Andhra Pradesh, West Bengal, Odisha, Uttar Pradesh, Bihar, and Chhattisgarh have demonstrated significant capacity for fish production, yet they lack adequate public investment to fully realize their potential. Addressing these disparities through increased public investments in inland fisheries infrastructure, research and development, and extension support services is critical for realizing the sectors full potential and reinforcing its role in national economic and food security strategies.

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10

Agricultural Development Indicators

Sant Kumar, S V Bangaraju and Ankita Kandpal

Agriculture is one of the strategically important sectors of Indian economy including other developing ones. The level of its development determines food security, poverty reduction, people's well-being, health, and economic development. Steady growth performance can be judged by the indicators for various agriculture related aspects. This chapter provides key indicators of agricultural development both at all-India and state levels. It broadly contains the indicators reflecting the performance of agriculture sector of various key aspects such as the position of Indian agriculture in terms of rank in global indices, nutrition level of population, export performance, and output and input indicators. Output indicators include value of production from agriculture, land productivity and agricultural growth, while input indicators encompass certified/ quality seeds availability, fertilizer and pesticide use, irrigated area, electricity consumption in agriculture, and extent of crop diversification. The chapter also covers environmental indicators related to agriculture and crop residue/biomass burning. The food security issues are also reflected through amount of stock handled (procurement and offtake) through PDS. The service and infrastructure development in the sector are shown by using rural road density, market density, R&D intensity, number of Primary Agricultural Credit Societies (PACS) and branches of scheduled commercial banks. It also includes major constraints hindering the growth of the sector like groundwater depletion, land holding size, and wasteland area.

Table 10.1. Agricultural development indicators

S.N.	Indicator	Value	Reference year
1.	Global Food Security Index (Rank)	68	2022
	1. Affordability	59.3	
	2. Availability	62.3	
	3. Quality and safety	62.1	
	4. Sustainability and adaptation	51.2	
2.	Global Multidimensional Poverty Index (Rank)	69	2023
3.	Global Hunger Index (Rank)	105	2024
4.	Prevalence of undernourishment (%)	13.7	2024
5.	Children affected by wasting (%)	18.7	2024
6.	Stunted children (%)	35.5	2024
7.	Child mortality (%)	2.9	2024
8.	Emissions from agriculture (million tons)		2024
	· CO_2	320.3	
	· N_2O	224.8	
	· CH_4	722.6	
	· F-gases	42.2	
9.	Biomass burned (million tons)		2022
	· Maize	9.95	
	· Rice	25.52	
	· Sugarcane	3.36	
	· Wheat	12.18	
	· All crops	51.01	

S.N.	Indicator			Value	Reference year
10.	Labour force employed in agriculture (million persons) Share in total labour employed (%) · Male · Female			253.03 36.3 64.4	2023-24
11.	Agricultural exports · Value (billion US $) · Share in total exports (%)			 48.29 11.05	2023-24
12.	Gross Value Added in agriculture, forestry, and fishing at 2011-12 prices (Rs. Lakh Crore) Percentage share in AgGVA · Agriculture · Livestock · Fisheries · Forestry and logging			 23.06 54.7 29.9 7.2 8.1	2022-23
13.	Agricultural growth (%)			4.38	2011-12 to 2022-23
14.	Land productivity (GVA/GCA, Rs. Lakh /ha)			1.09	2022-23
15.	Food grain yield (kg/ha)			2516.0	2023-24
16.	Certified/quality seed availability (Lakh quintal) Share (%) · public sector · private sector			514.26 26.0 74.0	2022-23
17.	Net sown area (m ha)			140.71	2022-23
18.	Gross cropped area (m ha)			219.36	2022-23
19.	NPK use (kg/ ha)			136.10	2022-23
20.	Pesticide use (kg/ha)			0.252	2023-24
21.	Irrigated area (% of GCA)			55.75	2022-23
22.	Area under micro-irrigation ('000 ha)			16,734.58	2023-24
23.	Extent of crop diversification (0 to 1 scale, 1-complete diversification)			0.910	2023-24
24.	Research & education intensity in agriculture (%)			0.40	2022-23
25.	Procurement of rice and wheat (million tons)			78.7	2023-24
26.	Total offtake for PDS (million tons)			67.7	2023-24
27.	Share of GCF in agriculture & allied in GCF of India (%)			2.56	2022-23
28.	Disbursement of Rural Infrastructure Development Fund (Rs. Crore)			40,475	2023-24
29.	Agricultural credit (Rs. Lakh Crore) · Short term loans · Medium term/long term loans			24.84 14.79 10.05	2023-24
30.	Scheduled commercial banks density (Branches/'000 sq. km.)			50	2023-24
31.	Rural road density (length in km /km^2 of geographical area)			1.65	2018-19
32.	Market density (number of agricultural markets/'000 km^2)			2.16	2022-23
33.	Livestock density (number/km^2)			163	2019
34.	Farmer's income (Rs./ month/household)			10,218	2018-19
35.	Primary Agricultural Cooperative Societies (number)			101,524	2023-24
36.	Consumption (kg/month/person)	Rural	Urban	Total	
	· Cereals · Pulses · Edible oil · Fish · Milk (litres) · Eggs (No.)	9.615 0.760 0.882 0.253 4.933 3.889	8.052 0.844 0.982 0.274 5.695 5.038	9.172 0.784 0.910 0.259 5.149 4.215	2022-23
37.	Poverty (Number in millions) Headcount ratio (%)			234 11.28	2023
38.	Total wastelands area (% of total geographical area)			16.96	2015-16

