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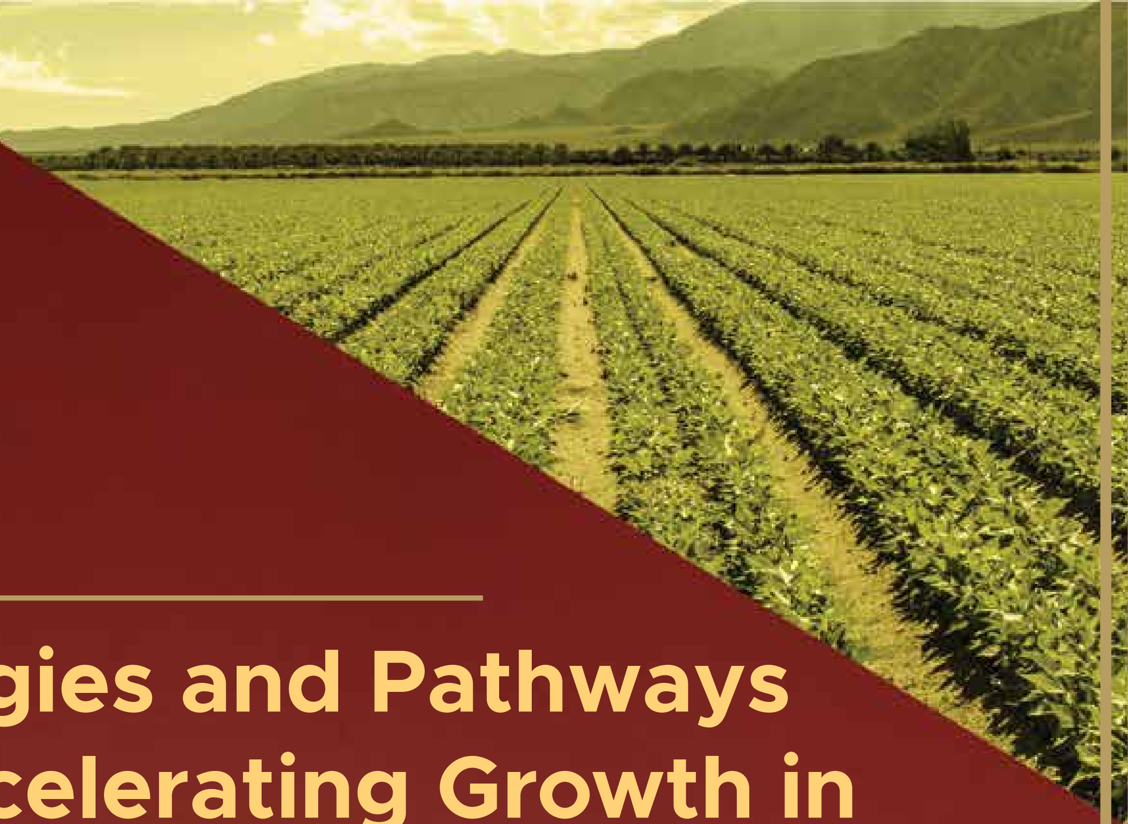

Strategies and Pathways for Accelerating Growth in Pulses towards the Goal of *Atmanirbharta*

2025

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AUTHORS:

Dr. Neelam Patel (Senior Adviser), NITI Aayog
Shri Sambuddha Goswami (Consultant-II), NITI Aayog
Dr. Harshika Choudhary (Consultant-I), NITI Aayog
Shri Karan Kumar (Young Professional), NITI Aayog
Dr. Shiv Charan Meena (Research Officer), NITI Aayog
Ms. Mayuri Gadhawe (Young Professional), NITI Aayog
Ms. Shubhangini Chaudhary (Young Professional), NITI Aayog

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2025

शिवराज सिंह चौहान

SHIVRAJ SINGH CHOUHAN

D.O. No. 42 /AM

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कृषि एवं किसान कल्याण और
ग्रामीण विकास मंत्री
भारत सरकार
कृषि भवन, नई दिल्ली

**Minister of Agriculture & Farmers Welfare
and Rural Development
Government of India
Krishi Bhawan, New Delhi**

MESSAGE

India stands as the largest producer, consumer, and importer of pulses globally, contributing approximately 25% of the world's production, 27% of global consumption, and 14% of global imports. Pulses hold a unique position in India's agricultural economy and food systems. They account for around 23% of the area under food grains and contribute 9-10% to the total food grain production in the country. With a cultivation area of approximately 30 million hectares and an average annual production of about 25 million tonnes (MT), pulses play a crucial role in ensuring nutritional security and sustaining agricultural livelihoods. However, the average productivity, at 851 kg/ha (2018-19 to 2022-23), highlights the need for focused interventions to boost yield and efficiency.

The Hon'ble Prime Minister has emphasized the need to achieve self-reliance in pulse production, recognizing the importance of pulses in combating protein deficiency and promoting sustainable agriculture. By embracing strategic interventions to enhance productivity, strengthen market linkages, and diminish import dependency, we can collectively achieve this inspiring vision for a resilient and prosperous future.

The Government of India (GoI) has launched several initiatives like the National Food Security Mission (NFSM) and the Pradhan Mantri Annadata Aay Sanrakshan Abhiyan (PM-AASHA) aim to enhance productivity and empower farmers. These initiatives optimize land use by strategically targeting rice fallow areas under the NFSM. Together, they strive to improve crop yields, expand the area for pulse cultivation, and ensure fair price support for farmers, paving the way for a vibrant and sustainable agricultural future.

The document "Strategies and Pathways for Accelerating Growth in Pulses towards the Goal of Atmanirbharta" offers a comprehensive roadmap to transform the pulse sector. It outlines strategies to enhance productivity through the adoption of high-yielding and climate-resilient varieties, expand pulse cultivation into non-traditional regions, and promote sustainable farming techniques. Furthermore, the strategy emphasizes the importance of integrating pulse production with market linkages, value addition, and robust procurement systems, ensuring higher incomes for farmers while meeting national demand. I commend the Agriculture Division of NITI Aayog for preparing this insightful and transformative document.

(Shivraj Singh Chouhan)

Agriculture & Farmers' Welfare Minister's Office : 120, Krishi Bhawan, New Delhi-110 001
Tel. : 011-23383370, 23782594, 23073789, 23782691

सुमन के. बेरी
उपाध्यक्ष
SUMAN K. BERY
VICE CHAIRMAN

Phones : 23096677, 23096688
Fax : 23096699
E-mail : vch-niti@gov.in

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Azadi Ka Amrit Mahotsav

भारत सरकार
नीति आयोग, संसद मार्ग
नई दिल्ली - 110 001
Government of India
NATIONAL INSTITUTION FOR TRANSFORMING INDIA
NITI Aayog, Parliament Street,
New Delhi - 110 001

Message

India's agricultural economy forms the backbone of our nation, employing nearly half of the workforce and serving as a critical driver of food and nutritional security. Even so, ensuring affordable and sustainable nutrition for over 1.25 billion people remains an ongoing challenge, particularly in addressing the protein needs of our population. Pulses, historically integral to our cropping systems and diets, are uniquely positioned to bridge this gap. Rich in protein and grown predominantly in rainfed areas, pulses are vital to supporting both nutritional security and the livelihoods of millions of smallholder farmers.

Despite their significance, pulses have often been secondary to highly incentivized crops like rice, wheat, and cash crops. Concentrated mainly in rainfed regions—home to more than 40% of the population and two-thirds of the livestock—pulses remain underutilized in realizing their full potential. Recognizing this, the government has prioritized pulses as a key focus area. The twin objectives of ensuring nutritional security and enhancing the incomes of rainfed farmers have driven policy interventions, including programs like Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), Pradhan Mantri Fasal Bima Yojana (PMFBY), Paramparagat Krishi Vikas Yojana (PKVY), Soil Health Management (SHM), Soil Health Card(SHC), and National Agriculture Market (e-NAM). These initiatives aim to address productivity challenges, promote sustainable practices, and integrate pulses into market systems.

I commend the Agriculture Division of NITI Aayog for this timely and comprehensive report. By adopting the outlined strategies, stakeholders across the value chain can contribute to securing India's nutritional future and empowering millions of farmers. Together, we can reimagine the role of pulses as a cornerstone of India's agricultural and economic progress.

Suman Bery

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प्रो. रमेश चन्द
सदस्य
Prof. Ramesh Chand
MEMBER

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भारत सरकार
नीति आयोग, संसद मार्ग
नई दिल्ली-110 001
Government of India
NATIONAL INSTITUTION FOR TRANSFORMING INDIA
NITI Aayog, Parliament Street
New Delhi-110 001
Tele. : 23096756, 23096774 Fax : 23730678
E-mail : rc.niti@gov.in

MESSAGE

Over the past decade, beginning 2015-16 production of pulses in India has shown remarkable growth. This has raised pulse production from 16 million tonnes (MT) during 2015-16 to more than 24 MT in year 2023-24. This has reversed the declining trend in per capita production until 2009-10 that resulted in the growing gap between demand and supply. Several strong initiatives were launched to revitalize pulse production and fill the gap between rising demand and supply. However, pulses price skyrocketed following the two consecutive droughts in years 2014-15 and 2015-16 catalyzed change. This rise in prices of pulses prompted the government to launch result-oriented farmer-centric initiatives. This strategic response encouraged farmers to expand their cultivation area and led to an unprecedented increase in the area under pulses, establishing an upward trend in production. Between 2013-14 and 2022-23, the area cultivated under pulses expanded by one-third, while production rose from 19.2 MT to 26 MT in 2022-23. This represents an annual compound growth rate of 3.4%, reflecting the highest level of growth for pulses in a decade since 1950-51. These achievements highlight the potential for growth in output of pulses in India.

India's reliance on pulse imports is a significant concern. Although imports decreased from a peak of 6.6 million tonnes (MT) in 2016-17 to approximately 2.5 MT in 2022-23, they surged again to 4.7 MT in 2023-24, accounting for nearly 20% of domestic demand. Achieving self-sufficiency in pulse production is crucial for meeting domestic needs and enhancing nutrition. This is particularly important as three-fourths of the area dedicated to pulses is rainfed, and pulse production serves as a key source of livelihood for farmers in marginal and agriculturally poor regions. A significant advantage of pulses is that they are environment friendly and exert minimum pressure on scarce natural resources such as water and soil. Additionally, pulse cultivation helps to fix atmospheric nitrogen in the soil, improving its fertility.

The *"Strategies and Pathways for Accelerating Growth in Pulses towards Achieving Atmanirbharta"* report highlight our achievements and presents the roadmap necessary for sustaining and building upon the progress of last ten years. With our unwavering commitment and a focus on incentive and innovation, we are set to move towards the goal of self-sufficiency (Atmanirbharta) in pulses which in turn will improve nation's nutrition security and farmers' prosperity.

[Ramesh Chand]

05.05.2025




बी. वी. आर. सुब्रह्मण्यम
B.V.R. Subrahmanyam
मुख्य कार्यकारी अधिकारी
Chief Executive Officer

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भारत सरकार
नीति आयोग, संसद मार्ग
नई दिल्ली - 110 001
Government of India
National Institution for Transforming India
NITI Aayog, Parliament Street,
New Delhi - 110 001
Tel. : 23096576, 23096574
E-mail : ceo-niti@gov.in

FOREWORD

India's agriculture has long been the cornerstone of its economy and within that landscape, pulses hold a significant place, contributing both to nutritional security and sustainable agriculture. Pulses are not only a key dietary source of protein, particularly for vegetarians, but they also contribute to soil health through nitrogen fixation, making them essential for sustainable farming.

Over the past several years, India has made remarkable strides in pulse production with a 49% increase in output since 2015-16, thanks to the concerted efforts of both farmers and the government. However, the challenge of achieving self-sufficiency remains, with India continuing to be the largest importer of pulses in the world. In 2023-24, the country imported 4.7 million tonnes of pulses, underscoring the importance of developing domestic production to meet the growing demand.

While we have made significant progress, there are still several constraints in pulse production, including low yields compared to global averages, reliance on rainfed and marginal lands, and the absence of climate-resilient, disease-resistant varieties. To overcome these challenges, NITI Aayog continues to emphasize the importance of strategic interventions with states and focusing on public-private collaboration for research and development of new varieties.

This report on ***"Strategies and Pathways for Accelerating Growth in Pulses towards Achieving Atmanirbharta"*** presents a comprehensive strategy to empower farmers, reduce our import dependency, and unlock the full potential of India's pulses sector. It reflects the government's commitment to ensuring food and nutritional security while enhancing the incomes of our farmers. I congratulate the Agriculture Division at NITI Aayog, for their dedication and hard work in producing this comprehensive and insightful report.

Dated: 14th February, 2025 **[B.V.R. Subrahmanyam]**

स्वच्छ भारत
एक कदम स्वच्छता की ओर

DEVESH CHATURVEDI
SECRETARY

भारत सरकार
कृषि एवं किसान कल्याण मंत्रालय
कृषि एवं किसान कल्याण विभाग
Government of India
Ministry of Agriculture & Farmers Welfare
Department of Agriculture & Farmers Welfare

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Message

Pulses are high in protein and primarily grown in rainfed regions, which is crucial for improving nutrition and supporting smallholder farmers. The government recognizes the potential of pulses, especially in rainfed areas supporting over 40% of the population. Initiatives like the Pradhan Mantri Krishi Sinchai Yojana (PMKSY) and the Electronic National Agriculture Market (e-NAM) encourage sustainable practices and market integration. Since 2015-16, India has experienced nearly a 49% increase in pulse production, attributed to dedicated farmers and government support.

2. While progress has been made in pulse production, significant challenges remain. Yields are still lower than the global average, and reliance on rainfed and marginal lands limits potential. Additionally, developing climate-resilient and disease-resistant plant varieties is crucial for sustainability. India's dependence on pulse imports is a concern; despite a drop from 6.6 million tonnes in 2016-17 to about 2.5 MT in 2022-23, imports surged to 4.7 MT in 2023-24, representing nearly 20% of domestic demand. Focusing strategies can enhance yield and efficiency, strengthen food security and promote sustainable agricultural practices.

3. The "*Strategies and Pathways for Accelerating Growth in Pulses towards the Goal of Atmanirbharta*" report outlines a comprehensive framework to enhance the pulse sector. It emphasizes improving productivity by promoting high-yielding, climate-resilient varieties and expanding cultivation into non-traditional areas. Key initiatives include integrating production with market linkages, enhancing mechanization, and increasing value addition to boost farmers' incomes and meet national demand. The report highlights the significance of pulses for sustainable agriculture and soil health while striving to achieve self-sufficiency in pulse cultivation.

4. I commend the Agriculture Division of NITI Aayog for this insightful report. I encourage all stakeholders to collaborate in implementing the strategies for achieving self-reliance (Atmanirbharta) in pulses. Together, we can enhance farmers' prosperity, promote nutritional security, and drive sustainable economic growth. By adopting these strategies, we can secure India's nutritional future and uplift millions of farmers, redefining the role of pulses in our agricultural and economic advancement.

(Dr. Devesh Chaturvedi)

New Delhi
10th February,2025

Office : Krishi Bhawan, New Delhi-110001, दूरभाष / Phone : 23382651, 23388444 फैक्स सं० / Fax No. : 23386004
E-mail : secy-agri@gov.in

NEELAM PATEL
SENIOR ADVISOR
Tel : 011-23096613
E-mail : neelam.patel@gov.in

सत्यमेव जयते

भारत सरकार
नीति आयोग, संसद मार्ग,
नई दिल्ली-110 001
Government of India
NATIONAL INSTITUTION FOR TRANSFORMING INDIA
NITI Aayog, Parliament Street,
New Delhi-110 001

Acknowledgement

I am pleased to present a report entitled "Strategies and Pathways for Accelerating Growth in Pulses towards the Goal of *Atmanirbharta*". Achieving self-sufficiency in pulses offers significant economic benefits to India by reducing import dependency and stabilizing the economy against global price fluctuations. To achieve this, it is essential to focus on increasing pulse production to meet domestic demand. If production does not keep up with consumption, reliance on imports will rise, highlighting the need for effective strategies to enhance pulse production and promote sustainability in Indian agriculture.

Pulses are essential to the Indian diet, providing a budget-friendly, sustainable, and climate-resilient source of plant-based protein and crucial micronutrients. Since the fiscal year 2015-16, domestic production of pulses has increased significantly by nearly 60%. Nonetheless, external factors, including the El Niño weather phenomenon, have resulted in fluctuations in pulse prices and imports. In the fiscal year 2023-24, India witnessed a notable rise in pulse imports, reaching a six-year high with a 90% increase compared to the previous fiscal year, which accounted for about 18.5% of domestic demand.

This report thoroughly analyses India's pulse sector to achieve self-sufficiency (*Atmanirbharta*). It commences with a rationale and objectives for the study, then examines the global pulse landscape and India's role. The report further investigates the Indian pulse sector at national and state levels, scrutinizing production trends, yield variability, and trade dynamics. A principal element of this report is its detailed examination of pulse demand and supply, including projections for 2030 and 2047. Furthermore, it introduces an innovative district cluster approach designed for targeted interventions to enhance pulse production and outlines a strategic roadmap for these interventions. Informed by a primary survey conducted by NITI Aayog of pulses growing farmers, the report presents actionable recommendations to address the anticipated demand-supply disparities by 2030 and 2047.

I want to acknowledge Honourable Vice Chairman Shri Suman Bery, NITI Aayog, for his encouragement and inspiration in our efforts. Appreciation is also extended to Shri B.V.R Subrahmanyam, CEO, NITI Aayog, for his leadership, guidance, and strategic direction that ensure the quality of our work. Additionally, I would like to thank Prof. Ramesh Chand, Member, NITI Aayog, for his valuable advice and suggestions that helped to refine the report.

I extend my compliments and gratitude to Smt. Subha Thakur, Additional Secretary, Crops, Admn. & Seeds; Dr. Praveen Kumar Singh, Agriculture Commissioner, Department of Agriculture & Farmers' Welfare (DA&FW); Dr. J.S. Sandhu, Professor Chair, Guru Gobind Singh Chair, Patanjali University, Uttarakhand; Dr. Shiv Kumar Agrawal, Regional Coordinator, South Asia & China Programme, International Center for Agricultural Research in the Dry Areas (ICARDA); Dr. GP Dixit, Director, ICAR-Indian Institute of Pulses Research, Kanpur; Dr. Aditya Pratap, Project Coordinator, All India Coordinated Research Projects (AICRP) (Kharif Pulses), ICAR; Dr. A.K Shivhare, Jt. Director, Directorate of Pulses Development (DPD), Bhopal; Dr. Shailesh Tripathi Project Coordinator, AICRP (Rabi Pulses), ICAR; Dr. C. Bharadwaj, Principal Scientist (Genetics), IARI; Dr. Anita Babbar, Principal Scientist (Chickpea), JNKVV, Jabalpur; Prof. S.K Jain (Plant Breeding & Genetics), Rajasthan Agricultural Research Institute, Durgapura, Jaipur; Dr. Prakash Gangashetty, Senior Scientist – (Pigeonpea) ICRISAT; Mr. Bimal Kothari, Chairman from India Pulses Grains Association (IPGA), and Mr. Sumit Gupta, Global CEO, WASEDA Global Commodities for their valuable comments and suggestions for framing the strategy and roadmap for increasing pulse production.

Contd…2/-

The successful completion of this report is a testament to the collective efforts of the Agriculture & Allied Sectors Division. I sincerely thank the entire team for their invaluable contributions, particularly those involved in the rigorous primary data collection across five central pulse-growing states of India, which provided the foundation for this study.

I am grateful to the line ministries, especially the Ministry of Agriculture and Farmers' Welfare (MoA&FW), for their support. I also thank the state departments of Rajasthan, Madhya Pradesh, Gujarat, Andhra Pradesh, and Karnataka for arranging the hassle-free and smooth collection of primary survey data from farmers.

I thank Shri Yugal Joshi, Program Director, and Ms. Keerti Tiwari, Director of Communications, NITI Aayog, for their thorough review and diligent document proofreading. Lastly, I would like to thank and acknowledge the role of every other stakeholder who has contributed actively or passively to making this document as and when time demands. With its comprehensive roadmap and strategic interventions, I am confident that this document will not only trigger a new paradigm of thinking but also serve as a practical guide for all states and districts to identify gaps and implement interventions, thereby shaping a more resilient and self-sufficient future for the pulse sector.

(Neelam Patel)

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Abbreviations

Abbreviations

AESR	Agro-Ecological Sub Region
AIDS	Almost Ideal Demand System
AIF	Agri-Infrastructure Fund
ARIMA	Autoregressive Integrated Moving Averages
AAGR	Average Annual Growth Rate
AICPIP	All India Coordinated Pulse Improvement Project
A3P	Accelerated Pulses Production
BAU	Business as Usual
CACP	Commission for Agricultural Costs & Prices
CAGR	Compound Annual Growth Rate
CPI	Consumer Price Index
CFLD	Cluster Frontline Demonstration
DACFW	Department of Agriculture, Cooperation and Farmers Welfare
DES	Diretorate of Economics & Statistics
DPD	Directorate of Pulses Development
ELM	Extreme Learning Machines
FPOs	Farmer Producer Organizations
e-NAM	National Agriculture Market Scheme
FAOSTAT	Food and Agriculture Organization Statistic
FYM	Farmyard Manure
GRNN	Generalized Regression Neutral Network
GMGR	Geometric Mean Growth Rate
GOI	Government of India
GDP	Gross Domestic Product
HA-HY	High Area and High Yield
HA-LY	High Area and Low Yield
HCES	Household Consumption Expenditure Survey
HIG	High-Income Growth
IPM	Integrated Pest Management
IIPR	Indian Institute of Pulses Research
ICAE	International Conference of Agricultural Economists
ICAR	Indian Council of Agricultural Research

ICMR	Indian Council of Medical Research
ISOPOM	Integrated Scheme of Oilseeds, Pulses, Oil Palm, and Maize
KVK	Krishi Vigyan Kendras
LA-LY	Low Area and Low Yield
LA-HY	Low Area and High Yield
Lha	Lakh hectares
Mha	Million hectares
MT	Million tons
MSP	Minimum Support Price
MoAF&W	Ministry of Agriculture & Farmers Welfare
MoSPI, GOI	Ministry of Statistics and Programme Implementation, Government of India
MPCE	Monthly Per Capita Consumption Expenditure
PSF	Price Stabilization Fund
PM-AASHA	Pradhan Mantri Annadata Aay Sanrakshan Abhiyan
PM-KSY	Pradhan Mantri Krishi Sinchayee Yojana
PM-FME	Pradhan Mantri Formalization of Micro Food Processing Enterprises
PM-FBY	Pradhan Mantri Fasal Bima Yojana
PKVY	Paramparagat Krishi Vikas Yojana
PM-RKVY	Pradhan Mantri Rashtriya Krishi Vikas Yojana
PDS	Public Distribution System
PDMC	Per Drop More Crop
PSB	Phosphate Solubilizing Bacteria
PSS	Price Support Scheme
MIS	Management Information System
NAFED	National Agricultural Cooperative Marketing Federation of India Limited
NBPGR	National Bureau of Plant Genetic Resources
NCCF	National Cooperative Consumers Federation of India
NAAS	National Academy of Agricultural Sciences
NFSM	National Food Security Mission
NIN	National Institute of Nutrition
NSC	National Seed Corporation
NSSO	National Sample Survey Organization
NNI	Net National Income
NPDP	National Pulses Development Project

QUAIDS	Quadratic Almost Ideal Demand System
RMS	Rabi Marketing Season
SDG	Sustainable Development Goals
SFPP	Special Food Grain Production Programme
SMAM	Sub-Mission on Agricultural Mechanization
SHM	Soil Health Management
SHC	Soil Health Card
SLSC	State-level Sanctioning Committee
SAUs	State Agriculture Universities
SDG	Sustainable Development Goals
SMAM	Sub-Mission on Agricultural Mechanization
SATHI	Seed Authentication, Traceability & Holistic Inventory
TRFA	Targetting Rice FallowArea
VRR	Higher Varietal Replacement Rate

Executive Summary

Executive Summary

Pulses, a group of annual legumes, are crucial for global food security and sustainable agriculture. They are rich in protein, fiber, vitamins, and minerals, benefiting both human and animal health. Beyond their nutritional benefits, pulses enhance soil health, conserve water, and help to mitigate climate change. Their unique properties support several Sustainable Development Goals (SDGs), including SDG 2 (Zero Hunger) by improving nutrition and food security and SDG 3 (Good Health and Well-being). Their low carbon footprint and nitrogen-fixing ability aid in reducing synthetic fertilizer use, aligning with SDG 13 (Climate Action) and SDG 15 (Life on Land). By encouraging sustainable farming practices and responsible consumption, pulses also contribute to SDG 12 (Responsible Consumption and Production). India recognizes their strategic importance as the world's largest producer and consumer of pulses.

Pulses are essential to the Indian diet, offering a budget-friendly and sustainable source of plant-based protein and vital micronutrients. In 2015-16, pulse production fell to 16.35 million tonnes (MT), leading to around 6 MT of imports to meet national demand. In response, the Government of India (GoI) has introduced various farmer-centric schemes since 2015-16, including the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), Pradhan Mantri Fasal Bima Yojana (PMFBY), Paramparagat Krishi Vikas Yojana (PKVY), Soil Health Management (SHM), and Soil Health Card (SHC), and National Agriculture Market scheme (e-NAM). Identifying the need for price support and market access, the GoI launched the Pradhan Mantri Annadata Aay Sanrakshan Abhiyan (PM-AASHA) scheme to procure pulses at Minimum Support Prices (MSP) where the Price Stabilization Fund (PSF) is now one of the components of PM-AASHA umbrella scheme for price stabilization interventions and daily price monitoring. Additionally, the e-Samridhi portal empowers pigeonpea, black gram, and lentil producers by facilitating procurement at better prices through the National Agricultural Cooperative Marketing Federation of India Limited (NAFED) and the National Cooperative Consumers Federation of India Limited (NCCF).

To achieve pulses self-sufficiency (Atmanirbharta), the government revitalized NFSM-Pulses, implementing it across 28 states and 2 UTs (J&K, Ladakh), with over 60% of funds dedicated to pulses. Key initiatives include: supporting breeder seed production; establishing 150 Seed Hubs at ICAR, SAUs, and KVKs for certified seed production; distributing seed mini-kits of recent varieties; and supporting cluster development, improved farm machinery, efficient irrigation system, plant protection, nutrient management, processing, and farmer training on cropping systems. The Targeting Rice Fallow Area (TRFA) initiative has been instrumental in promoting pulse cultivation.

To promote the pulse value chain, the government has introduced several initiatives. The Pradhan Mantri Rashtriya Krishi Vikas Yojana (PM-RKVY) focuses on state-specific projects, while the Per Drop More Crop (PDMC) scheme enhances irrigation efficiency. The Sub-Mission on Agricultural Mechanization (SMAM) supports farm mechanization and drone usage for timely operations. Additionally, the Seed Authentication, Traceability & Holistic Inventory (SATHI) portal ensures quality and traceability in seed production and distribution. Other schemes, including the Agri Infrastructure Fund (AIF), Pradhan Mantri Formalisation of Micro Food Processing Enterprises

(PMFME), Farmer Producer Organizations (FPOs), and Pradhan Mantri Fasal Bima Yojana (PMFBY), facilitate integrated development and risk management in the pulse sector.

Furthermore, the GoI significantly increased the increased the MSP for major pulse crops during 2016-17 and 2017-18 by offering bonuses, leading to an 18% rise in pulse production. To stabilize prices and enhance domestic availability, the Government approved a buffer stock of 0.15 MT of pulses on December 9, 2015, increasing it to 2.0 MT in September 2016. By the Rabi Marketing Season (RMS) of 2017-18, a total buffer of 2.05 MT was established through domestic procurement and imports for effective disposals. Starting in 2018-19, MSP procurement was conducted under the Price Support Scheme (PSS) by the Department of Agriculture, Cooperation and Farmers Welfare (D/oACFW). Pulses procured through the PSS were transferred to the Price Support Fund (PSF) to satisfy buffer requirements. This approach has led to the efficient use of PSS stocks for stabilization efforts, as controlled releases are made from the PSF. Hence, harmonization between the PSS and PSF has been accomplished, ensuring that farmers are provided with remunerative prices while managing supply-side interventions to stabilize consumer prices.

Implementing proactive pulse programs and monitoring mechanisms has notably increased the area, production, and productivity of pulses in India. From 2016-17 to 2021-22, production rose from 23.13 MT to a record 27.30 MT, with productivity increasing nearly 38%, from 0.656 t/ha in 2015-16 to 0.902 t/ha in 2022-23. Despite these gains, domestic production falls short of total demand, leading to imports of 2.496 MT in 2022-23. Import dependency has significantly decreased from 29% in 2015-16 to 10.4% in 2022-23. This remarkable achievement signifies a significant step forward in the nation's quest for self-sufficiency in the pulse sector. However, the fiscal year 2023-24 saw a 90% rise in imports to 4.739 MT, the highest level in six years, representing about 18.5% of domestic demand. This surge highlights the need for continued efforts to boost domestic production and reduce reliance on imports amid rising food prices that impact inflation.

Achieving self-sufficiency in pulses can significantly benefit India's economy by reducing import dependency and stabilizing against global price fluctuations. This stability ensures food security and supports rural livelihoods by providing consistent income for pulse farmers while promoting food sovereignty. To meet domestic demand, it is essential to increase pulse production. If production lags behind consumption, India could become more reliant on imports, highlighting the need for effective strategies to boost production and sustainability in agriculture. The Finance Minister has committed to improving the production, storage, and marketing of pulses. In the recent 2025-26 Union Budget, the Finance Minister noted past efforts that led to nearly achieving self-sufficiency in pulses. Farmers increased cultivation by 50%, supported by government procurement and fair pricing. The government will launch a six-year "Mission for Aatmanirbharta in Pulses" to further this goal, focusing on Tur, Urad, and Masoor. This mission aims to (1) develop and commercial availability of climate-resilient seeds, (2) enhance protein content, (3) increase productivity, (4) improve post-harvest storage and management, and (5) assure remunerative prices to farmers. Additionally, the central agencies, such as NAFED and NCCF, will be ready to procure these three pulses from farmers who register with them and enter into agreements over the next four years.

Key Highlights:

1. Pulses: A Global Perspective with A Focus on India

i. Pulse production globally has been growing steadily at 3% per year since the early 2000s, with developing countries accounting for nearly 75% of total output. Asia contributes over 44% of the global production.

ii. In 2022, the area for pulse cultivation reached about 97.09 million hectares (Mha), with a production of 96.04 MT and 0.989 tonnes per hectare (t/ha) productivity.

iii. In the past five years, dry bean[1] have become the leading crop in global pulses cultivation, covering 35.97 Mha (38.23% of the total area) and contributing 27.42 MT (30.27%) to production, although their yield is low at 0.774 t/ha.

- Chickpea occupy 14.45 Mha (15.36% of the total) and produce 15.97 MT (17.63%) with a yield of 1.107 t/ha.
- Pigeonpea produces 5.33 MT (5.88%) from 6.03 Mha (6.41% of the total area) at 0.883 t/ha yield.
- Lentil, occupying 5.23 Mha (5.5%), yields higher at 1.188 t/ha, totaling 6.20 MT (6.85%).
- Dry peas, covering 7.24 Mha (7.62%), have the highest yield efficiency at 1.9 t/ha, producing 13.75 MT (15.56%).
- Cowpeas occupy 15.07 Mha (15.54%) but yield the least at 0.612 t/ha, contributing 9.04 MT (10.23%) to global production.

iv. India is the world's largest pulse cultivator and producer contributing, ~38% of the global cultivated area for pulses and~28% of the global output.

v. From 2018 to 2022, India cultivated an average of 33.46 Mha of pulses, accounting for 35.87% of the global total, produced 24.76 MT of pulses during this period, contributing 27.40% of global production.

vi. However, India's yield is relatively lower than that of other top producers. India's average pulse yield was 0.740 t/ha, below the global average of 0.969 t/ha, emphasizing the need for more concerted efforts to improve yield efficiency significantly. If India matches the global average yield, there is a potential to increase pulse production by 7.66 MT, possibly making India self-sufficient.

vii. India ranks lowest in yield among the top ten pulse producers. Ethiopia leads with a yield of 1.894 t/ha, followed by Canada at 1.880 t/ha, USA at 1.874 t/ha, China at 1.821 t/ha, and Russia at 1.707 t/ha. Notably, India's yield is 2.5 times lower than that of Ethiopia, indicating significant potential for enhancement.

viii. India contributes 80.36% of the world's pigeonpea area and 78.10% of its production, but its average yield is 0.866 t/ha, slightly below the global average of 0.891 t/ha. By achieving the global average, India could increase production by 0.11 MT. Matching

1 *This includes: beans, species of Phaseolus (vulgaris, lunatus, angularis, aureus, etc.) and beans, species of Vigna (angularis, mungo, radiata, unguiculata, etc., (e.g., common bean, mungbean, urd bean, etc.); does not include: soya beans, green beans, green and dry lentil, bean shoots and sprouts, locust beans (carobs), castor beans, dry broad beans, and horse beans, and dry chickpea (garbanzo bean) (Source: https://unstats.un.org/unsd/classifications/Econ/Structure/Detail/EN/1074/01701).*

Malawi's yield could boost production by 3.70 MT. India could benefit from learning from Malawi's practices and utilizing pigeonpea germplasm to develop suitable varieties for local cultivation.

ix. India cultivates 10.11 Mha of chickpeas, representing 69.65% of the global total, and produces 11.57 MT, contributing 72.06% of global production. With an average yield of 1.145 t/ha, India slightly exceeds the global average of 1.106 t/ha. However, it ranks seventh among major producers, with a yield gap of 0.918 t/ha, which is more than 1.8 times lower than Ethiopia, the global top.

x. India is the largest producer of dry bean, cultivating 14.48 Mha, which is 40.88% of the global total. The country produced 5.94 MT, accounting for 21.68% of worldwide production. However, India's average yield is only 0.411 t/ha, compared to the global average of 0.774 t/ha. If India matched the global average yield, production could increase by 5.25 MT.

xi. India ranks second in lentil area and production, following Canada. The country cultivated 1.42 Mha of lentils, accounting for 27.15% of the global total, and produced 1.34 MT, contributing 21.66% of global output. With an average yield of 0.947 t/ha, which is below the global average of 1.187 t/ha, India could increase production by 0.34 MT if it matched the global average. If it reached China's yield, production could increase by 2.22 MT.

xii. India ranks fourth in the area and production of dry peas, cultivating 0.69 Mha, or 9.47% of the global total. The country produced 0.91 MT, contributing 6.61% of total global production. However, India's average yield of 1.326 t/ha is below the global average of 1.899 t/ha. If India matches the global average yield, production could increase by 0.39 MT. Additionally, achieving the yield of France could raise production by 1.30 MT.

xiii. Reasons for Low Productivity of Pulses in India:

- Pulse production in India faces significant challenges stemming from technological and environmental constraints. Unlike cereals, pulses have seen limited yield improvements due to a lack of high-yielding varieties and insufficient innovation. Farmers grapple with inadequate access to quality seeds, specialized production knowledge, and effective disease/pest management.
- Furthermore, the predominance of rainfed agriculture, coupled with insufficient irrigation infrastructure, renders pulse cultivation highly vulnerable to climatic vagaries.
- Economic factors, including volatile market prices, lower income returns compared to cereals, and inefficient marketing channels, further discourage farmers and limit market access, collectively hindering the sector's growth.
- Out of the 27 recorded El Niño years from 1951 to 2024, 15 experienced declines in both acreage and production of pulses. Cultivated area decreased by 2% to 9%, and production dropped by 6% to 30%, resulting in yield declines of 5% to 25% year-on-year. These findings highlight the vulnerability of pulse production to El Niño events and the need for effective mitigation strategies.
- Over the past 74 years, La Niña conditions occurred in 25 years. In 13 of these

years, both acreage and production increased, with cultivation area growing by 1-8%, production by 1-41%, and productivity by 1-20%. Interestingly, in three cases, the area decreased by 1-6%, but production and productivity still rose by up to 23% and 3-25%, respectively. Conversely, in eight years, decreases in acreage and production were noted, with area declining by 2-10%, production by 1-17%, and productivity by 4-14%. These results illustrate the complex effects of La Niña on pulse production, resulting in both positive and negative outcomes.

- During 22 favorable climatic years, India's pulse production significantly increased. In 10 of these years, both the area cultivated and production rose, with acreage growing by 1% to 14% and production by 2% to 45%, leading to productivity gains of 1% to 42%. Remarkably, production increased in five years despite a decline in cultivated areas due to improved agricultural practices and favorable conditions. Additionally, in two cases, production and productivity improved with a stable area. These findings illustrate the complex factors influencing pulse production, such as climate, production technologies, and policy interventions.

2. Overview of India's Pulse Sector: State-level Dynamics

i. India's economy is largely driven by agriculture, which provides 49% of employment. Pulses support the livelihoods of over 50 million farmers and their families, highlighting their importance in rural economies.

ii. India's vast rainfed areas, 52% of the country's total net sown area, support 40% of the population and 2/3rd of the livestock. About 90% of coarse cereals, 80% of pulses, 74% of oilseeds, 65% of cotton, and 48% of rice are produced in these rainfed regions.

iii. Pulses[2] are grown in all three seasons: kharif, rabi, and summer. Pulses grown during Kharif include pigeonpea, green gram, black gram, and minor pulses (moth bean, rajmash, horse gram, etc.). In the rabi season, the main pulses grown are chickpea, lentil, field bean, green gram, and black gram, while in the summer season, green gram and black gram are grown.

iv. Rabi pulses account for 67% of India's total pulse production from just 53% of the cultivated area, with chickpeas making up 70% of this output. In contrast, kharif pulses occupy 47% of the cultivated area but contribute only 33% to production, indicating a need for improved productivity in kharif pulses.

v. There are significant yield differences among pulse crops, with chickpea showing high yields (1.164 t/ha). At the same time, green gram and black gram suggest the need for crop-specific strategies to enhance productivity. The highest area under pulse cultivation was recorded at 30.7 Mha in 2021-22, while the peak production reached 27.3 MT in the same year. The productivity peaked at 0.902 t/ha in 2022-23.

vi. Since the mid-1980s, pea has consistently achieved the highest yield levels in most years. Following pea, chickpea has also recorded higher yields than other pulse

2 *Major and Minor Pulses cultivated in India are: chickpea (bengal gram/gram/chana), pigeonpea (red gram/arhar/tur), green gram (mungbean), black gram (urdbean/biri/mash), lentil (masur), fieldpea (pea/matar), clusterbean (guar), kidney bean (rajmash/common bean/snap bean/french bean), mothbean (moth), horsegram (kulthi), lathyrus (khesari/grass pea/chicking vetch/teora), and cowpea (lobia/barbati/black-eyed pea).*

crops, particularly since the 1990s, displaying a steady upward trend. Pigeonpea initially had high yields, but their growth has been limited. Lentils have shown notable improvements since 2010. Black gram yields are generally lower than those of pea, chickpea, pigeonpea, and lentil, with minimal growth until 2008-09. Green gram, with lower average yields than most crops except mothbean, has recently improved. Mothbean, the lowest-yielding crop, has also seen advances recently.

vii. India's pulse production is concentrated in a few states, with the top ten states, namely Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh, Karnataka, Gujarat, Andhra Pradesh, Jharkhand, Telangana and Tamil Nadu, contributing about 91.28% of the total output from 89.97% of the total area.

- Madhya Pradesh, Maharashtra, and Rajasthan are the top three pulses-producing states in the country. These top three states collectively account for a substantial portion, nearly about 55%, of India's pulse production.
- Madhya Pradesh is the largest pulse producer, with 5.44 Mha cultivation, making up 18.69% of the area and contributing 22.11% of total production. Maharashtra is second, with 4.56 Mha (15.66% of the area) and 16.46% of production. Rajasthan has the largest cultivation area at 6.07 Mha (20.85% of total area) ranks third in production at 16.3%.
- There are significant variations in pulse yields across different states. Gujarat is the most productive state, with a 1.333 t/ha yield. In contrast, Karnataka, with a yield of 0.623 t/ha, exhibits the lowest productivity among the top pulse-producing states, indicating a yield gap of 0.710 t/ha compared to Gujarat.
- Even leading states like Madhya Pradesh and Maharashtra have room for improvement in yields. Madhya Pradesh, the largest producer, has a yield gap of 0.325 t/ha compared to Gujarat, which ranks fourth with 1.008 t/ha. Similarly, Maharashtra, the second-largest producer, has a yield gap of 0.439 t/ha and ranks sixth with a yield of 0.894 t/ha.
- Rajasthan, the largest state for pulse cultivation, has a yield of 0.665 t/ha, ranking eighth among the top ten producing states and showing a yield gap of 0.668 t/ha compared to Gujarat.

viii. Six of the top ten pulse-producing states exceed the national average yield, while Andhra Pradesh, Rajasthan, Tamil Nadu, and Karnataka fall below it. If these four states matched the national average, it would increase major pulse production by 2.01 MT. To bridge these yield gaps and enhance overall pulse production, it is crucial to identify and address the specific factors limiting productivity in different regions. The yield gap between high-performing and low-performing states underscores the need for targeted interventions to improve productivity.

ix. Pulses accounted for about 21.9% of the total foodgrain area in 2022-23. Although area is significant, the contribution of pulses to total foodgrain production has declined over the decades, hitting a low of 5.6% in 2000-01. Since 2015-16, policy interventions have increased both the area and production share of pulses, which grew from 18.95% in 2014-15 to 23.61% in 2021-22. The production share also rose from 6.49% in 2015-16 to an average of 8.25% in the last three years, peaking at 8.92% in 2017-18.

x. Pulse production trends have varied significantly before and after 2004-05. Since 1950-51 average growth rate for pulse production over 55 year period was about 0.52%. After 2004-05, this rate surged to 4.20%, largely driven by green gram (7.2% growth), black gram (5.08%), and chickpea (4.68%).

- Green gram has experienced the most significant increase in its share of total pulse production, rising from 8.06% in 2004-05 to 14.12% in 2022-23. Chickpea also grew, increasing its share from 41.66% to 47.08%. In contrast, black gram's share has remained stable at about 10.1%. While these crops have driven India's total pulse production growth, other crops like pigeonpea, lentil, and pea have seen decreases of 5.16%, 1.59%, 2.67%, and 0.36% in their shares highlighting the need for targeted crop strategies.

xi. Among the top seven pulse-producing states, Rajasthan has become the leading driver of national pulse production growth, achieving an impressive rate of 8.05% after 2004-05, a significant increase of 6.5% from the period before. Maharashtra and Madhya Pradesh also showed strong growth rates of 4.61% and 4.27%, respectively, both exceeding the national average of 4.20%. Meanwhile, Karnataka increased its growth to 2.88% post-2004-05, up from 2.08% from 1950-51 to 2004-05, indicating effective region-specific practices implemented during this time.

- In contrast, other major pulse-producing states had growth rates below the national average, showing varied performance. Uttar Pradesh improved from -0.34% pre-2004-05 to 1.22%, yet still lags significantly. Andhra Pradesh dropped sharply from 3.30% to -1.94%, while Gujarat's rise from 3.15% to 3.48% also fell short of the national norm. These disparities underscore the need for targeted interventions at the state and district levels to align growth with national objectives and ensure sustainable pulse production.

xii. The analysis of yield growth volatility in pulse crops across states shows significant differences. Some states have achieved low volatility and stability, while others still experience considerable yield fluctuations. The decomposition analysis reveals a complex relationship between yield, area, and their interaction in shaping pulse production trends. While improving yield is essential for increasing production, expanding cultivated areas also plays a vital role.

3. The Pulse of India's Trade: A Deep Dive into The Sector's Dynamics

i. Global pulse production is primarily concentrated in 39 countries, accounting for 90% of the global production, though cultivated in 172 countries worldwide.

ii. The global pulse trade has witnessed about 27% growth over the past decade, expanding from 15 MT to 19 MT. It is projected to reach 22 MT by 2033 (OECD-FAO 2024), accounting for approximately 20% of global pulse production (IGC, Rabo Research 2024).

iii. Dry pea, chickpea, and lentil account for 68% of global trade. Asia, despite being a major consumer, relies on imports for 52% of its consumption while producing only 43%. In contrast, Africa has enhanced its production and remains largely self-sufficient. These disparities indicate increased trade and investment opportunities in the global pulse market.

iv. The global pulse trade is a significant market; about 20% of global pulse production is traded internationally, with Canada as the leading exporter. India and China, on the other hand, are the leading importers of pulses.

v. In 2022, total pulse exports reached USD 12.5 billion, up from USD 9.77 billion in 2020. The top exporters were Canada (26.6%), Myanmar (11.2%), Australia (10.3%), Russia (9.4%), the United States (4.6%), and Mozambique (3.3%). Despite being the largest producer, India ranked ninth in global pulse exports, with about 2.5% of the market share.

vi. On the import side, China is the largest importer in terms of quantity with 16.6% (2.55 MT) in global imports, followed by India (15.5%, 2.38 MT), Turkey (7.9%, 1.22 MT), Pakistan (7.1%, 1.09 MT), the United Arab Emirates (5.4%, 0.82 MT), and the USA (4.7%, 0.72 MT). Regarding import value, India is at the top, followed by China.

vii. Pulse imports in India, which were minimal in 1980-81 (0.17 MT), have surged to nearly 6 MT in 2015-16. This significant rise in imports, coupled with the relatively slow growth in domestic production, has substantially increased India's import dependency, from 1.84% in 1980-81 to approximately 29% in 2015-16.

viii. Since 2016-17 India has significantly decreased its reliance on imported pulses. Imports peaked at 6.61 MT in 2016-17 but fell to 2.496 MT by 2022-23. The GoI raised MSP on major pulse crops, attracting farmers to increase cultivation. Consequently, the area under pulses grew by 26.6%, from 23.55 Mha in 2014-15 to 29.81 Mha in 2017-18. Between 2014-15 and 2021-22, pulse production surged from 17.15 MT to 27.302 MT, achieving a CAGR of 6.87%, the highest recorded to date.

ix. India's import dependency has reached new highs in the fiscal year 2023-24, driven by factors like the El Niño weather pattern. Pulse imports soared by 84% year-on-year, reaching a six-year high of 4.739 MT, up from 2.496 MT last year.

x. In 2023-24, India significantly increased its pulse imports, driven primarily by a rise in red lentil (masur), yellow pea (matar), and black gram. Red lentil imports from Canada more than doubled to 1.2 MT, with Canada and Australia making up nearly 98% of these imports. Yellow pea imports from Russia and Turkey also rose significantly.

   - To meet production shortfalls, India imported pigeonpea and black gram, with Mozambique, Myanmar, and Tanzania supplying nearly 90% of pigeonpea and Myanmar providing about 96% of black gram imports.

xi. From 2015-16 to 2023-24, pea was the most imported pulse crop, averaging 1.23 MT per year, followed by lentil at 0.92 MT. Other notable imports included pigeonpea (0.61 MT), chickpea (0.50 MT), black gram (0.47 MT), and green gram (0.18 MT). Pea imports witnessed the most substantial increase in the last fiscal year, followed by lentil, chickpea, and black gram. Conversely, pigeonpea and green gram imports declined compared to the previous year.

xii. Since the 2013-14 agricultural year, MSPs for pulse crops have consistently risen. Lentil have seen the highest percentage increase at 127.1%, followed by green gram (92.9%), chickpea (82.3%), pigeonpea (75.6%), and black gram (72.1%). In absolute terms, green gram had the largest increase at Rs 4,182 per quintal, followed by lentils (Rs 3,750), pigeon peas (Rs 3,250), black gram (Rs 3,100), and chickpeas (Rs 2,550). This rise in MSPs reflects the government's efforts to support farmers, enhance financial security, and promote increased pulse cultivation, which is vital for boosting domestic production.

xiii. The cost of production varies among pulse crops. Green gram has the highest cost at Rs 5,788 per quintal, followed by black gram at Rs 4,883, pigeonpea at Rs 4,761, lentil at Rs 3,405, and chickpea at Rs 3,400. In terms of profit margins, lentils lead at 88.7%, followed by chickpea at 60.0%, pigeonpea at 58.6%, black gram at 51.5%, and green gram at 50.0%. This illustrates the varying profitability of different pulse crops.

4. Demand and Supply Scenarios of Pulses in India

i. The global pulse market is projected to grow, with per capita consumption reaching 8.6 kg by 2033 (OECD-FAO 2024). This growth is expected in nearly all regions, with Europe seeing the most significant increase at 3% annually.

ii. India has a disparity in pulse consumption between urban and rural areas, with urban areas consuming 0.08 kg more per person per month on average. Chhattisgarh shows the highest difference, followed by Telangana, Delhi, Arunachal Pradesh, Haryana, Tamil Nadu, Manipur, Jammu & Kashmir, Sikkim, Jharkhand, and West Bengal. Addressing these disparities is crucial for implementing targeted initiatives to enhance pulse consumption.

iii. Pigeonpea is the most consumed pulse in India, making up 29.1% of urban consumption and 29.8% of rural consumption in 2022-23. Chickpea is slightly more popular in rural areas (15.2%) than urban areas (14.1%). In contrast, urban areas consume more green gram (15.5%) compared to rural areas (13.6%).

- Lentils are more common in rural diets, with 15.8% versus 11.3% in urban areas. Black gram is preferred in urban settings (12.4%) over rural (9.8%). Peas are also favored in urban areas (3.2%) compared to rural (2.9%).
- Rural areas have higher consumption of pulses like moth and cowpea (2.9%) than urban areas (2.0%). Lastly, urban areas lead in pulse product consumption (12.5%), especially ready-to-eat foods, indicating a shift toward convenience.

iv. Per capita pulse consumption varies regionally, reflecting unique preferences. Pigeonpea is popular in urban Central and Western India and in rural South and Central India. Green gram is favored in urban Western India, while rural South and Western India prefer it. Lentil is the most popular pulse in both urban and rural areas of Northeastern and Eastern India. Black gram is common in South India, and chickpea are preferred in North and rural South India. Other pulses, excluding pea, are more common in rural North India, whereas pea is favored in urban South India. Pulse products are more popular in urban South India than in rural areas, followed by North and Western India.

v. The per capita net availability of pulses in India has exhibited a complex trajectory over the past several decades. Initially, between 1950-51 and 1970-71, there was a 14.5% decline, from 22.16 kg/year to 18.94 kg/year. Subsequently, a more significant decrease of 40.4% occurred between 1970-71 and 1980-81, reducing availability to 11.28 kg/year. However, a turnaround began in the following decades, between 1980-81 and 2000-01, a gradual increase of 2.9% was observed, bringing the per capita availability to 11.61 kg/year. A more substantial surge of 48.1% followed between 2000-01 and 2022-23, reaching 17.19 kg/year.

vi. The current dietary patterns in India deviate from ICMR-NIN dietary recommendations. Cereals, for instance, contribute significantly to the daily diet, i.e., 50-70% of total daily energy intake often exceeding the recommended limit of 45%, while pulses, meat, poultry, and fish contribute only 6-9%, falling short of the recommended 14% of total energy.

vii. The recent Household Consumption Expenditure Survey (HCES) 2022-23 data reveals that the pulse consumption in the average Indian diet remains well below the ICMR-NIN dietary recommended levels, leading to a widening gap between current consumption and the nutritional requirements from pulses across all states and UTs, both in rural and urban areas. While Himachal Pradesh exhibits the highest per capita consumption of 1.32 kg/person/month (in both rural and urban), it still falls short of the recommended levels for both vegetarians (2.55 kg/person/month) and non-vegetarians (1.65 kg/person/month).

viii. Pulses demand projections have been worked out using the following three approaches. i.e., (i) Static / Household Approach, using the population projection and the base year per capita net availability. This approach assumes short-term static behavior of consumption; (ii) Normative Approach, based on the dietary requirement as recommended by the ICMR-National Institute of Nutrition (NIN) and population projection; (iii) Behaviouristic Approach, which considers changes in the behavior of consumption of different food items on account of changing per capita income and prices, measured in terms of income/expenditure elasticities, base year per capita net availability and population projection.

ix. The Static/Household Approach estimates projected demand to reach 26.8 MT by 2030 and 29.3 MT by 2047. These projections are based on population growth forecasts and a base year per capita net availability of 17.69 kg/year (the last three-year average per capita consumption), translating to a total demand of 24.89 MT in 2022.

x. The Normative Approach projects a rise in pulse demand to 46.33 MT by 2030 and 50.26 MT by 2047.

xi. The two-scenario framework employed in the behaviouristic approach clearly shows India's potential pulses demand trajectory. Under the Business as Usual (BAU) scenario, demand for pulses and pulse products is projected to reach 35.16 MT by 2030 and 50.73 MT by 2047. Considering India's aspirations of becoming a developed nation by 2047, this analysis additionally considers the demand for pulses under a High-Income Growth (HIG) scenario. This HIG scenario, assuming an estimated 8% annual per capita NNI growth, projected a demand of 43.76 MT by 2030 and 50.73 MT by 2047.

xii. Furthermore, the analysis suggests that India's per capita consumption is expected to reach the maximum required demand for pulses based on the ICMR-NIN recommended dietary requirement (i.e., 30.62 kg/person/year) by 2039 under the BAU Scenario-I and by 2031 under the HIG Scenario-II, respectively. This represents an eight-year advancement compared to the BAU situation, highlighting the significant impact that rapid economic growth can have on pulse demand in India.

xiii. The total pulse production (based on aggregated data) forecasts a steady increase, reaching an estimated 34.45 MT by 2030 and 51.57 MT by 2047, up from 26.06 MT in 2022. Interestingly, the aggregated production estimates derived from the individual pulse crop's forecasts closely align (32.1 MT by 2030 and 50.7 MT by 2047) with the projections based on aggregate data. This convergence between the two approaches strengthens the validity and reliability of the overall production forecasts.

xiv. The national-level pulse supply is projected to be 30.6 MT by 2030 and 45.8 MT by 2047. However, it is crucial to acknowledge that unforeseen factors could potentially impact these projections.

xv. The household/static approach scenario projects a surplus situation. By 2030, a surplus of 3.79 MT is anticipated, increasing to 16.48 MT by 2047.

xvi. The normative scenario based on ICMR-NIN dietary guidelines shows a significant demand-supply gap of 15.74 MT by 2030, decreasing to 4.47 MT by 2047. To close this gap, India's pulse production must increase by 1.86 times by 2030 and 2.02 times by 2047 compared to current levels.

xvii. Under the behaviouristic approach, the BAU scenario estimates a gap of 4.57 MT is projected by 2030, increasing slightly to 4.94 MT by 2047. To bridge this gap, pulse output would need to grow by a factor of 1.41 times and 2.04 times by 2030 and 2047, respectively, from the current level of supply. The HIG scenario projects a significant gap of 13.17 MT by 2030, decreasing to 4.94 MT by 2047. To achieve equilibrium, pulse output would need to be amplified by a factor of 1.76 times and 2.04 times by 2030 and 2047, respectively. To ensure a sustainable and secure future for the pulse sector, it is crucial to consider these diverse scenarios and develop appropriate strategies to address potential challenges and opportunities.

5. Strategies and Roadmap to Achieve Self-Sufficiency for Atmanirbharta in Pulses

i. To achieve self-sufficiency, India must adopt a multifaceted strategy focusing on three key pillars: (i) value addition and reducing post-harvest losses in pulses, (ii) expanding the area under pulse cultivation (Horizontal Expansion), and (iii) improving productivity (Vertical Expansion).

ii. The quadrant approach offers a valuable tool for achieving self-sufficiency in pules, identifying district clusters using four quadrants [i.e., (i) High Area-High Yield (HA-HY), (iii.) High Area-Low Yield (HA-LY), (iii) Low Area-High Yield (LA-HY), and (iv) Low Area-Low Yield (LA-LY)] for the pulse crops cultivated in India.

iii. The HA-HY cluster should focus on vertical expansion strategies to increase yields, taking learnings from global pulse production leaders. The HA-LY cluster, with large areas but lower yields, also needs vertical initiatives, benefiting from benchmarking against India's top districts. The LA-HY cluster has smaller cultivated areas but high yields, offering opportunities for horizontal expansion. Learning from national leaders can enhance cultivation practices here. Meanwhile, the LA-LY cluster, which has low areas and yields, requires a combined approach of horizontal and vertical strategies. Benchmarking against high-performing districts is crucial for this cluster to implement necessary improvements.

- Pigeonpea: HA-HY cluster: 48 districts (majorly from Jharkhand, Uttar Pradesh, Maharashtra, and Gujarat); LA-HY cluster: 212 districts (majorly from Uttar Pradesh, Bihar, Gujarat, Tamil Nadu, West Bengal, Haryana, Madhya Pradesh, and Rajasthan); HA-LY cluster: 55 districts (majorly from Maharashtra, Telangana, Karnataka, Jharkhand, and Andhra Pradesh); LA-LY cluster: 239 districts (majorly from Madhya Pradesh, Uttar Pradesh, Assam, Chhattisgarh, Karnataka, Andhra Pradesh, Telangana and Arunachal Pradesh).
- Chickpea: HA-HY cluster: 99 districts (majorly from Madhya Pradesh, Rajasthan, Jharkhand, Uttar Pradesh, and Gujarat); LA-HY cluster: 165 districts (majorly from Uttar Pradesh, Telangana, Madhya Pradesh, West Bengal, and Andhra Pradesh); HA-LY cluster: 63 districts (majorly from Jharkhand and Maharashtra); LA-LY cluster: 208 districts (majorly from Assam, Bihar, Chhattisgarh, Karnataka, and Tamil Nadu).
- Green gram: HA-HY cluster: 53 districts (majorly from Jharkhand, Madhya Pradesh Bihar, and Andhra Pradesh); LA-HY cluster: 234 districts (majorly from Uttar Pradesh Gujarat, Arunachal Pradesh, Assam, West Bengal, Bihar, Telangana, Punjab, Andhra Pradesh, and Jharkhand); HA-LY cluster: 82 districts (majorly from Odisha, Rajasthan, Maharashtra, and Karnataka); LA-LY cluster: 250 districts (majorly from Uttar Pradesh, Chhattisgarh, Madhya Pradesh, Tamil Nadu, Karnataka, and Telangana).
- Black gram: HA-HY cluster: 68 districts (majorly from Jharkhand, Andhra Pradesh, Tamil Nadu, Maharashtra, and Uttar Pradesh); LA-HY cluster: 193 districts (majorly from Uttar Pradesh, Telangana, Bihar, and Arunachal Pradesh); HA-LY cluster: 97 districts (majorly from Madhya Pradesh, Tamil Nadu, Maharashtra, and Chhattisgarh); LA-LY cluster: 237 districts (majorly from Uttar Pradesh, Karnataka, Madhya Pradesh, and Odisha).
- Lentil: HA-HY cluster: 46 districts (majorly from Madhya Pradesh, Uttar Pradesh, and Jharkhand); LA-HY cluster: 131 districts (majorly from Uttar Pradesh, Madhya Pradesh, and Rajasthan); HA-LY cluster: 52 districts (majorly from Jharkhand and Uttar Pradesh); LA-LY cluster: 145 districts (majorly from Assam, Chhattisgarh, and Uttar Pradesh).
- Pea: HA-HY cluster: 28 districts (majorly from Uttar Pradesh, Himachal Pradesh, and Arunachal Pradesh); LA-HY cluster: 75 districts (majorly from Uttar Pradesh and Rajasthan); HA-LY cluster: 72 districts (majorly from Jharkhand and Uttar Pradesh); LA-LY cluster: 238 districts (majorly from Madhya Pradesh, Bihar, Assam, Chhattisgarh, and West Bengal).
- Mothbean: Rajasthan is the dominant contributor to the mothbean in India, accounting for 97.97% of the area and 96.42% of the production. HA-HY

cluster: represented by Barmer (Rajasthan), Bandipore (Jammu & Kashmir), and Ahmadabad (Gujarat): HA-LY cluster: 7 districts (six from Rajasthan and one from Haryana); LA-HY cluster: 39 districts predominantly in Gujarat, Jammu & Kashmir, and Rajasthan; LA-LY cluster: 22 districts primarily in Rajasthan, and Haryana.

iv. Utilizing just one-third of the total rice fallow area across ten states for pulse cultivation can significantly enhance domestic production, a potential increase of up to 2.85 MT. Further, intercropping pulses with sugarcane in regions like Uttar Pradesh and Maharashtra can unlock an additional 3 Mha of cultivable land, potentially yielding 2.4 MT of pulses. Similarly, optimizing the rice-wheat cropping system in states like Uttar Pradesh, Bihar, and Haryana can make space for an additional 4 Mha for pulse cultivation, with the potential to increase production by 2.8 MT (ICAR-IIPR 2024). Overall, these strategies could unlock a total of 8.05 MT of additional pulse production, advancing India's self-sufficiency.

v. The Cluster Frontline Demonstration (CFLD) results in various agroecological conditions in India revealed a yield gap between current farming practices and Technological Interventions (TI), ranging from 24% in peas to 68% in pigeonpea. By adopting existing, proven, and advanced technologies with effective and efficient farming practices, domestic pulse production could rise by approximately 46.3% or 12.05 MT.

vi. By addressing factors like seed, feed, and wastage, the supply of pulses could increase by 10.7 MT, improving farmer profitability and strengthening agricultural resilience. A dedicated program focusing on advanced technologies, such as improved seed varieties, modern machinery, and optimal agronomic practices, is essential. These interventions are crucial for bridging the demand-supply gap and ensuring India's self-sufficiency in pulses.

vii. Abiotic and Biotic Stress Management: Mitigating the Impact on Pulse Production: To ensure the sustainable and productive cultivation of pulses, effective management strategies for both abiotic and biotic stresses are crucial. These stresses, including drought, heat stress, pests, and diseases, can significantly impact yield and quality. A comprehensive approach involving a combination of sustainable agronomic practices, technological innovations, and strategic policy interventions is necessary to address these challenges.

viii. Pulse Varietal Development through Genetic Diversity and Modern Breeding Techniques: India has a rich genetic diversity of pulse crops, with the ICAR–National Bureau of Plant Genetic Resources (NBPGR) holding about 70,000 accessions. However, much of this genetic wealth is underutilized. To better use these resources, breeding programs should be modernized to efficiently extract desirable traits and develop improved varieties. By incorporating modern tools like genomics, the process of varietal development can be accelerated, reducing the time needed to bring high-performing varieties to market. Key objectives include enhancing genetic potential and improving tolerance to biotic and abiotic stresses.

- A higher Varietal Replacement Rate (VRR) is crucial for improving crop yield, as newer varieties typically resist diseases, pests, and extreme weather better. To effectively reach grassroots farmers, need a clear strategy that includes distributing seed mini-kits and enhancing agricultural extension services through local officer training and demonstration plots. Collaborating with organizations like KVKs, FPOs, and cooperatives can also help make seed procurement and distribution more affordable and accessible.

ix. Post-Emergence Herbicide in Pulses: A Pathway to Enhanced Yield and Production: The sensible use of post-emergence herbicides in pulse crops can significantly enhance yields and overall production. By effectively controlling weeds, these herbicides can optimize resource utilization, reduce competition for nutrients and water, and boost crop productivity. For instance, applying Imazethapyr, Quizalofop-p-ethyl, and Clodinafop-propargyl + sodium acifluorfen can increase yields in pigeon pea, green gram, and black gram by 28.9%, 33.1%, and 37.6%, respectively. Similarly, Topramezone and Quizalofop-p-ethyl in chickpeas and lentils can enhance yields by 19.6% and 15.2%, leading to an additional 2.7 MT and 0.75 MT of production, respectively. Overall, the adoption of these herbicides could lead to an estimated increase of 6.9 MT in total pulse production. However, it is crucial to use them responsibly and follow recommended practices to minimize environmental impacts. Integrating cultural, mechanical, and biological weed management strategies can further optimize herbicide use and enhance productivity.

x. Enhancing Nutritional Quality in Pulses through Nutrition-Sensitive Breeding Programs: The nutrient profile of pulses can be enhanced by integrating nutritional quality traits into breeding programs. Certain genotypes have been found to possess significantly higher nutrient content. For example, some chickpea varieties (such as ICC 5912) and pigeonpea lines (HPL 8, HPL 40) contain 26-27% protein, compared to the 20-22% typically found in commercial varieties. Similarly, the L4704 lentil line boasts more than double the iron and zinc content of standard commercial types. Targeted, nutrition-sensitive breeding can significantly enhance nutritional security.

xi. Value Addition and Reducing Post-Harvest Losses in Pulses: Post-harvest losses in pulses occur at various stages, from harvest to consumer consumption. A recent NABCONS study (2022) assessed post-harvest losses across 54 crops/commodities in all 15 agro-climatic zones of India, including major pulse-producing districts. The estimated post-harvest losses in pulses (i.e., pigeon pea, chickpea, black gram, and green gram) ranged from 5.65% in pigeonpea to 6.74% in chickpea. These losses are primarily attributed to factors such as shattering of grains during harvesting, spillage during various operations, and mishandling. To minimize these losses and improve the overall efficiency of the pulse value chain, it is crucial to adopt advanced post-harvest technologies and best practices.

- Reducing post-harvest loss by 1% further, the potential supply of total pulses could increase by 0.27 MT and 0.41 MT in 2030 and 2047, respectively. The potential increase in pigeonpea supply by 2030 is estimated to be 0.04 MT, and by 2047, it is projected to reach 0.05 MT. Chickpea production is expected to increase by 0.15 MT in 2030 and 0.21 MT in 2047. The potential increase in green gram production is 0.05 MT in 2030 and 0.10 MT in 2047. Black gram production is projected to increase by 0.03 MT in 2030 and 0.05 MT in 2047.

xii. The Role of Mechanization: A Key to Increased Efficiency and Yield: Mechanization of pulse production offers a promising avenue to enhance productivity, reduce labour costs, and improve overall efficiency. By adopting suitable farm machinery for various operations, such as tillage, planting, harvesting, inter-cultivation, threshing, and processing, farmers can significantly optimize their production processes. For example, mechanization can lead to a 10-15% increase in productivity (ICAR-IIPR (2024)) by improving efficiency and reducing labor requirements.

xiii. The proposed strategic interventions, encompassing both horizontal and vertical expansion approaches, offer a promising pathway to reduce import dependence. By implementing these strategies effectively, India can significantly boost domestic pulse production, potentially increasing total pulse production by 20.10 MT. This substantial increase can not only have the potential to mitigate the current import dependency of 4.739 MT but also address the projected demand gap of 15.74 MT by 2030 (i.e., the most demanding scenario), estimated through the normative approach utilizing ICMR-NIN dietary requirement and establish India as a self-sufficient nation in the pulse sector.

xiv. By 2030 and 2047, these interventions could lead to a projected pulses supply of 48.44 MT and 63.64 MT, achieving self-sufficiency under all three demand approaches (i.e., Household/Static, Normative, and Behaviouristic). All the scenarios project a surplus –i.e., 21.64 MT and 34.33 MT under the Household Approach; 2.11 MT and 13.38 MT under the Normative Approach; 13.28 MT and 12.91 MT under the Behavioristic Approach (BAU); and 4.68 MT and 12.91 MT under the Behaviouristic Approach (HIG) by 2030 and 2047 respectively.

xv. Over the past five years (2017-18 to 2022-23), India's pulse sector has experienced a modest growth rate of about 2.50%. If this current growth trend continues, it will be sufficient to meet the projected demand based on the household approach, which considers only the population growth factor.

xvi. However, achieving self-sufficiency in pulses requires a more ambitious strategy. The Behaviouristic Approach takes into account potential changes in food consumption patterns resulting from factors such as rising income levels, lifestyle changes, and price fluctuations. This necessitates a higher growth rate. Under the Business as Usual (BAU) scenario, a compounded annual growth rate (CAGR) of 3.82% is required for the period from 2022 to 2030. For the longer term, from 2022 to 2047, a slightly elevated CAGR of 2.70%, compared to recent growth rates, is necessary.

xvii. The High-Income Growth (HIG) scenario presents an even more challenging outlook. In this case, a significantly steeper CAGR of 6.69% is needed for the 2022-2030 period. For the longer-term goal of self-sufficiency by 2047, a CAGR of 2.70%, which is slightly higher than recent growth rates, will be required from 2022 to 2047.

xviii. The Normative Approach adds another layer of complexity. It indicates that additional efforts must be made to accelerate pulse production in order to meet the projected dietary requirements. To meet the anticipated demand by 2030, a significantly higher CAGR of 7.46% is necessary for the period from 2021 to 2030. For the long-term goal of self-sufficiency by 2047, a slightly elevated CAGR of 2.66% compared to recent growth rates is needed for the entire period from 2021 to 2047. These findings highlight the critical need for strategic interventions to accelerate domestic production and bridge the gap between current growth trends and self-sufficiency goals.

xix. To achieve this ambitious target, a focused approach using the "Quadrant Strategy" on a district-wise cluster basis is essential. This strategy prioritizes clusters LA-LY, as well HA-LY and LA-HY potential. By targeting these clusters and implementing tailored interventions, India can maximize production.

xx. By combining the potential gains from strategic interventions with the existing production level, India can achieve self-sufficiency in all scenarios, even with the recent growth trend of 2.50%. A more focused and rigorous implementation of the proposed strategic interventions is necessary to accelerate this progress. It emphasizes a scalable approach that prioritizes clusters with LA-LY and those with HA-LY and LA-HY potential. This more intensive approach has the potential to pave the way for India to achieve Atmanirbharta in its pulses sector, ensuring a secure and sustainable future for its needs.

6. Recommendations and Way Forward

Achieving self-sufficiency in pulse production is crucial for India's food security and soil health. NITI Aayog surveyed 885 farmers in five major pulse-producing states (i.e., Rajasthan, Madhya Pradesh, Gujarat, Andhra Pradesh, and Karnataka) of the top seven to gather insights. These findings, along with previous strategies, underpin recommendations to strengthen the pulse sector, increase domestic production, and ensure sustainability.

i. Focus on Area Retention of Pulses and Diversification

- Crop Clusters and Technology Customization: Crop-wise clustering facilitates horizontal and vertical expansion efforts for targeted growth in pulse production. States and districts are grouped into four clusters (HA-HY, HA-LY, LA-HY, and LA-LY) based on the area under cultivation and yield performance for each pulse crop, allowing for more tailored growth strategies. Developing customized technology specific to each cluster is essential for yield improvement. Additionally, establishing Agro-Ecological Sub Region (AESR)-based model farms for each crop can support the horizontal dissemination of advanced cultivation practices.
- Horizontal Expansion in Rice Fallow Areas: Utilizing just one-third of the total rice fallow area across ten states for pulse cultivation can significantly enhance domestic production. Estimates suggest a potential increase of up to 2.85 MT in pulse output. This statistic underscores the immense potential of these currently fallow lands. A combination of incentives and strategic planning is necessary to tap into this potential effectively. Providing incentive packages for input costs and guaranteeing remunerative prices can motivate farmers to adopt pulse cultivation in these areas. Identifying suitable areas for pulse cultivation, with the involvement of experts and state governments, is crucial. A phased approach, starting with pilot projects in key states, can help refine strategies and maximize impact.

ii. Seed Traceability and Quality Assurance

- A significant factor contributing to low pulse productivity is using low-quality traditional seed varieties. Seed is a carrier of technological advancements, and the supply of improved varieties can significantly enhance crop performance. A phased approach should be adopted to distribute high-quality seeds and seed treatment kits to farmers in targeted districts with high potential for yield growth and area expansion to address this issue. Given that a significant portion of pulse production is concentrated in specific regions, with 50 districts contributing 50% of the total output and 111 districts contributing 75%, these districts should be the special focus for raising the production of pulses to attain self-sufficiency in pulses.

- Cluster-Based Seed Village: To ensure a consistent supply of high-quality seeds, establishing cluster-based seed hubs at the block level, following the "One Block-One Seed Village" model, is crucial. These hubs, facilitated by Farmers' Producer Organizations (FPOs), can guarantee farmers' access to high-quality pulse seeds on time, thereby enhancing seed and varietal replacement rates. Implementing end-to-end traceability from breeder to farmer for quality assurance is crucial.

iii. Strengthening Farmer Producer Organizations (FPOs) and District-Level Value Chain Planning

- This can be a game changer in the pulses sector. Through this, the pulse value chain can be easily shortened; it can also add a lot of value to the hands of pulse growers. Identifying the pulses-growing clusters and bringing on a single platform to integrate with the backward and forward linkages will help the farmers to reduce the cost of production substantially.
- In addition to that, this will also help in capturing additional value by undertaking the processing of pulse grains and delivering the product directly to urban consumers through organized retailers. The shortening of the value chain will help the consumers in accessing the produce at a reasonable price, even if the support price of pulses is increased substantially. The by-products of processed pulses are also nutritious feed for livestock, which can also be additional benefits for the farmers if the processing mills are set up near these farmers.

iv. Effective Procurement

- The procurement of pulses after harvest needs to be strengthened immediately. Most of the pulse growers are currently unable to reach regulated markets to sell their produce; instead, village traders are their main buyers. Therefore, to ensure remunerative prices for these growers, it is very important to bring the procurement centers to the growers' doorstep, particularly during harvest season. Standardization of prices and procurement by using mobile vans or regulating the village traders to make public all the information related to the transactions may reduce the ambiguities and exploitation of the smallholders. In the medium term, it can be facilitated by forming Farmer Producer Organization (FPO) and linking it with the National Agricultural Market through e-platforms.

v. Price Support and Market Interventions

- To ensure remunerative prices for pulse producers and incentivize cultivation, providing a price guarantee is crucial and implement the same either by paying the gap between MSP and prices received by the producers in the market or by procurement by public agencies. Both these provisions are already there in the scheme "PM AASHA" operated by the Ministry of Agriculture and Farmers' Welfare. Its operational part needs to be strengthened for effective and comprehensive coverage.

vi. Integrating Pulses into the Public Distribution System

- Keeping in view the widespread under- and malnutrition among women and children in India, to achieve the target of zero hunger and good health and well-being prescribed in sustainable development goals (SDG), it is necessary to provide pulses to all the poor households at affordable prices. Although this would further increase the demand for pulses, it can be managed if sufficient steps for enhancing domestic production are already taken. Therefore, compulsory inclusion of pulses in the existing schemes, such as the mid-day meal scheme or public distribution system (PDS), shall be ensured so that the minimum pulse consumption by poor households is maintained even during the scarcity in pulse production.

vii. Customization and Development of Farm Equipment

- A collaborative approach to developing small-sized multi-crop harvesting farm machines and other farm equipment for plant protection can greatly assist producers in lowering labor costs.

viii. Potential in Summer Pulses

- To enhance irrigation efficiency, a robust Management Information System (MIS) network is essential, particularly during the reproductive phase of crops. This can ensure timely irrigation and optimal water use. Additionally, opening canals to exploit potential irrigable areas is crucial for mitigating the effects of consecutive droughts. Emphasizing the adoption of early-maturing varieties of crops like rice, potato, wheat, and sugarcane can help prevent pre-harvest sprouting caused by unexpected pre-monsoon rains.

ix. Resource Requirement for Input Incentive Package

- Pulses are a legume crop, and they can take nitrogen from the environment and fix it in the soil for plant use. The estimates of the amount and value of nitrogen fixed by pulses in the soil in India. Different pulses fix 58-70 kg of Nitrogen per hectare of area under their cultivation. All five pulses taken together fix 2.91 LT of Nitrogen (N) in the soil. This quantity is equivalent to 6.48 LT of urea. Pulses, on average, enrich soils by 66 kg N, which is valued at Rs. 3233 per hectare. Based on this, the total value of N fixed in 27 Mha area under cultivation of pulses comes to Rs. 8811 crores. If this much nitrogen is to be applied to soil, it will involve a subsidy on urea to the tune of Rs. 7841 crores. These facts highlight the value of ecological services rendered by pulses to society.

- To incentivize farmers to increase pulse production, a portion of the ecological services provided by pulse cultivation can be utilized. Implementing incentive packages, such as providing high-quality seeds and seed treatment kits at subsidized rates (e.g., half the MSP), can encourage farmers to expand their cultivation, particularly in intensive pulse-producing districts.

x. Bio-fertilization Strategies

- To enhance summer crop yields, especially for pulses, several bio-fertilization strategies have proven effective. Field monitoring across various states by DPD, Bhopal, has shown that the use of NPK liquid bio-fertilizers significantly boosts the productivity of summer green gram and black gram. These bio-fertilizers help reduce the leaching of essential nutrients like potassium and nitrogen as well as mitigate phosphorus fixation in soils, thereby making nutrients more available to plants.
- For optimal results, it is recommended to apply NPK liquid bio-fertilizer at a rate of 500 ml per acre, mixed with 50-100 kg of farmyard manure (FYM) or compost, and incorporate it into the soil before sowing. Additionally, using other liquid bio-fertilizers, such as Liquid Rhizobium, Phosphate Solubilizing Bacteria (PSB), and NPK-3 (a combination of Rhizobium, PSB, and Potassium Mobilizing Bacteria) at the same dosage rate further enhances soil nutrient availability by converting fixed phosphorus into a form accessible to crops.

xi. Advancing Research & Development for Pest-Resistant Pulse Varieties

Pulses, a vital source of protein, are particularly susceptible to pests and diseases. An estimated 30% of pulse crops are lost annually due to these issues, with pests like pod borers, aphids, and pod flies causing severe damage. Addressing these challenges and ensuring sustainable pulse production is crucial for long-term success. Prioritizing the development of pest-resistant varieties through the application of modern biotechnology tools is essential to enhance the genetic resilience of pulse crops. Additionally, fostering public-private partnerships can optimize logistics and handling practices, addressing broader challenges within the pulse sector. Integrating pulse crops into farmers' overall cropping systems can further optimize resource utilization and enhance productivity.

- Developing short-duration, pest- and disease-resistant cultivars specific to production regions: Developing improved cultivars specific to production regions is crucial for breaking the yield barrier. The success of chickpea cultivation in the central and southern regions serves as an excellent example. Focusing on the development of super early varieties without yield penalties with pest- and disease resistance can significantly enhance pulse production and productivity in India.
- Developing machine-harvestable and herbicide-tolerant varieties for HA-HY regions/districts: Development of machine-harvestable and herbicide-tolerant varieties of pulses, especially chickpea, lentil, mung bean, and black gram, will

allow pulses production at a commercial scale with production efficiency. This will also allow for public-private partnerships for pulse production and market linkages.

- Climate-resilient varieties to insulate pulse production from seasonal shocks and fluctuations: Pulses are vulnerable to climate shocks due to their nature of cultivation in marginal areas, and the development of climate-resilient varieties with tolerance to drought, waterlogging, frost, and heat stresses will stabilize not only production but also market prices.
- Improved varieties enriched with nutrients (protein, iron, zinc): Pulses varieties biofortified with protein, iron, and zinc content will contribute to nutritional security. In addition, efforts to reduce the anti-nutritional factors such as ODAP in grass pea will contribute to enhanced consumption of pulses in the country.

xii. Robust Early Warning Systems and Proactive Adaptation Strategies

- To mitigate the impact of adverse weather conditions like El Niño on pulse production, robust early warning systems, and proactive adaptation strategies are crucial. These systems should monitor weather patterns, predict potential impacts on pulse crops, and disseminate timely advisories to farmers. In addition, developing climate-resilient crop varieties, implementing efficient water management practices, and diversifying cropping patterns are essential strategies for mitigating vulnerability to extreme weather events.

xiii. Data-driven Transformation

- Addressing disparities in pulse crop yields requires a data-driven approach and robust systems to bridge regional gaps. Advancing research and development is essential for the transformation of the pulse sector. A deeper understanding of climate-crop interactions, coupled with the development of innovative solutions, is critical to enhancing the resilience of this sector. Such advancements can provide returns that surpass the benefits offered by input subsidies. Furthermore, implementing comprehensive monitoring systems of interventions and import prices, leveraging ICT platforms like the SAATHI Portal, Krishi Mapper, etc. facilitates informed decision-making, ultimately ensuring the long-term sustainability and productivity of the pulse sector.

Chapter I: Introduction

Introduction

1.1 Background

Pulses[3], annual leguminous crops, are pivotal in the global food system. Their dry grains (come in various shapes and sizes) are rich in plant-based protein, essential minerals, dietary fibre, vitamins, and phytochemicals. They are a valuable source of nutrition, providing valuable amino acids for both humans and livestock. Beyond their nutritional value, pulses offer significant benefits for sustainable agriculture, playing an important role in cropping systems because of their ability to fix atmospheric nitrogen, enhancing their significance as crops suited for dry and rain-fed areas, and improving soil fertility, which has been displaying slow deterioration. Additionally, pulses are well-suited for crop diversification and intensification, providing a sustainable approach to agriculture. With their low water and carbon footprints and soil-conserving properties, pulses offer a valuable solution for sustainable agriculture and climate change mitigation, particularly in rainfed regions. These multifaceted benefits emphasize the critical role of pulses in ensuring food security, promoting environmental sustainability, and contributing to a more resilient agriculture. The United Nations Food and Agriculture Organization (FAO) recognizes 11 types of pulses, i.e., dry bean[4], chickpea dry, pigeonpea dry, lentil dry, dry pea, cowpea dry, dry broad bean/ horse bean, dry bambara bean, vetches, lupins, and pulses n.e.c. (not elsewhere classified – minor pulses that don't fall into one of the other categories). Globally, pulse production has been on a steady rise, with a 3% annual increase since the early 2000s, with developing countries accounting for nearly 75% of the world's total output. Asia, in particular, has emerged as a major producer, contributing more than 44% of the global total. As of 2022, the global area dedicated to pulses reached approximately 97.09 million hectares (Mha), resulting in a total production of 96.04 million tonnes (MT) and an average productivity rate of 0.989 tonnes per hectare (t/ha) (FAOSTAT, FAO)[5]. Pulses are grown in 172 countries worldwide, with India being the world's largest cultivator (~38% of the global cultivated area for pulses), producer (~28% of global production), consumer (~27% of world consumption), and importer (~14%) of pulses in the world (FAOSTAT, FAO 2024).

Chickpea (bengal gram/gram/chana), pigeonpea (red gram/arhar/ tur), green gram (mungbean), black gram (urdbean/biri/mash), lentil (masur), fieldpea (pea/matar), clusterbean (guar), kidney bean (rajmash/common bean/snap bean/french beans), mothbean (moth), horse gram (kulthi), lathyrus (khesari/grass pea/chicking vetch/teora) and cowpea (lobia/barbati/black-eyed pea) are the twelve major and minor pulses cultivated in about 28.9 Mha in India with production of [6]. These crops thrive in diverse climatic and edaphic conditions, typically concentrated in a few states, with the top ten states (Madhya Pradesh, Maharashtra,

3 *Pulses are annual leguminous crops yielding from one to twelve grains or seeds of variable size, shape, and colour within a pod. The term "pulses" is limited to crops harvested solely for dry grain, excluding crops harvested green for food (green pea, green bean, etc.) classified as vegetable crops. Also excluded are those crops used mainly for oil extraction (e.g., soybeans and groundnuts) and leguminous crops (e.g., seeds of clover and alfalfa) used exclusively for sowing purposes. Specific pulses can be skinned and partially crushed or split to remove the seed coat (Source: https://www.fao.org/faostat/en/#data/QCL).*

4 *This includes beans, species of Phaseolus (vulgaris, lunatus, angularis, aureus, etc.) and beans, species of Vigna (angularis, mungo, radiata, unguiculata, etc., (e.g., common bean, mungbean, urd bean, etc.); does not include: soya beans, green beans, green and dry lentil, bean shoots and sprouts, locust beans (carobs), castor beans, dry broad beans, and horse beans, and dry chickpea (garbanzo bean) (Source: https://unstats.un.org/unsd/classifications/Econ/Structure/Detail/EN/1074/01701).*

5 *https://www.fao.org/faostat/en/#home*

6 *https://desagri.gov.in/#*

Rajasthan, Uttar Pradesh, Karnataka, Gujarat, Andhra Pradesh, Jharkhand, Telangana and Tamil Nadu) contributing about 91.28% of the total production from 89.97% of the total cultivated area. Geographically, the optimal conditions for pulse cultivation in India include temperatures ranging from 20°C to 27°C, rainfall between 250-600 mm, and soils ranging from sandy to loamy. However, recent estimates indicate a decline in both area and production for the 2023-24 season, with figures standing at 27.51 Mha and 24.25 MT, respectively (DES, MoA&FW). Chickpea reign supreme in India's pulse production, contributing about 47.4% of the total output over the past five years. This dominance is followed by pigeonpea (15.4%), green gram (12.02%), black gram (10.3%), and lentil (5.4%) (DES, MoA&FW).

Pulse crops are cultivated under various agro-climatic conditions and seasons in India. They are often grown in marginal and less fertile soils, making efficient use of limited resources and water, a vital component of the country's cropping and consumption patterns. India's vast rainfed areas, 52% of the country's total net sown area, support 40% of the population and 2/3rd of the livestock. About 90% of coarse cereals, 80% of pulses, 74% of oilseeds, 65% of cotton, and 48% of rice are produced in rainfed regions. India's economy has been dominated by agriculture, which contributes to employment at 49%. Pulse cultivation impacts the livelihoods of more than 5 crore farmers and their dependents across the country, highlighting its importance in rural economies.

The Government of India (GoI), recognizing the importance of food and nutritional security, enacted the Food Security Act of 2013 to ensure access to adequate, affordable, and quality food for all. Ensuring food and nutritional security at an affordable rate for more than 1.4 billion people remains a national concern and a priority for the government. Pulses, a vital component of the Indian food basket, contribute significantly to national food and nutritional security. Comprising 8.05% of the total foodgrain basket over the past five years, pulses offer a cost-effective source of plant-based protein, vitamins, dietary fibre, and minerals. Often referred to as the "poor man's meat," pulses are particularly important for those with limited access to dairy and animal products. Their role in addressing health concerns like obesity, diabetes, and malnutrition is substantial. As a staple food, pulses are integral to Indian diets, providing essential variability in taste and nutrients and contributing to overall well-being.

Recognizing the dual objectives of achieving food and nutritional security while enhancing the income of farmers, the GoI has initiated various farmer-centric strategies and programs such as the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), Pradhan Mantri Fasal Bima Yojana (PMFBY), Paramparagat Krishi Vikas Yojana (PKVY), Soil Health Management (SHM) and Soil Health Card (SHC), and the National Agriculture Market scheme (e-NAM) since 2015-16 to achieve the targeted outcomes and instrumental in supporting agriculture production and promoting sustainable agricultural practices. Over the years, the government of India (GoI) has introduced numerous policies and initiatives to enhance pulse production, improve supply chain efficiency, and stabilize prices. These interventions, while making some headway, have not fully bridged the demand-supply gap. Key government initiatives in the pulse sector include the All India Coordinated Pulse Improvement Project (AICPIP, 1966), Pulses Development Scheme (1969-1974), National Pulses Development Project (NPDP) (1985-1990), Special Food Grain Production Programme (SFPP) on Pulses (1988-1989), Technology Mission on Oilseeds, Pulses, and Maize (TMOP&M) (1990 onwards), Integrated Scheme of Oilseeds, Pulses, Oil palm, and Maize (ISOPOM) (2004-2010), National Food Security Mission (NFSM) - Pulses (2007-2012), and Accelerated Pulses Production Programme (A3P) (2010-2014), designed to actively promote key technologies like Integrated Nutrient Management (INM) and Integrated Pest Management (IPM) to ensure higher returns for farmers and catalyze growth in the identified pulse crops. These initiatives aim to enhance productivity, improve quality, and ensure food security by promoting sustainable practices and technological advancements in pulse cultivation nationwide.