Source:

1. Global Food Security Index report, 2022
2. Global Hunger Index report, 2022
3. Multidimensional Poverty Index report,2022, UNDP & OPHI
4 to 9. FAOSTAT
10. KLEMS database RBI
11. Directorate General of Commercial Intelligence and Statistics, Ministry of Commerce and Industry, GoI
12 to 14. National Account Statistics
15 to 23. Directorate of Economics and Statistics, Ministry of Agriculture and Farmer's Welfare, GoI
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30. Bank Branch Statistics, RBI
31. Basic Road Statistics of India, Ministry of Road Transport and Highways
32. AGMARKNET
33. Livestock Census
34. NSSO data as stated in NSS Report 587.
35.National Federation of State Cooperative Banks Ltd. (NAFSCOB)
36. NSSO 68th round
37. Global Multidimensional Poverty Index Report, 2023, UNDP & OPHI and Rajya Sabha Unstarred Q.No. 1524, Answered on August 5, 2024
38. NRSC-Wasteland atlas of India

Table 10.2. Agricultural development indicators of states, 2022-23

State/ Union Territory	GSVA (agri & allied activities) Rs. '000 Crore	Foodgrains yield (kg/ha)	Share of agriculture in state GVA (%)	Land productivity (Rs. lakh /ha)	Agricultural growth (% growth in GSVA)
1	2	3	4	5	6
Andhra Pradesh	213.78	3134	30.71	2.95	8.53
Assam	40.78	2373	15.89	1.05	3.10
Bihar	85.33	3106	20.17	1.16	3.00
Chhattisgarh	44.87	22.81	15.71	0.79	4.84
Gujarat	163.47	2324	13.49	1.11	4.48
Haryana	87.10	4058	16.72	1.33	3.69
Himachal Pradesh	17.04	2392	13.52	1.91	2.95
Jammu & Kashmir	18.31	2097	15.50	1.61	3.47
Jharkhand	27.81	1436	11.52	1.51	1.71
Karnataka	128.57	1710	10.81	0.87	5.22
Kerala	44.88	2728	8.51	1.78	-0.90
Madhya Pradesh	201.84	2268	34.44	0.67	6.93
Maharashtra	222.63	1347	11.02	0.87	3.75
Odisha	64.89	1798	14.89	1.30	3.90
Punjab	99.98	4737	23.02	1.23	2.21
Rajasthan	200.31	1515	27.44	0.73	4.90
Tamil Nadu	144.23	2839	11.15	2.27	5.48
Telangana	101.36	3606	15.40	1.26	5.77
Uttar Pradesh	282.90	2876	22.42	1.00	3.79
Uttarakhand	14.49	2532	7.81	1.50	1.18
West Bengal	155.54	3142	18.81	1.52	2.57
All-India	2394.61	2516	16.72	1.09	4.38

Source: *Column 2, 4 and 6. National Account Statistics (http://www.mospi.nic.in/); Column 3: Directorate of Economics and Statistics, Ministry of Agriculture & Farmer's Welfare, Government of India (dacnet.nic.in); Column 5. National Account Statistics (http://www.mospi.nic.in/); Directorate of Economics and Statistics, Ministry of Agriculture & Farmer's Welfare, Government of India (dacnet.nic.in)*