However, despite these efforts, pulse production fell to 16.35 MT in 2015-16, significantly below national demand. Consequently, India was forced to import nearly 6 MT of pulses from other countries to bridge the gap. In response to those challenges, the GoI has launched several initiatives since 2015-16. For instance, the Pradhan Mantri Annadata Aay Sanrakshan Abhiyan (PM-AASHA) scheme ensures farmers' price support through the procurement of pulses, oilseeds, and copra at a Minimum Support Price (MSP). During the period 2014-15 to 2023-24, a quantity of 17.052 MT of pulses has been procured under the Price Support Scheme (PSS). The e-Samridhi Portal, a farmer-centric initiative, empowers pigeonpea, black gram, and lentil producers by facilitating procurement at MSP through the National Agricultural Cooperative Marketing Federation of India Limited (NAFED) and the National Cooperative Consumers Federation of India Limited (NCCF). The Government is committed to procuring 100% of these pulses from the registered farmers on the e-Samridhi Portal. Additionally, the government has reinvigorated the NFSM-Pulses program with a clear roadmap to achieve self-sufficiency in the pulse sector. It is implemented in all 28 states and 2 union territories (J&K and Ladakh), with over 60% of funds allocated to pulses to boost pulse production. Key initiatives under NFSM-Pulses include supporting breeder seed production, establishing 150 Seed Hubs at Indian Council of Agricultural Research (ICAR) institutes, State Agriculture Universities (SAUS), and Krishi Vigyan Kendras (KVKs) to increase quality seed production, and distribution of seed mini-kits of pulses free of cost to the farmers of the varieties notified within 10 years. Additionally, ICAR, KVKs, and SAUs conduct demonstrations on improved agricultural practices. By assisting Central Seed Agencies, the NFSM aims to enhance the availability of quality certified seeds of the latest pulse varieties, thereby contributing to increased production and productivity. These interventions, along with support for cluster demonstrations, improved farm machinery, efficient water tools, plant protection, nutrient management, processing equipment, and farmer training on cropping systems, NFSM-Pulses aims to enhance pulse production and productivity significantly. The Targeting Rice Fallow Area (TRFA) initiative under the NFSM-Pulses program focuses on promoting lentil cultivation in states like Assam, Bihar, Jharkhand, Chhattisgarh, Madhya Pradesh, West Bengal, and Odisha, and green gram and black gram cultivation in Tamil Nadu, Madhya Pradesh, Maharashtra, Jharkhand, Gujarat, West Bengal, and Karnataka. To further support the development of the pulse value chain, the government has implemented various schemes. The Pradhan Mantri Rashtriya Krishi Vikas Yojana (PM-RKVY) for state-specific pulse projects with State Level Sanctioning Committee (SLSC) approval. Per Drop More Crop (PDMC) to build irrigation infrastructure for efficient water use. The Sub-Mission on Agricultural Mechanization (SMAM) for comprehensive farm mechanization and drone use for timely operations. The Seed Authentication, Traceability & Holistic Inventory (SATHI) portal ensures quality and traceability in seed production and distribution. Additionally, schemes like the Agri Infrastructure Fund (AIF), Pradhan Mantri Formalisation of Micro Food Processing Enterprises (PMFME), Farmer Producer Organizations (FPOs), and Pradhan Mantri Fasal Bima Yojana (PMFBY) provide support for integrated development and risk management in the pulse sector. In addition to that, GoI announced a significant raise in MSP by declaring bonuses on all major pulse crops during the years 2016-17 and 2017-18. The increase in prices attracted farmers to increase the area under pulses, resulting in a historic 18% surge in the area under pulse production. Furthermore, to enhance domestic availability and stabilize prices, the Government took a significant step by approving the establishment of a buffer stock of 0.15 MT of pulses on December 9, 2015. Recognizing the need for more impactful market intervention, it was determined that a greater buffer stock of about 2.0 MT would be essential. This important recommendation received the Government's approval in September 2016. As a result, a robust buffer of 2.050 MT of pulses was created through a strategic combination of domestic procurement and imports by the Rabi Marketing Season (RMS) 2017-18 for regular and effective disposals. Since 2018-19 and onwards, the Government has decided that procurement at the MSP will take place under the PSS of the DACFW. If procurement is not necessary under the PSF, the need for maintaining an appropriate buffer will be met using PSS stocks. Since the Rabi season of 2017, procurement has been conducted under MSP operations of the PSS, and pulses procured through the PSS have been subsequently transferred to the PSF to satisfy buffer requirements. This approach has facilitated the efficient use of PSS stocks for stabilization efforts, with controlled releases made from the PSF. As a result, harmonization between the PSS and PSF has been achieved, ensuring that farmers receive remunerative prices while managing supply-side interventions to stabilize consumer prices.

Implementing proactive pulse programs and robust monitoring mechanisms by GoI has led to significant growth in the area, production, and productivity of pulses. The period from 2016-17 to 2021-22 witnessed notable increases, with production reaching 23.13 MT in 2016-17 to 25.46 MT in 2020-21 and 27.30 MT in 2021-22, achieving a record-breaking pulse production. During this time, pulse productivity increased nearly 38% from 0.656 t/ha in 2015-16 to 0.902 t/ha in 2022-23. Despite these advancements, India's domestic production still falls short of meeting the country's total demand, resulting in imports of 2.496 MT in 2022-23 though the import dependency has significantly decreased from about 29% in 2015-16 to around 10.4% in 2022-23. This remarkable achievement signifies a major step forward in the nation's quest for self-sufficiency in the pulses sector.

1.2 Rationale for Atmanirbharta in Pulses

"Atmanirbharta," the Hindi term for self-reliance or self-sufficiency, has become a guiding principle for Indian government policies. This pursuit of self-sufficiency holds immense strategic value for economic advancement, food security, and cultural heritage preservation. It is pivotal for the transformation of a country into a developed nation. Achieving self-reliance in the pulse economy offers several compelling benefits. Firstly, reducing import dependency will strengthen national food security and ensure greater stability in the food supply. Secondly, it will invigorate the domestic agricultural sector by promoting pulse cultivation, which is crucial for rainfed farmers. This move will create employment opportunities, boost rural incomes, and stimulate local economies. Additionally, cultivating pulses improves nutritional security for the population and enhances soil fertility, benefiting overall agricultural health. Finally, attaining self-sufficiency in pulse production will significantly reduce foreign exchange outflows, thus decreasing the country's import expenditures and contributing to economic stability.

Achieving self-sufficiency in pulses is not just an economic goal; it is a strategic imperative for a self-reliant and prosperous India. As reaffirmed by the Finance Minister, the government is committed to strengthening the production, storage, and marketing capabilities for pulses to achieve this objective. In the recent Union Budget for 2025-26, the Finance Minister emphasized that ten years ago, the country made concerted efforts and succeeded in nearing self-sufficiency in pulses. Farmers responded to this need by increasing the cultivated area by 50%, while the government ensured procurement and offered remunerative prices. Since then, with rising incomes and improved affordability, our consumption of pulses has increased significantly. To further this goal, the government will launch a six-year initiative called the

"Mission for Aatmanirbharta in Pulses," with a special focus on Tur, Urad, and Masoor. This mission will emphasize: (1) The development and commercial availability of climate-resilient seeds, (2) Enhancing protein content, (3) Increasing productivity, (4) Improving post-harvest storage and management, and (5) Assuring remunerative prices to farmers. Additionally, the central agencies, such as NAFED and NCCF, will be ready to procure these three pulses from farmers who register with them and enter into agreements over the next four years.

At the 32nd International Conference of Agricultural Economists (ICAE) in August 2024, the Honorable Prime Minister highlighted India's remarkable transformation in the agricultural sector. Recalling the challenges faced by India's food security during its early years of independence, the Honorable Prime Minister emphasized the country's remarkable progress in becoming a global agricultural powerhouse. Today, India is the world's largest producer of milk, pulses, and spices and the second-largest producer of food grains, fruits, vegetables, cotton, sugar, tea, and farmed fish. These achievements are evidence of India's successful policies and investments in agriculture, which have not only ensured food security at home but also contributed to addressing global food and nutrition challenges.

1.2.1 Minimizing Import Dependency

The GoI has successfully increased pulse production through targeted policies and interventions from about 16-19 MT (i.e., in 2010-11 to 2015-16) to 25-27 MT in the past 2-3 years. While imports peaked at 6.6 MT in 2016-17 from 3-5 MT per annum from 2010-11 to 2014-15, they have steadily declined since then with some fluctuations, reaching their lowest level in the last ten years of around 2.47 MT in 2020-21. During 2022-23, imports are well within 2.5 MT. These developments highlight India's progress towards reducing import dependency and fostering a more self-sufficient pulse sector (DGCI&S, MoC; and DES, MoA&FW).

However, despite a nearly 60% jump in overall domestic production since 2015-16, which has helped India cut down on imports in the last few years, external factors such as the El Niño weather pattern in the previous year have contributed to fluctuations in pulse prices and imports. In the last fiscal year, 2023-24, India's pulse imports skyrocketed by 84% year-on-year, reaching a six-year high. The import of pulses reached 4.739 MT (DGCI&S, MoC), a stark contrast to the prior year's 2.496 MT, which was about a 90% increase and about 18.5% of domestic demand. In value terms, the country's spending on imports rose about 93% to USD 3.74 billion from only US$1.94 billion in 2022-23, largely imported from Canada, Myanmar, Australia, Tanzania, Mozambique, and Russia, covering 87% of the total imports. Simultaneously, India has exported 0.63 MT of pulses to the world for the worth of US$ 0.69 billion during the year 2023-24 to major export destinations (i.e., Bangladesh, China, UAE, USA, and Sri Lanka) (DGCI&S, MoC). The surge in imports during 2023-24, highlights the need for continued efforts to enhance sustainable domestic production and reduce reliance on imports. Among pulses, the import has largely surged for yellow pea (imported from Canada and Russia) and red lentil (imported from Canada and Australia). Primarily, these two pulses are driving the overall pulse imports. The country's imports of red lentil from Canada have more than doubled to about 1.2 MT, despite strained diplomatic relations. Further, the Reserve Bank of India has highlighted that food price pressures pose challenges in bringing inflation down to the target of 4%, and the price of pulses plays an essential role in inflation numbers. These trends underscore the complex interplay of global economic factors influencing global trade and domestic supply-demand dynamics. The government is actively exploring new markets like Brazil and Argentina to diversify import sources and stabilize the domestic pulse market.

In January 2024, the Government of India expressed confidence in achieving complete import independence in pulses by December 2027. To facilitate this goal, a new online portal was launched to streamline the procurement process. This portal enables farmers to directly sell pigeonpea to the National Agricultural Cooperative Marketing Federation of India (NAFED) or the National Cooperative Consumers' Federation of India (NCCF) at the minimum support price (MSP) or at the prevailing market price, whichever is higher. Further, in a significant step towards enhancing pulse production, the government has launched a pilot contract farming project in collaboration with the NCCF. This initiative, rolled out in Tamil Nadu, Bihar, Jharkhand, and Gujarat, aims at cultivating pigeonpea and lentil on 1,500 hectares of farmland. This marks the government's first foray into contract farming, a strategic move to expand pulse cultivation. The government aims to boost domestic production and reduce reliance on imports by incentivizing farmers and providing technical support.

Achieving self-sufficiency in pulses requires concerted efforts to accelerate production and meet the growing domestic demand. If domestic production does not keep pace with consumption, reliance on imports will inevitably increase. Therefore, it is imperative to implement a range of strategies to enhance pulse production, meet the nutritional needs of the growing population, improve the trade balance by reducing imports, and promote sustainability within the Indian agricultural system.

1.2.2 Achieving Nutritional Security

Pulses stand out as nutritional powerhouses and may impact substantially on SDG 2 (Zero Hunger). They are essential food crops globally due to their high protein content, which can significantly improve global nutrition, eradicate hunger, and tackle chronic health conditions like obesity and diabetes. With their balanced composition of carbohydrates (mainly starches, 55-65% of the total weight), proteins including essential amino acids (18-25%, much higher than cereals), fat (1-4%), and the remainder consists of water and inedible substance pulses offer a wide-ranging nutritional package. The energy content of most pulses is between 300 and 540 kcal/100g.

Pulses, a staple in India's diets, align seamlessly with the ethos of self-reliance (*Atmanirbhar*) in India's agricultural sector. Pulses provide a low-fat protein source (20-25%), high in fibre, and with a low glycemic index. Compared to cereals, pulses contain 1.67 times more iron, 2.47 times more protein, 3.54 times more vitamin A, and 5.31 times more dietary folate. Pulses help lower the risk of coronary heart disease due to their high dietary fibre content, which is known to reduce low-density lipoprotein (LDL) cholesterol—a key risk factor for the condition. Pulses also contain essential vitamins and minerals, including iron, potassium, and folate. These can help reduce the risk of neural tube defects (NTDs) like spina bifida in newborns and are crucial for overall health and vitality. Moreover, they are excellent sources of antioxidants, supporting cellular protection and immune function. As gluten-free options, pulses cater to diverse dietary needs, ensuring accessibility and sustainability in food systems. The widespread habit of eating pulses and rice, chapatti with pulses, and *idli* with pulse-infused sambhar are a few examples of this combination in the daily Indian food platter. The nutritional value of vegetarian and plant-based diets is notably enhanced when pulses are consumed alongside cereals.

A healthy and balanced meal (food) includes generous amounts of vegetables, adequate whole grains and pulses or beans, and modest portions of nuts or seeds, complemented by a selection of fruits and plain fermented yogurt or curd. It is free of added sugars or contains very minimal amounts and is seasoned with minimal oil/fats and salt for taste. According to the Indian Council of Medical Research -National Institute of Nutrition (ICMR-NIN), 'My Plate for the Day' recommends[7] sourcing macronutrients and micronutrients from a minimum of eight food groups, with vegetables, fruits, green leafy vegetables, roots, and tubers forming half the plate of the recommended foods daily. The primary portion is comprised of cereals and millets, followed by pulses, meat, eggs, nuts, oilseeds, and dairy products like milk and curd. Intake of cereals should be limited to 45% of the total energy, while for pulses, eggs, and flesh foods, the total energy percentage should be around 14% to 15%. 30g of pulses can be substituted with fish/flesh foods. Total fat intake should be less than or equal to 30% energy, while nuts, oilseeds, milk, and milk products should contribute 8%–10% of total energy per day respectively.

However, as per the data, cereals contribute 50% to 70% of total energy daily. Pulses, meat, poultry, and fish together contribute to 6% to 9% of the total energy per day as against the recommended intake level of 14% of total energy from these foods. In a large segment of the country's population, the intake of micronutrient-dense foods (whole grains, pulses, beans, nuts, fresh vegetables, fruits, etc.) is found to be lower than the recommended levels, whereas, the intake of refined cereals is found to be higher. A steady increase in the intake of unhealthy foods among people complicates the matter further. As a result, the majority of the population, including children, suffer from malnutrition and its adverse health outcomes.

While overall food grain production, especially cereals, has risen consistently over the past few decades, the per capita availability of food grains indicates adequacy in cereals (464g), with pulses remaining low. Due to the limited availability and high cost of pulses and meat, a significant proportion of the Indian population relies heavily on cereals, resulting in poor intake of essential macronutrients (essential amino acids and essential fatty acids) and micronutrients. Low intake of essential nutrients can disrupt metabolism and increase the risk of insulin resistance and associated disorders from a young age.

1.2.3 Enhancing Sustainable Development

Pulses, a vital component of global food systems, contribute significantly to sustainable development. Beyond their nutritional value, pulses are crucial in climate resilience, biodiversity conservation, and poverty reduction. The symbiotic relationship between pulses and soil can enhance soil structure by improving aggregate stability, aeration, and water-holding capacity while also supporting microbial biodiversity. This, in turn, boosts soil health and increases crop yields. Pulses have deep root systems that allow them to access water stored deeper in the soil, enabling them to thrive better than crops with shallower roots under water-stressed conditions. Additionally, the resilience of pulses to various climate stresses makes them a valuable option for adapting to climate change. By fostering diverse crop rotations and fixing atmospheric nitrogen, the cultivation of pulses supports several Sustainable Development Goals (SDGs), including SDG 2 (Zero Hunger), SDG 3 (Good Health and Well-being) along with SDG 13 (Climate Action) and SDG 15 (Life on Land). By encouraging sustainable farming practices and responsible consumption, pulses align with SDG 12 (Responsible Consumption and Production). The United Nations designated February 10th as World Pulse Day to raise awareness of these benefits.

7 *ICMR-NIN, Dietary Guidelines for Indians. Expert Committee Members-2024. https://main.icmr.nic.in/sites/default/files/upload_documents/DGI_07th_May_2024_fin.pdf*

Achieving self-sufficiency in pulses offers substantial economic benefits for India. By reducing import dependency and enhancing domestic production, India can stabilize its economy by mitigating fluctuations in global market prices. This stability secures food security and boosts rural livelihoods by providing steady income opportunities for farmers engaged in pulse cultivation. Furthermore, self-sufficiency in pulses enhances food sovereignty, ensuring access to nutritious food for all citizens. This strategic shift towards self-reliance in pulses strengthens India's economic resilience and reinforces its sustainable agriculture and food security leadership, driving holistic socio-economic development across the nation.

Recognizing the pivotal role of the pulse sector in ensuring food security, diminishing import reliance, and sustaining rural livelihoods, the following terms of reference are outlined to accomplish the proposed task titled *"Strategies and Pathways for Accelerating Growth in Pulses towards the Goal of Atmanirbharta."* Understanding the interconnectedness of various stakeholders and factors is crucial for achieving Atmanirbharta; the critical inquiries mentioned above are explored in the following chapter and pave the way for effective strategies to bridge the demand-supply gap and achieve self-reliance in the pulses sector.

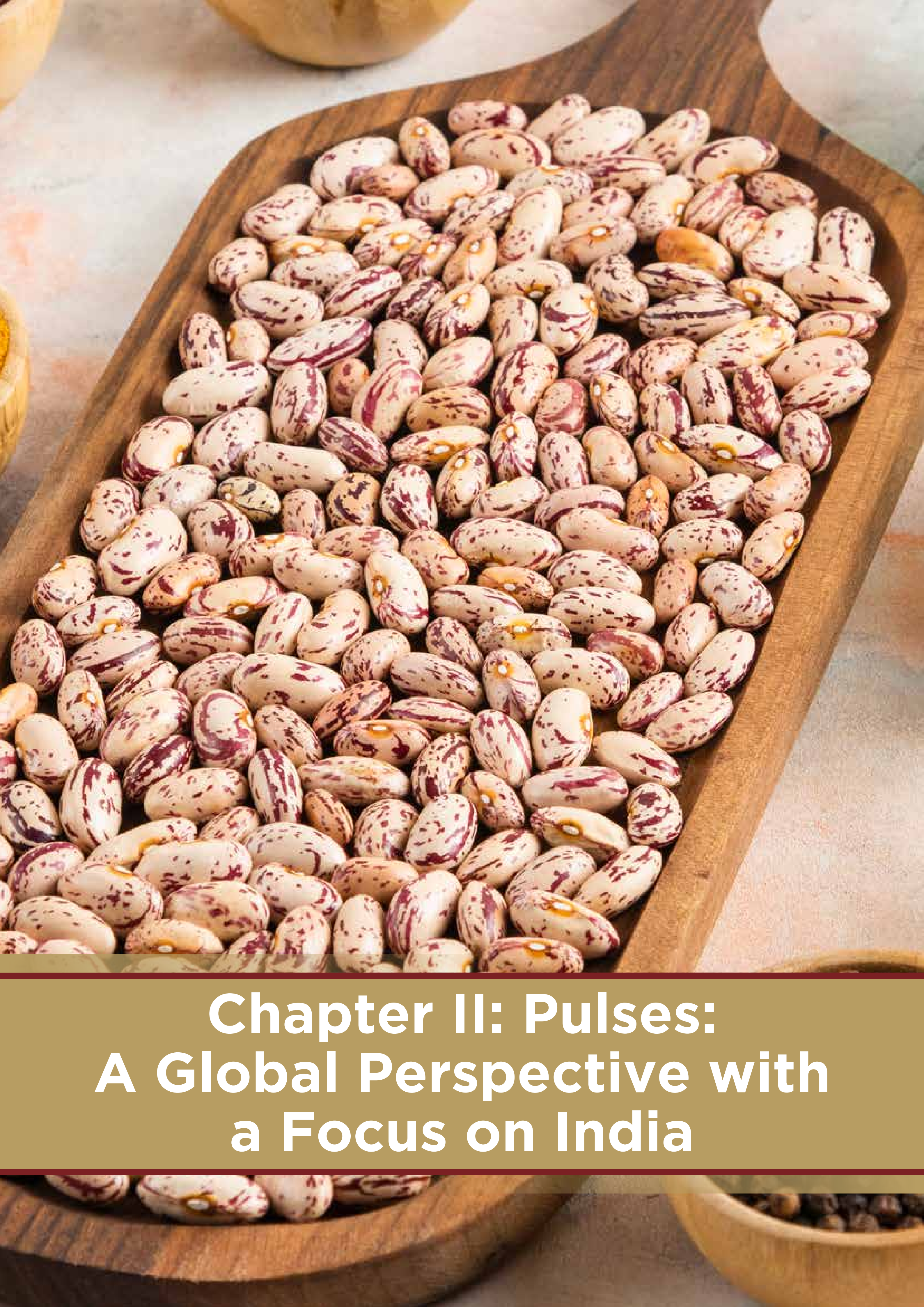
1.3 Terms of Reference (TOR)

i. Analyzing Pulse Sector Performance and Demand-Supply Gap:

- Conduct a comprehensive review of existing literature and analyses to gain insights into historical trends (area, production, yield, import/export, and consumption) of major pulses in India and the global context.
- Evaluate the effectiveness of past strategies implemented to achieve self-reliance in pulse production in India.
- Examine the intricate interplay of various factors that influence and shape India's pulse trade, aiming to enhance profitability and encourage farmers in the context of benefit-cost advantages of pulse crop cultivation to attain self-sufficiency.
- Analyze the current gap between domestic demand and supply of total and significant pulses in India, identifying key factors contributing to the current shortage.

ii. Achieving *Atmanirbharta*: Framework and Strategies

- Develop a comprehensive framework for formulating a practical and implementable roadmap with actionable strategies to achieve self-sufficiency (*Atmanirbharta*) in the pulse sector.
- This framework will incorporate:
- District-level Clustering for Targeted Interventions:
  - » Employ a data-driven four-quadrant approach (High Area-High Yield, High Area-Low Yield, Low Area-High Yield, and Low Area-Low Yield) to categorize district-level clusters across India for major pulses (i.e., Pigeonpea, Green gram, Lentil, Chickpea, Pea & Beans, Moth, and Black Gram). By leveraging the quadrant analysis, identify high-potential clusters for specific pulses, enabling targeted interventions.
  - » **Productivity Enhancement Strategies:** Develop a practical and implementable roadmap with actionable productivity enhancement strategies (focusing on overcoming yield stagnation) for major pulses within the identified clusters. The proposed strategies will encompass both horizontal and vertical expansion initiatives, aligning with the cluster framework to enhance growth in domestic pulse production. This approach aims to attain *Atmanirbharta*, or self-sufficiency, in this sector.

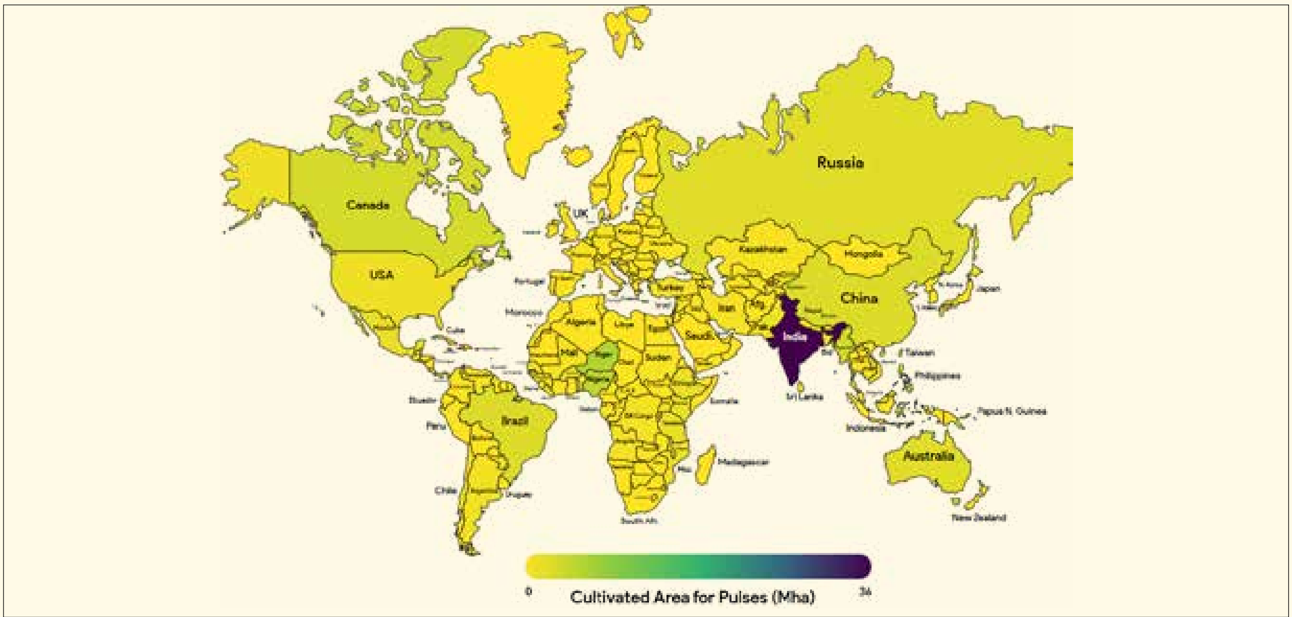


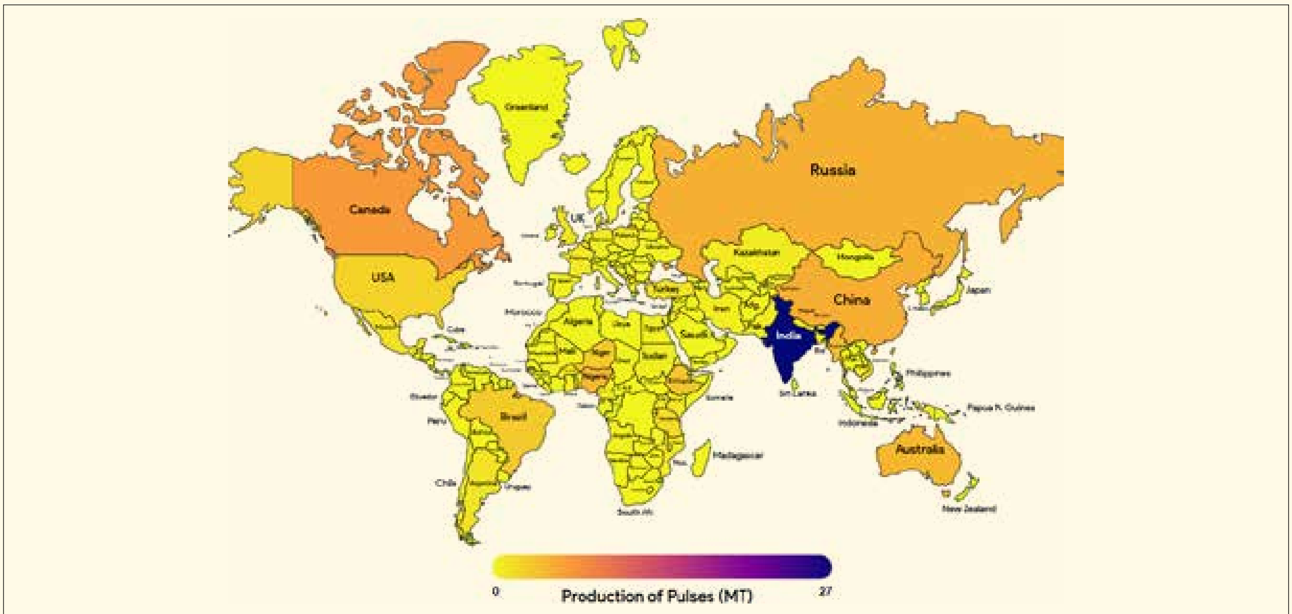
Chapter II: Pulses: A Global Perspective with a Focus on India

Pulses: A Global Perspective with a Focus on India

2.1 Introduction

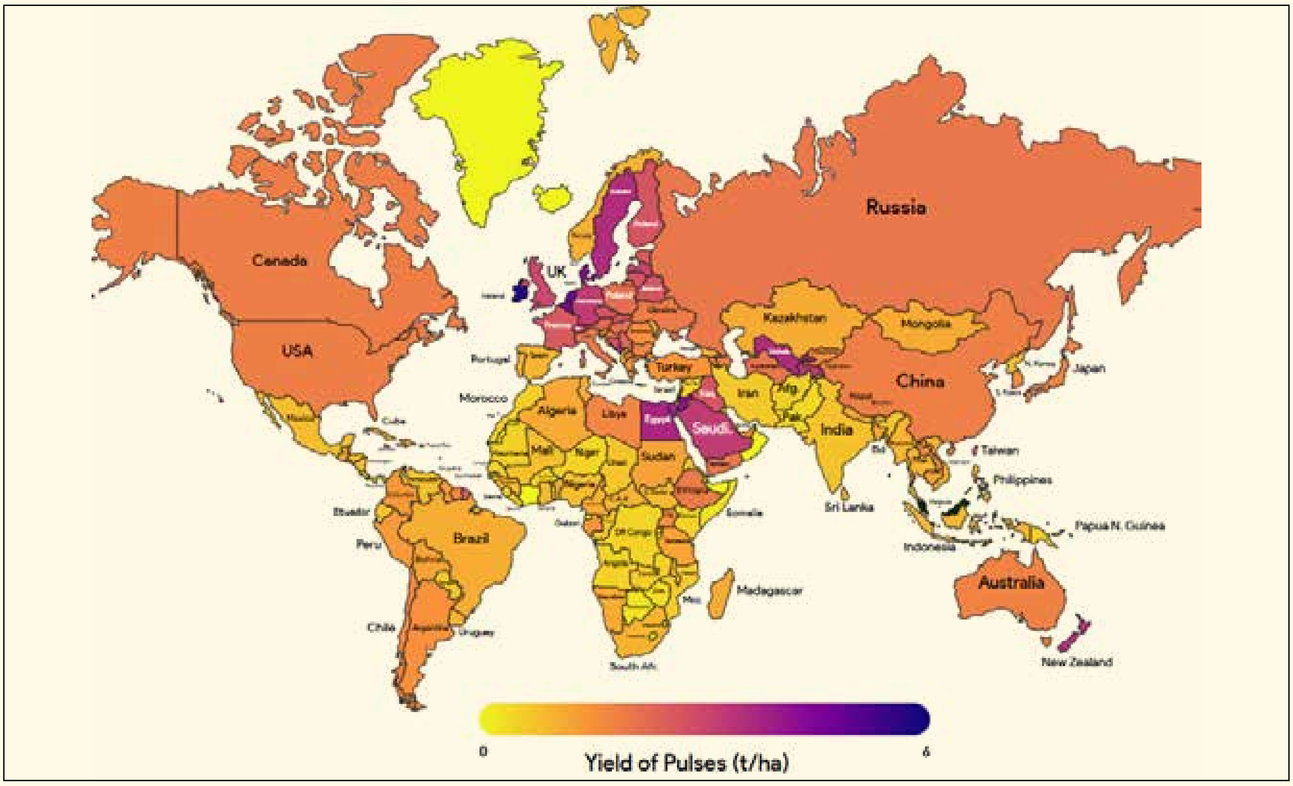
The global pulse sector presents a diverse and dynamic scenery. In 2022, the global area under pulse[8] cultivation reached a significant 97.09 Mha, resulting in a production of 96.04 MT. This translates to an average global yield of 0.989 t/ha (FAOSTAT, FAO)[9]. Notably, pulses are cultivated in a staggering 172 countries worldwide. The following maps visually represent the worldwide spatial patterns of pulse cultivated area, production, and yield (Map 2.1).





8 *The United Nations Food and Agriculture Organization (FAO) recognizes 11 types of pulses: dry beans, chickpea, pigeonpea, lentil, dry pea, cowpea, dry broad bean, bambara bean, vetches, lupin and pulses n.e.s. (not elsewhere specified – minor pulses that don't fall into one of the other categories).*

9 *https://www.fao.org/faostat/en/#home*



Source: Authors computation from FAOSTAT database (2024)

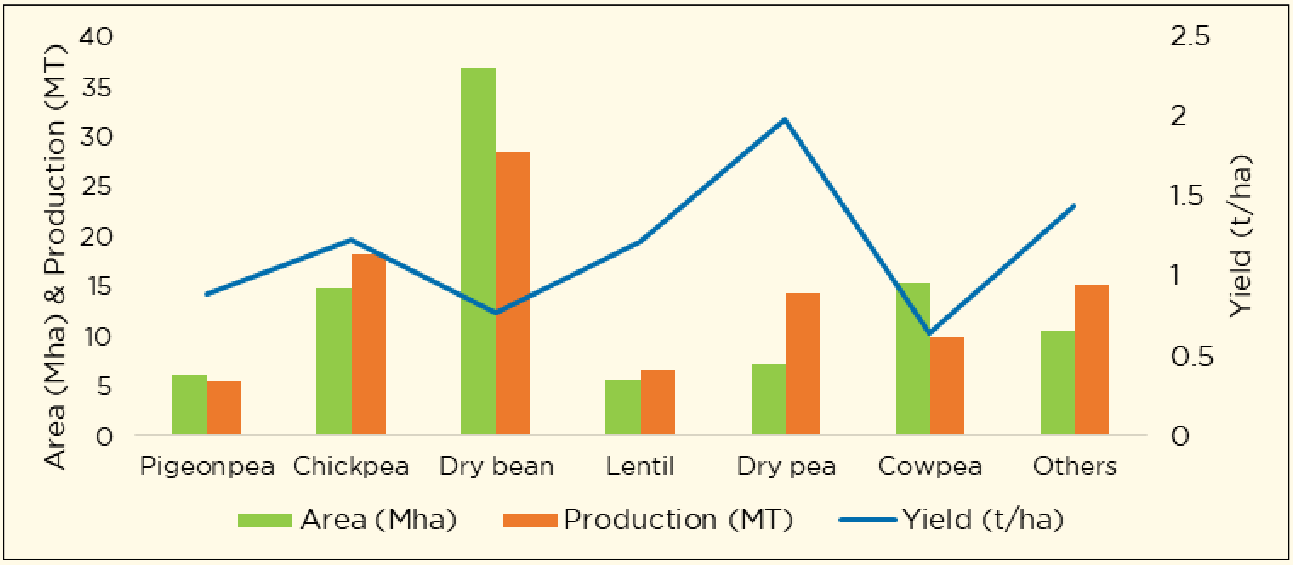
Map 2.1: Spatial Patterns of Global Cultivated Area, Production, and Yield of Pulses (2022)

Among various pulse crops, dry bean holds the top spot in terms of cultivated area, covering 38% globally and grown in 105 countries. Chickpea, dry pea, pigeonpea, lentil, cowpea, and other pulses[10], with their respective shares of 15% (in 49 countries), 7% (in 95 countries), 6% (in 24 countries), 6% (in 43 countries), 16% (in 33 countries), and 11% of the total pulses cultivated area, having its specific geographic distribution.

This diverse distribution extends to production, with dry bean again leading the pack at 29% share of global pulse production. Other major contributors are chickpea, dry pea, pigeonpea, lentil, cowpea, and other pulses, with respective shares of 19%, 15%, 5%, 7%, 10%, and 15%, respectively. India's prominence as a leading producer of several pulse crops further underscores its significance in the global pulse market.

Interestingly, the yield varies significantly across pulse crops. Dry pea stands out with the highest productivity at 1.979 t/ha, followed by chickpea (1.222 t/ha), lentil (1.209 t/ha), pigeonpea (0.883 t/ha), dry bean (0.770 t/ha), and cowpea (0.643 t/ha), where other pulses yield was 1.434 t/ha. These figures highlight the diverse productivity levels across pulse crops, reflecting the influence of various factors such as climate, soil conditions, and cultivation practices. These offer valuable insights for optimizing production practices and maximizing returns. The accompanying figure (Figure 2.1) presents the crop-wise global scenario of pulses for the year 2022. Recognizing these global trends and diverse productivity levels across pulse varieties offers valuable insights for optimizing production practices and maximizing returns in India's journey towards self-sufficiency in pulses.

10 *Other pulses include dry broad beans, bambara beans, vetches, lupins, and pulses n.e.c. (not elsewhere classified – minor pulses that don't fall into one of the other categories).*



Source: Authors computation from FAOSTAT database (2024).

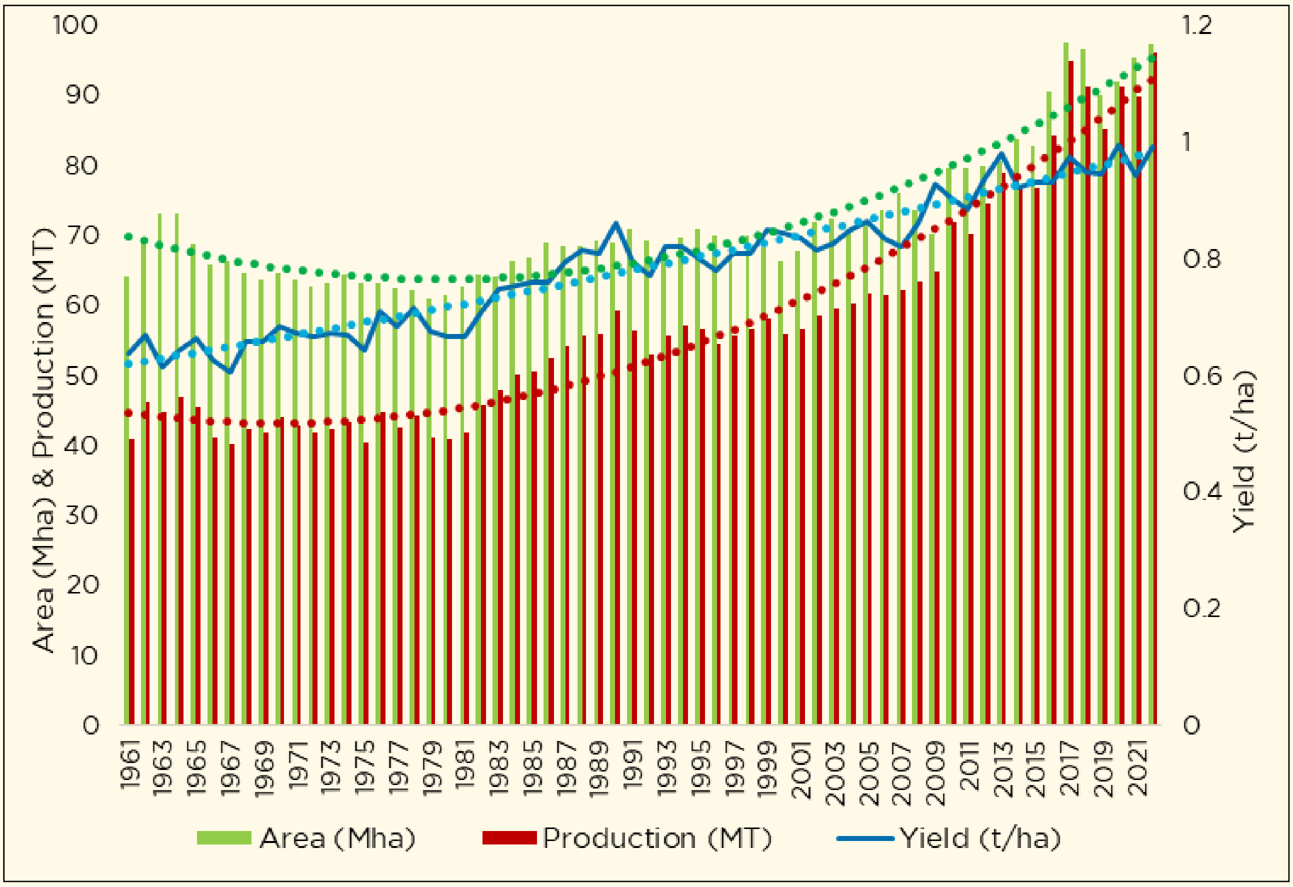
Figure 2.1: Global Scenario of Pulses in 2022: Crop-Wise Distribution

2.2 Temporal Analysis of Global Pulse Area, Production, and Yield Patterns: Last Six-Decade Trends (1961-2022)

The cultivation of pulses has a long-standing tradition in almost all regions of the world. For centuries, legumes have been integral to traditional agricultural systems. The global pulse scenario has significantly transformed over the past six decades (Figure 2.2). While the area under pulse cultivation experienced fluctuations and a declining trend in the initial two decades, it exhibited an upward trend in the '80s followed by a declining trend in the '90s. From 1961 to 2000, the global area under pulse cultivation increased from 64.01 Mha to 66.26 Mha, peaking at 70.76 Mha in 1991. However, a remarkable expansion occurred between 2000 and 2022, with the area growing from 66.26 Mha to 97.09 Mha.

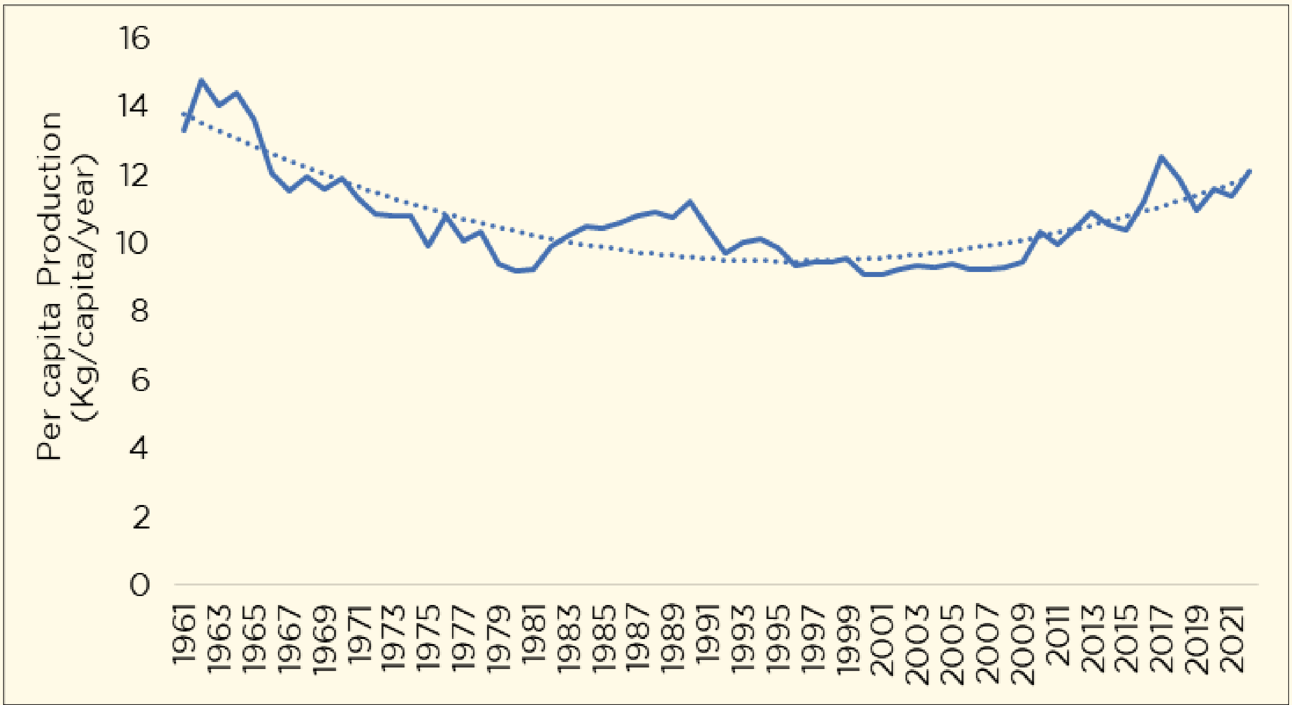
Before the 2000s, global pulse production stagnated due to the widespread decline of traditional crop rotation systems, particularly in low-income countries. This was compounded by factors such as weak disease resilience, limited genetic diversity, inadequate access to high-yielding varieties, and insufficient policy support for pulse growers. From 1961 to 2000, global pulse production increased subtly from 40.78 MT to 55.86 MT. However, since the early 2000s, the sector has experienced significant growth, averaging an annual increase of 3.27% globally until 2022. Asia and Africa have been key drivers of this growth, accounting for over half of the production increase in the past decade. Between 2000 and 2022, global pulse production surged from 55.86 MT to 96.04 MT. This surge is primarily driven by the expansion of cultivation area and gradual improvements in yield, supported by advancements in agricultural technology, better seed varieties, and improved farming practices. Per capita pulse production globally has exhibited a fluctuating trend over the years. In the year 1961, it stood at 13.273 kg/capita but subsequently declined to 9.209 kg/capita by 1981. It then experienced a period of growth, reaching 11.183 kg/capita in 1990. However, a downward trend followed till 2000, leading to stagnation between 9.0-9.4 kg/capita until 2009. Since then, per capita production has shown a significant upward trajectory, reaching 12.072 kg/capita in 2022, with a peak of 12.525 kg/capita in 2017 (Figure 2.3). This recent increase indicates positive strides in global pulse production and consumption.

While the initial phase until 1975 led to a stagnant period in global pulse productivity, subsequent years witnessed a gradual recovery and growth, peaking at 0.860 t/ha in 1990 from an initial level of 0.637 t/ha in 1961. However, productivity declined slightly to 0.840 t/ha by 2000. In recent decades, the pace of improvement in pulse yields has accelerated significantly. By 2022, the global yield had increased to 0.989t/ha. This positive trend in yield can play a crucial role in boosting pulse production.



Source: Authors computation from FAOSTAT database (2024)

Figure 2.2: Global Area, Production, and Yield Trend of Total Pulses (1961-2022)



Source: Authors computation from FAOSTAT (2024) and World Bank database

Figure 2.3: Global Pulse per Capita Production (kg/capita/year)

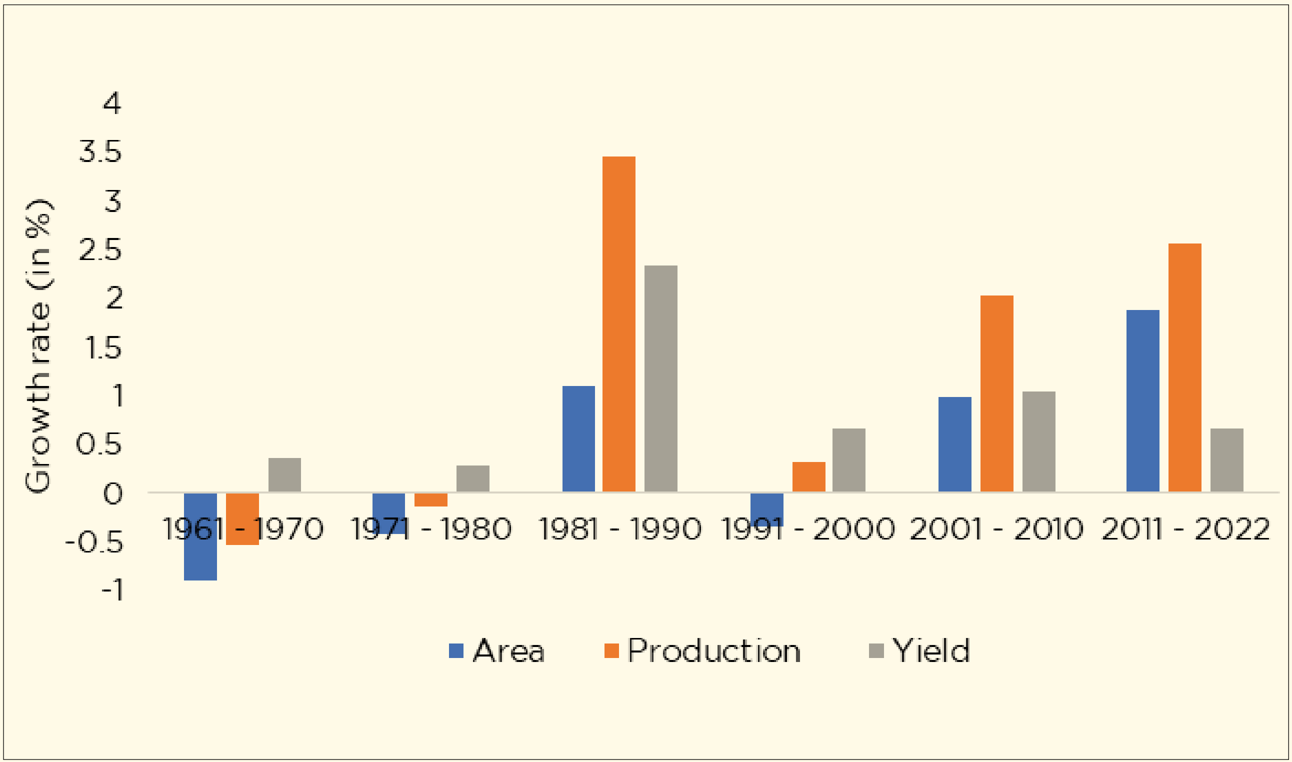
2.3 Decadal Growth Patterns: Area, Production, And Yield of Total Pulses (1961-2022)

While the early decades of the 1960s and 1970s witnessed a decline in both the cultivated area and production of pulses, with annual growth rates -0.89% to -0.42% for the area and -0.54% and -0.13% for production, yields during these periods demonstrated a positive growth rate, 0.36%, and 0.29% respectively.

A significant turnaround happened in the 1980s, with marked increases in both area and production growth, reaching 1.1% and 3.46%, respectively. Concurrently, yield growth also accelerated to 2.33%. The 1990s saw a continued positive production growth at 0.32%, although the cultivation area growth rate declined to -0.34%. Nevertheless, yields continued a positive growth rate of 0.67%.

The early 2000s maintained this positive momentum, with production growth at 2.03%, supported by a growth rate of 0.98% in the cultivation area and a further improvement in yield growth to 1.04% from the previous decade. However, the most substantial advancements in pulse cultivation have occurred from the 2011 to 2022 period, with the area cultivated for pulses growing at a rate of 1.88% and global pulse production increasing by 2.55%. Yield growth during this period also remained positive at 0.67%.

This sustained growth underscores the critical role of pulses in global agriculture and food security. Overall, the continuous expansion of the pulse sector in the later periods highlights its importance in enhancing food security, promoting sustainable agricultural practices, and improving livelihoods worldwide. The decadal growth in global area, yield, and production of total pulses is depicted in Figure 2.4.



Source: Authors computation from FAOSTAT database (2024).

Figure 2.4: Decadal Growth Rates in Area, Production, and Yield of Total Pulses in the World (%) (1961-2022)

For a comprehensive understanding of the decadal growth trends in the global pulse area, production, and yield, refer to Table 2.1 below. This table presents detailed data on the growth rates of major pulse crops, including pigeonpea, chickpea, dry bean, lentil, dry pea, and cowpea, across various decades from 1961 to 2022. The table offers valuable insights into the evolving dynamics of pulse cultivation, production, and yield on a global scale.

Table 2.1: Decadal Growth Rates of Area, Production and Yield of Major Pulses: Global Scenario (1961-2022)

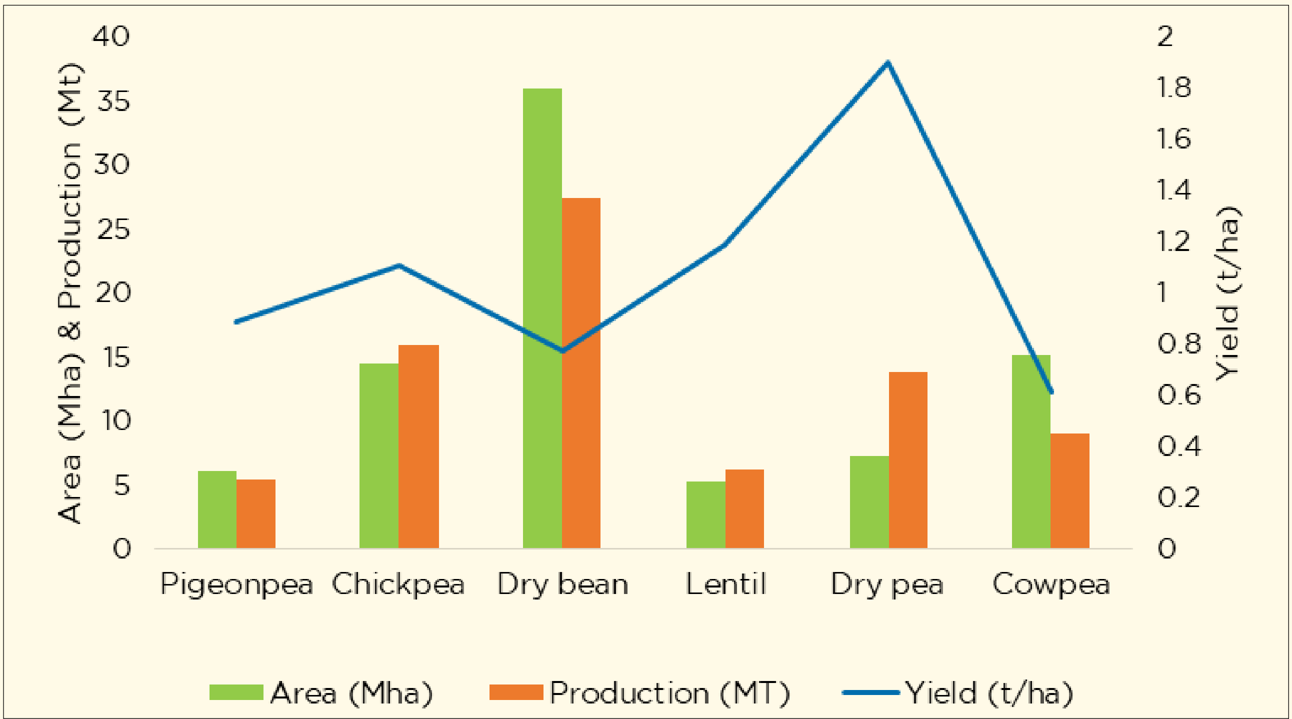
Crops		Decadal growth rate (%)					
		1961-1970	1971-1980	1981-1990	1991-2000	2001-2010	2011-2022
Area	Pigeonpea	1.01	0.22	2.52	0.03	0.88	0.99
	Chickpea	-2.45	0.47	0.19	1.93	1.75	1.02
	Dry bean	-0.05	0.31	0.22	-1.05	1.06	1.82
	Lentil	0.51	3.28	4.95	1.07	-0.81	2.62
	Dry pea	-3.16	-0.94	3.54	-3.53	0.00	1.21
	Cowpea	10.74	-5.80	4.62	5.15	2.43	2.85
Production	Pigeonpea	-0.10	0.22	3.54	0.04	2.40	3.59
	Chickpea	-2.56	1.20	2.73	3.42	3.15	3.76
	Dry bean	0.47	0.50	1.02	-0.33	2.24	1.29
	Lentil	1.96	3.25	7.52	1.20	0.89	3.11
	Dry pea	-1.35	-0.53	7.34	-3.21	-0.61	2.94
	Cowpea	3.81	0.53	5.64	5.35	5.30	3.56
Yield	Pigeonpea	-1.10	0.30	0.99	0.01	1.51	1.67
	Chickpea	-0.11	0.73	2.53	1.47	1.37	2.07
	Dry bean	0.52	0.19	0.79	0.73	1.17	-0.51
	Lentil	1.44	-0.03	2.46	0.13	1.72	0.47
	Dry pea	1.14	1.86	0.40	3.67	0.33	-0.60
	Cowpea	-6.25	6.72	0.98	0.19	2.80	0.68

Source: Authors computation from FAOSTAT database (2024).

2.4 Global Scenario of Major Pulses and India's Performance Among the Top Ten Producers in the Recent Five Years (2018-2022)

In the recent five years (Figure 2.5), dry bean has been the dominant force in global pulses cultivation, occupying 35.97 Mha (38.23% of the total area) and contributing 27.42 MT (30.27%) to global production. However, their relatively low yield of 0.774 t/ha highlights the need to improve cultivation practices. Chickpea, while covering a smaller area of 14.45 Mha (15.36% of the total area) and producing 15.97 MT, which accounts for 17.63% of global production, demonstrates a moderate yield of 1.107 t/ha, making it a significant contributor to both area and output. Pigeonpea accounts for 5.33 MT (5.88% of the global total) grown on 6.03 Mha (6.41% of the total), producing a yield of 0.883 t/ha. Despite occupying only 5.23 Mha (5.5% of the total area), Lentil exhibits a notably higher yield of 1.188 t/ha, contributing 6.20 MT, or 6.85%, to global production. Dry pea, with an area of 7.24 Mha (7.62% of the total area), also demonstrate the highest yield efficiency compared to other major pulse crops, producing 13.75 MT (15.56% of the global production) with a yield of 1.9 t/ha. While covering a substantial area of 15.07 Mha (15.54% of the total area), Cowpea has the lowest yield of 0.612 t/ha. However, they still contribute significantly to global pulse production, totalling 9.04 MT (10.23% of the total).

This reveals significant variability in pulse yields across different types of crops. Dry pea and lentil, in particular, demonstrate higher yield efficiency than other pulse crops, suggesting potential opportunities for optimizing cultivation practices and improving global pulse productivity. These insights can inform policy strategies aimed at enhancing pulse production, especially of lentil and dry pea, and promoting sustainable agriculture.



Source: Authors computation from FAOSTAT database (2024).

Figure 2.5: Crop-Wise Pulses Global Scenario:2018-2022

India has significantly strengthened its position as a global leader in pulse production in recent years. As the world's largest producer and consumer of pulses, India's contribution to the global pulse market has been substantial. Over the past five years (2018-2022), India has consistently maintained its position among the top pulse producers, demonstrating its expertise in cultivating and producing a diverse range of pulse crops. The following analysis provides a detailed comparison of India's performance with other major producers, focusing on key pulse crops such as pigeonpea, chickpea, dry bean, lentil, and dry pea.[11]

11 *Excluded cowpea from the below analysis, because in the Indian context, cowpea is a minor pulse cultivated mainly in arid and semi-arid tracts of grown in pockets of Punjab, Haryana, Delhi, and West UP along with a considerable area in Rajasthan, Karnataka, Kerala, Tamil Nadu, Maharashtra and Gujarat. Niger ranks first in area (39%) and Nigeria stands 2nd rank in area (31%) at the Global level. However, Nigeria stands first in production with a 42% share and Niger is in second position in production (29%) followed by Burkina (8%) respectively. Under major countries, the highest productivity is recorded in Ghana (1.662 t/ha) followed by Nigeria (0.865 t/ha) and Cameroon (0.818 t/ha).*

2.4.1 Total Pulses

Over the past five years (2018-2022), India has led the world in pulse cultivation area and production. India cultivated 33.46 Mha of pulses, accounting for 35.87% of the global total. This significant area under cultivation is a witness to India's commitment to pulse production. In terms of production, India produced 24.76 MT of pulses, contributing 27.40% of the global total (Table 2.2).

Table 2.2: Global Scenario by Top Ten Pulse Producing Countries (2018-2022)

Top Ten Producing Country	Area (Mha)	Producti on (MT)	Yield (t/ha)	Contribution (%)		Ranking (Yield)
				Area	Production	
India	33.46	24.76	0.74	35.87	27.4	10
Canada	3.43	6.45	1.88	3.68	7.13	2
China	2.67	4.86	1.821	2.86	5.38	4
Nigeria	4.93	4.07	0.827	5.28	4.51	9
Russia	2.19	3.73	1.707	2.34	4.13	5
Myanmar	3.85	3.66	0.95	4.13	4.05	8
Australia	2.25	2.98	1.324	2.41	3.29	6
Ethiopia	1.6	3.03	1.894	1.72	3.36	1
Brazil	2.71	2.94	1.085	2.9	3.25	7
USA	1.31	2.45	1.874	1.4	2.71	3
World	93.29	90.38	0.969	NA	NA	NA

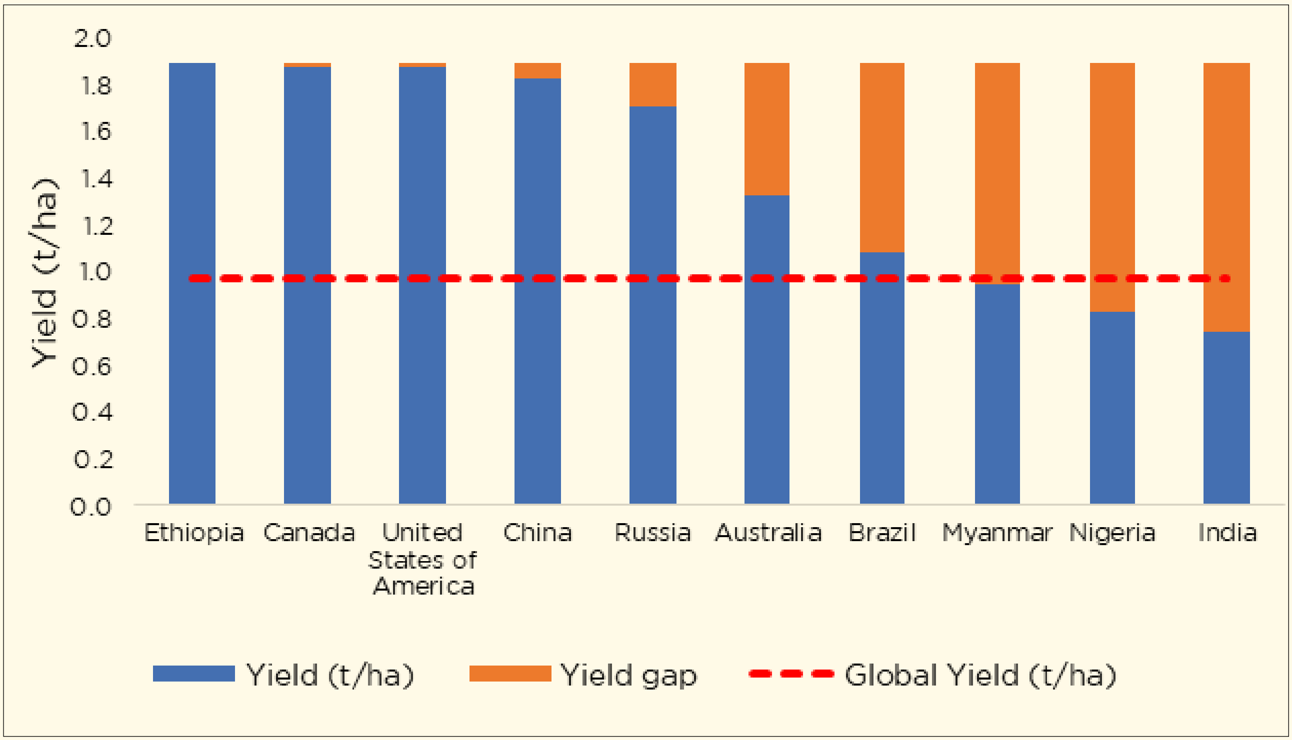
Source: Authors computation from FAOSTAT database (2024).

While India ranks first in area and production, its yield per hectare (t/ha) is comparatively lower than that of leading producers. The average pulse yield in India stands at 0.740 t/ha, significantly under the global average of 0.969 t/ha, highlighting the need for intensified efforts to enhance yield efficiency. Among the top ten pulse-producing countries, India has the lowest yield. It's important to note that India cultivates a wide variety of pulse crops with different yield levels, while other countries typically focus on just one or two pulse species. Therefore, calculating the average productivity of pulses in India might not yield accurate representations. Ethiopia leads the yield rankings at 1.894 t/ha, followed by Canada at 1.880 t/ha, the United States at 1.874 t/ha, China at 1.821 t/ha, and Russia at 1.707 t/ha. The yield gap in India is substantial, measuring 1.154 t/ha, which is over 2.5 times lower than Ethiopia's yields12 (Figure 2.6). This highlights the potential for India to narrow the yield gap and increase productivity through more efficient agricultural practices and adopting advanced

12 *In Ethiopia, faba bean followed by common bean, chickpea, lentil, and lathyrus are grown. Faba bean and common bean (in India known as rajmash) yields are much higher as compared to other pulse crops.*

technologies. India's dominance in global pulse production is undeniable though by focusing on enhancing yield efficiency, India can further strengthen its position in the global pulse market and contribute more effectively to global food security. If India matches the global average yield, there is a potential to increase pulse production by 7.66 MT, potentially making India self-sufficient.

Figure 2.6: Yield Gap among Top Ten Pulse-Producing Countries (2018-2022)



Source: Authors computation from FAOSTAT database (2024).

2.4.2 Pigeonpea

India leads the world in both area and production of pigeonpea. India cultivated 4.63 Mha of pigeonpea, accounting for 80.36% of the global total. Regarding production, India produced 4.01 MT of pigeonpea, contributing 78.10% of the global total (Table 2.3).

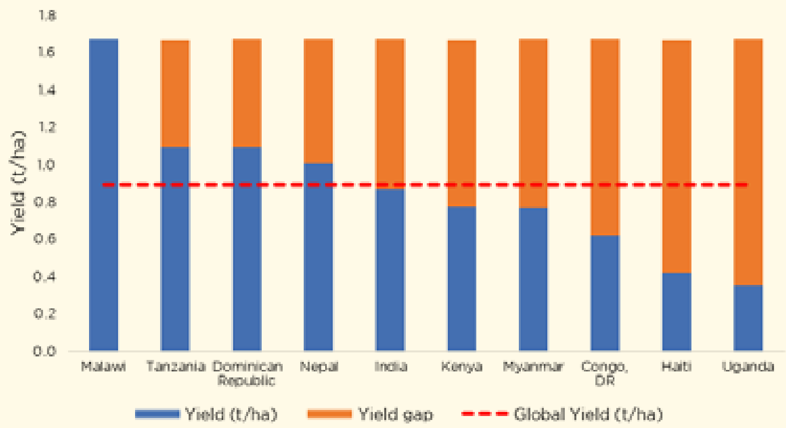
Table 2.3: Global Scenario by Top Ten Pigeonpea Producing Countries (2018-2022)

Top Ten Producing Country	Area (Mha)	Production (MT)	Yield (t/ha)	Contribution (%)		Ranking (Yield)
				Area	Production	
India	4.63	4.01	0.866	80.36	78.1	5
Malawi	0.26	0.43	1.666	4.44	8.3	1
Myanmar	0.44	0.34	0.764	7.61	6.54	7
Tanzania	0.15	0.16	1.094	2.6	3.2	2
Kenya	0.13	0.1	0.775	2.26	1.97	6
Dominican Republic	0.02	0.02	1.094	0.38	0.46	3
Haiti	0.05	0.02	0.417	0.81	0.38	9
Nepal	0.02	0.02	1.003	0.29	0.32	4
Uganda	0.05	0.02	0.346	0.83	0.32	10
Congo	0.01	0.01	0.619	0.19	0.13	8
World	5.76	5.13	0.891	NA	NA	NA

Source: Authors computation from FAOSTAT database (2024).

While India leads in area and production, its yield (t/ha) is lower than some other major producers. India's average pigeonpea yield was 0.866 t/ha, slightly below the global average of 0.891 t/ha. Malawi leads with a yield of 1.666 t/ha, followed by Tanzania at 1.094 t/ha. India ranked 5th among major pigeonpea-producing countries, with a substantial yield gap (i.e.,0.801 t/ha), which is more than 1.9 times lower compared to global top Malawi (Figure 2.7), emphasizes the need for more concerted efforts to improve yield efficiency in pigeonpea production. If India can match the global average yield, there is a potential to increase pigeonpea production by 0.11 MT. By matching the pigeonpea yield of Malawi, India could increase the production by 3.70 MT. India may learn from the experience of Malawi and explore possibilities of using pigeonpea germplasm in Malawi for developing varieties suitable for cultivation in India.

Figure 2.7: Yield Gap among Top Ten Pigeonpea-Producing Countries (2018-2022)



Source: Authors computation from FAOSTAT database (2024).

2.4.3 Chickpea

India leads the world in chickpea cultivation area and production. India cultivated 10.11 Mha of chickpea, accounting for 69.65% of the global total. In terms of production, India produced 11.57 MT of chickpea, contributing 72.06% of the global total (Table 2.4).

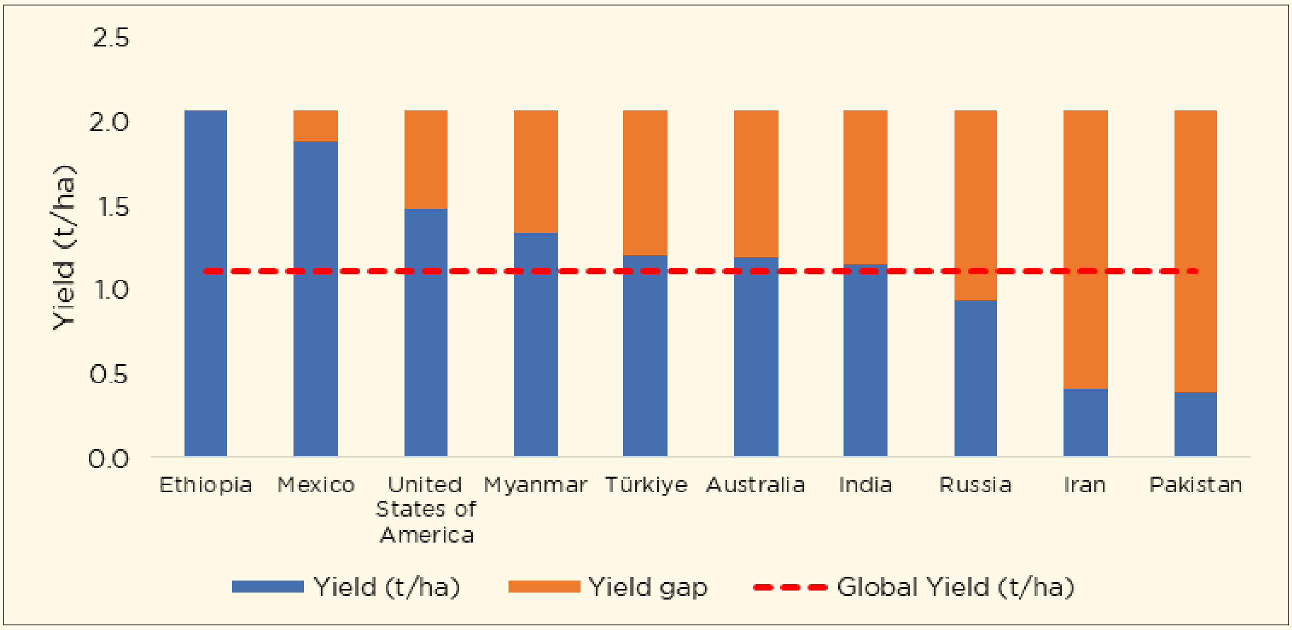
Table 2.4: Global Scenario by Top Ten Chickpea Producing Countries (2018-2022)

Top Ten Producing Country	Area (Mha)	Production (MT)	Yield (t/ha)	Contribution (%)		Ranking (Yield)
				Area	Production	
India	10.11	11.57	1.145	69.65	72.06	7
Australia	0.57	0.68	1.199	3.93	4.26	5
Türkiye	0.5	0.59	1.187	3.42	3.67	6
Myanmar	0.36	0.49	1.336	2.5	3.02	4
Ethiopia	0.23	0.46	2.062	1.55	2.89	1
Russia	0.47	0.44	0.932	3.26	2.74	8
Pakistan	0.92	0.36	0.394	6.35	2.26	10
USA	0.18	0.27	1.481	1.25	1.67	3
Mexico	0.11	0.21	1.872	0.77	1.3	2
Iran	0.44	0.18	0.406	3.05	1.12	9
World	14.51	16.06	1.106	NA	NA	NA

Source: Authors computation from FAOSTAT database (2024).

While India leads in area and production, its yield (t/ha) is relatively lower than some other major producers. India's average chickpea yield was 1.145 t/ha, slightly above the global average of 1.106 t/ha. Compared with other top chickpea producers, India's performance is mixed; its yield is lower than in countries like Ethiopia, Mexico, the USA, Myanmar, Turkey, and Australia. These countries have demonstrated higher yields, indicating the potential for India to improve its productivity through advancements in agricultural practices and technology. Ethiopia leads with a yield of 2.062 t/ha, followed by Mexico at 1.872 t/ha. India ranked 7th among major chickpea-producing countries, with a substantial yield gap (i.e.,0.918 t/ha), more than 1.8 times lower compared to global top Ethiopia (Figure 2.8). If India were to match the country with the highest yield of chickpea, i.e., Ethiopia, there is a potential to increase the production significantly by 9.27 MT.

Figure 2.8: Yield Gap among Top Ten Chickpea-Producing Countries (2018-2022)



Source: Authors computation from FAOSTAT database (2024).

2.4.4 Dry Bean

India ranks top in terms of both area and production of dry bean. India cultivated 14.48 Mha of dry beans, accounting for 40.88% of the global total. Regarding production, India produced 5.94 MT of dry beans, contributing 21.68% of the global total (Table 2.5).

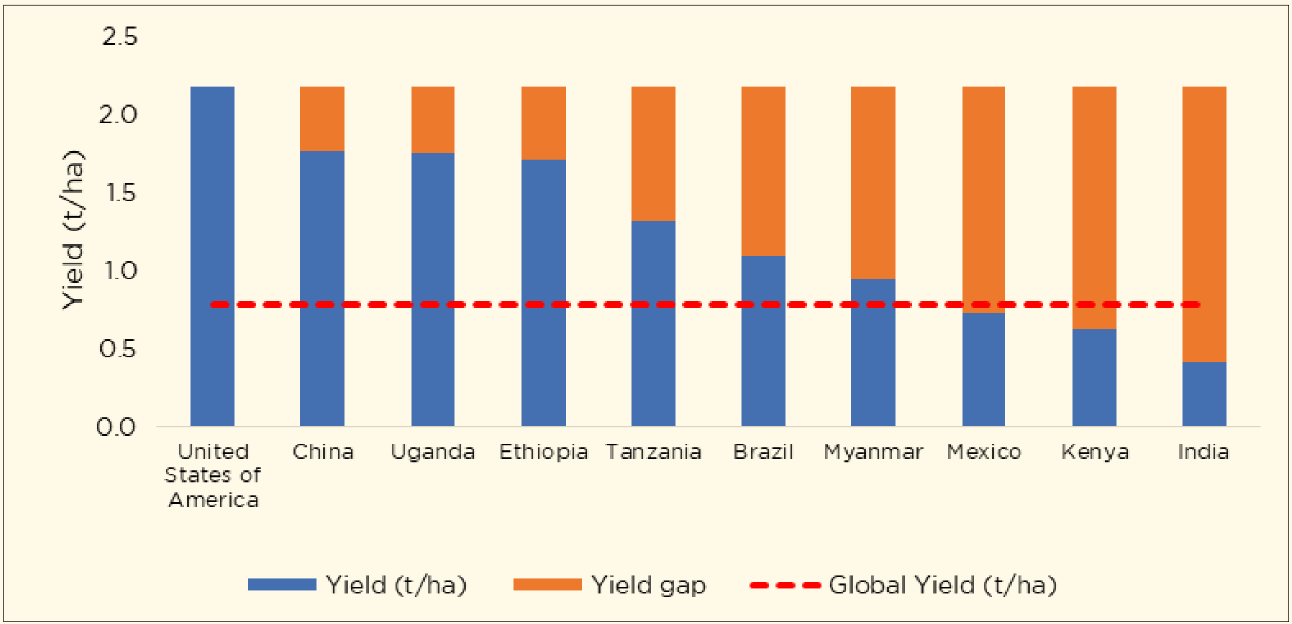
Table 2.5: Global Scenario by Top Ten Dry Bean Producing Countries (2018-2022)

Top Ten Producing Country	Area (Mha)	Production (MT)	Yield (t/ha)	Contribution (%)		Ranking (Yield)
				Area	Production	
India	14.48	5.94	0.411	40.88	21.68	10
Brazil	2.69	2.92	1.085	7.6	10.65	6
Myanmar	2.88	2.69	0.934	8.14	9.81	7
China	0.75	1.32	1.755	2.12	4.8	2
Tanzania	0.95	1.25	1.311	2.7	4.56	5
USA	0.52	1.14	2.172	1.48	4.15	1
Mexico	1.5	1.08	0.724	4.23	3.96	8
Uganda	0.56	0.98	1.751	1.57	3.56	3
Kenya	1.15	0.71	0.617	3.24	2.58	9
Ethiopia	0.33	0.57	1.707	0.94	2.07	4
World	35.41	27.42	0.774	NA	NA	NA

Source: Authors computation from FAOSTAT database (2024).

While India leads in area and production, its yield (t/ha) is significantly lower than the top-producing countries. India's average dry bean yield was 0.411 t/ha, far below the global average of 0.774 t/ha. Among the top ten producers, India ranks lowest, stressing the need for improvements in yield efficiency. The United States leads with a yield of 2.172 t/ha, followed by China at 1.755 t/ha. India's yield gap is substantial (i.e.,1.761 t/ha), more than 5.3 times lower than the global top United States (Figure 2.9). India's larger yield gap highlights the need to adopt more efficient agricultural practices and technologies to narrow the yield gap and increase productivity. If India matches the global average yield, there is a potential to increase dry bean production by 5.25 MT.

Figure 2.9: Yield Gap among Top Ten Dry Bean-Producing Countries (2018-2022)



Source: Authors computation from FAOSTAT database.

2.4.5 Lentil

India ranks second in terms of both area and production of lentil, following Canada. India cultivated 1.42 Mha of lentil, accounting for 27.15% of the global total. In terms of production, India produced 1.34 MT of lentil, contributing 21.66% of the global total (Table 2.6).

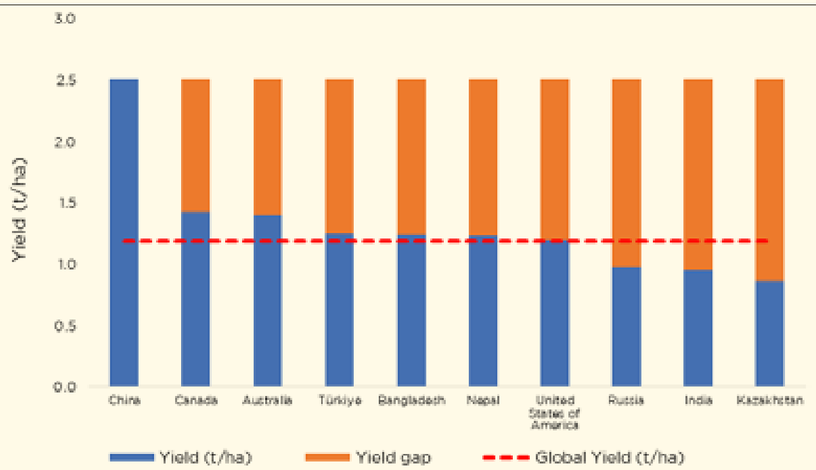
Table 2.6: Global Scenario by Top Ten Lentil Producing Countries (2018-2022)

Top Ten Producing Country	Area (Mha)	Production (MT)	Yield (t/ha)	Contribution (%)		Ranking (Yield)
				Area	Production	
Canada	1.62	2.27	1.403	30.93	36.56	3
India	1.42	1.34	0.947	27.15	21.66	9
Australia	0.46	0.66	1.422	8.83	10.58	2
Turkey	0.29	0.36	1.25	5.46	5.76	4
USA	0.23	0.27	1.193	4.38	4.4	7
Nepal	0.2	0.25	1.236	3.91	4.07	6
Bangladesh	0.15	0.18	1.24	2.79	2.92	5
Russia	0.18	0.17	0.973	3.38	2.78	8
China	0.07	0.17	2.515	1.27	2.69	1
Kazakhstan	0.13	0.12	0.864	2.58	1.88	10
World	5.23	6.2	1.187	NA	NA	NA

Source: Authors computation from FAOSTAT database.

While India is the second largest in terms of area and production, its yield (t/ha) is significantly lower compared to the major lentil-producing countries. India's average lentil yield is 0.947 t/ha, which is below the global average of 1.187 t/ha. China leads with 2.515 t/ha yield, followed by Canada at 1.422 t/ha. India's ranking of 9th among the top ten lentil-producing countries presents an opportunity for improvement. India's yield gap is substantial (i.e.,1.569 t/ha), more than 2.66 times lower compared to global top China (Figure 2.10), which stresses the need for more concerted efforts to narrow the yield gap and increase productivity. If India can match the global average yield, there is a potential to increase lentil production by 0.34 MT. Additionally, if India matches the country with the highest yield of lentil, i.e., China, there is a potential to increase the production by 2.22 MT.

Figure 2.10: Yield Gap among Top Ten Lentil-Producing Countries (2018-2022)



Source: Authors computation from FAOSTAT database.

2.4.6 Dry Pea

India ranks fourth in terms of both area and production of dry pea. India cultivates 0.69 Mha of dry pea, accounting for 9.47% of the global total, lower than the top three producers: Canada, Russia, and China. In terms of production, India produces 0.91 MT of dry pea, contributing 6.61% of the global total (Table 2.7).

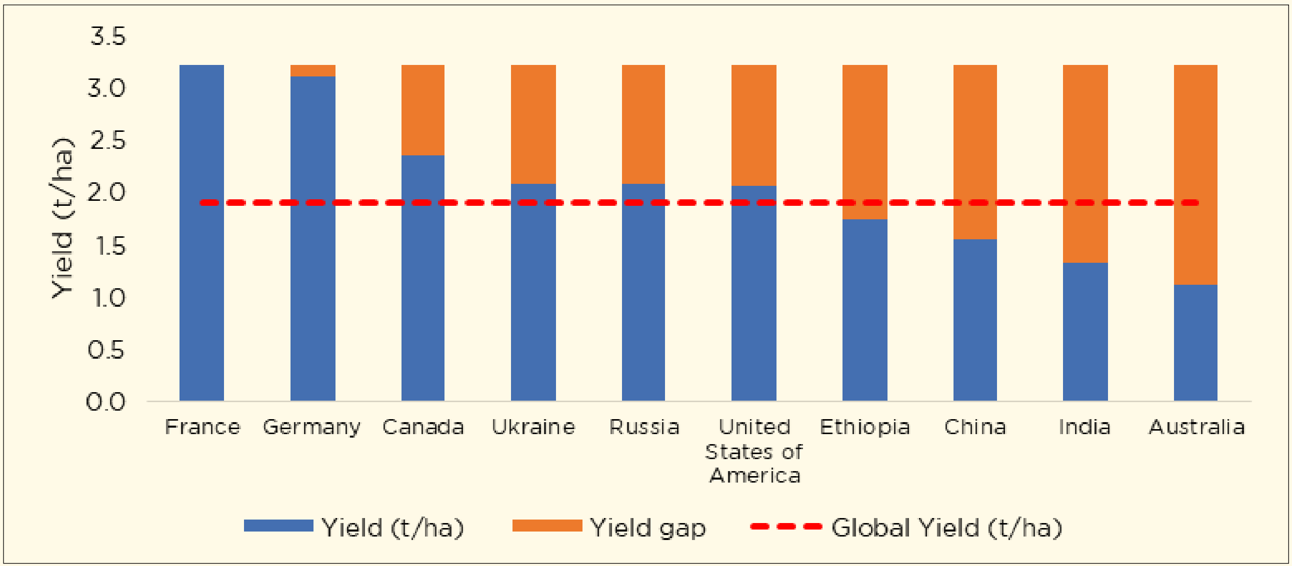
Table 2.7: Global Scenario by Top Ten Dry Pea Producing Countries (2018-2022)

Top Ten Producing Country	Area (Mha)	Production (MT)	Yield (t/ha)	Contribution (%)		Ranking (Yield)
				Area	Production	
Canada	1.54	3.62	2.354	21.21	26.29	3
Russia	1.37	2.84	2.077	18.88	20.65	4
China	0.95	1.47	1.546	13.14	10.7	8
India	0.69	0.91	1.326	9.47	6.61	9
USA	0.37	0.76	2.066	5.07	5.52	6
Ukraine	0.26	0.53	2.073	3.53	3.86	5
France	0.17	0.56	3.219	2.41	4.09	1
Ethiopia	0.22	0.38	1.731	3.06	2.79	7
Australia	0.24	0.27	1.112	3.35	1.96	10
Germany	0.09	0.27	3.109	1.19	1.96	2
World	7.24	13.75	1.899	NA	NA	NA

Source: Authors computation from FAOSTAT database.

India's yield (t/ha) is significantly lower compared to the top-producing countries. India's average dry pea yield is 1.326 t/ha, which is below the global average of 1.899 t/ha. France leads with a yield of 3.219 t/ha, followed by Germany at 3.109 t/ha. India's ranking of 9th among the top ten dry pea-producing countries highlights the potential for India to increase productivity. India's yield gap is substantial (i.e.,1.893 t/ha), more than 2.43 times lower than the global top France (Figure 2.11). If India can match the global average yield, there is a potential to increase dry pea production by 0.39 MT. Additionally, if India matches the country with the highest yield of dry pea, i.e., France, there is a potential to increase production by 1.30 MT.

Figure 2.11: Yield Gap among Top Ten Dry Pea-Producing Countries (2018-2022)



Source: Authors computation from FAOSTAT database.

2.5 Biotic and Abiotic Constraints Limiting Pulse Productivity in India

Various biotic and abiotic stresses significantly hinder the productivity of pulse crops in India. The reliance on rainfed agriculture and their cultivation of marginal and submarginal lands makes them highly vulnerable to adverse weather conditions such as drought, floods, and extreme temperatures. Biotic stresses, including insect pests, diseases, and weeds, further impact crop yields. The limited availability of quality seeds and other production inputs and poor adoption of improved technologies exacerbate these challenges. Addressing these factors through targeted interventions, such as enhanced seed availability, efficient water management, and integrated pest management, is crucial to enhance pulse production and ensure nutritional security.

A significant yield gap exists between research farms and farmer fields ranging from 220-601 kg/ha for different pulse crops (e.g., 477– 563 kg/ha in pigeonpea, 225–601 kg/ha in chickpea, 368–492 kg/ha in black gram, 253–510 kg/ha in lentil, 220–417 kg/ha in kidney beans, and 372–494 kg/ha in cowpea), as reported by Choudhary (2013) and Pooniya et al. (2015). Abiotic stresses, such as drought and heat stress, pose significant challenges, particularly in arid and semi-arid regions, leading to a 50% reduction in seed yield. Additionally, poor drainage and waterlogging during the rainy season and salinity and alkalinity in both semi-arid tropics and the Indo-Gangetic Plains further exacerbate the situation. Biotic stresses, including insect pests, diseases, and weeds, also contribute to substantial yield losses, with diseases alone accounting for 10-15% of food legume production in India, as Pande et al. (2009) reported. To address these challenges and ensure sustainable and profitable pulse production, there is an urgent need to develop and implement technologically feasible and economically viable farming practices.

Each type of pulse crop encounters distinct challenges during various growing seasons, which can greatly affect both yield and quality. Table 2.8 summarizes key biotic and abiotic stresses across different seasons, which are majorly responsible for a large extent of the instability and low yields in the country. This will help to determine the crucial regions/areas that require targeted interventions and management practices to enhance pulse production and guarantee the long-term viability of these essential crops.

Table 2.8: Key Constraints to Pulse Production in India: Biotic and Abiotic Stresses

Pulse Crop	Season	Stress	
		Biotic	Abiotic
Pigeonpea	Kharif-early	Weeds, Fusarium wilt, blight, pod borer	Waterlogging, nutrient stress
	Medium late	Weeds, Fusarium wilt, sterility mosaic, pod-borer complex	Cold, terminal drought, waterlogging
	Pre-rabi	Weeds, wilt, leaf blight, pod-fly	Cold, terminal drought
Chickpea	Timely sown	Weeds, Fusarium wilt, root rot, chickpea stunt, grey mould, pod-borer	Low temperature, Frost, Nutrient stress
	Early sown	Fusarium wilt, root rot, blight, stunt, pod-borer	Low temperature, Frost, salinity stress
	Late sown	Weeds, Fusarium wilt, pod-borer	Terminal drought, heat, nutrient stress
Green Gram	Kharif	Weeds, mosaic virus, cercospora, sucking insect-pests	Pre-harvest sprouting, high temperature, terminal drought
	Zaid	Mosaic virus, root, and stem rot, stem Agromyza, sucking insect pests	Pre-harvest sprouting, drought, high-temperature stress
	Rabi	Weeds, powdery mildew, rust	Terminal drought
Black Gram	Kharif	Weeds, mosaic and leaf curl virus, anthracnose	Terminal drought
	Zaid	Mosaic virus, root, and stem rot, stem Agromyza	Pre-harvest sprouting, temperature, drought
	Rabi/Rice fallow	Leaf spot	Terminal drought
Lentil	Rabi	Fusarium wilt, root rots, rust, Stemphylium blight	Waterlogging, frost, Terminal drought and heat
Cluster bean	Kharif	Weeds	Moisture and nutrient stress

Source: Experts consultations; Reddy 2009; and Rana et al. 2016.