Note: GSVA estimates are at 2011-12 prices, growth estimates pertain to the period 2011-12 to 2022-23

Table 10.3. Agricultural input use indicators of states

State	Consumption of NPK (kg/ ha)	Consumption of pesticides (kg/ha)	Irrigated area (% of GCA)	Area under micro-irrigation ('000 ha)	Electricity use in agriculture (% of total)	Extent of crop diversification (0 to 1)	Rural road density (per km2)	Agri R&E intensity (% of GSVA)	PACS (Number)
1	2	3	4	5	6	7	8	9	10
	2022-23	2023-24	2022-23	2023-24	2022-23	2023-24	2018-19	2022-23	2023-24
Andhra Pradesh	262.2	0.271	54.21	2094.69	12.05	0.874	1.08	0.21	1955
Assam	63.5	0.117	15.15	45.61	0.78	0.615	5.09	0.46	903
Bihar	225.1	0.137	78.40	132.73	10.51	0.783	3.17	0.20	8484
Chhattisgarh	126.9	0.319	36.05	405.12	23.60	0.526	0.78	0.25	2059
Gujarat	129.5	0.131	74.05	1946.30	17.88	0.911	1.27	0.29	10193
Haryana	204.1	0.611	95.04	753.94	19.17	0.783	1.14	0.09	787
Himachal Pradesh	65.2	0.313	23.00	14.74	0.83	0.835	1.31	1.21	2113
Jammu & Kashmir	101.0	0.382	42.24	1.18	3.67	0.856	0.54	1.20	620
Jharkhand	154.7	0.371	17.09	61.16	0.56	0.863	1.02	0.42	4459
Karnataka	139.0	0.123	42.33	2852.20	33.33	0.924	1.87	0.28	6001
Kerala	61.4	0.210	20.43	35.55	1.59	0.789	6.69	0.58	1558
Madhya Pradesh	93.1	0.020	56.28	758.72	39.33	0.868	1.18	0.05	4537
Maharashtra	111.3	0.344	23.35	2296.84	24.33	0.891	2.07	0.44	21060
Odisha	108.0	0.228	32.19	228.91	2.39	0.676	1.96	0.26	4320
Punjab	227.4	0.632	93.04	60.09	23.49	0.629	2.93	0.25	3533
Rajasthan	64.8	0.067	44.67	2507.50	38.61	0.904	0.92	0.09	8187
Tamil Nadu	163.1	0.307	60.48	1455.50	13.54	0.849	2.08	0.35	4516
Telangana	184.6	0.530	69.78	359.00	32.23	0.623	1.25	0.24	918
Uttar Pradesh	186.1	0.419	81.27	429.89	16.71	0.824	1.84	0.06	7178
Uttarakhand	148.1	0.084	58.48	34.80	3.10	0.860	1.28	0.86	670
West Bengal	161.9	0.409	66.45	156.52	2.54	0.710	3.20	0.07	4850
All-India	136.1	0.252	55.75	16,734.58	18.98	0.910	1.65	0.40	101,524