2.5.1 A Review of Biotic Stress and Its Impact on Pulse Crop Productivity in India

Biotic stress refers to the damage caused to plants by living organisms, such as weeds, insect pests, disease-causing agents, nematodes, and allelopathic chemicals. Among these, fungi, bacteria, and viruses are particularly significant, affecting various parts of the plant throughout all stages of growth in food legumes. The degree of damage depends on the plant's ability to resist specific stresses under varying environmental conditions. Unregulated weed growth, disease outbreaks, and insect infestations can cause complete crop failure in severe situations. These pressures drastically lower agricultural output and quality, even in milder climates, making the produce less marketable and less profitable for producers. The viability of pulse farming is further threatened by the cost of controlling these pressures using pesticides, herbicides, and other control methods. Farmers and agricultural scientists can develop targeted mitigation strategies by identifying the specific biotic stresses associated with each pulse crop and understanding their seasonal patterns. Integrated pest management (IPM), the cultivation of disease-resistant varieties, and effective insect pest and weed control practices are critical approaches to minimizing the harmful effects of biotic stress. Implementing these measures can improve pulse crop productivity, enhance farmers' profitability, and ensure food security. Table 2.9 details the yield losses caused by weeds, diseases, and insect pests in key pulse crops.

Table 2.9: Impact of Biotic Stresses on Major Pulse Crops in India

Pulse Crop	Weeds	Yield Loss (%)	Disease	Yield Loss (%)	Insect-pest	Yield Loss (%)
Pigeonpea	Celosia argentea, Portulaca oleracea, Commelina benghalensis, Eclipta alba, Euphorbia parviflora, Trianthema portulacastrum, etc.	30-90	Sterility mosaic virus, Fusarium wilt, Phytophthora stem blight, Alternaria leaf spot and powdery mildew	20-70	Pod-borer and leaf roller	70-80
Chickpea	Chenopodium album, Melilotus indica, Avena ludoviciana, Lathyrus tuberosus, Medicago spp. etc.	20-35	Fusarium wilt, Ascochyta blight, Botrytis grey mould, stunt virus	50-100	Pod-borer and cut-worm	10-90
Green Gram, Black Gram, and Cowpea	Cynodon dactylon, Cyprus rotundus, Cynodon dactylon, Cyprus rotundus, Physalis minima etc.,	50-90	Yellow mosaic virus, Cercosora leaf spot, powdery mildew, leaf crinkle virus, and root rot	10-100	Pod-borer	20-55

Pulse Crop	Weeds	Yield Loss (%)	Disease	Yield Loss (%)	Insect-pest	Yield Loss (%)
Lentil	Phalaris spp., Guizotia scabra, Avena spp., Chenopodium spp., Fumaria parviflora	~50	Rust, wilt, Stemphylium blight, collar rot	20-70	Pod-borer, aphids	–
Field Pea	Avena spp., Circium arvense, Anagalis arvensis, Chenopodium album, etc.	15-67	Powdery mildew, rust, downy mildew, wilt	10-30	Stem and pod-borer, leaf minor	

Source: Experts consultations; Rana et al. (2016); Das (2008); Pande et al. (2009); Pooniya et al. 2015; Chandrashekar et al. (2014); Satyagopal et al. (2014)

2.5.2 A Review of Abiotic Stress and Its Impact on Pulse Crop Productivity in India

Abiotic stresses such as waterlogging, drought, frost, and temperature extremities, i.e., cold waves and heatwaves, poor soil conditions, and salinity, are some of the most detrimental factors affecting the growth and productivity of crops, especially in rainfed and un-irrigated regions. These are largely unavoidable and are further intensified by changing climatic conditions. Different pulse crops face specific abiotic stresses that impact plant physiology, morphology, biochemistry, and molecular structure and negatively impact growth phases, and yield.

Dubey et. al. (2011) assessed the impact of climate change on pulse productivity and adaptation by the 200 pulse growers of the Bundelkhand region of Uttar Pradesh in India. Researchers found that the increasing temperatures and reduced rainfall directly correlate with yield reductions in chickpea, pigeonpea, and lentil. With every 0.1°C increase in temperature (maximum, minimum, and temperature differences), the yield of pigeonpea (22.86, 9.39, and 2.90 kg/ha), chickpea (38.49, 13.46, and 12.73 kg/ha), and lentil (40.70, 14.22, and 13.46 kg/ha) declined considerably in Bundelkhand. The study highlighted that an increase in average maximum temperature exerts a profound effect on yield compared to the rise in minimum temperature and temperature difference. Furthermore, every drop of 10 mm in annual rainfall reduces the yield for pigeon pea (8.05 kg/ha), chickpea (12.35 kg/ha), and lentil (13.05 kg/ha). Climate-induced shifts in post-monsoon rainfall patterns, especially increased rainfall in January and February, worsen reproductive stress in rabi pulses. Delayed sowing intensifies these challenges as the crop undergoes terminal heat and drought stress that cause forced maturity, which ultimately hampers crop yield, especially during its phenological growth period. For instance, lentil yield dropped by 33.5% in West Bengal and chickpea yield by 17.5% with delayed sowing in the same region (Bera 2021).

Drought stress is another critical issue affecting pulse crops like chickpea, which are highly sensitive during both vegetative and reproductive stages, resulting in yield losses of 20–30% (Pandiyan et al. 2023). These impacts underscore the urgent need for mitigation strategies, including molecular and physiological approaches, to enhance drought resilience and minimize the adverse effects of climate change on pulse productivity. Adaptation measures such as developing early maturing heat- and drought-tolerant pulse varieties, optimizing sowing times, and employing efficient water management practices are essential to safeguard yields and ensure food security in a changing climate.

Changing climatic patterns exacerbate the intensity and frequency of extreme events such as droughts, floods, heatwaves, cold waves and unseasonal heavy rainfall, causing significant environmental, agricultural as well as socio-economic impacts. In India, El Niño/ Southern Oscillation (ENSO) is the primary driver of interannual variability in the Indian Summer Monsoon Rainfall (ISMR). It is a major climate phenomenon with a quasi-periodic nature, characterized by significant changes in the sea surface temperatures (SSTs) over the tropical Pacific Ocean and associated ocean-atmospheric interactions. ENSO has two phases, i.e., the positive phase (El Niño – warm phase) and the negative phase (La Nina – cold phase), which are typically associated with weaker and stronger ISMR, respectively. In El Niño years, India often faces warmer temperatures and less rainfall, causing droughts in some parts of the country. On the other hand, La Nina brings cooler sea surface temperatures, resulting in increased rainfall in some parts of the country.

During the 21st century, India is predicted to experience warmer than the global average. In the past 74 years (from 1951 to 2024), 27 years witnessed El Niño and 25 years as La Niña years, represented in Table 2.10. In the past, El Niño events have frequently caused below-average rainfall in various parts of the country, which has resulted in crop failure, water scarcity, and agricultural distress (Economic Survey Report 2024).

Table 2.10: Historical El Niño and La Niña Events and their Severity-based Classification

El Niño – 27 years				**La Niña – 25 years**		
Weak (11 years)	**Moderate (7 years)**	**Strong (6 years)**	**Very Strong (3 years)**	**Weak (12 years)**	**Moderate (6 years)**	**Strong (7 years)**
1952-53	1951-52	1957-58	1982-83	1954-55	1955-56	1973-74
1953-54	1963-64	1965-66	1997-98	1964-65	1970-71	1975-76
1958-59	1968-69	1972-73	2015-16	1971-72	1995-96	1988-89
1969-70	1986-87	1987-88		1974-75	2011-12	1998-99

1976-77	1994-95	1991-92		1983-84	2020-21	1999-00
1977-78	2002-03	2023-24		1984-85	2021-22	2007-08
1979-80	2009-10			2000-01		2010-11
2004-05				2005-06		
2006-07				2008-09		
2014-15				2016-17		
2018-19				2017-18		
				2022-23		

Source: Golden Gate Weather Services, 2024

The trends and impact of El Niño and La Niña events on total pulse crops area and production over the 74 years (1951-2024) are depicted in Figure 2.12. A quadrant analysis was employed to delve deeper into the impact of El Niño, La Niña, and normal years on pulse cultivation. This analysis categorized years into four cases: (1) area increase and production increase, (2) area increase and production decrease, (3) area decrease and production increase, and (4) area decrease and production decrease. By examining the year-on-year (YoY) changes in area, production, and productivity within each category, the study aimed to understand the specific impact of these climatic phenomena on the pulses sector in India.

Figure 2.12: Trends and Impacts of El Niño and La Niña Events on Total Pulse crops' Area and Production over the 74 years (1951-2024)

Note: In the figure above, on the x-axis, "E" represents El Niño events, and "L" represents La Niña events. In the subsequent row, the letters "W," "M," "S," and "VS" indicate the intensity of the events, corresponding to Weak, Moderate, Strong, and Very Strong, respectively

Source: Authors' computation

El Niño Years: Out of the 27 El Niño years recorded between 1951 and 2024, a significant majority (15 years) witnessed a decline in both acreage and production of pulses. In these years, the area under cultivation decreased by 2-9%, while production declined by 6-30%. Consequently, yield also decreased, ranging from 5-25% year-on-year. Pulses production declined to the level of 17.15 MT in the year 2014-15 and 16.35 MT in the year 2015-16 mainly due to back-to-back droughts in the country. In two specific instances, although there was a slight increase in the area under cultivation (2-6%), production (5-9%) and yield (10-11%) decreased. There is also one circumstance where production decreased by 13% without any change or no significant change in cultivated area, highlighting the complex impact of El Niño (Table 2.11). These findings underscore the vulnerability of pulse production to El Niño events and emphasize the need for robust strategies to mitigate its adverse effects.

Table 2.11: Impact of El Niño Intensity on Total Pulse Crops' Area and Production (1951-2024)

	Production ↑	**Production**
Area ↑	• **Weak (6 years)** Area – ↑ by 0-9% Production – ↑ by 5-38% Productivity - ↑ by 3-28% • **Moderate (2 years)** Area – ↑ by 3-5% Production – ↑ by 1-6% Productivity - ↑ by 3-28% *(Note: In some cases, area increased but insignificant increase in production and even productivity decreased by 4%, e.g. FY 2009-2010)*	• **Very Strong (2 years)** Area – ↑ by 2-6% Production – ↓ by 5-9% Productivity - ↓ by 10-11%
Area ↓	• **Very Strong (1 year)** Area – ↓ by 4% Production – ↑ by 3% Productivity - ↑ by 7%	• **Weak (5 years)** Area – ↓ by 2-6% Production – ↓ by 11-30% Productivity - ↓ by 5-25% • **Moderate (4 years)** Area – ↓ by 2-7% Production – ↓ by 12-17% Productivity - ↓ by 7-12% • **Strong (6 years)** Area – ↓ by 3-9% Production – ↓ by 6-20% Productivity - ↓ by 2-16%

Source: Authors' computation

La Niña Years: Over the past 74 years, 25 years have experienced La Niña conditions. During these years, 13 instances saw increases in both acreage and production, with the area under cultivation growing by 1-8%, production by 1-41%, and productivity by 1-20%. Interestingly, the area decreased by 1-6% in three cases while output and productivity increased by up to 23% and 3-25%, respectively. Conversely, 8 years witnessed declines in both acreage and production, ranging from 2-10% for area, 1-17% for production, and 4-14% for productivity. These findings underscore the complex impact of La Niña on pulse production, with both positive and negative effects on area, production, and yield. For a more detailed understanding, refer to Table 2.12.

Table 2.12: Impact of La Niña Intensity on Total Pulse Crops' Area and Production

	Production ↑	Production
Area ↑	• **Weak (4 years)** Area – ↑ by 1-18% Production – ↑ by 1-41% Productivity - ↑ by 2-20% *(Note: FY 2016-17 recorded a large increase in area as well as production by 18% & 41% respectively and productivity by 20%)* • **Moderate (4 years)** Area – ↑ by 2-7% Production – ↑ by 1-11% Productivity - ↓ by 1-5% *(Note: Notable increase in production (11%) and productivity (8%) with only a 3% increase in area)* • **Strong (5 years)** Area – ↑ by 6-13% Production – ↑ by 1-30% Productivity - ↓ by 2-17% *(Note: In FY 1973-74, production increased by 1% but productivity decreased by 10%)*	• **Strong (1 year)** Area – ↑ by 3% Production – ↓ by 6% Productivity - ↑ by 12%

	Production ↑	**Production**
Area ↓	• **Weak (3 years)** Area – ↓ by 1-6% Production – ↑ by 0-23% Productivity - ↑ by 3-25% *(Note: In FY 1964-65, area reduction is only 1% but the production increased by 23% and productivity by 25%)*	• **Weak (5 years)** Area – ↓ by 2-7% Production – ↓ by 1-17% Productivity - ↓ by 4-14% *(except for 2 years, productivity increased by 2-5%)* *(Note: In FY 2008-09, area reduction was 7% but the production reduction is much less (1%) and notable increase in productivity i.e. 5%)* • **Moderate (2 years)** Area – ↓ by 3-7% Production – ↓ by 6-12% Productivity - ↓ by 0-10% • **Strong (1 year)** Area – ↓ by 10% Production – ↓ by 10% Productivity – No change

Source: Authors' computation

Normal Years: During favorable climatic conditions (i.e., 22 normal years), India's pulse production witnessed significant growth. In 10 of these years, both the area under cultivation and production increased, with acreage growing by 1-14% and output by 2-45%. This led to a corresponding increase in productivity of 1-42% (Table 2.13). Interestingly, despite a decrease in area, production increased in five instances, highlighting the impact of improved agricultural practices and favorable conditions. In two cases, production and productivity increased even with a stable area. However, in only one year, both area and production declined. These findings underscore the complex interplay of various factors influencing pulse production, including climatic conditions, agricultural practices, and policy interventions.

Table 2.13: Area and Production during Normal Years

	Production ↑	Production
Area ↑	• **10 Years** Area – ↑ by 1-14% Production – ↑ by 2-45% Productivity - ↑ by 1-42% (except for FY 2013-14, decreased by 3%)	• **3 Years** Area – ↑ by 1-3% Production – ↓ by 7-10% Productivity - ↑ by 8-12%
Area ↓	• **5 Years** Area – ↓ by 1-5% Production – ↑ by 3-8% Productivity - ↑ by 8-14%	• **1 Year** Area – ↓ by 3% Production – ↓ by 16% Productivity - ↓ by 14%
No Change in Area	• **2 Years** Area – No change Production – ↑ by 4-5% Productivity - ↑ by 4%	• **1 Year** Area – No change Production - ↓ by 2% Productivity - ↓ by 2%

Source: Authors' computation

The ability of plants to effectively withstand and survive these harsh conditions is a complex process, influenced by a range of interactions between the plants and their specific environments. Intricate physiological, biochemical, and molecular responses involved in these interactions, enable plants to adapt to and mitigate the adverse effects of abiotic stresses. Understanding and enhancing these tolerance mechanisms are crucial for improving crop resilience and sustaining agricultural productivity in vulnerable areas. The major abiotic stresses that negatively affect pulse crop production led to a significant reduction in crop productivity, a comprehensive analysis is presented in Table 2.14.

Table 2.14: Impact of Abiotic Stresses on Major Pulse Crops in India

Pulse Crop	Abiotic stress and their impact on pulse crop
Pigeonpea	• Waterlogging: » at the seedling stage, decreases the plant population » even short duration of water logging, cause a decline in leaf area development, dry weight accumulation/plant » reduction in root dry weight • Extreme moisture and temperature during crop growth and flowering • High rainfall in initial crop growth stages • Highly sensitive to temperature fluctuations, causing massive flower drop, forced drying, and bending of apical leaves when subjected to cold stress (<5°C) • Low temperature (<4°C) in Northeast Plain Zone for a period of 3-4 days leading to cold injury at the flower bud initiation stage
Chickpea	• Low & High temperature » Seedlings exposed to chilling temperature (<5°C) show irreversible damage » High temperature increases flower shedding and pollen sterility » >42°C temperature at the terminal stage causes seed hardening due to incomplete sink development • Waterlogging » The vegetative stage more sensitive to waterlogging » Reduction in no. of leaves, branches, and leaf area per plant » Reduction in yield at reproductive stage than vegetative because of increased dropping of flowers and loss of pod setting

Pulse Crop	Abiotic stress and their impact on pulse crop
Green Gram and Black Gram	• Waterlogging » Vegetative stage is more sensitive to waterlogging, » Yield reduction at the reproductive stage than vegetative because of increased dropping of flowers or loss of pod setting • Heat & drought stress » High temperature during the reproductive stage shows a negative impact on floral bud development » Delayed flowering and maturity • Salinity • Pre-harvest sprouting » Delayed rains at maturity cause pre-harvest sprouting and asynchronous pod maturity North region: High biomass stressed by temperature extremities leading to long crop duration, frost damage, flower drop South region: Low biomass stressed by terminal drought leading to short crop duration, harsh post-anthesis period
Lentil	• Temperature » Temperature $<7^\circ$C show retarded growth » Foliage growth ceases at 6-15°C » $>40^\circ$C during the reproductive stage results in complete failure of anthesis, pod setting & induces the hardening of seeds • Drought • Waterlogging

Source: Rana et al (2016), Basu et al (2016), Hatfield and Prueger 2015, and https://agritech.tnau.ac.in/agriculture/agri_drought_effect_on_crops.html

2.6 From Limited Yields to Global Leadership: Addressing Challenges and Opportunities in India's Pulse Production

The low productivity of pulses in India presents a complex challenge, arising from a confluence of factors. Unlike cereals, which experience significant yield increases due to the development of high-yielding varieties, pulses have not witnessed similar technological breakthroughs. This lack of innovation, limited access to high-quality seeds, and inadequate knowledge of seed management, weed control, and fertilizer application specific to pulses further hinder pulse cultivation (Chand, 2016). Additionally, pulses are inherently susceptible to various diseases and pests, and farmers often lack the necessary expertise to effectively manage these challenges.

One significant challenge is the predominance of rainfed agriculture, making pulse cultivation highly vulnerable to erratic weather conditions such as droughts and floods. Furthermore, the cultivation of pulses on marginal lands exacerbates the problem, as these lands are often less fertile and more susceptible to degradation. Inadequate irrigation infrastructure, particularly in rainfed areas, results in unreliable water supply, affecting crop yields and stability.

Economic constraints also play a significant role in hindering pulse production. The fluctuating market prices and low prices of produce, e.g., income disadvantage vis-a-vis rice & wheat, discourage farmers from investing in pulse cultivation. Extended marketing channels with numerous intermediaries further increase marketing costs and reduce efficiency, limiting market access for pulse growers.

Government initiatives such as the Pradhan Mantri Fasal Bima Yojana and procurement programs have been implemented to mitigate the risks faced by pulse growers. These initiatives aim to provide insurance coverage against yield losses and ensure remunerative prices through price intervention. Additionally, the shift in price parity towards phosphatic fertilizers, a crucial nutrient for pulse growth, is a positive development. However, the success of these initiatives hinges on the availability of quality seeds and improved pulse varieties to maximize their impact on pulse production.

Developing high-yielding, disease-resistant, and climate-resilient pulse varieties can significantly enhance productivity. Improving access to quality seeds, fertilizers, and other inputs can empower farmers to adopt best practices. The adoption of advanced agricultural technologies, such as precision agriculture, Information and communications technology (ICT), and drone technology, can further optimize resource use and increase yields. Applying cost-effective management practices to optimize resource use and reduce production costs is crucial. Strengthening the pulse value chain and extension services, enhancing rural infrastructure, and promoting knowledge sharing among farmers can help address knowledge gaps and improve farming practices.

Government initiatives like ISOPOM and NFSM Pulses, which focus on promoting sustainable agriculture practices and providing technical assistance to farmers, can play a crucial role in improving pulse production. Enhancing soil fertility through nitrogen fixation, adapting rainfed agriculture to rainfall variability, and implementing crop insurance schemes can mitigate risks and incentivize farmers to cultivate pulses. Furthermore, providing price support and subsidizing inputs can ensure remunerative prices for farmers, encouraging them to invest in pulse cultivation. By addressing these challenges through targeted policy interventions and implementing appropriate strategies, a combination of technological advancements, policy interventions, improved agricultural practices, and market support, India can accelerate growth in pulse production, achieve self-sufficiency, and strengthen its position further in the global pulse market.

Chapter III: Overview Of India's Pulse Sector: State-Level Dynamics

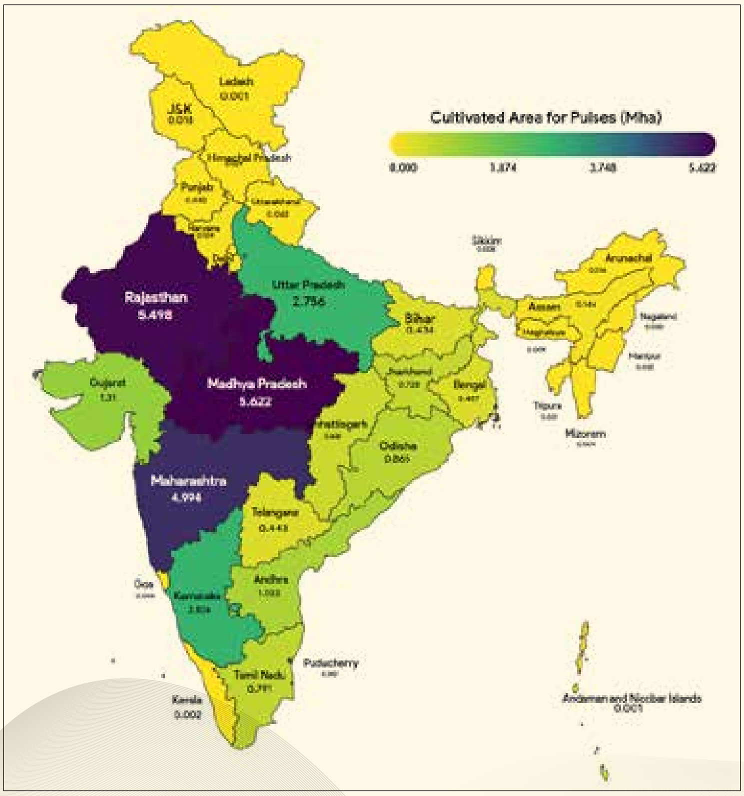
Overview Of India's Pulse Sector: State-Level Dynamics

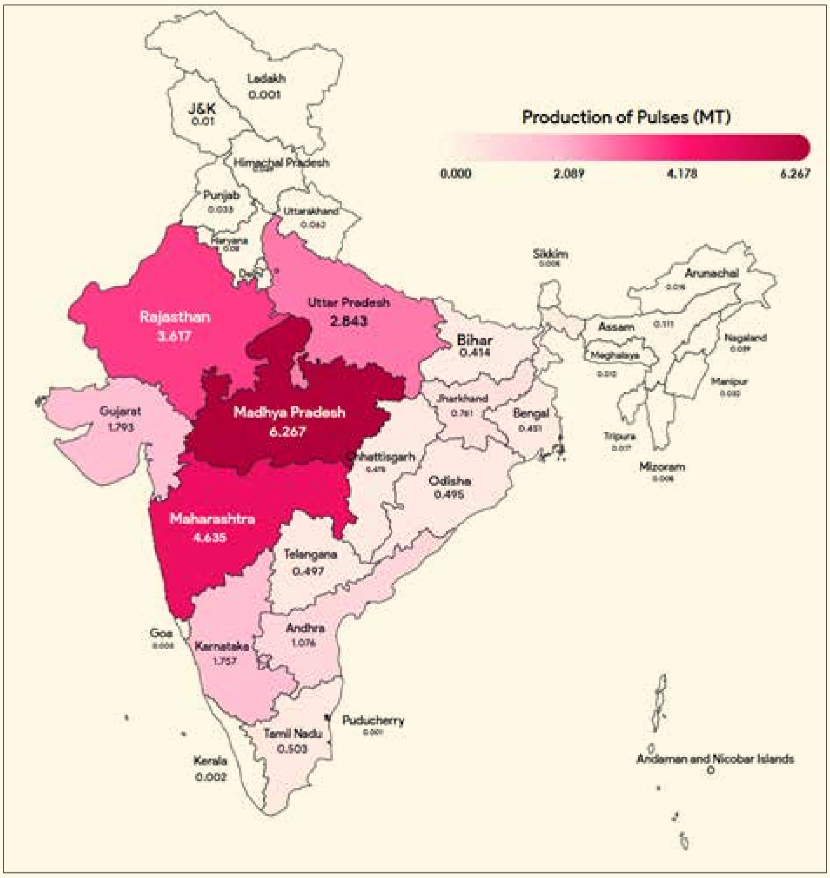
3.1 Introduction

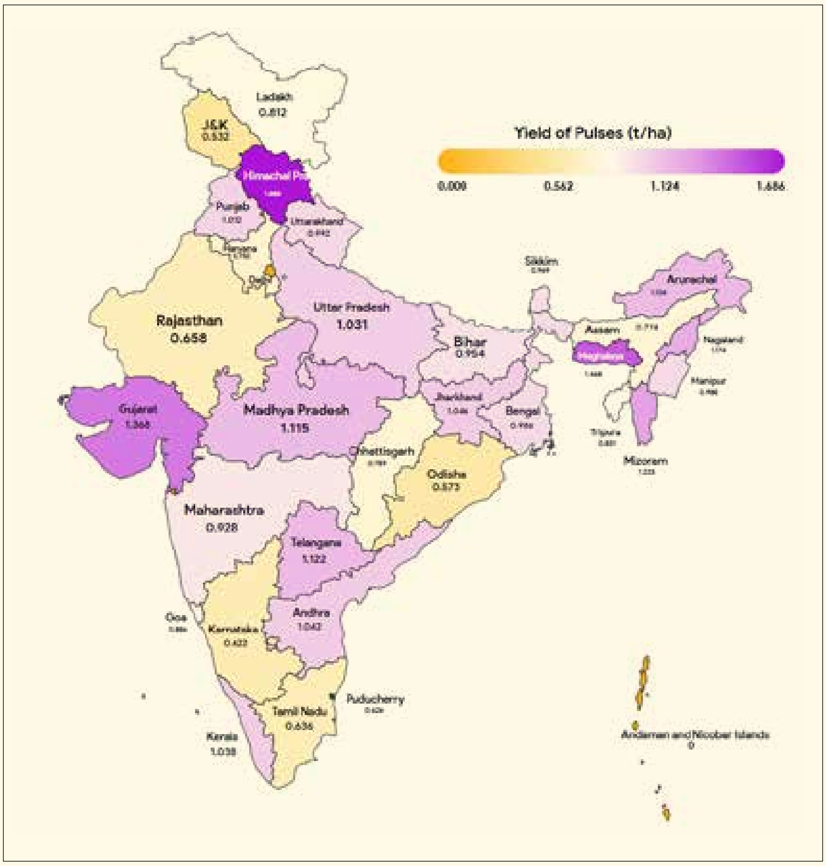
In 2022, India maintained the leading position in the global pulse market, responsible for 38% of global cultivation and 28% of production. Domestic pulse production has grown significantly in the past few years, reaching . This translates to a remarkable 42% increase in total production over the past ten years. However, recent estimates indicate a decline to 24.25 MT in the 2023-24 season. Pulses have traditionally occupied a secondary role in cropping patterns, primarily concentrated in rainfed ecologies. Notably, these rainfed regions sustain over 40% of India's population and two-thirds of its livestock, with more than 80% of total pulses cultivated there. Pulses hold historical significance in Indian dietary patterns, serving as the sole source of high-quality protein (20-25%) for a significant portion of the population, particularly the 43% who identify as vegetarian (urban – 48%, rural – 41%). This vital crop provides livelihood security for over 50 million farmers and their dependents, highlighting its immense socio-economic importance.

Chickpea (bengal gram/gram/chana), pigeonpea (red gram/arhar/tur), green gram (mung bean), black gram (urdbean//biri/mash), lentil (masur), field pea (pea/matar), clusterbean (guar), kidney bean (rajmash/common bean/snap bean/french bean), mothbean (moth), Horse gram (kulthi), lathyrus (khesari/grass pea/chicking vetch/teora) and cowpea (lobia/barbati/black-eyed pea) are the twelve major and minor pulses grown and consumed in India. Chickpea dominates India's pulse production, accounting for about 47.4% of the total output over the past five years. Pigeonpea follows with a 15.4% share, followed by green gram at 12.02%, black gram at 10.3%, and lentil at 5.4% (DES, MoA&FW). Notably, Madhya Pradesh, Maharashtra, and Rajasthan are the top three pulses-producing states in the country. The top 10 states, namely Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh, Karnataka, Gujarat, Andhra Pradesh, Jharkhand, Telangana and Tamil Nadu, collectively contribute 91.28% of the total pulse production. The following maps visually represent the spatial patterns of pulse cultivated area, production, and yield in the country (Map 3.1).

Map 3.1: Spatial patterns of cultivated area, production, and yield of total pulses: India (2022)




Production of Pulses (MT)
0.000
2.089
4.178
6.267
Ladakh
0.001
J&K
0.01
Himachal Pradesh
Punjab
0.033
Uttarakhand
0.062
Haryana
0.08
Delhi
Rajasthan
3.617
Uttar Pradesh
2.843
Bihar
0.414
Sikkim
Arunachal
Assam
0.111
Nagaland
Meghalaya
Manipur
Tripura
Mizoram
Gujarat
1.793
Madhya Pradesh
6.267
Jharkhand
0.761
Bengal
0.451
Chhattisgarh
Odisha
0.495
Maharashtra
4.635
Telangana
0.497
Goa
Karnataka
1.757
Andhra
1.076
Puducherry
Tamil Nadu
0.503
Kerala
0.002
Andaman and Nicobar Islands
0


Yield of Pulses (t/ha)
0.000
0.562
1.124
1.686
Ladakh
0.812
J&K
0.532
Punjab
1.012
Uttarakhand
0.992
Haryana
Delhi
Rajasthan
0.658
Uttar Pradesh
1.031
Bihar
0.954
Sikkim
Arunachal
Assam
0.774
Nagaland
Meghalaya
Manipur
Tripura
Mizoram
Gujarat
1.368
Madhya Pradesh
1.115
Jharkhand
Bengal
Chhattisgarh
Odisha
0.573
Maharashtra
0.928
Telangana
1.122
Andhra
1.042
Goa
Karnataka
0.622
Puducherry
Tamil Nadu
0.636
Kerala
1.038
Andaman and Nicobar Islands
0

3.2 National Area, Production, and Yield Trends of Total Pulses (1960-61 to 2022-23)

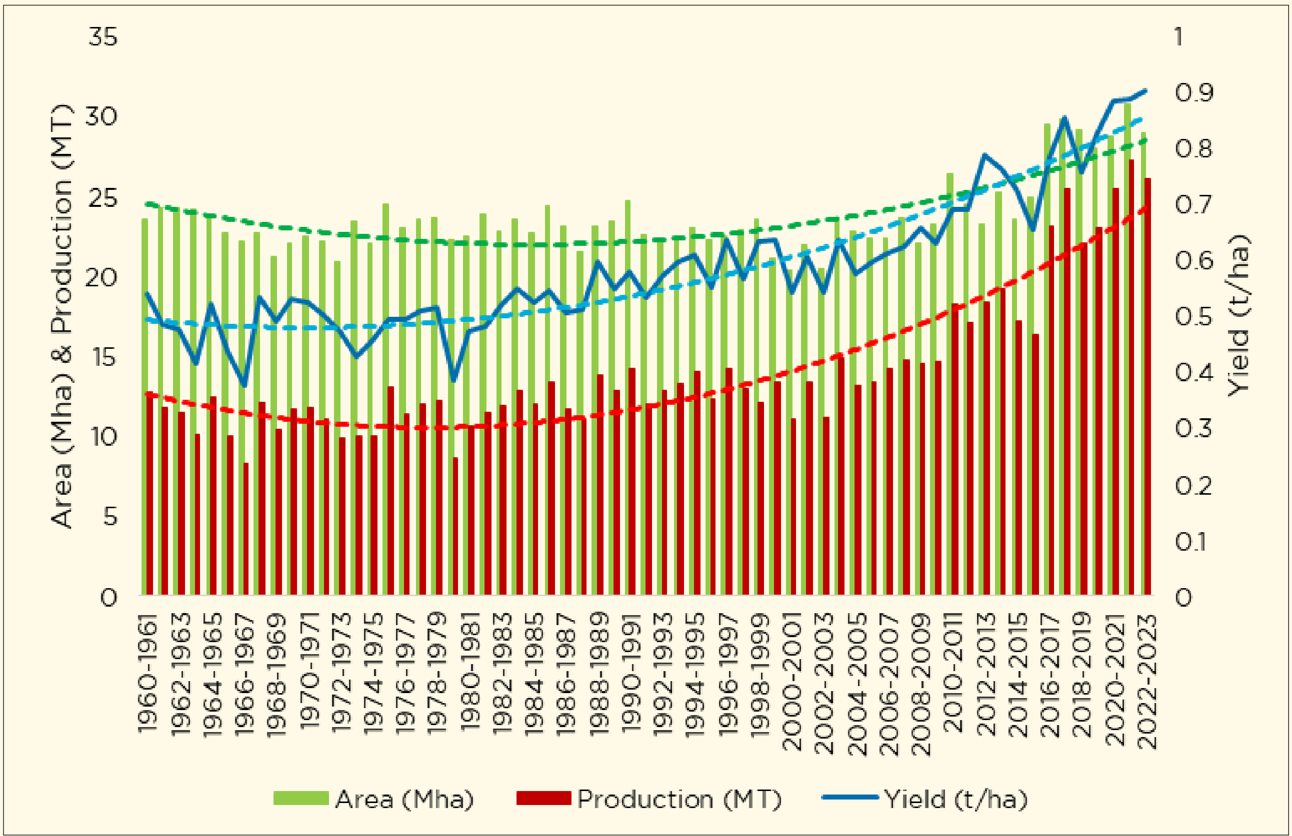
India's area under pulse cultivation experienced fluctuations and a declining trend in the initial three decades (Figure 3.1). There was some recovery in the area under pulses during the mid-70s, mid-80s, and early '90s, but afterward, the area under pulses either stagnated or declined. The trend has been encouraging only in recent years due to the government's interventions. GoI announced a significant raise in MSP by declaring bonuses on all major pulse crops during 2016-17 and 2017-18. The increase in prices attracted farmers to increase the area under pulse, resulting in a historic 26.6% surge in the area under pulse cultivation, from 23.55 Mha in 2014-15 to 29.81 in 2017-18. Between 2014-15 and 2021-22, the area under pulse cultivation increased by more than 30%, and production surged from 17.15 MT to 27.302 MT in 2021-22. This impressive growth translates to a CAGR of 6.87%, the highest recorded to date.

Since the beginning of the green revolution in the country, cereal production has been boosted significantly; the production of pulses, in contrast, faced a noteworthy setback. The annual production of pulses was 11.4 MT from 1960-61 to 1965-66, the years preceding the green revolution, and it merely increased to an average of 17.7 MT, during the 2010-11 to 2015-16. This shows that the production of pulses increased by about 55% during the past nearly 50 years from the onset of the green revolution, while the population surged by 171.3% during the same period. Consequently, the per capita availability of pulses declined significantly, falling from about 21.39 kg/year to about 15.89 kg/year. This decline led to increased imports of pulses to meet domestic demand. In contrast, India raised cereal production substantially during the same period, significantly higher than the growth witnessed in the population. Within cereals, the highest increase has been seen in wheat.

Until 2015-16, India's pulse production growth was relatively slow due to a lack of comparative advantage compared to other major crops like rice and wheat. Key factors, such as relatively low yields and prices compared to other crops, hindered the sector's growth. For instance, between 2000-01 and 2015-16, the annual growth rates of chickpea and pigeonpea, together accounted for two-thirds of the total pulses production, were 1.42% and 0.68%, respectively. Similarly, the annual growth rates of their minimum support prices (MSPs) (at 2011-12 prices) were 2.4% and 4.7%, respectively. Additionally, pulses are often cultivated in marginal environments with low and erratic rainfall and poor soil quality, making them highly vulnerable to production risks. Pulses production declined to 17.15 MT in 2014-15 and 16.35 MT in 2015-16, mainly due to back-to-back droughts in the country. Consequently, market prices of pulses skyrocketed in 2015-16 and 2016-17. Recognizing the issue, the government implemented a series of policy measures to boost production, spotting the contribution of prices and technologies in increasing rice and wheat production. A significant increase in MSP for various pulses was raised from 8% to 16% in 2016-17 and 2017-18, providing a much-needed incentive to farmers, resulting in a historic 20.8% surge in the area under pulse production from 24.91 Mha in 2015-16 to 29.81 in 2017-18 While a significant increase in MSP for pulses was implemented between 2008-09 and 2012-13, it did not translate into substantial production growth due to constraints in seed availability and procurement mechanisms. To address these challenges, the government reinvigorated the NFSM-Pulses program and established seed production hubs to ensure the supply of high-quality seeds of climate-resilient varieties. Additionally, the government initiated a robust procurement mechanism at MSP to incentivize farmers and stabilize prices. This comprehensive policy approach led to a remarkable 42% increase in pulse production in 2016-17 compared to the previous year. Consequently, India's reliance on pulse imports decreased significantly, from about 29% in 2015-16 to around 10.4% in 2022-23.

While the initial phase of the Green Revolution led to a decline in pulse productivity, subsequent years witnessed a gradual recovery and subsequent growth. This growth has helped mitigate the impact of decreasing cultivation area on overall production. In recent decades, the pace of improvement in pulse yields has accelerated significantly. By 2022-23, the average yield had increased to 0.902 t/ha, up from 0.540 t/hain 2000-01. However, recent estimates indicate a slight decline to 0.881 t/ha in the 2023-24 season (DES, MoA&FW). Nonetheless, even the highest yield of pulses falls well below that of cereals (i.e., wheat and rice), and India's pulse yields still lag behind those of other major pulse-producing countries. Advancing research and development, promotion of advanced agricultural technologies, and improved farming practices are essential to bridge this gap and further enhance productivity.

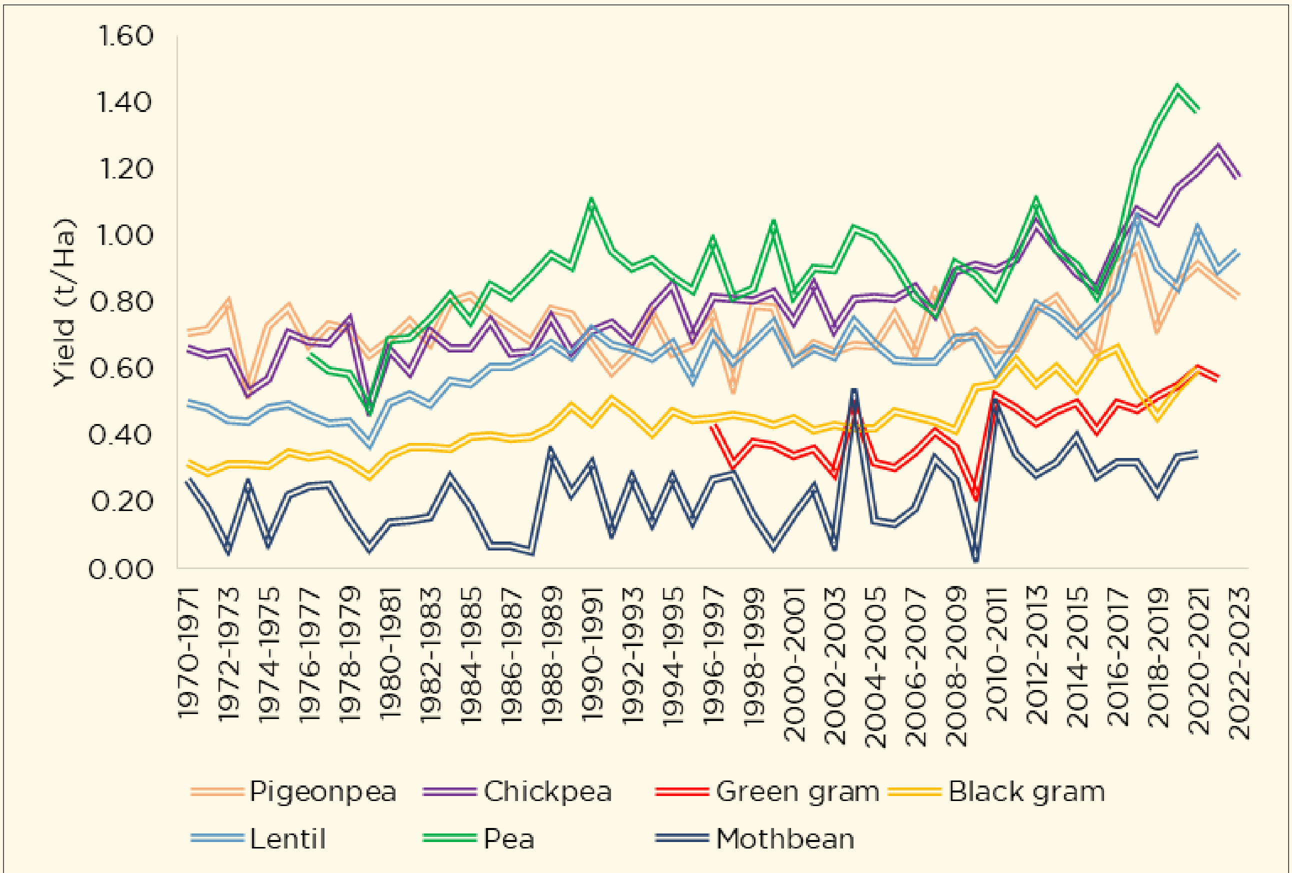
Figure 3.1: National Area, Production and Yield Trend of Total Pulses (1960-61 to 2022-23)



Source: Authors' computation, data from DES, MoA&FW

The long-term yield trends (Figure 3.2) for seven key pulse crops—pigeonpea, chickpea, green gram, black gram, lentil, pea, and moth bean—reveal a complex interplay of factors influencing their performance. The data indicates notable fluctuations in yields, accompanied by a discernible upward trend over the years. These fluctuations can be attributed to various factors, including erratic weather conditions such as droughts and floods, cultivation on marginal lands with limited inputs, inadequate availability of quality seeds, fertilizers, pesticides, and irrigation facilities, high susceptibility to pests and diseases, and low MSP and procurement, all these factors contribute to low profitability and incentives. The upward trajectory was interrupted around 2015-16, witnessed a notable dip in yield, likely due to two consecutive years of below-normal rainfall, particularly the erratic rainfall during the 2015 monsoon season, which significantly impacted farmers across the country, especially those reliant on monsoon rains. However, the post-2016 period witnessed an uptrend, primarily driven by government initiatives.

Figure 3.2: Trend in Yield (t/ha) of Major Pulse Crops Grown in India (1970-71 to 2022-23)

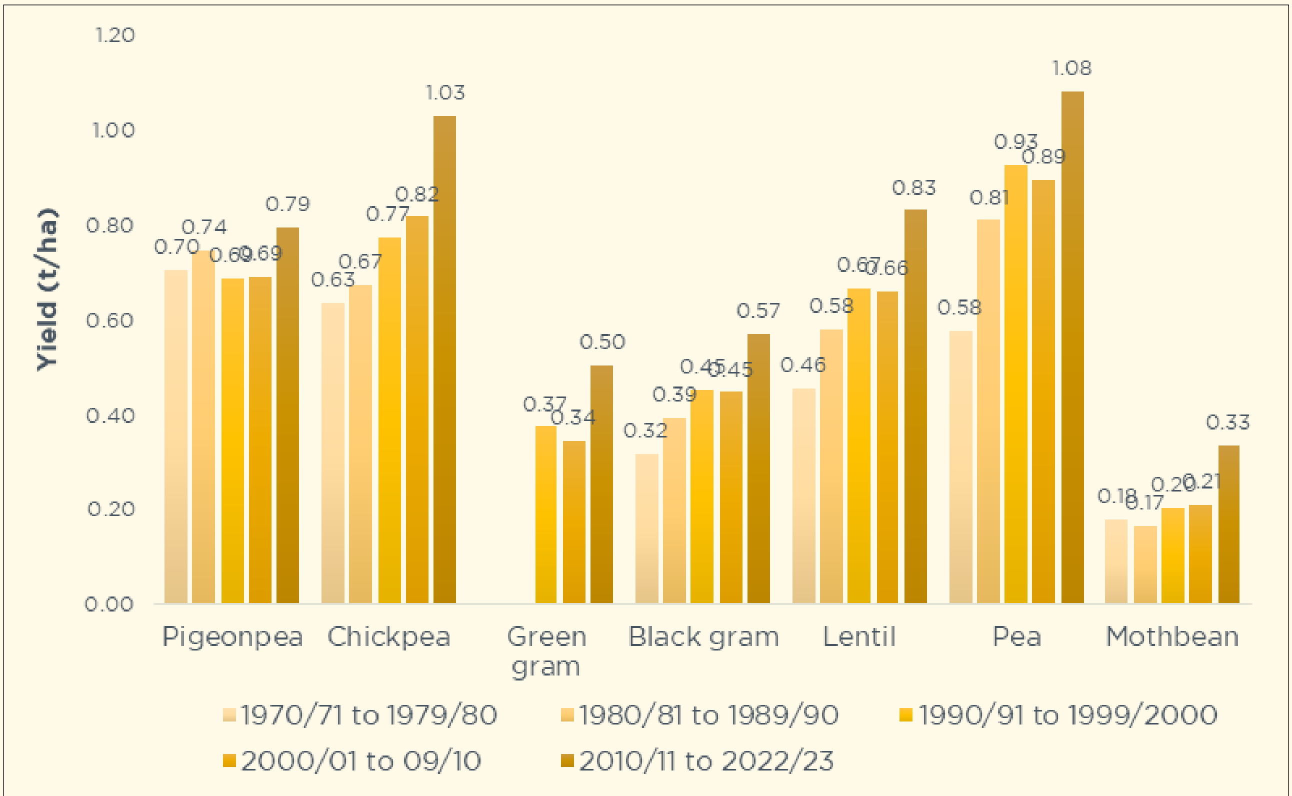


Source: Authors' computation, data from DES, MoA&FW

The figure above (Figure 3.2) reveals distinct yield trends for the seven pulse crops. Pea has consistently exhibited the highest yield level among all the major pulse crops since the mid-1980s, with yearly fluctuations in most of the years. Chickpea, following Pea, has also shown a higher yield level than other pulse crops, particularly since the 1990s. Both pea and chickpea have witnessed significant growth in recent years. Pigeonpea, while initially exhibiting high yields, has seen limited growth over time. Lentil has experienced a notable increase in yield levels, especially after 2010. Black gram generally yields lower than pea, chickpea, pigeonpea, and lentil and showed limited growth until 2008-09. Green gram, with an overall lower average yield than other crops except for mothbean, has shown an upward trend in recent years. Mothbean, the lowest-yielding crop, has exhibited some improvement over time but remains significantly lower than the other pulses.

Comparing chickpea and pigeonpea, the two most important Indian pulse crops, a stark difference emerges when analyzing decadal average yields. Chickpea's yield has shown a consistent upward trend, increasing from 0.63 t/ha in the initial decade to 1.03 t/ha by 2022-23. In contrast, pigeonpea's yield has risen more modestly, from 0.70 t/ha to 0.79 t/ha over the same period. While pigeonpea has experienced fluctuations, chickpea's yield has consistently increased across all five decades. Green gram has exhibited a significant increase in yield, particularly in the last decade, after a period of lower yields in the earlier decades. Black gram has shown a moderate upward trend, with a more pronounced increase in the recent period. Lentil, initially with lower yields, has experienced a significant increase in yield, especially in the last decade. Pea has demonstrated remarkable improvements in the 1980s, 1990s, and 2010s. Mothbean remains the lowest-yielding crop, although it has shown some progress in recent periods.

Figure 3.3: Yield (t/ha) of Major Pulse Crops Grown in India (1970-71 to 2022-23): A Decadal Comparison

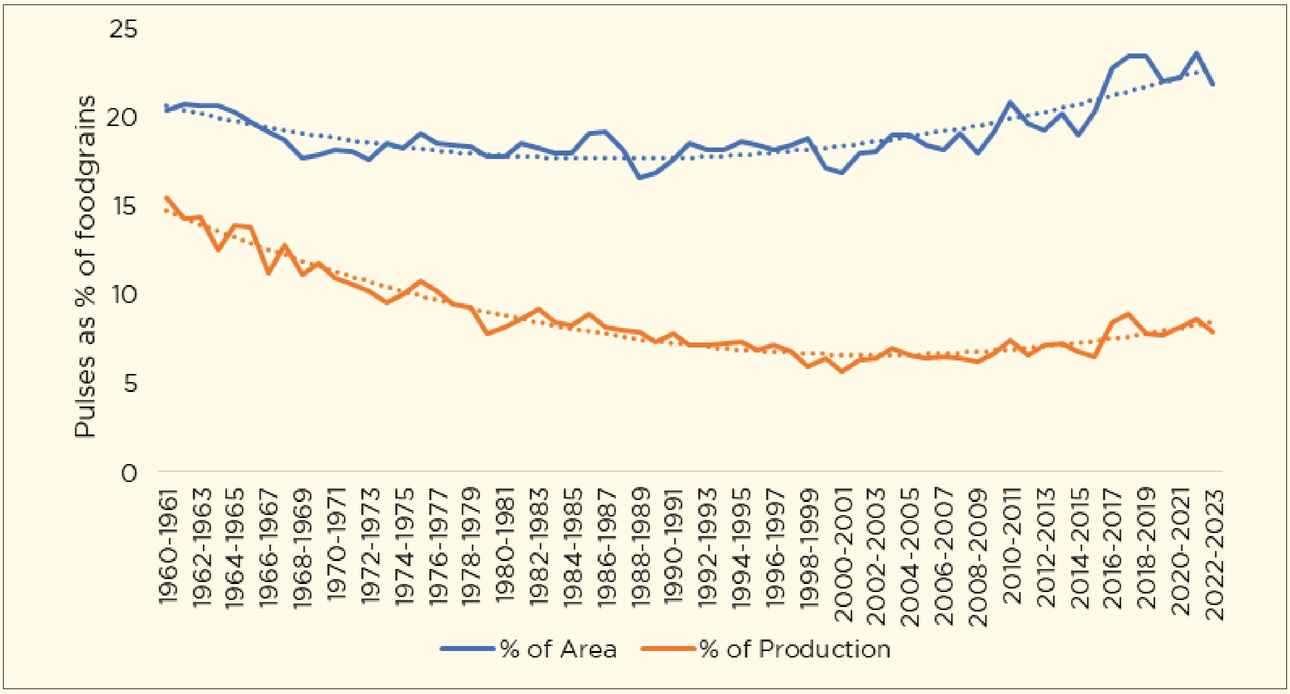


Source: Authors' computation, data from DES, MoA&FW

3.3. Contribution of Pulses in Total Foodgrains

While pulses account for a significant portion of the total foodgrain area, their contribution to overall production has declined over the decades (Figure 3.4). Pulses account for 21.9% of the total foodgrain area in 2022-23; their contribution to total production is a mere 7.9%. This represents a significant decline from 1960-61, when pulses contributed 15.5% to total foodgrain production despite occupying a smaller share of the cultivated area. The production share of pulses reached its lowest point in the past six decades in 2000-01 at 5.6% and increased to only 6.5% in 2015-16. However, government interventions initiated since 2015-16 have revitalized the pulse sector. The government's multi-pronged strategy to safeguard the interests of both farmers and consumers has led to an increased contribution of pulses to the total food grain basket. To address the declining production contribution of pulses, the government has intensified its efforts under the FNS-Pulses (formerly known as NFSM). This approach involves a synergistic combination of research and development, procurement, marketing, import-export policies, etc. The share of pulses in the total foodgrain area has increased substantially, reaching 21.86% in 2022-23, with a peak of 23.61% in 2021-22 from 18.95% in 2014-15. Similarly, the production share has risen from 6.49% in 2015-16 to an average of 8.25% in the last three years, peaking at 8.92% in 2017-18. These positive trends indicate the effectiveness of government policies in promoting pulse production and enhancing its contribution to the overall foodgrain basket.

Figure 3.4: Pulses as % of Total Foodgrains Area and Production (1960-61 to 2022-23)



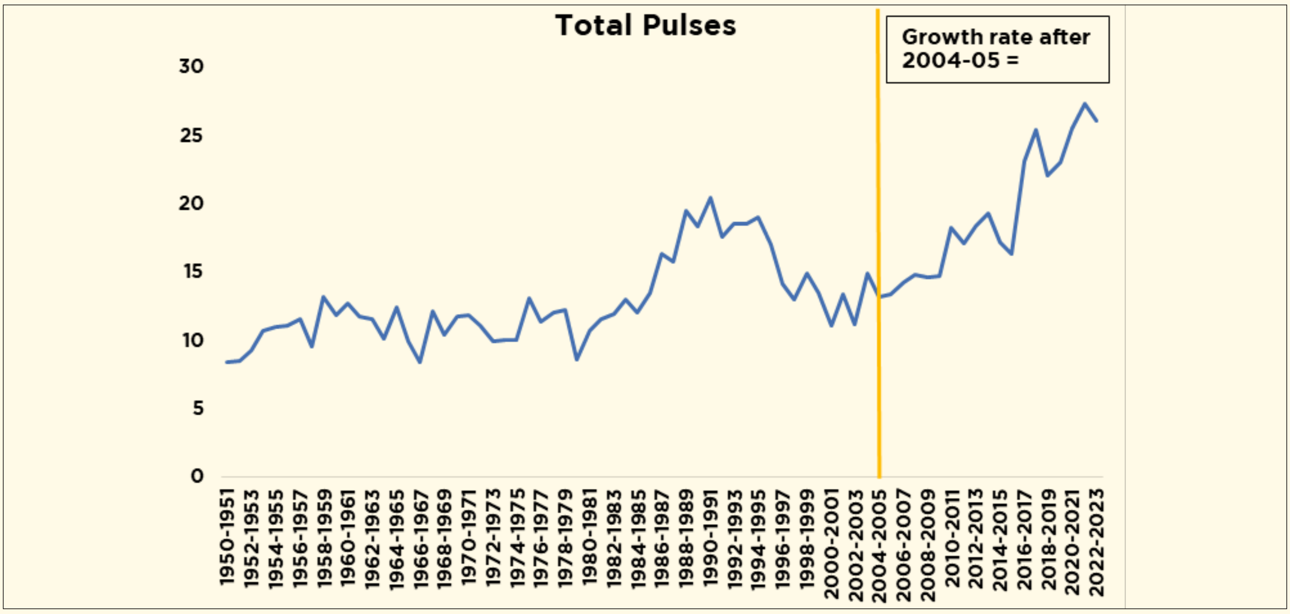
Source: Authors' computation, data from DES, MoA&FW

3.4: Temporal Dynamics of Structural Breaks in Indian Pulse Production

3.4.1 Crop-wise Analysis

There has been distinct structural break in the production trajectory of total pulses during 2003-04 and 2004-05. The trend in pulse production has followed markedly different paths before and after the fiscal year 2004-05. The average trend growth rate for pulse production over the 55-year period leading up to 2004-05 was approximately 0.52%. In contrast, this rate experienced a significant acceleration, rising to 4.20% in the two decades that followed 2004-05 (please see Figure 3.5).

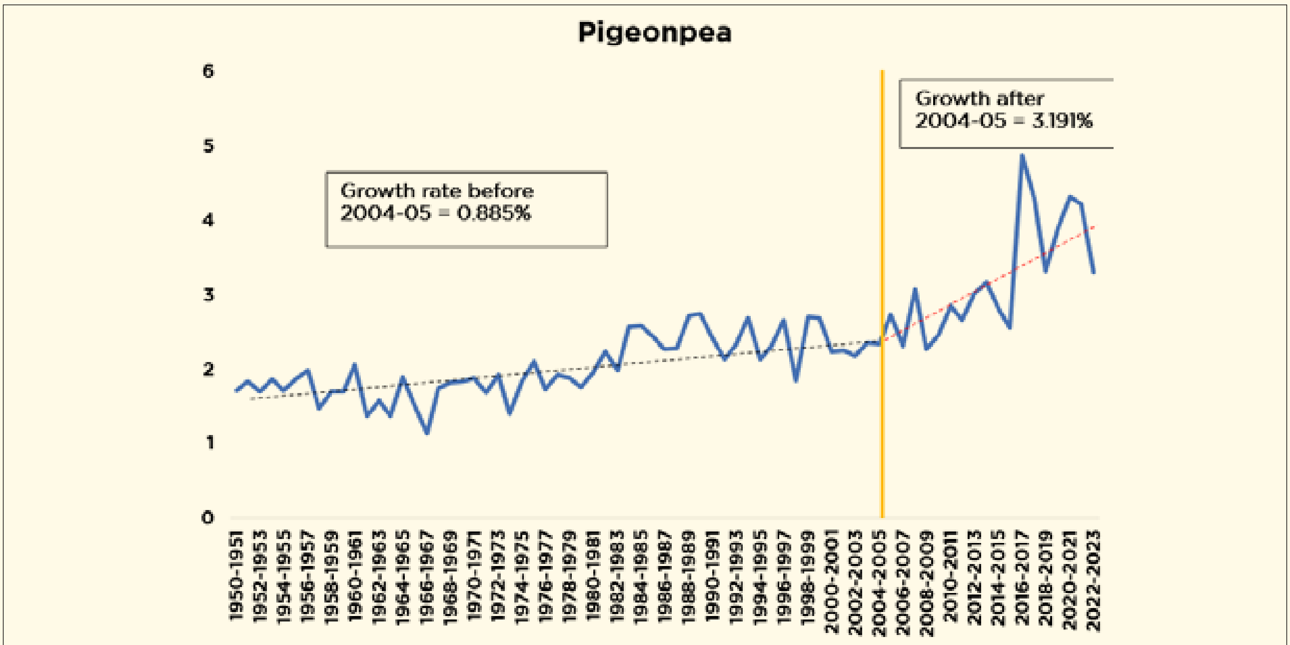
Figure 3.5: Total Pulse Production (MT): Structural Break (1950-51 to 2022-23)



Source: Authors' computation, data from DES, MoA&FW

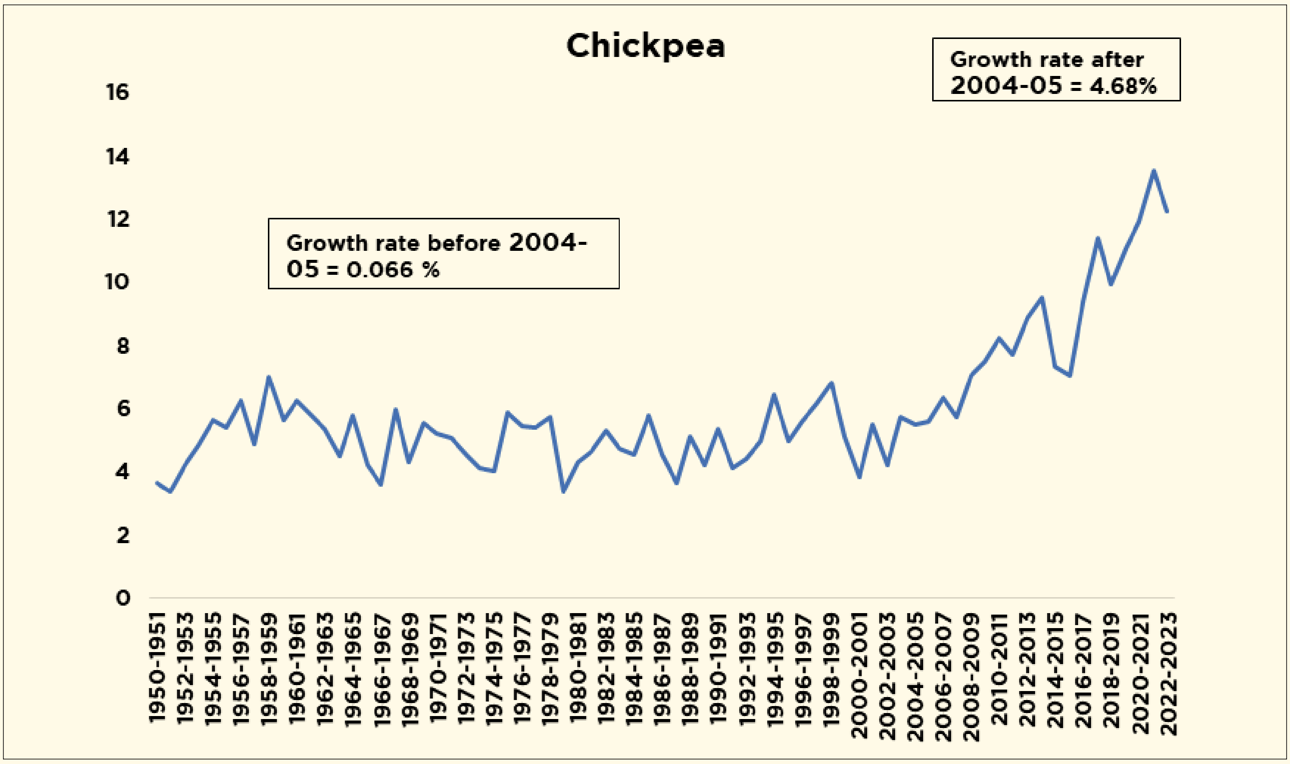
A detailed examination of individual pulse crops reveals that the structural break in 2004-05 coincides with a notable increase in trend growth rates for several crops. Specifically, the growth of national pulse production post-2004-05 is predominantly driven by green gram, black gram, and chickpea, demonstrating trend growth rates of 7.2%, 5.08%, and 4.68%, respectively. These growth rates surpass the average post-2004-05 total pulse production trend growth rate of 4.20%. Conversely, other pulse crops, including pigeonpea, lentil, and pea, exhibit growth rates that fall below the average for total pulse production during this period. The structural break figures for all six pulse crops are depicted in Figure 3.6 - 3.11.

Figure 3.6: Total Pigeonpea Production (MT): Structural Break (1950-51 to 2022-23)



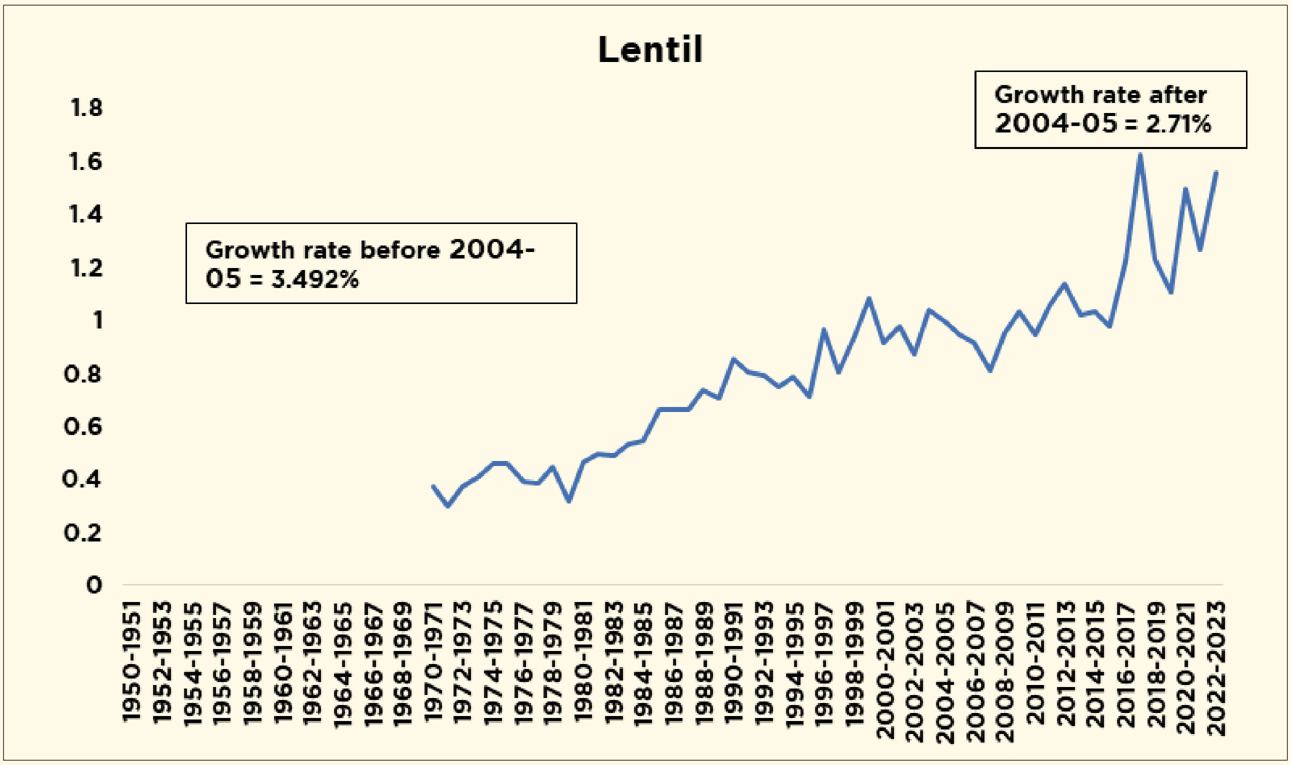
Source: Authors' computation, data from DES, MoA&FW

Figure 3.7: Total Chickpea (MT) Production: Structural Break (1950-51 to 2022-23)



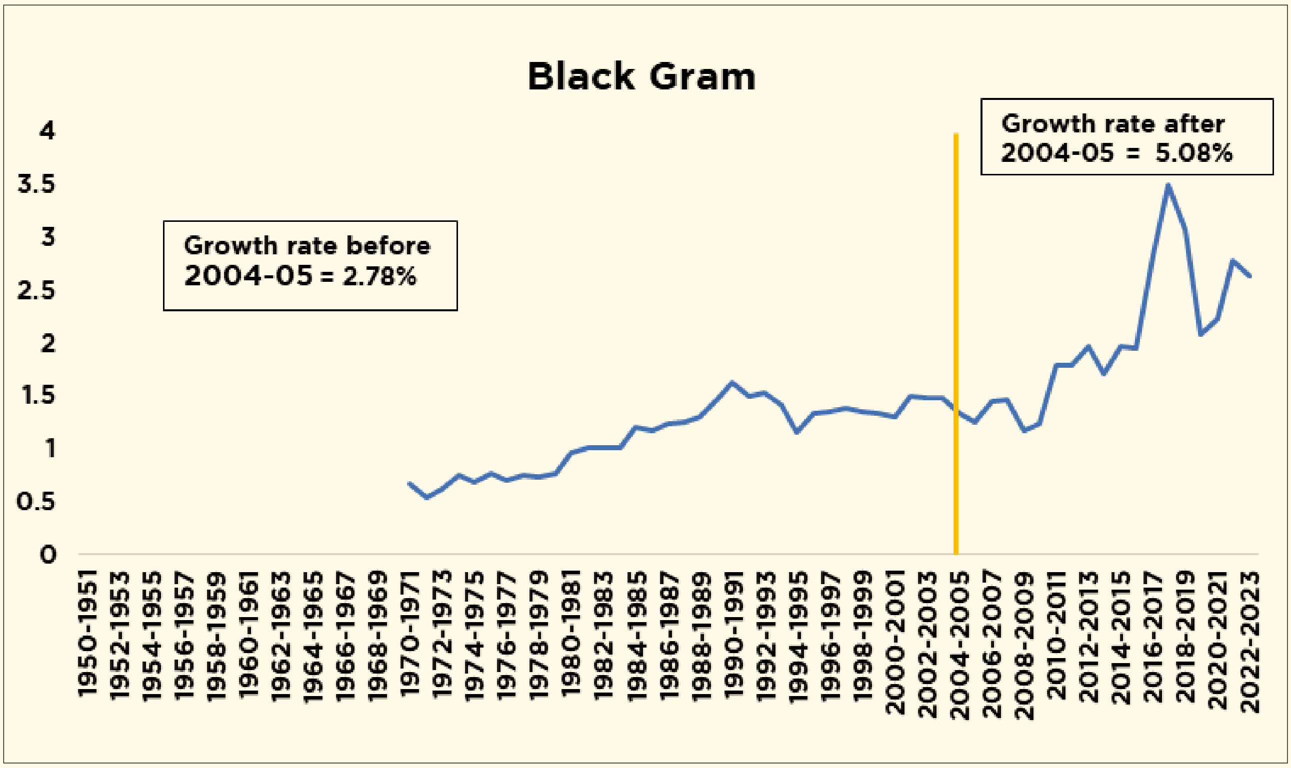
Source: Authors' computation, data from DES, MoA&FW

Figure 3.8: Total Lentil Production (MT): Structural Break (1970-71 to 2022-23)



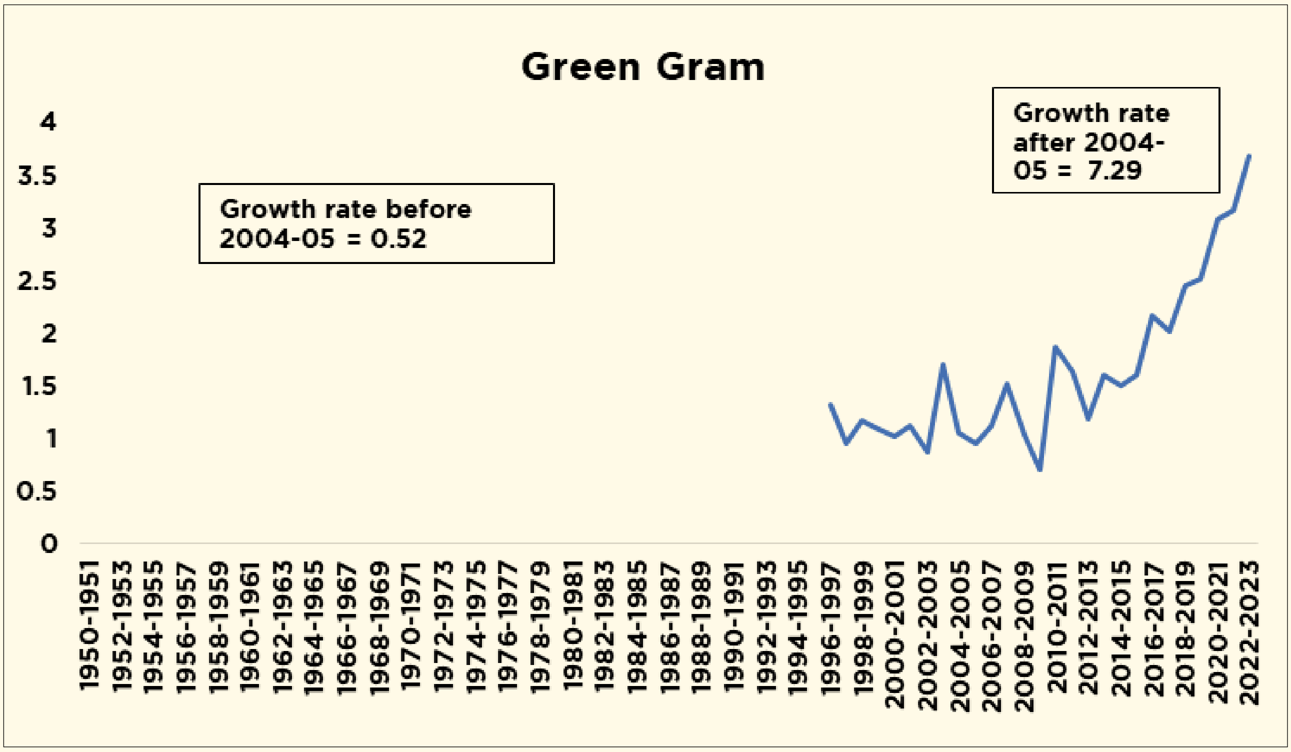
Source: Authors' computation, data from DES, MoA&FW

Figure 3.9: Total Black Gram (MT) Production: Structural Break (1970-71 to 2022-23)



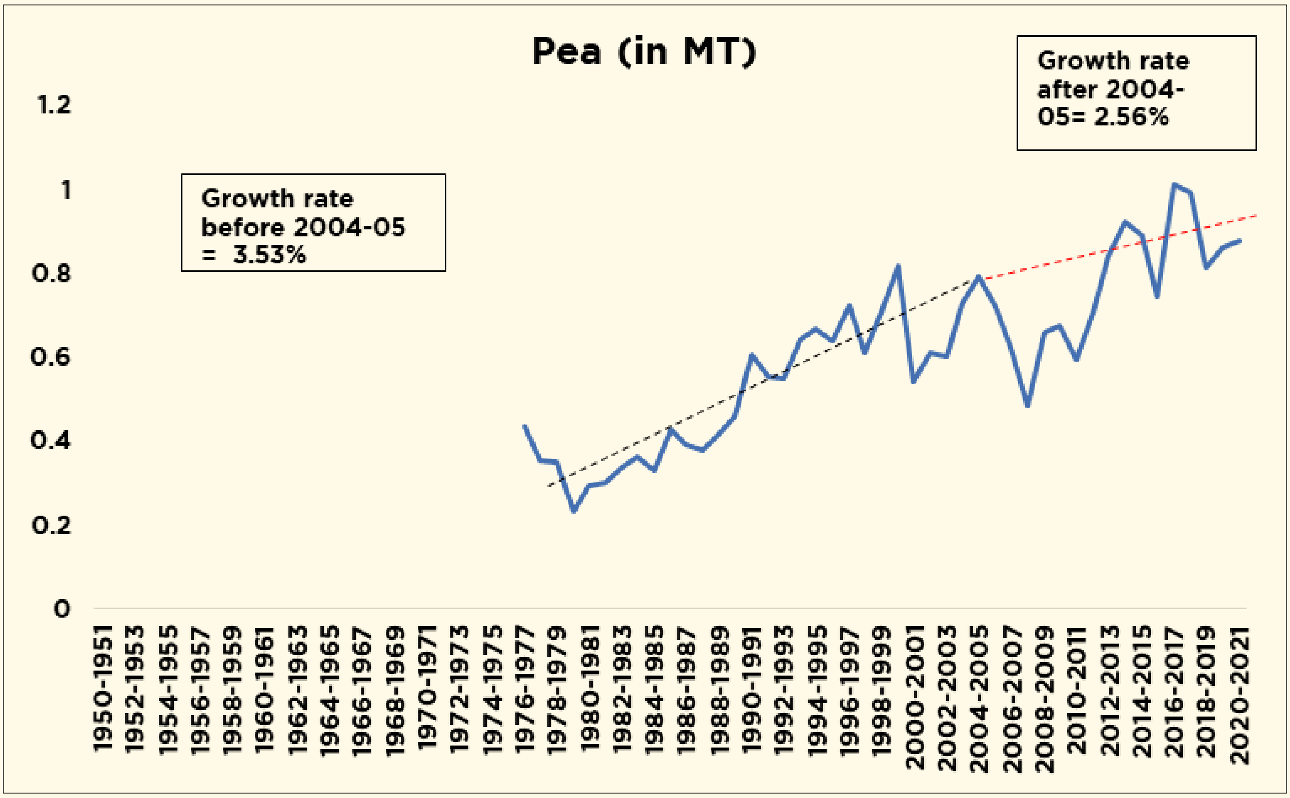
Source: Authors' computation, data from DES, MoA&FW

Figure 3.10: Total Green Gram (MT) Production: Structural Break (1996-97 to 2022-23)



Source: Authors' computation, data from DES, MoA&FW

Figure 3.11: Total Pea Production: Structural Break (1976-77 to 2020-21)



Source: Authors' computation, data from DES, MoA&FW

In terms of their share within total pulse production, green gram has experienced the most significant increase, rising from 8.06% in 2004-05 to 14.12% in 2022-23. Chickpea also grew, increasing its share from 41.66% to 47.08% during the same timeframe. In contrast, the share of black gram has remained relatively same at approximately 10.1%. Given the substantial contributions of these crops, their growth has been a key driver of India's total pulse production following the structural break. Notably, the shares of other pulse crops, namely pigeonpea, lentil, and pea, have decreased by 5.16%, 1.59%, 2.67%, and 0.36%, respectively. Consequently, targeted interventions for specific pulse crops are essential to elevate overall pulse production growth up to 4% and beyond.

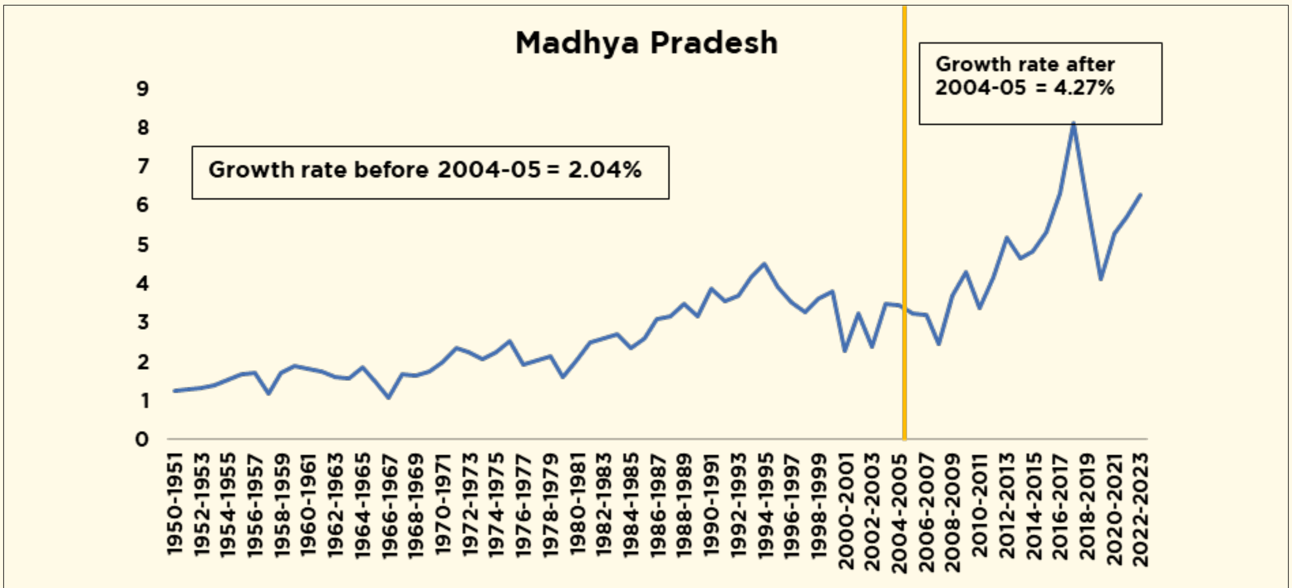
To achieve self-sufficiency in pulses, the government plans to implement a six-year initiative entitled the "Mission for Aatmanirbharta in Pulses," with a particular focus on pigeonpea, black gram, and lentil, as stated by the Finance Minister in the recent Union Budget for 2025-26. This mission will prioritize: (1) the development and commercial availability of climate-resilient seeds, (2) the enhancement of protein content, (3) increased productivity, (4) improvements in post-harvest storage and management, and (5) the assurance of remunerative prices for farmers. Furthermore, central agencies such as NAFED and NCCF will be prepared to procure these three pulses from farmers who register with them and enter into agreements over the next four years.

3.4.2 State-wise Analysis

India's pulse production, which is heavily concentrated in seven key states, experienced a significant shift in growth dynamics after 2004-05. Madhya Pradesh (22.11%), Maharashtra (16.46%), Rajasthan (16.3%), Uttar Pradesh (10.33%), Karnataka (7.83%), Gujarat (6.5%), and Andhra Pradesh (4.16%) collectively contribute approximately 82.65% of the nation's total pulse output, based on the average from 2018-19 to 2022-23. Within this group, growth drivers underwent a notable reconfiguration. Specifically, Rajasthan emerged as the primary catalyst for national pulse production growth, exhibiting an impressive 8.05% growth rate after 2004-05, representing a substantial increase of 6.5% from the pre-2004-05 period. This growth, along with Maharashtra's 4.61% and Madhya Pradesh's 4.27% growth rates, surpassing the national average of 4.20%, demonstrates a clear regional dominance of driving overall production expansion. Given the significant contributions of these states to pulse production, their growth has been crucial to India's total pulse output following the structural break. Karnataka also showed a considerable increase of 2.88% post-2004-05, up from 2.08% from 1950-51 to 2004-05. This marked acceleration indicates the effective implementation of region-specific practices in the post-2004-05 era.

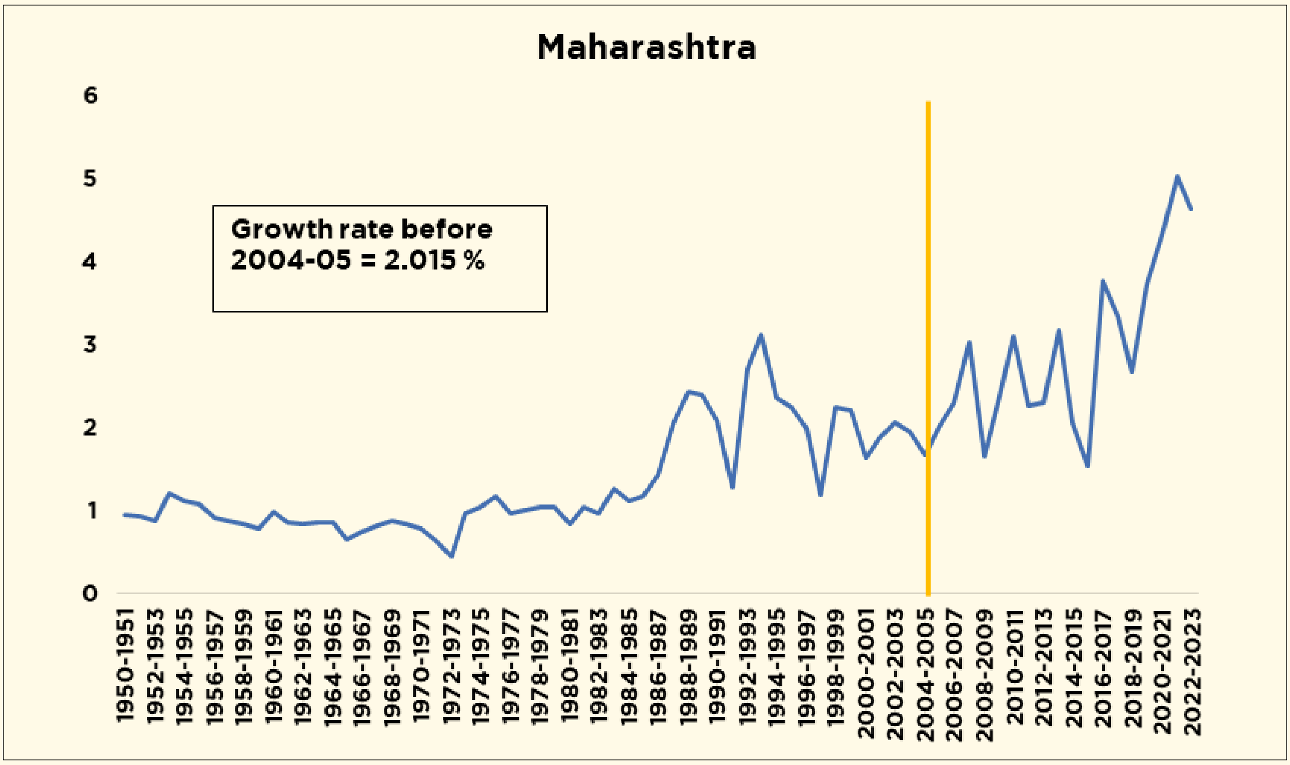
In contrast, the other major pulse-producing states exhibited growth rates below the national average, highlighting a divergence in performance. Although improving from a negative growth rate of -0.34% pre-2004-05 to a positive 1.22%, Uttar Pradesh still lags significantly behind. Andhra Pradesh experienced a dramatic decline, shifting from a robust 3.30% growth rate in the pre-2004-05 period to -1.94% afterward. Gujarat's modest increase to 3.48% from 3.15% also fell short of the national average. These disparities emphasize the need for state and district-level targeted interventions to align their growth trajectories with national objectives. Tailored agricultural strategies are essential to address the specific constraints faced by each state and its districts, ensuring balanced and sustainable growth in national pulse production. The structural break figures for major pulse-producing states are illustrated in the subsequent figures (see Figure 3.12-3.18).