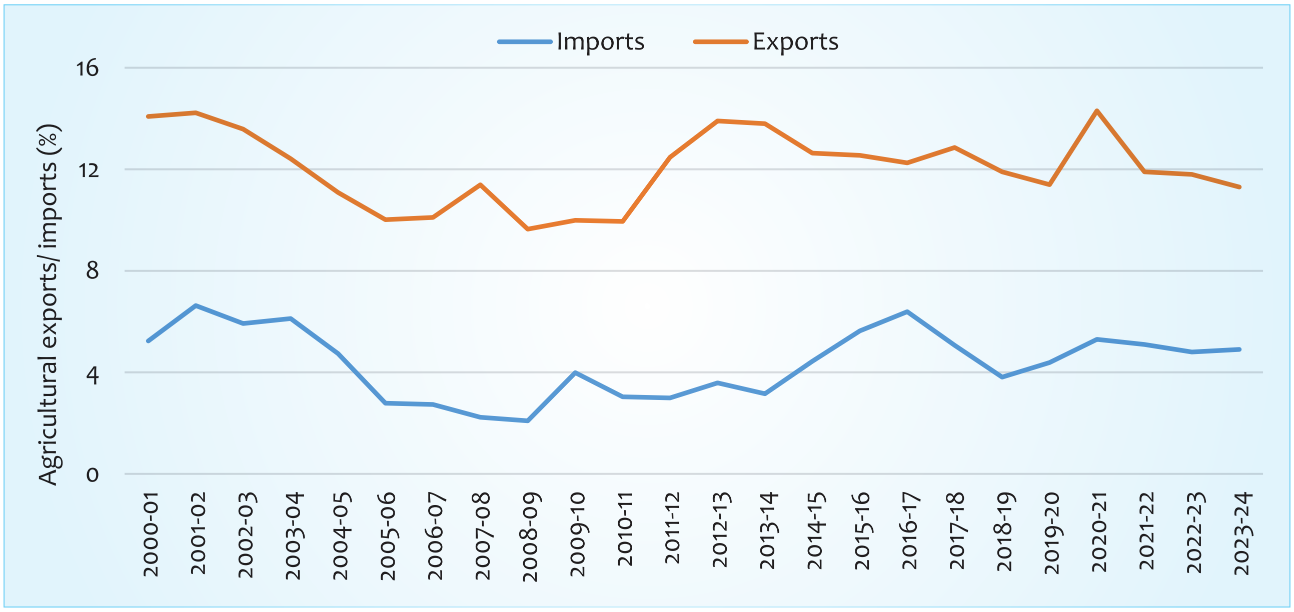
Table 10.3. ......Contd.....

State	Agricultural wages (Rs. /day)		Livestock density (number/ km^2	Market density (number/ 000 km^2	Stage of groundwater extraction (%)	Scheduled commercial banks (branches/ 000 km^2)	Agricultural Credit (Rs. 000 Crore)	Farmer's income (monthly average per hh)	Average size of land holdings (ha)	Total wastelands (% of total area)
	Male	Female								
Year	2022-23		2019	2023	2023	2024	2023-24	2018-19	2015-16	2015-16
	11	12	13	14	15	16	17	18	19	20
Andhra Pradesh	512	362	209	1.95	28.3	48	296.795	10480.0	0.94	14.71
Assam	438	397	230	2.88	12.54	41	11.141	10675.0	1.09	11.48
Bihar	362	319	387	0.00	44.76	79	66.587	7542.0	0.39	8.16
Chhattisgarh	271	200	117	1.38	47.17	23	3.3014	9677.0	1.24	8.04
Gujarat	270	250	137	2.07	51.68	45	139.980	12631.0	1.88	11.09
Haryana	545	463	157	6.45	135.74	120	87.604	22841.0	2.22	3.75
Himachal Pradesh	442	419	79	1.13	34.95	32	10.943	12153.0	0.95	41.01
Jammu & Kashmir	442	503	37	0.11	24.20	9	9.828	18918.0	0.59	79.06
Jharkhand	306	274	296	2.52	31.38	41	21.507	4895.0	1.10	14.76
Karnataka	475	299	151	2.94	66.26	59	201.783	13441.0	1.36	6.9
Kerala	876	619	75	0.00	54.55	183	152.289	17915.0	0.18	5.89
Madhya Pradesh	324	269	132	1.81	58.57	25	112.905	8339.0	1.57	12.83
Maharashtra	399	259	107	3.02	53.83	47	164.051	11492.0	1.34	11.72
Odisha	381	312	117	3.44	46.33	37	50.475	5112.0	0.95	11.83
Punjab	489	426	139	8.66	163.76	135	90.535	26701.0	3.62	0.92
Rajasthan	413	332	166	1.41	148.77	24	152.212	12520.0	2.73	23.04
Tamil Nadu	681	329	188	2.21	73.91	99	439.195	11924.0	0.75	6.32
Telangana	466	328	291	2.52	38.65	54	153.497	9403.0	1.00	12.71
Uttar Pradesh	333	311	281	2.63	70.76	78	166.626	8061.0	0.73	3.54
Uttarakhand	497	409	83	1.16	51.69	43	12.139	13552.0	0.85	23.79
West Bengal	372	306	422	6.05	44.81	112	72.020	6762.0	0.76	1.86
All-India	395	329	163	2.16	59.26	50	2,484.167	10,2018	1.08	16.96

Source:

Column 2,3,4,5,6,7,11,12 &17; Directorate of Economics and Statistics, Ministry of Agriculture & Farmer's Welfare, Government of India (dacnet.nic.in)
Column 8. Basic Road Statistics of India 2018-19, Ministry of Road Transport and Highways, GoI
Column 9. Combined Finance and Revenue Accounts, Comptroller and Auditor General of India
Column 10. National Federation of State Cooperative Banks Ltd. (NAFSCOB)
Column 13. Livestock census, 2019
Column 14. http://www.agmarknet.gov.in/
Column 15. Dynamic Ground Resources of India, Ministry of Jal Shakti, GoI, (https://cgwa-noc.gov.in/landingpage/ LatestUpdate/ NCDGWR2023.pdf)
Column 16. Bank Branch Statistics, RBI
Column 18. NSSO data as stated in NSS Report 587.
Column 17. Agriculture Census, 2015-16
Column 20. NRSC-Wasteland atlas of India 2019 (https://dolr.gov.in/ documents/wasteland-atlas-of-india)

Figure 10.1. Share of agricultural exports and imports to national trade (2000/01 to 2023/24)

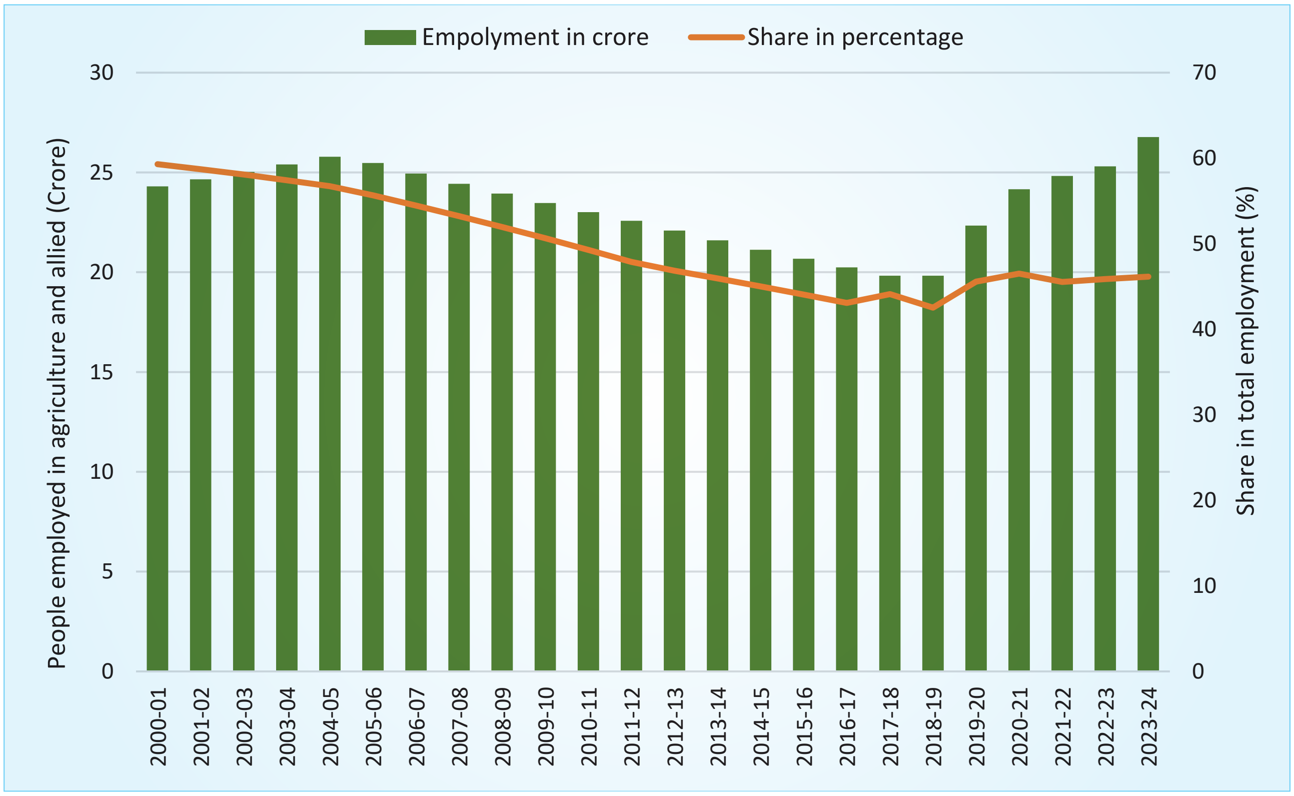


Source: DGCIS.