Figure 3.12: Total Pulse Production in Madhya Pradesh (MT): Structural Break (1950-51 to 2022-23)



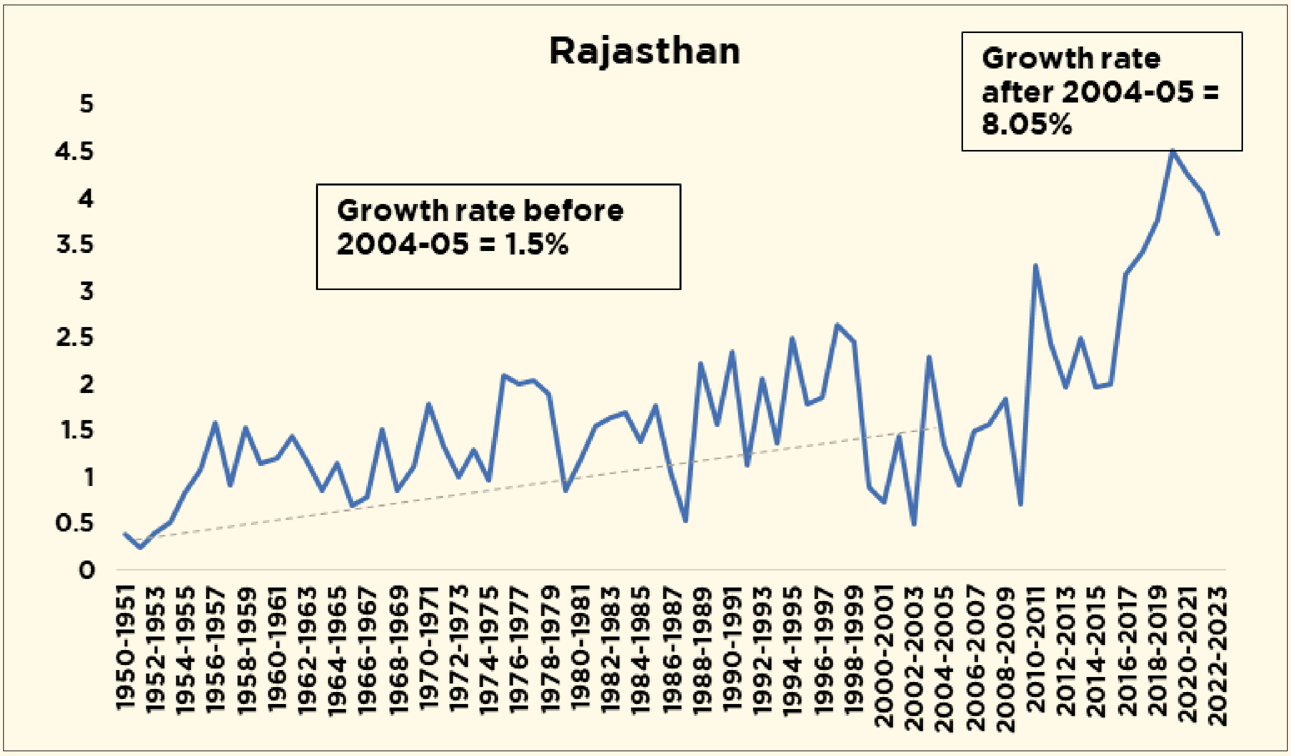
Source: Authors' computation, data from DES, MoA&FW

Figure 3.13: Total Pulse Production in Maharashtra (MT): Structural Break (1950-51 to 2022-23)



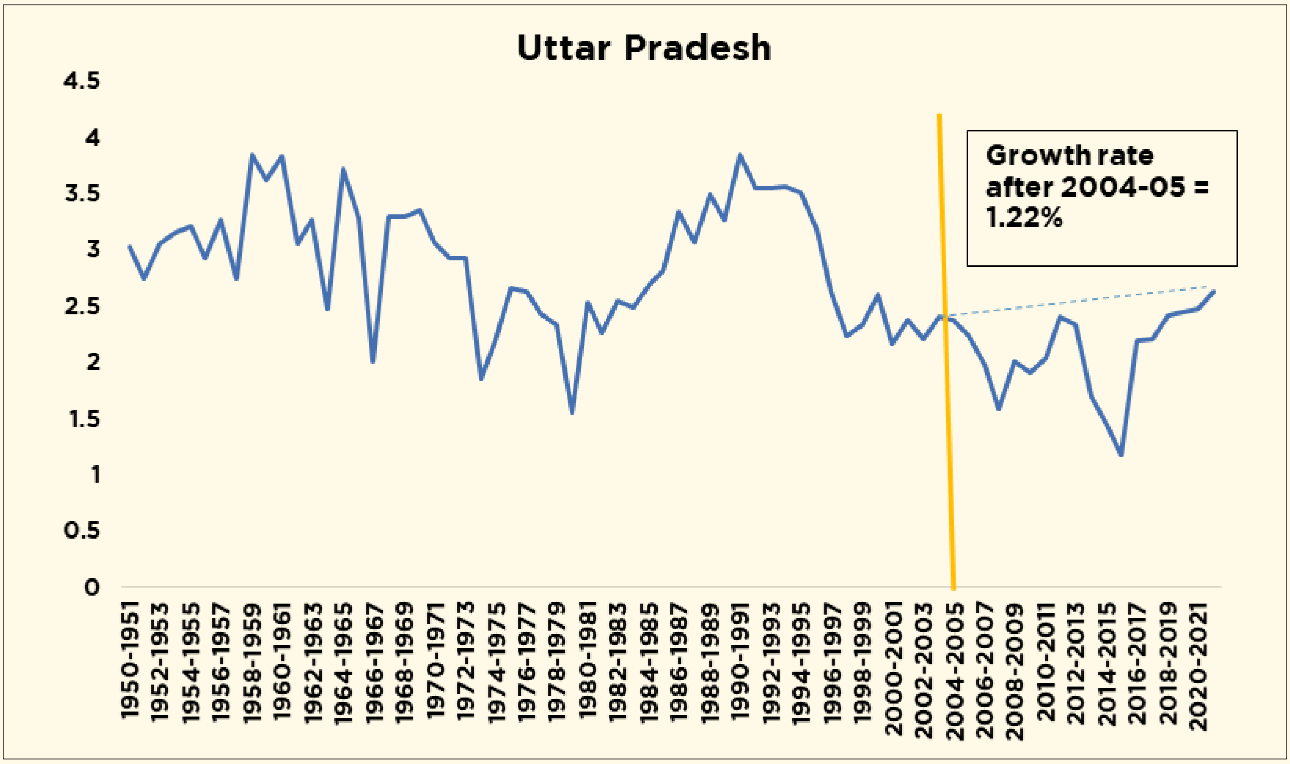
Source: Authors' computation, data from DES, MoA&FW

Figure 3.14: Total Pulse Production in Rajasthan (MT): Structural Break (1950-51 to 2022-23



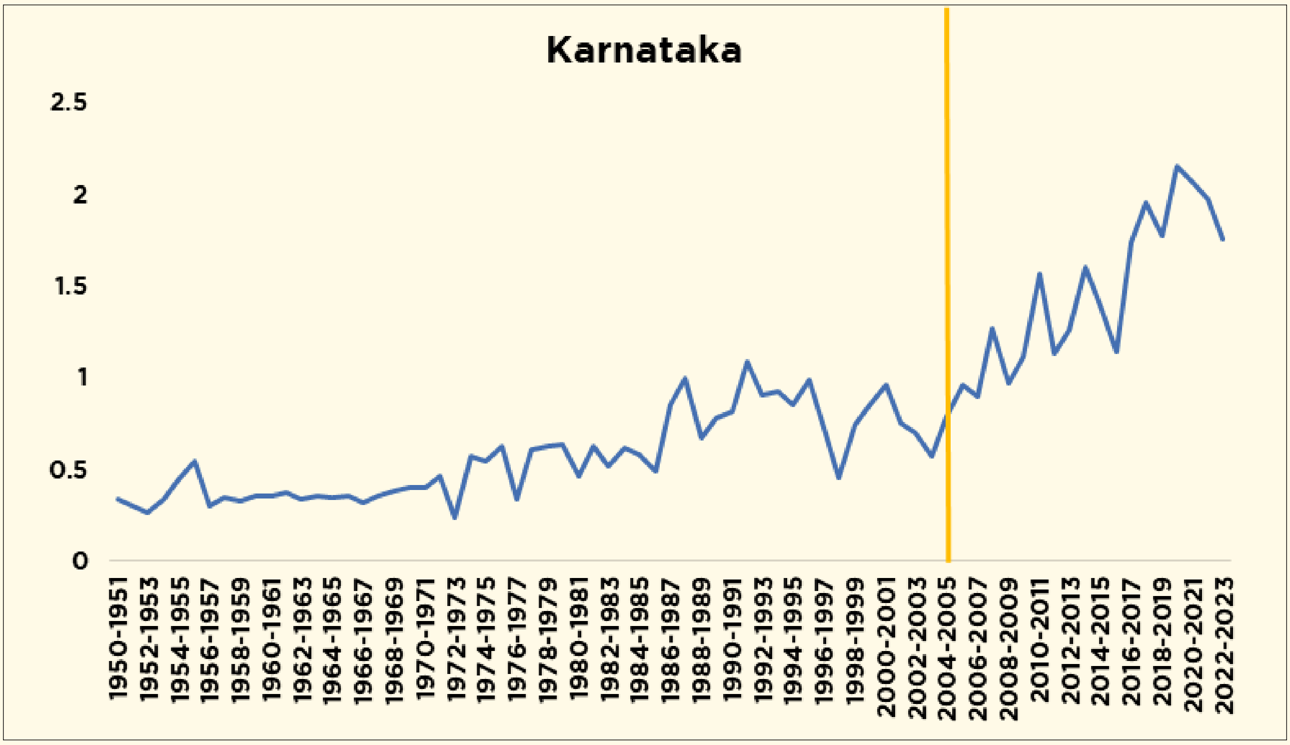
Source: Authors' computation, data from DES, MoA&FW

Figure 3.15: Total Pulse Production in Uttar Pradesh (MT): Structural Break (1950-51 to 2022-23)



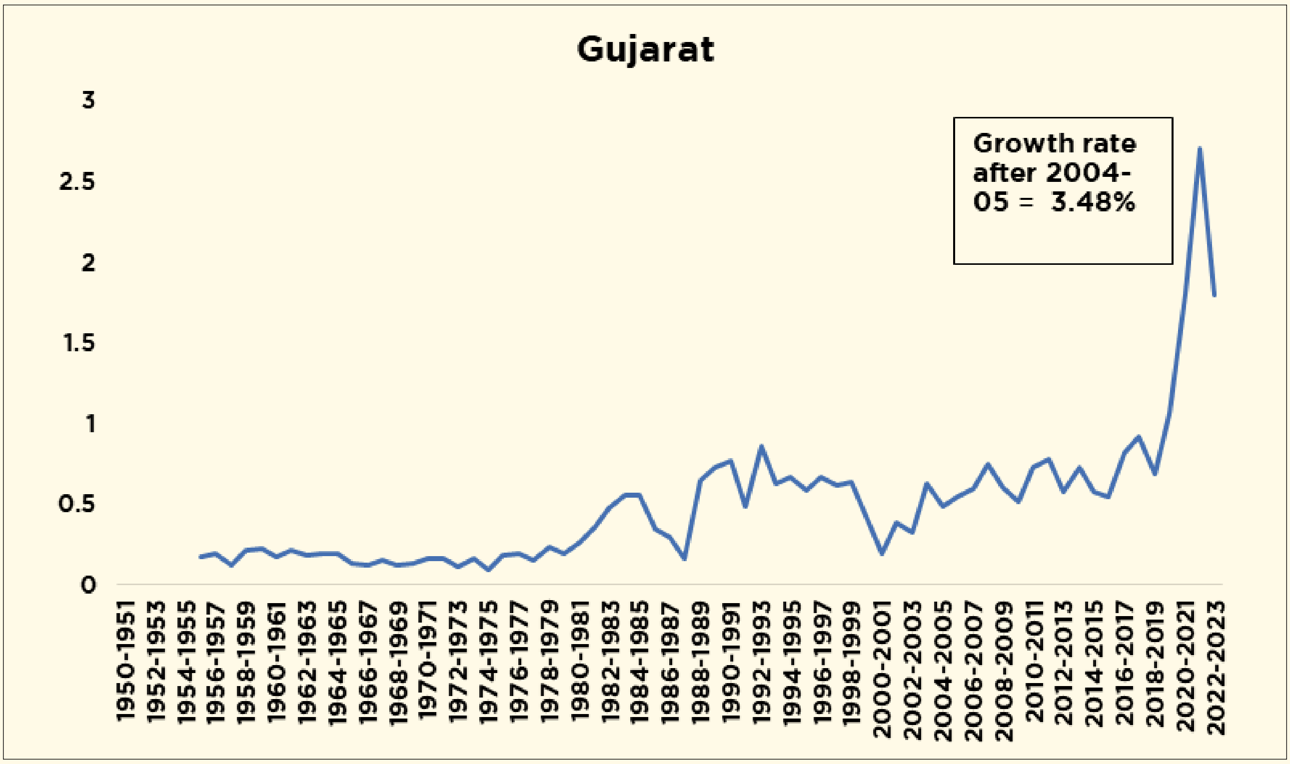
Source: Authors' computation, data from DES, MoA&FW

Figure 3.16: Total Pulse Production in Karnataka (MT): Structural Break (1950-51 to 2022-23)



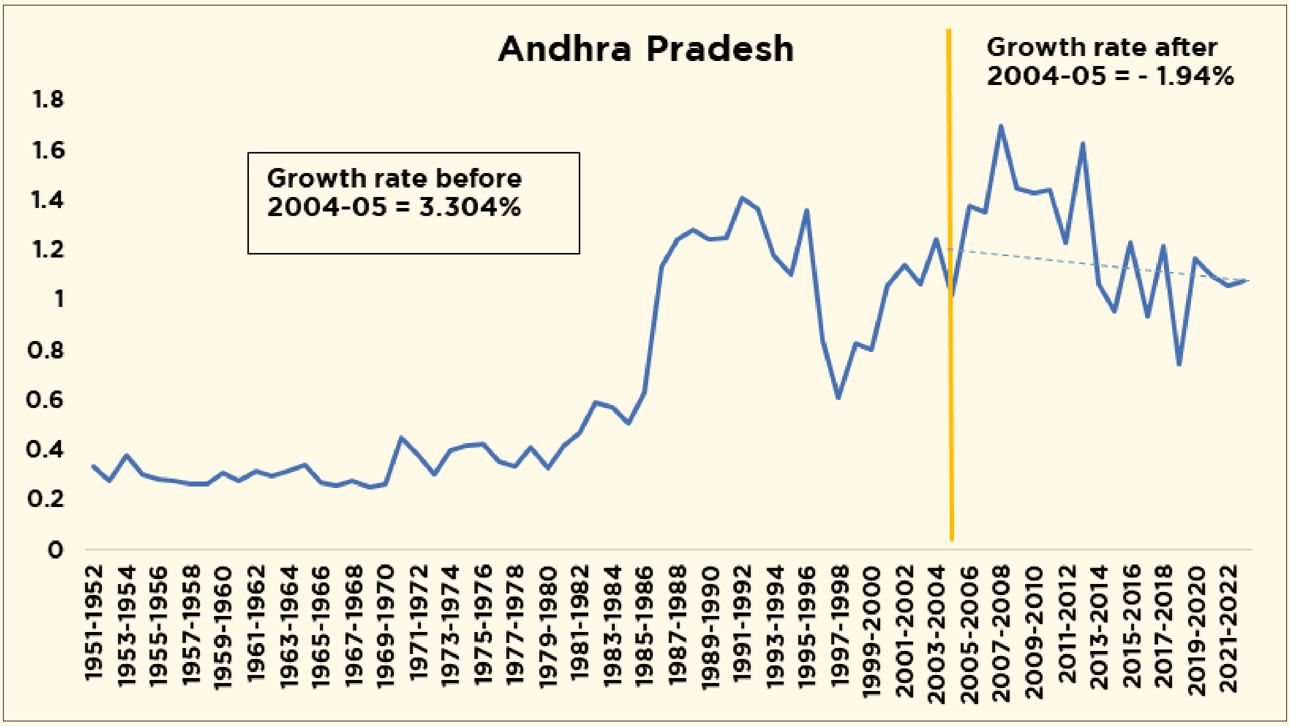
Source: Authors' computation, data from DES, MoA&FW

Figure 3.17: Total Pulse Production in Gujarat (MT): Structural Break (1950-51 to 2022-23)



Source: Authors' computation, data from DES, MoA&FW

Figure 3.18: Andhra Pradesh (MT): Structural Break (1951-52 to 2022-23)



Source: Authors' computation, data from DES, MoA&FW

3.5 Area, Production, and Yield of Major Pulses by Major Producing States in the Recent Five Years (2018-19 to 2022-23): A Comparative Analysis

India cultivates a diverse range of pulses across seasons. In the kharif season, major pulse crops grown in India are pigeonpea, black gram, green gram, cowpea, horse gram, and mothbean. In the rabi season, the major pulse crops cultivated are chickpea, lentil, pea, lathyrus, and kidney bean. In contrast, in the spring/summer season, the major pulse crops cultivated are black gram, green gram, and cowpea.

Rabi pulses play a dominant role in India's pulse production. As shown in Table 3.1, rabi crops contribute 67% to the total pulse production despite accounting for only 53% of the total area cultivated with pulses. This significant contribution is primarily driven by chickpea, which occupies 65% of the total cultivated area and contributes 70% of the total production in the rabi season. However, the data also highlights disparities in productivity between kharif and rabi pulses. Despite occupying a significant portion of the cultivated area, Kharif pulses contribute relatively less to overall production. This suggests a need for targeted interventions to improve the productivity and efficiency of kharif pulse cultivation. Furthermore, the table reveals variations in yield across different pulse crops and seasons. While some crops, like chickpea, exhibit relatively high yields, others, such as black gram and green gram, have lower yields. This underscores the importance of crop-specific strategies to enhance productivity and optimize resource use. In conclusion, the data presented in Table 3.1 provides valuable insights into India's pulse production scenery. By understanding the crop-wise and season-wise trends, policymakers and researchers can develop targeted interventions to address the specific challenges faced by different pulse crops and improve overall pulse production in India.

Table 3.1: Crop-wise Pulses Area, Production and Yield & Season-wise Share (Average of 2018-19 to 2022-23)

Crop	Season	Area (Mha)	Production (MT)	Yield (t/ha)	Contribution %	
					Area	Production
Pigeonpea	Kharif	4.56	3.81	0.837	16	15
Chickpea	Rabi	10.09	11.75	1.164	35	47
Green gram	Kharif	3.7	1.76	0.476	13	7
	Rabi	1.41	1.22	0.862	5	5
	Total	5.11	2.98	0.583	18	12
Black gram	Kharif	3.67	1.77	0.481	13	7
	Rabi	0.91	0.79	0.867	3	3
	Total	4.58	2.56	0.558	16	10
Lentil	Rabi	1.44	1.33	0.926	5	5
Other Pulses*	Kharif	1.67	0.76	0.454	6	3
	Rabi	1.66	1.6	0.965	6	6
	Total	3.34	2.36	0.708	11	10
Total Pulses	Kharif	13.6	8.1	0.595	47	33
	Rabi	15.51	16.69	1.076	53	67
Total Pulses	**Total**	**29.11**	**24.79**	**0.851**	NA	NA

***Note:** *Other pulses include pea, mothbean, cowpea, horse gram, lathyrus, kidney bean, and clusterbean.*

***Source:** Authors' computation, data from DES, MoA&FW.*

3.5.1 Total Pulses (Kharif + Rabi)

India holds the position of the largest pulse producer globally, yet the average yield of 0.851 t/ha recorded from 2018-19 to 2022-23 suggests significant potential for improving productivity throughout the country. To achieve self-sufficiency in pulses and improve farmers' livelihoods, it is imperative to implement strategies that focus on increasing yields and stability, optimizing resource utilization, and addressing the challenges faced by the pulse sector. India achieved record-high pulse production in recent years. The highest area under pulse cultivation was recorded at 30.7 Mha in 2021-22, while the peak production reached 27.3 MT in the same year. The productivity reached a peak of 0.902 t/ha in 2022-23.

India's pulse production is concentrated in a few states, with the top ten states contributing about 91.28% of the total output from 89.97% of the total area (Table 3.2). Rajasthan, the largest state in terms of area under cultivation (i.e., 6.07 Mha), contributes 20.85% of the total pulse-growing area. However, despite its large area, Rajasthan ranks third in terms of production, contributing only 16.3% to the total. Madhya Pradesh, with 5.44 Mha under cultivation (18.69% of the total area), is the largest producer, contributing 22.11% of the total production. Maharashtra, with 4.56 Mha under cultivation (15.66% of the total area), is the second-largest producing state, contributing 16.46% to the total production. These top three states collectively account for a substantial portion, nearly about 55% of India's pulse production.

Table 3.2: Indian Scenario by Major Pulse (Kharif + Rabi) Producing States (2018-19 to 2022-23)

Major Producing States	Area (Mha)	Production (MT)	Yield (t/ha)	Contribution %		Ranking (Yield)
				Area	Production	
Madhya Pradesh	5.44	5.48	1.008	18.69	22.11	4
Maharashtra	4.56	4.08	0.894	15.66	16.46	6
Rajasthan	6.07	4.04	0.665	20.85	16.3	8
Uttar Pradesh	2.44	2.56	1.046	8.38	10.33	2
Karnataka	3.12	1.94	0.623	10.72	7.83	10
Gujarat	1.21	1.61	1.333	4.16	6.5	1
Andhra Pradesh	1.22	1.03	0.844	4.19	4.16	7
Jharkhand	0.79	0.82	1.038	2.71	3.31	3
Telangana	0.53	0.53	0.998	1.82	2.14	5
Tamil Nadu	0.81	0.53	0.646	2.78	2.14	9
All India	29.11	24.78	0.851	NA	NA	NA

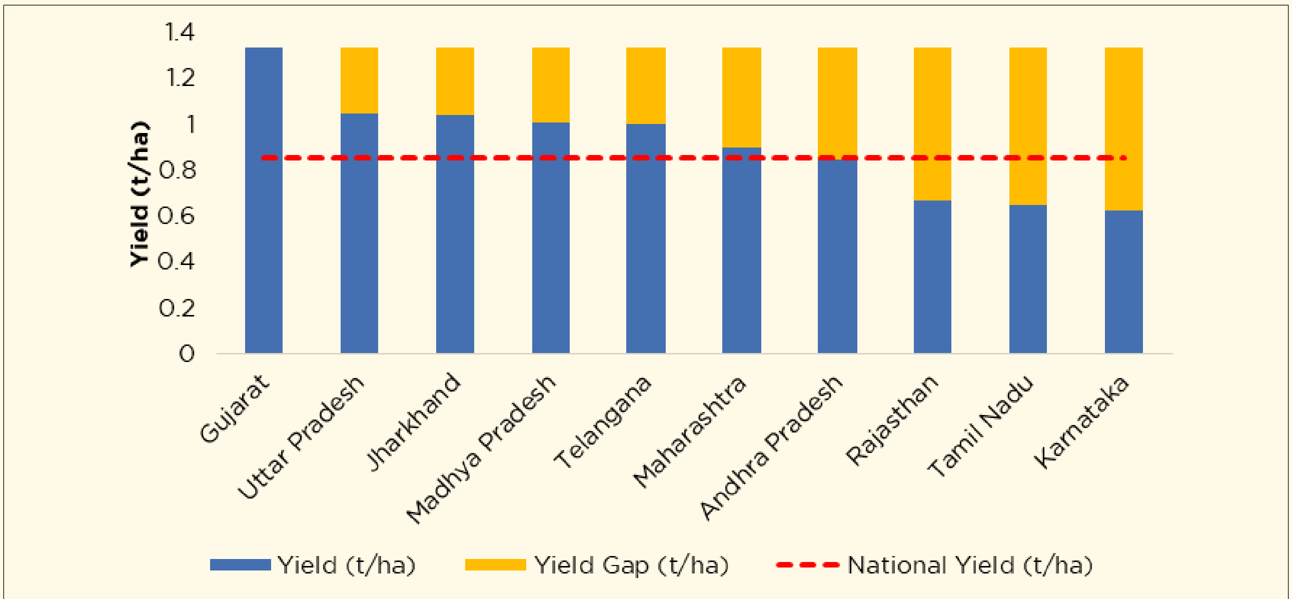
Source: Authors' computation, data from DES, MoA&FW

There are significant variations in pulse yields across different states. Gujarat stands out as the most productive state, with a 1.333 t/ha yield. In contrast, Karnataka, with a yield of 0.623 t/ha, exhibits the lowest productivity among major pulse-producing states, indicating a yield gap of 0.710 t/ha compared to Gujarat (Figure 3.19). This wide yield gap underscores the potential for improving productivity in states like Karnataka.

Even the top-producing states, such as Madhya Pradesh and Maharashtra, have room for improvement. Madhya Pradesh, despite being the largest producer, has a yield gap of 0.325 t/ha compared to Gujarat, ranked fourth in terms of yield at 1.008 t/ha among the top ten producing states. Similarly, Maharashtra, the second-largest producer, has a yield gap of 0.439 t/ha, ranked sixth with a yield of 0.894 t/h. Rajasthan, the largest state in terms of area under pulse cultivation, has a relatively low yield of 0.665 t/ha, ranked eighth among the top ten producing states with a substantial yield gap of 0.668 t/ha compared to Gujarat. While six states have achieved higher productivity levels than the national average yield of 0.851 t/ha, four major pulse-producing states—Andhra Pradesh, Rajasthan, Tamil Nadu, and Karnataka—have yields below this average. If these four states can match the national average yield, it leads to an additional 2.01 MT of major pulse production. Furthermore, if they can achieve the yield levels of Gujarat, the highest-yielding state, the potential increase in production will reach 7.42 MT, potentially rendering India self-sufficient in the pulse sector. This indicates a significant potential for yield improvement in these states, which could contribute to a substantial increase in overall pulse production.

To bridge these yield gaps and enhance overall pulse production, it is crucial to identify and address the specific factors limiting productivity in different regions due to differences in agro-ecological conditions. The yield gap between high-performing and low-performing states underscores the need for targeted interventions to improve productivity. Strategies such as adopting advanced agricultural practices, promoting high-yielding varieties, improving seed quality and irrigation infrastructure, enhancing soil health and efficient water management, optimizing fertilizers, pest and disease management practices, and strengthening extension services can help bridge this gap. Develop climate-resilient varieties amenable to machine harvest and advanced agronomic practices can further boost pulse productivity.

Figure 3.19: Yield Gap among Major Pulse-producing States (2018-19 to 2022-23)



Source: Authors' computation, data from DES, MoA&FW

The relationship between irrigated area and pulse yield is multifaceted and influenced by various factors. While irrigation can significantly boost pulse yields, it's crucial to consider other factors such as soil fertility, climate conditions, rainfall patterns, water availability, crop and water management practices, and access to quality seeds. Combining increased irrigation with improved agronomic practices, a balanced approach is essential to achieving sustainable and profitable pulse production. The figure (Figure 3.20) provides insights into the share of the irrigated pulse area to the total irrigated food grain area across the top ten pulse-yielding states.

Figure 3.20: Share of Pulses Irrigated Area to Total Food Grain Irrigated Area by Major Pulse Producing States (%) (2018-19 to 2022-23)

State	Share of Pulses Irrigated Area to Total Food Grain Irrigated Area (%)	Yield (t/ha)
Gujarat	22.01	1.333
Uttar Pradesh	3.21	1.046
Jharkand	10.35	1.038
Madhya Pradesh	18.93	1.008
Telangana	2.5	0.998
Maharashtra	27.57	0.894
Andhra Pradesh	1.45	0.844
Rajasthan	25.76	0.665
Tamil Nadu	5.08	0.646
Karnataka	12.97	0.623

Source: Authors' computation, data from DES, MoA&FW

3.5.2 Kharif Pulses

Kharif pulses, cultivated across 13.60 Mha in India, contribute 8.09 MT to the total production, with the top ten states contributing about 94.55% of the total production from 94.34% of the total area (Table 3.3). However, the national average yield of 0.595 t/ha indicates the need to enhance the overall productivity of Kharif pulses. Ever the highest area and production in total kharif pulses was 14.8 Mha during 2018-19 and 9.6 MT during 2016-17, respectively. The productivity reached a peak of 0.668 t/ha during 2017-18.

Rajasthan emerges as the leading state in Kharif pulse cultivation, with 3.95 Mha under cultivation, contributing 29.04% of the national area. Despite the large area, its contribution to total production is 21.38%. Maharashtra, the second-largest state by area, with 2.10 Mha under cultivation, contributes 19.16% to the total production. Karnataka, the third-largest, with 2.13 Mha, contributes 16.32%.

Table 3.3: Indian Scenario by Major Pulse (Kharif) Producing States (2018-19 to 2022-23)

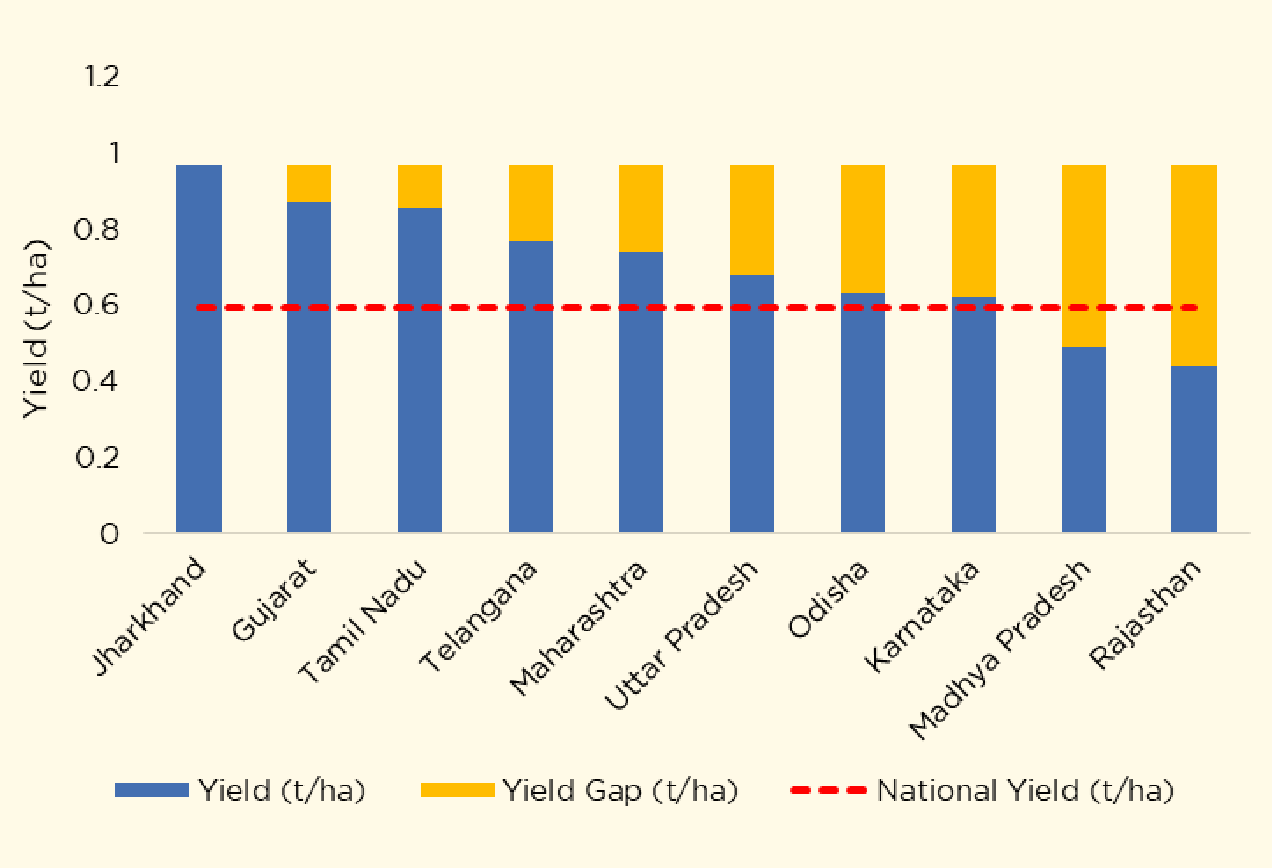
Major Producing States	Area (Mha)	Production (MT)	Yield (t/ha)	Contribution %		Ranking (Yield)
				Area	Production	
Rajasthan	3.95	1.73	0.437	29.04	21.38	10
Maharashtra	2.1	1.55	0.74	15.44	19.16	5
Karnataka	2.13	1.32	0.621	15.66	16.32	8
Madhya Pradesh	1.93	0.95	0.489	14.19	11.74	9
Uttar Pradesh	0.86	0.59	0.679	6.32	7.29	6
Jharkhand	0.42	0.4	0.968	3.09	4.94	1
Gujarat	0.45	0.39	0.87	3.31	4.82	2
Telangana	0.36	0.28	0.768	2.65	3.46	4
Odisha	0.44	0.28	0.63	3.24	3.46	7
Tamil Nadu	0.19	0.16	0.856	1.4	1.98	3
All India	13.6	8.09	0.595	NA	NA	NA

Source: Authors' computation, data from DES, MoA&FW

A significant yield gap exists across different states in Kharif pulse production. While states like Jharkhand and Gujarat, with smaller cultivation areas, have achieved relatively higher yields, others with larger cultivation areas, including Rajasthan, Madhya Pradesh, Maharashtra, and Karnataka, have lower productivity levels. For instance, Jharkhand, with a small cultivation area of 0.42 Mha, has the highest yield of 0.968 t/ha, contributing significantly to 4.94% of the total production. Similarly, despite a smaller area of 0.45 Mha, Gujarat has a relatively higher yield of 0.870 t/ha, ranked second, showcasing more efficient resource utilization than other top-producing states.

On the other hand, Rajasthan, the largest producing state and having the most significant area under cultivation, records the lowest yield of 0.437 t/ha with a yield gap of 0.531 t/ha compared to Jharkhand (Figure 3.21). This highlights a notable disparity in pulse productivity despite Rajasthan's vast cultivated area. Madhya Pradesh, with a yield of 0.489 t/ha (ranked ninth), also faces a significant yield gap of 0.479 t/ha. Maharashtra, the second-largest producing state with a yield of 0.740 t/ha (ranked fifth), also experiences a 0.347 t/ha gap. Karnataka, the third-largest producing state with a yield of 0.621 t/ha (ranked eighth), experiences a gap of 0.347 t/ha. These states are key players in Kharif pulse production, indicating that productivity could be enhanced to utilize the cultivated land better. While eight states have achieved higher productivity levels than the national average yield, the remaining two states among the top ten producers, i.e., Rajasthan and Madhya Pradesh, have a yield below the national average of 0.595 t/ha. If these two states achieve the national average yield, there is a potential to increase major pulse (Kharif) production by 0.82 MT. Additionally, if these states reach the yield levels of Jharkhand, the highest-yielding state for major pulses (Kharif), there is a potential to increase production by 3.02 MT. Addressing these disparities by increasing efficiency and productivity in lower-yielding states could significantly boost the overall production of Kharif pulses in the country.

Figure 3.21: Yield Gap among Major Pulse (Kharif) Producing States (2018-19 to 2022-23)



Source: Authors' computation, data from DES, MoA&FW

3.5.3 Rabi Pulses

Rabi pulses, cultivated across 16.69 Mha in India, contribute 15.51 MT to the total production, with the top ten states contributing about 91.37% of the total production from 88.52% of the total area (Table 3.4). However, the national average yield of 1.076 t/ha is almost double that of the kharif pulses. The highest area and production in total rabi pulses was 16.8 Mha during 2022-23 and 19.1 MT during 2021-22, respectively. The productivity peaked at 1.148 t/ha during 2022-23.

Madhya Pradesh is the leading state in Rabi pulse cultivation, with 3.51 Mha under cultivation (22.63% of the total area), contributing 27.20% of the total production. Maharashtra, the second-largest state by area, with 2.47 Mha under cultivation, contributes 15.16% to the total production. Rajasthan, the third-largest, with 2.12 Mha, contributes 13.84%.

Table 3.4: Indian Scenario by Major Pulse (Rabi) Producing States (2018-19 to 2022-23)

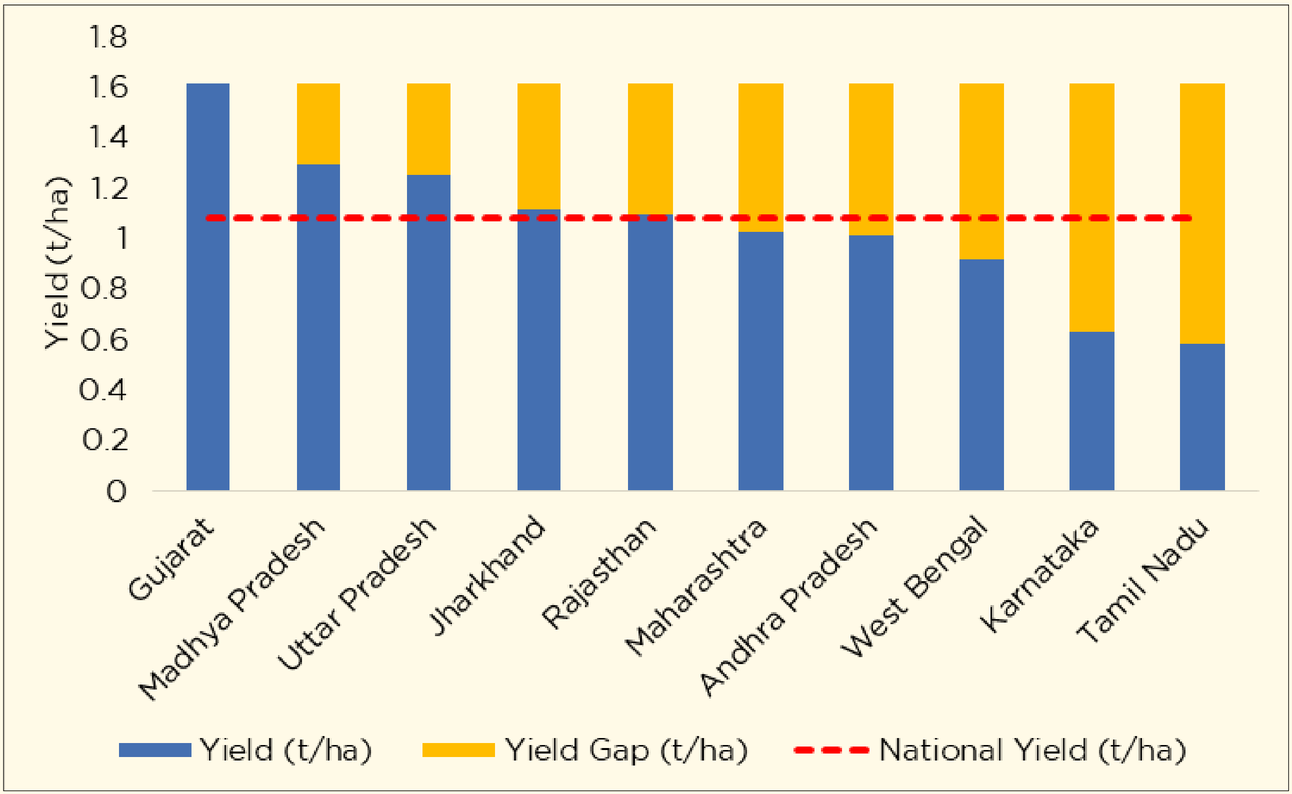
Major Producing States	Area (Mha)	Production (MT)	Yield (t/ha)	Contribution %		Ranking (Yield)
				Area	Production	
Madhya Pradesh	3.51	4.54	1.294	22.63	27.2	2
Maharashtra	2.47	2.53	1.025	15.93	15.16	6
Rajasthan	2.12	2.31	1.091	13.67	13.84	5
Uttar Pradesh	1.58	1.97	1.247	10.19	11.8	3
Gujarat	0.76	1.22	1.608	4.9	7.31	1
Andhra Pradesh	0.9	0.91	1.011	5.8	5.45	7
Karnataka	0.99	0.62	0.627	6.38	3.71	9
Jharkhand	0.38	0.42	1.114	2.45	2.52	4
Tamil Nadu	0.63	0.37	0.584	4.06	2.22	10
West Bengal	0.39	0.36	0.913	2.51	2.16	8
All India	15.51	16.69	1.076	NA	NA	NA

Source: Authors' computation, data from DES, MoA&FW

The yield analysis of Rabi pulses reveals differences in productivity among the top-producing states. Gujarat leads with 1.608 t/ha yield, significantly higher than the national average. This reflects its efficient farming practices and favorable growing conditions. Tamil Nadu and Karnataka show the lowest yield of 0.584 t/ha and 0.627 t/ha, leading to a yield gap of 1.084 t/ha and 0.981 t/ha, respectively, compared with Gujarat (Figure 3.22). This gap indicates enormous opportunities for improvement in those states' Rabi pulse production.

On the other hand, Madhya Pradesh, with the largest area, has a yield gap of 0.314 t/ha (ranked second). With the second largest area, Maharashtra has a yield gap of 0.583 t/ha (ranked sixth). Rajasthan, with the third largest area, has a yield gap of 0.517 t/ha (ranked fifth). Uttar Pradesh also has a yield gap of 0.361 t/ha (ranked third) compared to Gujarat, which signals the potential for increased efficiency in its Rabi pulse farming. While five states have achieved higher productivity levels than the national average yield, the remaining five states among the top ten producers, i.e., Maharashtra, Andhra Pradesh, West Bengal, Karnataka, and Tamil Nadu, have a yield below the national average of 0.595 t/ha. If these five states match the national average yield, there is a potential to increase major pulse (rabi) production by 1.003 MT. Additionally, if these states were to reach the yield levels of Gujarat, the highest-yielding state for major pulses (rabi), there is a significant potential to increase production by 3.86 MT. This data underscores the significant potential for increased efficiency in Rabi pulse farming in lower-yielding states, which can lead to a substantial enhancement in Rabi pulse production in India.

Figure 3.22: Yield Gap among Major Pulse (Rabi) Producing States (2018-19 to 2022-23)



Source: Authors' computation, data from DES, MoA&FW

3.5.4 Pigeonpea

Pigeonpea, commonly known as red gram, arhar, or tur, is a vital pulse crop in India, holding significant cultural and nutritional importance. As the second most crucial pulse crop after chickpea, it is widely consumed as split pulses or '*dal*'. Pigeonpea seeds are rich in essential nutrients, including iron, iodine, and amino acids like lysine, threonine, cystine, and arginine, making them valuable dietary components. This emphasis on the nutritional value of pigeonpea will make the audience feel more informed and aware of the importance of this crop in the Indian diet.

Pigeonpea, a tropical crop, is predominantly cultivated in semi-arid regions of India. The sowing time and method vary based on the variety. Early-maturing varieties are typically sown in the first fortnight of June, while medium and late-maturing varieties are sown in the second fortnight of June. Line sowing using a seed drill or desi plough or dibbling on ridges and beds are recommended planting methods, depending on the specific area and soil conditions. Pigeonpea thrives in temperatures ranging from 26°C to 30°C during the rainy season and 17°C to 22°C during the post-rainy season. It's important to note that pigeonpea is sensitive to low radiation levels during pod development. Flowering during the monsoon or cloudy weather can adversely affect pod formation and yield. It is successfully grown in well-drained black cotton soils with a pH range of 7.0-8.5. Proper soil preparation, including adequate tillage and drainage, is crucial for optimal growth and yield. A well-prepared seedbed provides the ideal environment for seed germination and subsequent plant development.

The total area under Pigeonpea cultivation is 4.55 Mha, resulting in a total production of about 3.81 MT. The top ten states contribute about 97.63% of the total production from 97.57% of the total area. The average national yield is 0.837 t/ha, which reflects the potential for productivity improvements across the country (Table 3.5). Ever highest area and production in pigeonpea were 5.3 Mha and 4.9 MT during 2016-17. Productivity reached a peak of 0.967 t/ha during 2017-18.

Table 3.5: Indian Scenario by Major Pigeonpea Producing States (2018-19 to 2022-23)

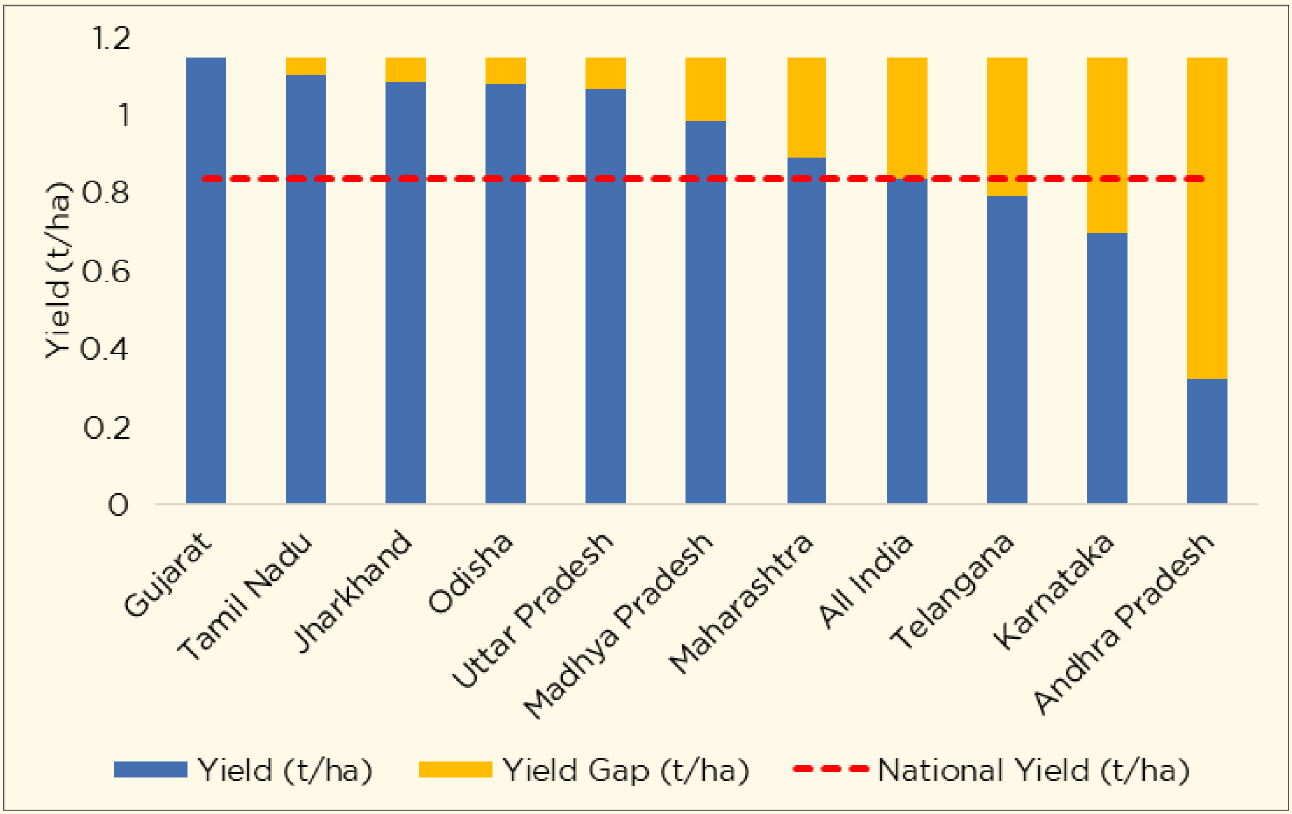
Major Producing States	Area (Mha)	Production (MT)	Yield (t/ha)	Contribution %		Ranking (Yield)
				Area	Production	
Maharashtra	1.25	1.11	0.891	27.47	29.13	7
Karnataka	1.52	1.06	0.699	33.41	27.82	9
Uttar Pradesh	0.29	0.31	1.065	6.37	8.14	5
Gujarat	0.24	0.28	1.147	5.27	7.35	1
Jharkhand	0.23	0.25	1.086	5.05	6.56	3
Madhya Pradesh	0.21	0.21	0.986	4.62	5.51	6
Telangana	0.29	0.23	0.79	6.37	6.04	8
Odisha	0.13	0.14	1.081	2.86	3.67	4
Andhra Pradesh	0.24	0.08	0.323	5.27	2.1	10
Tamil Nadu	0.04	0.05	1.102	0.88	1.31	2
All India	4.55	3.81	0.837	NA	NA	NA

Source: Authors' computation, data from DES, MoA&FW

The production of pigeonpea is concentrated in several key states, each contributing to the overall output in different ways. Maharashtra, the largest producer (1.11 MT) in the country, despite having the second largest area under cultivation (27.47% of the total), has a relatively lower yield of 0.891 t/ha, ranking seventh among the top ten producing states. Karnataka, while having the highest area under cultivation (33.41% of the total area), also faces challenges with a very low yield of 0.699 t/ha (ranked ninth), leading to a total production of 1.06 MT. States like Uttar Pradesh, Gujarat, and Jharkhand exhibit higher yields while having smaller cultivation areas. Uttar Pradesh, with a yield of 1.065 t/ha (ranked fifth), and Gujarat, with a yield of 1.147 t/ha (ranked top), are among the top-yielding states. Jharkhand, with a yield of 1.086 t/ha (ranked third), also demonstrates strong productivity.