Figure 10.2. Institutional credit to agriculture and allied sectors (2000/01 to 2023/24)

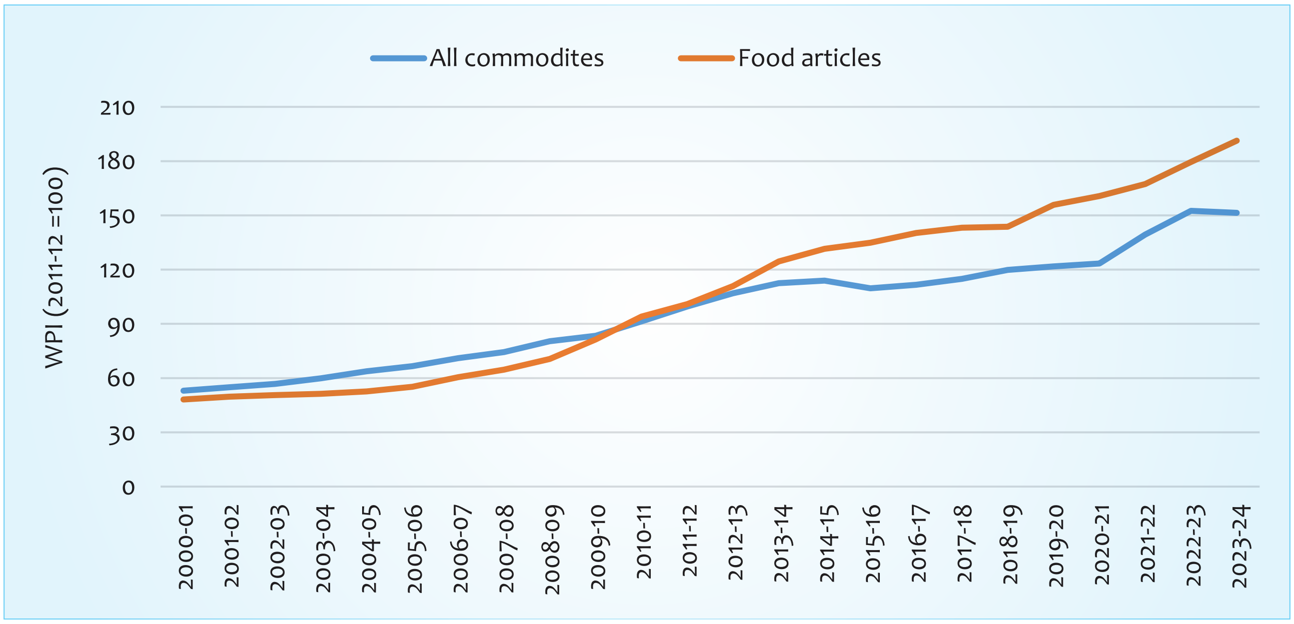
Source: RBI.

Figure 10.3. Employment in agriculture and allied sectors (2000/01 to 2023/24)



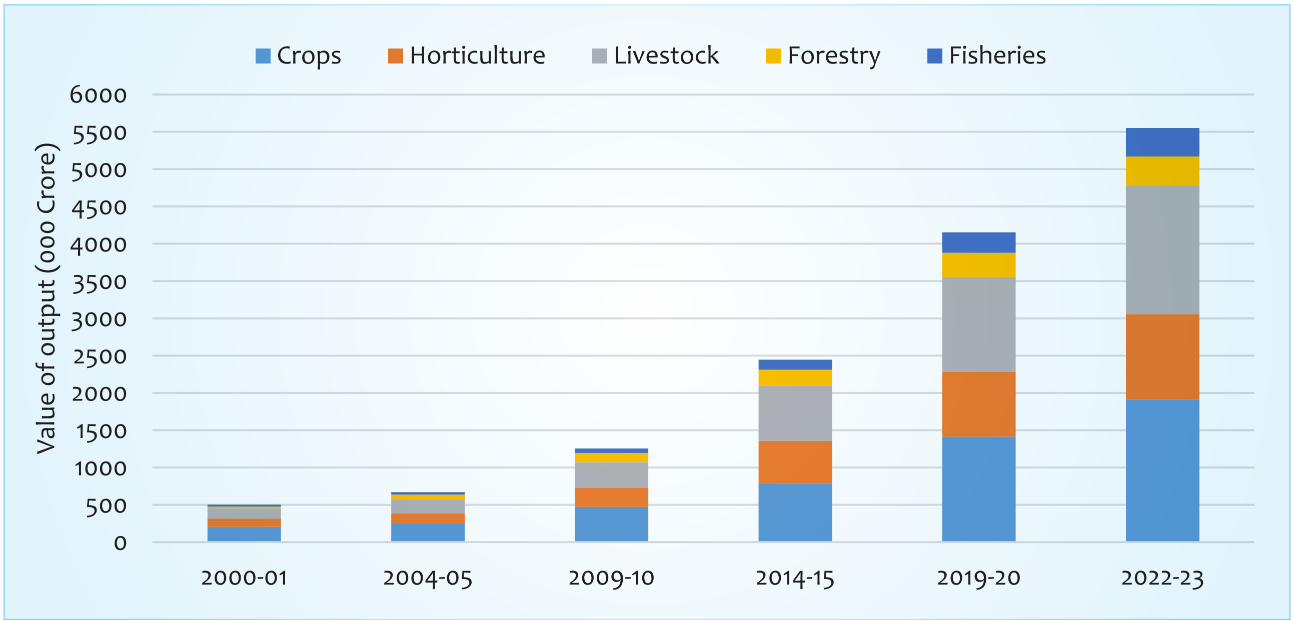
Source: MoSPI.

Figure 10.4. Trend in wholesale price indices (annual average, 2000/01 to 2023/24)



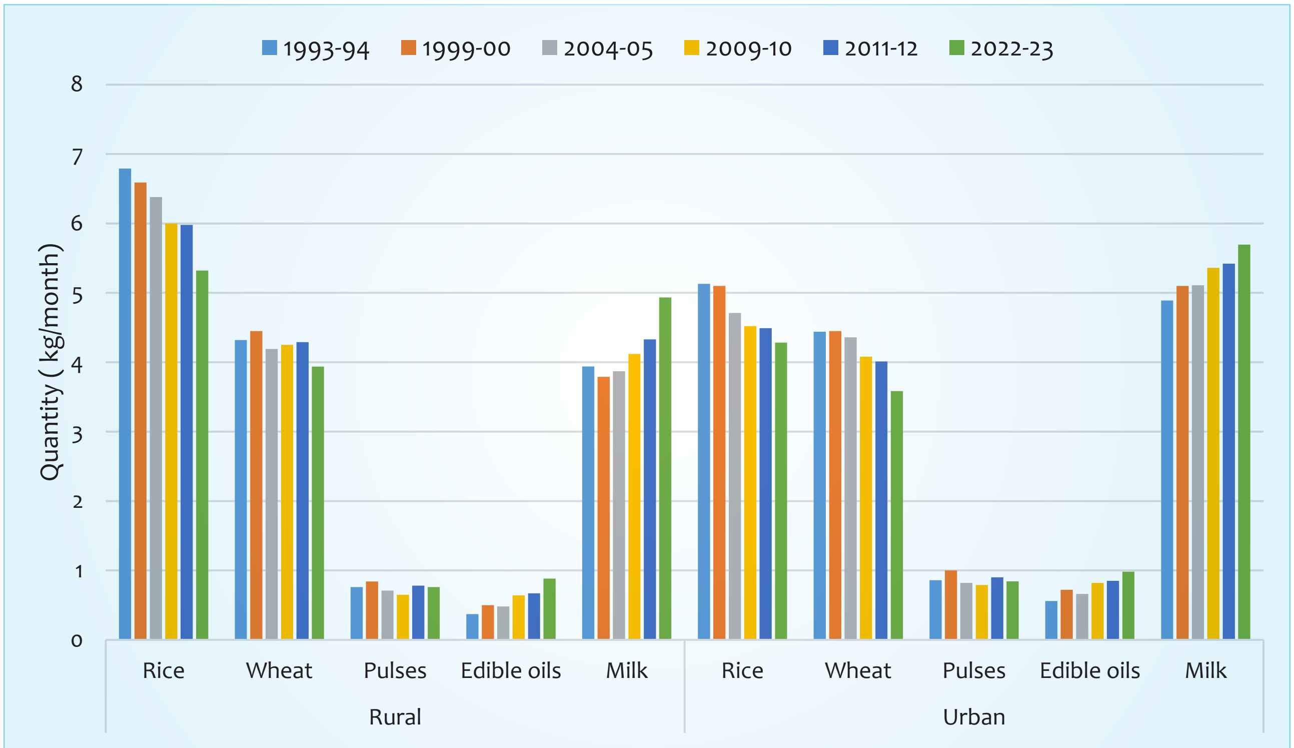
Source: Ministry of Commerce and Industry.

Figure 10.5. Value of agricultural and allied sectors (2000/01 to 2022/23)



Source: MoSPI.

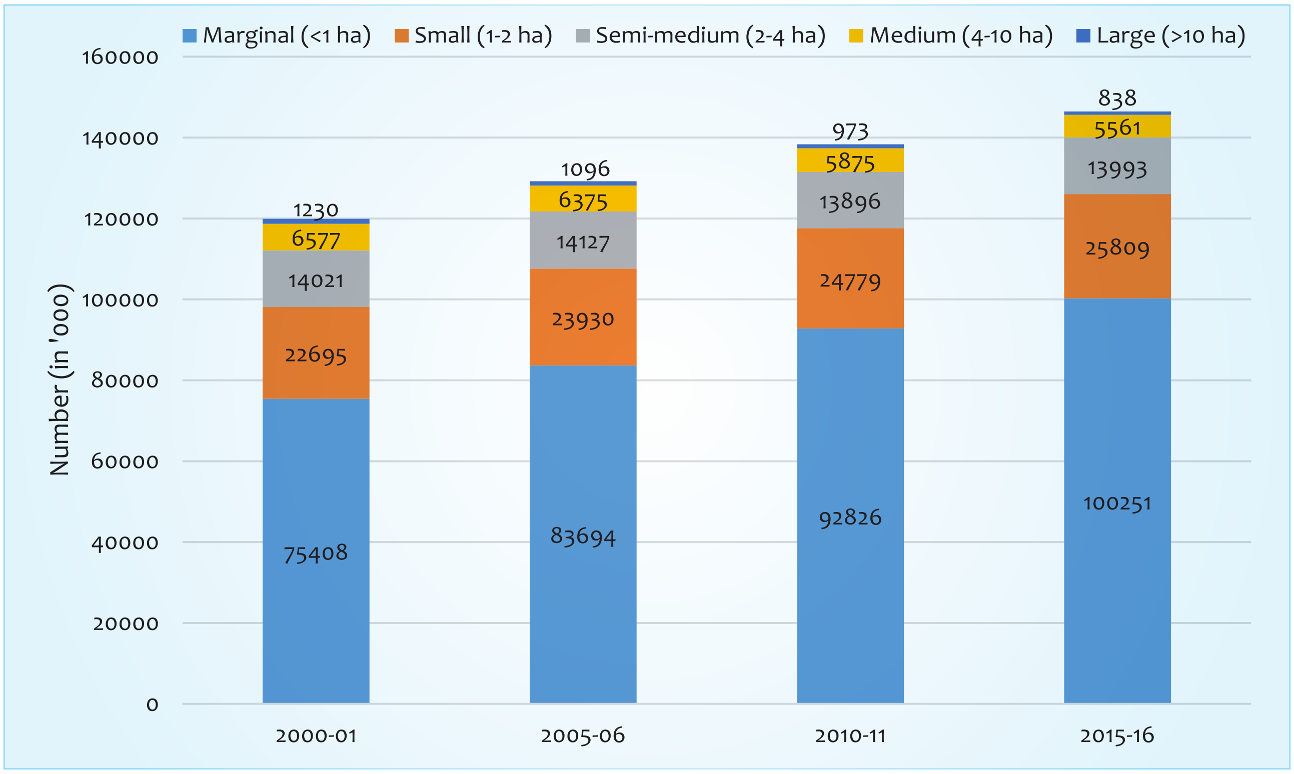
Figure 10.6. Changing per capita food consumption pattern (kg/month,1993/94 to 2022/23)



Source: MoSPI.

Note: Milk consumption is in litres.

Figure 10.7. Number of operational holdings in agriculture (2000/01 to 2015/16)



Source: MoA&FW.

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This report presents a comprehensive and strategic analysis of India's agricultural development, encompassing critical domains such as public investment, crop diversification, advancements in irrigation technologies, farm mechanization, market infrastructure and reforms, and the expansion of emerging sectors like livestock and fisheries. It underscores the persistent regional disparities and articulates actionable policy imperatives to foster sustainable, resilient, and inclusive agricultural growth.

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