The yield gap analysis for tur highlights significant disparities among states. Andhra Pradesh has the lowest yield of 0.323 t/ha, resulting in a substantial yield gap of 0.824 t/ha compared to Gujarat (Figure 3.23). Karnataka also faces a significant yield gap of 0.448 t/ha. Similarly, Maharashtra, the largest producer, has a yield gap of 0.256 t/ha compared to Gujarat. While seven states have achieved higher productivity levels than the national average yield, the remaining three states among the top ten producers, i.e., Telangana, Karnataka, and Andhra Pradesh, have a yield below the national average of 0.837 t/ha. If these three states can achieve the national average yield, there is a potential to increase pigeonpea production by 0.34 MT. Additionally, if these states reach the yield levels of Gujarat, the highest-yielding state for pigeonpea, there is a potential to increase production by 0.98 MT. Addressing these gaps can lead to enhanced overall production and better utilization of the available cultivated land in the country.

Figure 3.23: Yield Gap among Major Pigeonpea Producing States (2018-19 to 2022-23)



Source: Authors' computation, data from DES, MoA&FW

3.5.5 Chickpea

Chickpea, also known as Bengal gram, is the largest produced pulse in South Asia and the third largest globally, after common bean and field pea. Chickpea is widely appreciated as a healthy food. It is a protein-rich supplement to cereal-based diets, especially for the poor in developing countries.

Chickpea is primarily a winter-season crop. However, it is sensitive to frost, adversely affecting flower development and seed formation. Optimal growth and yield are achieved in areas with moderate rainfall, ranging from 600 to 900 mm per annum. Chickpea can be cultivated on various soil types, from coarse-textured sandy soils to fine-textured deep black soils (vertisols). However, well-drained, deep loams or silty clay loams with a pH ranging from 6.0 to 8.0 are considered ideal. Proper field preparation is crucial for optimal growth. The soil should be well-tilled and drained to ensure adequate aeration and prevent waterlogging. Removing crop residues from the previous crop can help reduce the risk of soil-borne diseases, such as collar rot. A rough seedbed is prepared in heavy soils to prevent compaction from winter rains, ensuring adequate soil aeration and facilitating easy seedling emergence. The optimal sowing time for chickpea varies across regions. In North India, rainfed conditions favor sowing in the second fortnight of October while irrigated in the first fortnight of November. For Central and South India, the ideal sowing period is the first fortnight of October to the first fortnight of November. Late sowing, particularly in December or January, can reduce yield and seed quality due to moisture stress and high temperatures during the critical pod-filling stage. Chickpea is typically sown using line sowing methods, either with a double box seed drill or a local plough. Broad Bed and Furrow or Ridge and Furrow methods are used in low-lying or shallow lands to reduce the risk of wilting, as shallow-rooted crops are more susceptible to moisture stress.

The total area under chickpea cultivation in India is about 10.09 Mha, resulting in a total production of around 11.75 MT. The top ten states contribute about 98.39% of the total production from 98.4% of the total area. The average national yield is 1.164 t/ha, which reflects the potential for productivity improvements across the country (Table 3.6). The highest area, production, and productivity in chickpea was achieved in 2021-22 with 10.7 Mha, 13.5 MT, and 1.261 t/ha, respectively.

Table 3.6: Indian Scenario by Major Chickpea Producing States (2018-19 to 2022-23)

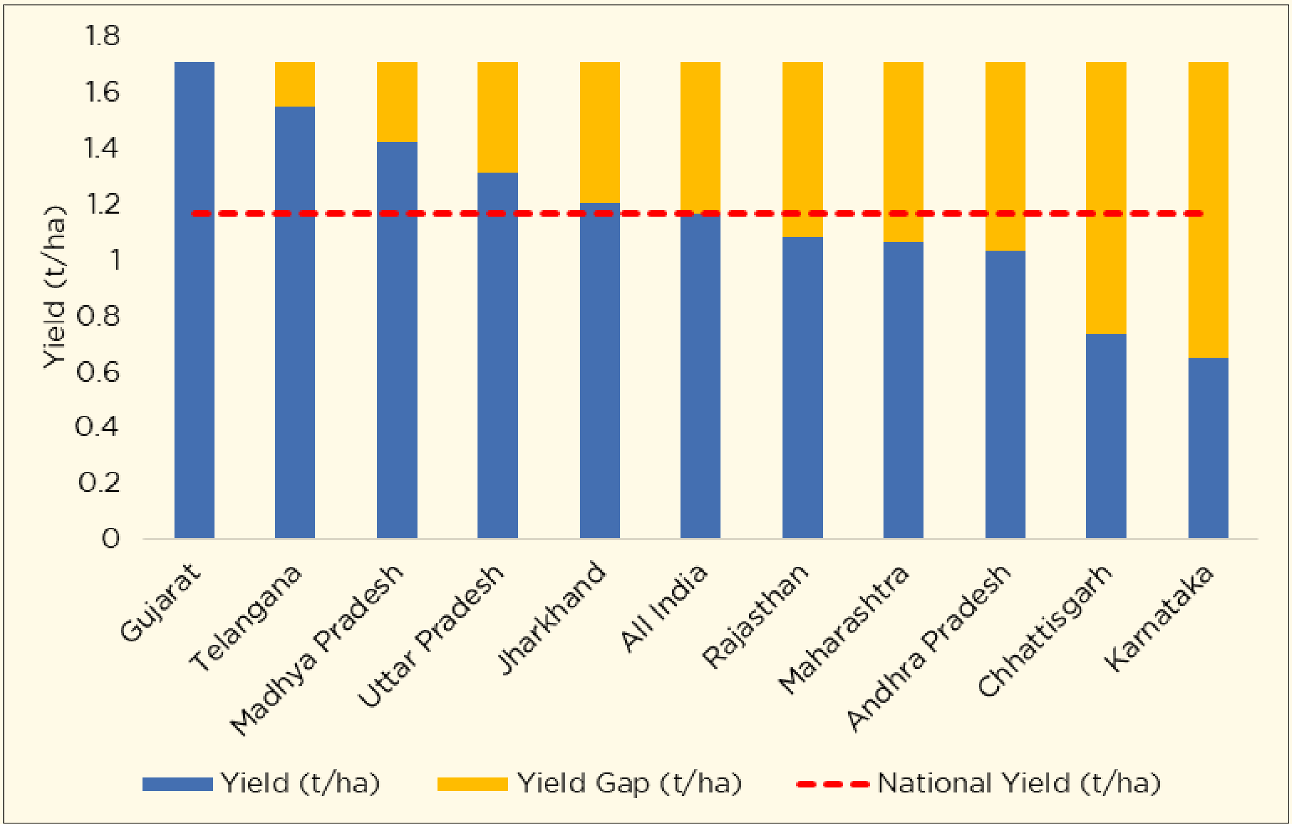
Major Producing States	Area (Mha)	Production (MT)	Yield (t/ha)	Contribution %		Ranking (Yield)
				Area	Production	
Madhya Pradesh	2.25	3.19	1.421	22.3	27.15	3
Maharashtra	2.33	2.46	1.058	23.09	20.94	7
Rajasthan	2.08	2.25	1.081	20.61	19.15	6
Gujarat	0.65	1.11	1.702	6.44	9.45	1
Uttar Pradesh	0.62	0.81	1.311	6.14	6.89	4
Karnataka	0.85	0.55	0.648	8.42	4.68	10
Andhra Pradesh	0.44	0.45	1.031	4.36	3.83	8
Jharkhand	0.24	0.29	1.198	2.38	2.47	5
Chhattisgarh	0.33	0.24	0.734	3.27	2.04	9
Telangana	0.14	0.21	1.545	1.39	1.79	2
All India	10.09	11.75	1.164	NA	NA	NA

Source: Authors' computation, data from DES, MoA&FW

Madhya Pradesh, the country's largest producer (3.19 MT), has the second largest area under chickpea cultivation (22.30% of the total) and has a yield of 1.421 t/ha, ranking third among the top ten producing states. While having the highest area under cultivation

(23.09% of the total area), Maharashtra harvests a lower yield of 1.058 t/ha (ranked seventh), leading to a total production of 2.46 MT. Rajasthan, having the third largest area under cultivation (20.61% of the total area), also faces challenges with a lower yield of 1.081 t/ha (ranked sixth), leading to a total production of 2.25 MT. Gujarat is recognized for its highest productivity, with a yield of 1.702 t/ha from an area of 0.65 Mha, resulting in a total production of 1.11 MT. On the other hand, Karnataka has the lowest yield at 0.648 t/ha, creating a yield gap of 1.054 t/ha when compared to Gujarat (Figure 3.24). Madhya Pradesh, the largest producing state, faces a yield gap of 0.281 t/ha. Maharashtra is the largest state in the chickpea-cultivated area, with a yield gap of 0.644 t/ha. Rajasthan has the third largest cultivated area, having a yield gap of 0.621 t/ha. While five states have achieved higher productivity levels than the national average yield, the remaining five states among the top ten producers, i.e., Rajasthan, Maharashtra, Andhra Pradesh, Chhattisgarh, and Karnataka, have a yield below the national average of 1.164 t/ha. If these five states match the national average yield, there is a potential to increase chickpea production by 1.05 MT. Additionally, if these states reach the yield levels of Gujarat, the highest-yielding state for chickpea, there is a potential to increase the production by 4.30 MT. Addressing these yield gaps through improved agricultural practices can significantly boost overall production.

Figure 3.24: Yield Gap among Major Chickpea Producing States (2018-19 to 2022-23)



Source: Authors' computation, data from DES, MoA&FW

3.5.6 Green gram

Green gram or mungbean is a versatile legume crop that is an excellent source of high-quality protein. It can be consumed in various forms, including whole grains, sprouts, and split pulses (dal). Beyond human consumption, green gram is also used as a green manure crop to improve soil fertility. Additionally, the seed husks can be used as cattle feed. In India, green gram is cultivated in different seasons, including summer, when it can be grown after harvesting crops like pea, chickpea, potato, and mustard. Cultivating jayad green gram is crucial in regions with paddy-wheat crop rotations, as it helps enhance soil fertility and diversify the cereal-based monoculture.

Green gram thrives under high temperatures, less humidity, and moderate rainfall of about 600-800 mm. Waterlogging is fatal for root development and nitrogen fixation during the early vegetative stage. While it is primarily a rain-fed crop, it can be successfully cultivated under assured irrigated conditions during summer, particularly in the Indo-Gangetic plains of Northern India. The best soil for its cultivation is loam soil with good drainage. It should be avoided on alkaline, saline, or waterlogged soils. Proper field preparation is essential for optimal growth and yield. The land should be ploughed 2-3 times and planked to create a fine seedbed free of clods and weeds. For summer or spring cultivation, tillage should be carried out after irrigation to ensure adequate moisture for seed germination and early growth. The optimal sowing time for green gram varies depending on the season. For the rainy season crop, sowing should be done during the last week of June or the first to mid-week of July. For the summer or spring crop, sowing should be done after the harvest of previous crops (potato, sugarcane, mustard, and cotton, etc.), ideally in the first fortnight of March. Late sowing can adversely affect yield, as high temperatures during the flowering stage can lead to reduced pod formation and seed development. Water management is crucial for successful green gram cultivation in summer. For kharif-season crops, a single life-saving irrigation during the early pod formation stage is required. However, 3-4 irrigations may be required for summer or spring crops. The first irrigation should be applied 20-25 days after sowing, followed by additional irrigations at 10–15-day intervals as needed. It is important to avoid waterlogging, especially during the flowering stage, as excess moisture can negatively impact plant health and yield.

The total area under green gram cultivation in India is about 5.11 Mha, with a total production of around 2.98 MT. The top ten states contribute about 93.62% of the total production from 95.12% of the total area. The average national yield for green gram across the country stands at 0.583 t/ha, indicating potential opportunities for improving productivity across the country (Table 3.7). The highest area and production in green gram were 5.6 Mha and 3.7 MT during 2021-22, respectively, and productivity peaked at 0.663 t/ha during 2022-23.

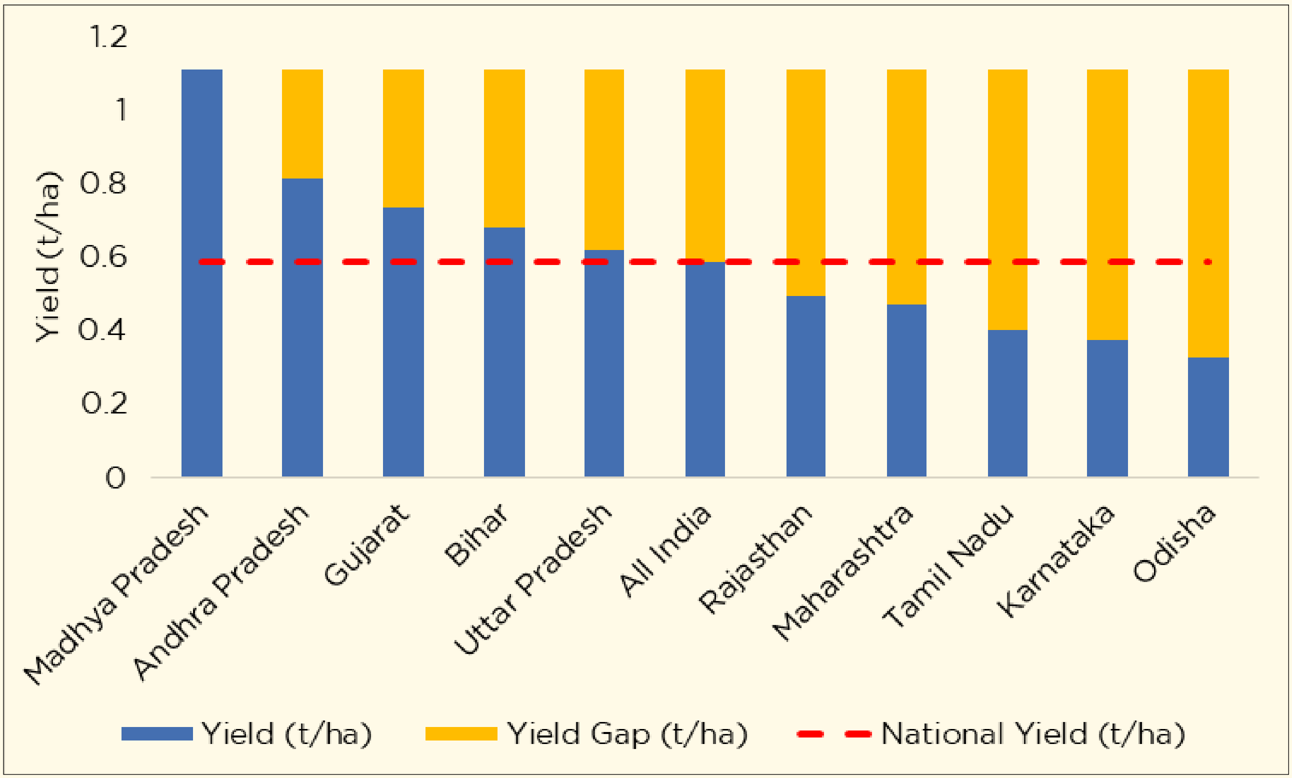
Table 3.7: Indian Scenario by Major Green Gram Producing States (2018-19 to 2022-23)

Major Producing States	Area (Mha)	Production (MT)	Yield (t/ha)	Contribution %		Ranking (Yield)
				Area	Production	
Rajasthan	2.45	1.2	0.492	47.95	40.27	6
Madhya Pradesh	0.67	0.75	1.109	13.11	25.17	1
Maharashtra	0.39	0.18	0.47	7.63	6.04	7
Karnataka	0.44	0.16	0.372	8.61	5.37	9
Bihar	0.17	0.11	0.679	3.33	3.69	4
Gujarat	0.14	0.1	0.735	2.74	3.36	3
Andhra Pradesh	0.1	0.08	0.814	1.96	2.68	2
Odisha	0.24	0.08	0.327	4.7	2.68	10
Tamil Nadu	0.17	0.07	0.401	3.33	2.35	8
Uttar Pradesh	0.09	0.06	0.618	1.76	2.01	5
All India	5.11	2.98	0.583	NA	NA	NA

Source: Authors' computation, data from DES, MoA&FW

Rajasthan is by far the largest producer and cultivator, covering an area of 2.45 Mha (47.95% of the total) and achieving a total production of 1.20 MT (40.27% of the total). The yield in Rajasthan is a real concern (i.e. only 0.492 t/ha), ranking sixth in terms of yield among the top ten producing states. Madhya Pradesh is the second largest producer and cultivator, with an area of 0.67 Mha (13.11% of the total) and a total output of 0.75 MT. The yield in this state is significantly higher than Rajasthan by 0.617 t/ha (Figure 3.25), making it the leading state in terms of yield. Maharashtra, the third largest producing state's yield is also concerning (i.e., only 0.470 t/ha), ranked seventh with a yield gap of 0.639 t/ha compared to Madhya Pradesh. Karnataka, the fourth largest producing state, also exhibits a yield gap of 0.737 t/ha (ranked ninth) compared to Madhya Pradesh. Bihar is the fifth largest producer, resulting in a yield of 0.679 t/ha (ranked fourth) with a yield gap of 0.43 t/ha. Andhra Pradesh stands out with a yield of 0.814 t/ha from an area of 0.1 Mha, producing 0.08 MT of green gram. This positions Andhra Pradesh as the second-highest contributor in terms of yield. Gujarat, with an area of 0.14 Mha and a production of 0.10 MT, yield is 0.735 t/ha, ranking it third among the states. Odisha has the lowest yield at 0.327 t/ha, creating a yield gap of 0.782 t/ha compared to Madhya Pradesh. While five states have achieved higher productivity levels than the national average yield, the remaining five states are among the top ten producers, i.e., Rajasthan, Maharashtra, Tamil Nadu, Karnataka, and Odisha, have a yield below the national average of 0.583 t/ha. If these five states can achieve the national average yield, there is a potential to increase green gram production by 0.45 MT. Additionally, if these states reach the yield levels of Madhya Pradesh, the highest-yielding state for green gram, there is a potential to increase production by 2.39 MT. Addressing these gaps can lead to improved overall production and better utilization of the cultivated land in the country.

Figure 3.25: Yield Gap among Major Green Gram Producing States (2018-19 to 2022-23)



Source: Authors' computation, data from DES, MoA&FW

3.5.7 Black gram

Black gram, or urdbean, is a significant pulse crop cultivated across India. It is consumed in various forms, including whole or split dal, husked, unhusked, or perched. Additionally, it serves as nutritive fodder for milch animals. Black gram is also used as a green manure crop to improve soil fertility. Its high lysine content makes it an excellent complement to rice, ensuring a balanced protein intake for human nutrition.

Black gram thrives in hot and humid tropical climates. It is primarily a warm-weather crop well-suited to regions with moderate rainfall. In northern India, where winter temperatures are low, black gram is typically cultivated during the rainy and summer seasons. In the Eastern states, it is also grown during winter. In contrast, with less climatic variation, central and southern states allow for cultivation in both winter and rainy seasons. Black gram can be cultivated on various soil types, from sandy to heavy clay. However, well-drained loam soils with a pH of 6.5 to 7.8 are considered ideal. It is important to avoid alkaline and saline soils. The land is prepared like any other kharif season pulse crop. However, more thorough preparation is required for summer cultivation to create a fine seedbed free of weeds and crop residues. The sowing time for black gram varies depending on the season. In the kharif season, sowing is typically done in the later part of June or early July, coinciding with the onset of the monsoon. For the rabi season, sowing is recommended in the second fortnight of October for upland areas and the second fortnight of November for rice fallows. In the summer, sowing is usually done between the third week of February and the first week of April. Water management is crucial for successful black gram cultivation.

In the kharif season, irrigation is generally not required if rainfall is adequate. However, if moisture stress occurs during the critical pod formation stage, supplemental irrigation may be necessary. For summer crops, 3-4 irrigations are typically required at 10–15-day intervals. Maintaining adequate soil moisture during the flowering and pod development stages is essential for optimal yield. Black gram can tolerate partial waterlogging more compared to mungbean.

The total area under black gram cultivation in India is about 4.58 Mha, resulting in a total production of 2.56 MT. The top ten states contribute about 97.63% of the total production from 97.57% of the total area. The average national yield for black gram across the country is 0.558 t/ha, highlighting the potential for enhancing productivity (Table 3.8). Ever highest area in black gram was 5.6 Mha during 2018-19. Production and productivity peaked during 2017-18 with 3.5 MT and 0.662 t/ha, respectively.

Table 3.8: Indian Scenario by Major Black Gram Producing States (2018-19 to 2022-23)

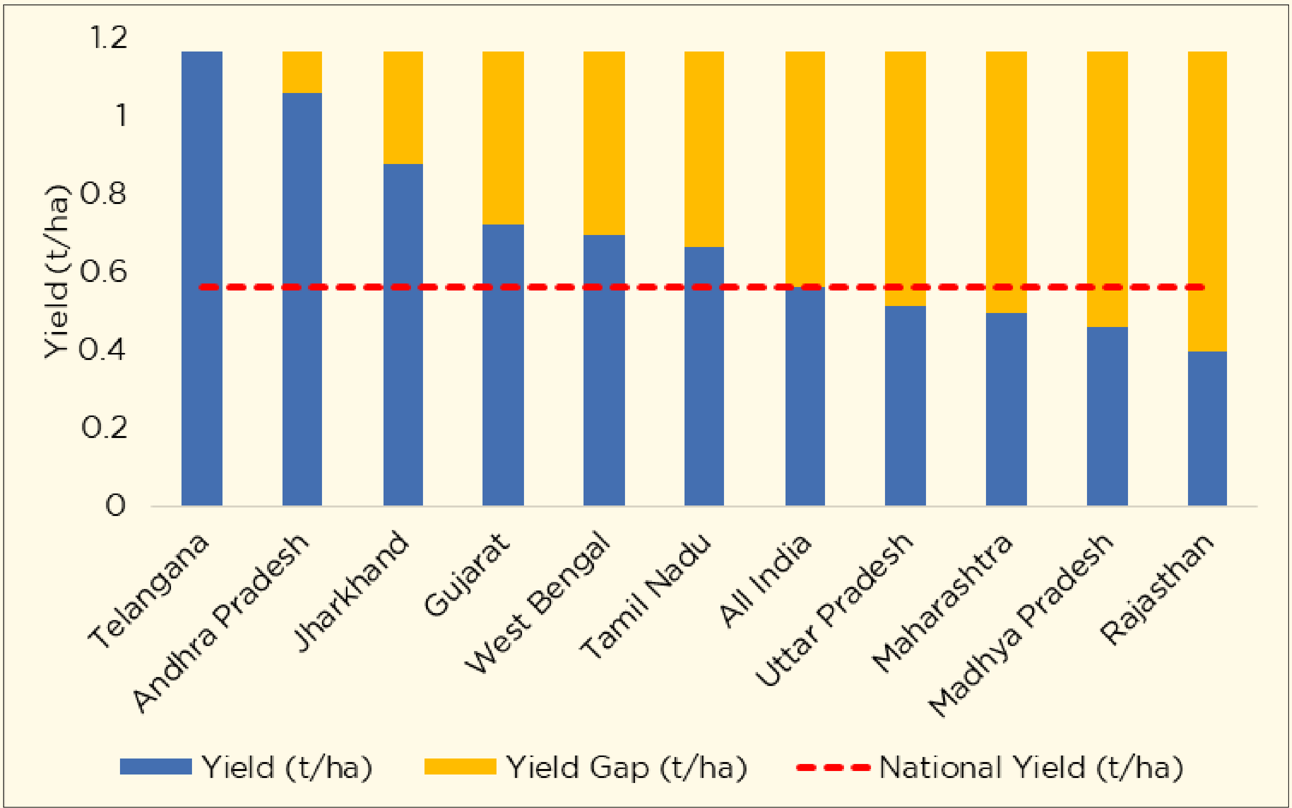
Major Producing States	Area (Mha)	Production (MT)	Yield (t/ha)	Contribution %		Ranking (Yield)
				Area	Production	
Madhya Pradesh	1.7	0.78	0.455	37.12	30.47	9
Andhra Pradesh	0.35	0.37	1.057	7.64	14.45	2
Uttar Pradesh	0.57	0.29	0.512	12.45	11.33	7
Tamil Nadu	0.41	0.27	0.659	8.95	10.55	6
Rajasthan	0.48	0.19	0.394	10.48	7.42	10
Maharashtra	0.38	0.19	0.494	8.3	7.42	8
Jharkhand	0.13	0.11	0.874	2.84	4.3	3
Gujarat	0.13	0.09	0.72	2.84	3.52	4
West Bengal	0.07	0.05	0.692	1.53	1.95	5
Telangana	0.04	0.04	1.161	0.87	1.56	1
All India	4.58	2.56	0.558	NA	NA	NA

Source: Authors' computation, data from DES, MoA&FW

Madhya Pradesh is by far the largest producer and cultivator, with an area of 1.70 Mha under cultivation (37.12% of the total) and a total production of 0.78 MT (30.47% of the total). The yield in Madhya Pradesh is a real concern (i.e. only 0.455 t/ha), ranking it ninth in terms of yield among the top ten producing states. Andhra Pradesh, the second-largest producing state, stands out with a significantly higher yield of 1.057 t/ha from an area of 0.35 Mha, resulting in a total production of 0.37 MT. This makes Andhra Pradesh the second most productive state among the top ten producers. Uttar Pradesh is the second largest cultivator, with an area of 0.57 Mha and the country's third-largest producer (0.29

MT). The yield in Uttar Pradesh is also low, only 0.512 t/ha, ranking the state eighth in the country. Tamil Nadu yielded 0.659 t/ha, ranking it sixth overall. The yield gap analysis for black gram reveals distinct differences in productivity across states. Telangana leads, with a yield of 1.161 t/ha, significantly above the national average of 0.558 t/ha, followed by Andhra Pradesh. Rajasthan has the lowest yield, leading to a yield gap of 0.767 t/ha (Figure 3.12) compared to Telangana. Madhya Pradesh, the largest producer and cultivator, faces a yield gap of 0.706 t/ha. This highlights opportunities for increasing yield efficiency, which could enhance overall production. Uttar Pradesh, the third largest producer, also shows a yield gap of 0.649 t/ha. While six states have achieved higher productivity levels than the national average yield, the remaining four states among the top ten producers, i.e., Uttar Pradesh, Maharashtra, Madhya Pradesh, and Rajasthan, have a yield below the national average of 0.558 t/ha. If these four states match the national average yield, there is a potential to increase black gram production by 0.30 MT. Additionally, if these states reach the yield levels of Telangana, the highest-yielding state for black gram, there is potential to increase production by 2.19 MT. Addressing these yield gaps through improved agricultural practices can significantly boost overall production.

Figure 3.26: Yield Gap among Major Black Gram Producing States (2018-19 to 2022-23)



Source: Authors' computation, data from DES, MoA&FW

3.5.8 Lentil

Lentil, or masur, is a widely consumed pulse in India. It is primarily consumed as dal, either whole or split, and is used in various culinary preparations, including soups and snacks. Lentil is known for its high nutritional value, particularly its high protein content and micronutrients, especially iron, zinc, and folate, and easy digestibility. It is often recommended for patients due to its gentle nature on the digestive system. Additionally, the dry leaves, stems, and empty and broken pods of lentil plants can be used as valuable fodder for livestock.

Lentil is a cool-season crop that can tolerate severe winter conditions. It thrives in temperatures ranging from 18°C to 30°C. Cold temperatures during vegetative growth and warmer temperatures during maturity are ideal for optimal yield and quality. Well-drained loam soils with a neutral pH are best for lentil cultivation. Acidic soils are not suitable for lentil cultivation. The soil should be friable and weed-free to ensure uniform seed depth during sowing. On heavy soils, one deep ploughing followed by two to three cross-harrowing is needed to improve soil structure and facilitate drainage. The field should be leveled to ensure even water distribution during irrigation by giving a gentle slope. The optimal sowing time for lentil varies depending on the region and irrigation conditions. In rainfed areas, sowing should be done in the first fortnight of October in Central and South India and the second fortnight of October in North India. Under irrigated conditions, sowing can be delayed to the first fortnight of November in North India. Late sowing, typically in the first week of December, for rice fallows of the North Eastern Plains Zone (NEPZ) or fields vacated late by kharif crops under irrigated conditions. Lentil can be effectively integrated into various cropping systems. The most common rotations under sequential cropping are as follows: in rainfed areas, lentil can be grown after a fallow period. In irrigated areas, it can be cultivated after crops like paddy, maize, cotton, bajra, jowar, or groundnut. Common intercropping systems for lentil include lentil with sugarcane, lentil with linseed, and lentil with mustard. Irrigation management is crucial for lentil cultivation. The first irrigation should be applied 40-45 days after planting, and the second light irrigation during the pod-filling stage. The most critical stages for moisture stress are pod formation and flower initiation. Two light irrigations can significantly improve lentil yield in regions with limited winter rainfall and low soil moisture, such as Central India. However, excessive irrigation can negatively impact crop performance.

The total area under lentil cultivation in India is about 1.44 Mha, resulting in a total production of around 1.33 MT. The top eight states contribute about 99.03% of the total production from 97.98% of the total area. The average national yield across the country is 0.926 t/ha, indicating room for growth in productivity across the country (Table 3.9). Ever highest area in Lentil was 1.64 Mha during 2022-23. Production and productivity peaked during 2017-18 with 1.62 MT and 1.047 t/ha respectively.

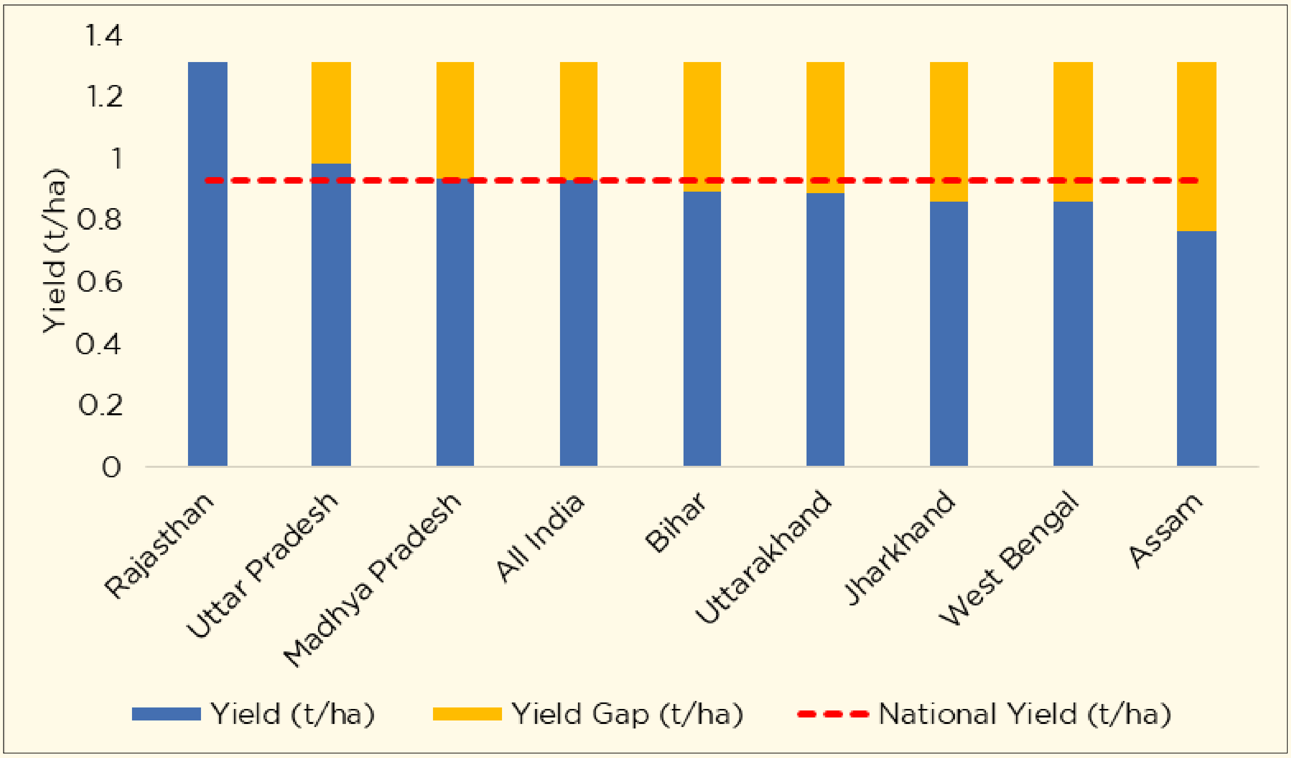
Table 3.9: Indian Scenario by Major Lentil Producing Countries States (2018-19 to 2022-23)

Major Producing States	Area (Mha)	Production (MT)	Yield (t/ha)	Contribution %		Ranking (Yield)
				Area	Production	
Uttar Pradesh	0.49	0.48	0.981	34.12	36.17	2
Madhya Pradesh	0.5	0.46	0.931	34.68	34.89	3
West Bengal	0.16	0.14	0.859	11.28	10.45	7
Bihar	0.14	0.12	0.891	9.68	9.32	4
Jharkhand	0.06	0.06	0.861	4.39	4.14	6
Rajasthan	0.02	0.03	1.313	1.32	1.88	1
Assam	0.03	0.02	0.762	1.74	1.43	8
Uttarakhand	0.01	0.01	0.887	0.77	0.75	5
All India	1.44	1.33	0.926	NA	NA	NA

Source: Authors' computation, data from DES, MoA&FW

Uttar Pradesh is the leading producer (0.48 MT), with 36.17% of the total production in the country, cultivating an area of 0.49 Mha. The yield in Uttar Pradesh is 0.981 t/ha, ranking the state second in yield among the top eight producing states. Madhya Pradesh, the largest cultivator, covers an area of 0.50Mha (34.68% of the total), producing 0.46 MT (34.89%). The yield in Madhya Pradesh is slightly lower than Uttar Pradesh at 0.931 t/ha, ranking it third. West Bengal, with an area of 0.16 Mha, the third largest producing state, produces 0.14 MT of lentil (10.45% of the total), yielding 0.859 t/ha. It ranks seventh among the top eight producing states. Bihar also contributes significantly, with an area of 0.14 Mha and a total production of 0.12 MT, achieving a yield of 0.891 t/ha, ranked fourth. The yield gap analysis for lentil reveals notable differences in productivity across states. Rajasthan has the highest yield at 1.313 t/ha, significantly above the average national yield of 0.926 t/ha. In contrast, Assam has the lowest yield at 0.762 t/ha, resulting in a yield gap of 0.551 t/ha compared to Rajasthan (Figure 3.27). While a leading producer, Uttar Pradesh faces a yield gap of 0.332 t/ha. Madhya Pradesh, the largest cultivator, also shows a notable yield gap of 0.382 t/ha compared to Rajasthan. While three states have achieved higher productivity levels than the national average yield, the remaining five states among the top eight producers, i.e., Bihar, Uttarakhand, Jharkhand, West Bengal, and Assam, have a yield below the national average of 0.926 t/ha. If these five states achieve the national average yield, there is a potential to increase lentil production by 0.019 MT. Additionally, if these states can reach the yield levels of Rajasthan, the highest-yielding state for lentil, there is a potential to increase production by 0.16 MT. Addressing these gaps can lead to enhanced overall production and better utilization of the available cultivated land in the country.

Figure 3.27: Yield Gap among Major Lentil Producing States (2018-19 to 2022-23)



Source: Authors' computation, data from DES, MoA&FW

3.5.9 Pea

Pea or matar is an important pulse crop globally, ranking third in importance after dry bean and chickpea. It is India's third most popular rabi pulse after chickpea and lentil. Pea contributes significantly to meeting the protein and nutrient demands of the population. Dry grains are used in various culinary preparations, both whole and split into the 'dal'. Besides vegetables, Pea is cultivated as a forage crop for cattle and as a cover crop to prevent soil erosion. However, the primary focus remains on producing mature seeds for human consumption.

Being a winter-season crop, pea requires a cool growing season with moderate temperatures. High temperatures are more harmful to pea crops than frost, which can damage plants during the flowering stage. High humidity associated with cloudy weather can lead to the spread of fungal diseases like damping-off and powdery mildew. The optimum monthly temperature range for pea growth is 13°C-18°C. Well-drained loamy soils (free from excessive soluble salts) with a neutral pH range of 6.5 to 7.5 are ideal for pea cultivation. The field should be well-prepared and free of crop residues to ensure optimal growth. Deep ploughing followed by 2-3 harrowing and planking is required to create a fine tilth. It is important to avoid powdery seedbeds, as they can hinder drainage and aeration, potentially leading to poor plant growth and increased disease incidence. Intercropping with autumn sugarcane can be a beneficial practice for lentil cultivation. Pea is primarily a rainfed crop, relying on residual soil moisture and exhibiting some drought tolerance. One or two irrigations applied 45 days after sowing and during the pod-filling stage may be the optimal irrigation schedule.

India's total area under pea cultivation spans 0.75 Mha, with a total production of around 0.91 MT. The top eight states contribute about 93.41% of the total production from 92% of the total area. The national average yield is 1.222 t/ha, though significant variations exist between states, indicating potential for productivity improvements (Table 3.10). Pea's highest area and production were 1.06 Mha and 1.01 MT during 2016-17. The productivity peaked at 1.440 t/ha during 2019-20.

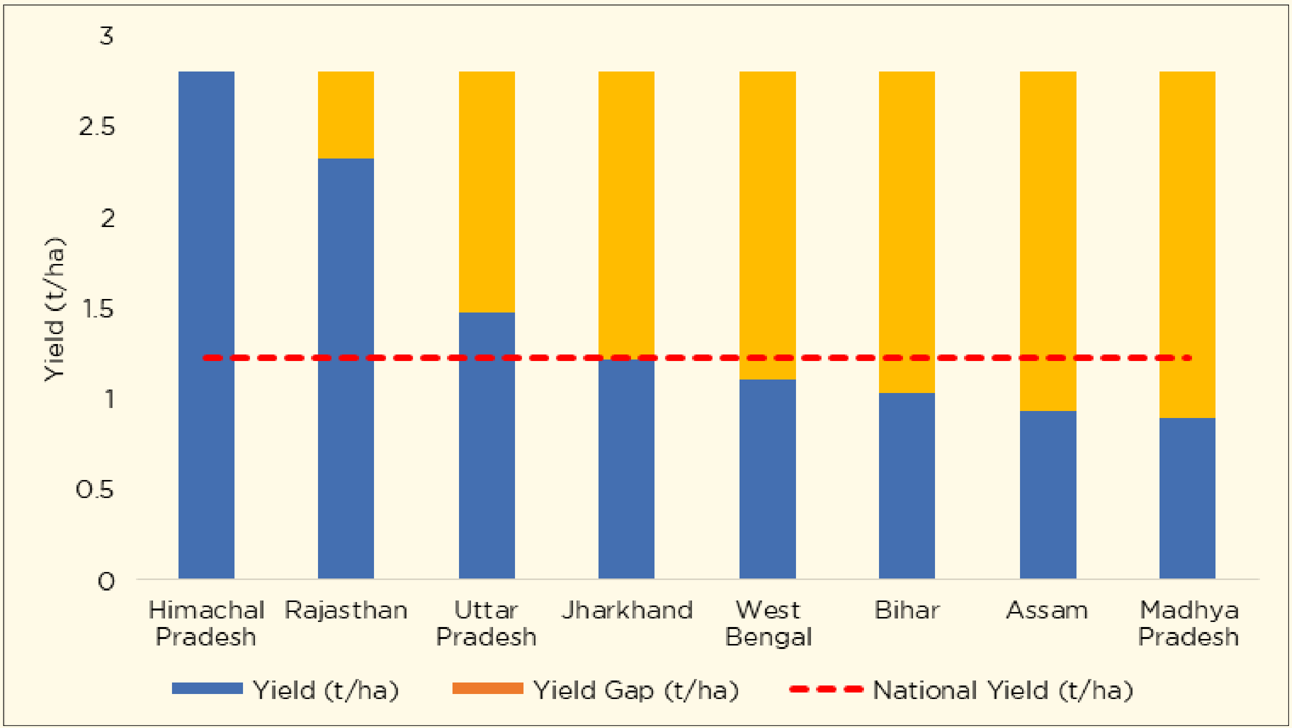
Table 3.10: Indian Scenario by Major Pea Producing States (2016-15 to 2020-21)

Major Producing States	Area (Mha)	Production (MT)	Yield (t/ha)	Contribution %		Ranking (Yield)
				Area	Production	
Uttar Pradesh	0.34	0.5	1.476	45.33	54.95	3
Madhya Pradesh	0.2	0.17	0.889	26.67	18.68	8
Jharkhand	0.06	0.07	1.216	8	7.69	4
Himachal Pradesh	0.01	0.02	2.802	1.33	2.2	1
Rajasthan	0.01	0.02	2.319	1.33	2.2	2
Assam	0.03	0.03	0.926	4	3.3	7
West Bengal	0.02	0.02	1.105	2.67	2.2	5
Bihar	0.02	0.02	1.034	2.67	2.2	6
All India	0.75	0.91	1.222	NA	NA	NA

Source: Authors' computation, data from DES, MoA&FW

Uttar Pradesh, by far, leads the country in pea cultivation and production, contributing 45.33% of the area and 54.95% of production with a yield of 1.476 t/ha. Madhya Pradesh follows in second place, covering 26.67% of the area and contributing 18.68% of the total production with the lowest yield of 0.889 t/ha among the top eight producing states, resulting in a huge yield gap of 1.913 t/ha when compared to Himachal Pradesh, the highest yielding state (2.802 t/ha) in the country (Figure 3.28). Rajasthan, the fifth largest producer of pea ranked second, with a yield gap of 0.483 t/ha. States like Jharkhand, West Bengal, and Assam show yield gaps of 1.586 t/ha, 1.697 t/ha, and 1.876 t/ha, ranked fourth, fifth, and seventh in terms of yield, respectively. While three states have achieved higher productivity levels than the national average yield, the remaining five states among the top eight producers, i.e., Jharkhand, West Bengal, Bihar, Assam, and Madhya Pradesh, have yielded below the national average. If these five states match the national average yield, there is potential to increase pea production by 0.081 MT. Additionally, if these states reach the yield levels of Himachal Pradesh, the highest-yielding state for pea, there is a potential to increase production by 0.60 MT. Addressing these yield gaps could lead to substantial gains in overall pea production in India.

Figure 3.28: Yield Gap among Major Pea Producing States (2016-17 to 2020-21)



Source: Authors' computation, data from DES, MoA&FW

3.5.10 Mothbean

Mothbean, a native crop of northern and western parts of India, is highly adaptable to hot and dry climatic conditions. It serves multiple purposes, including food, feed, fodder, green manure, and green pasture. The green pods of mothbean are a popular vegetable, while the mature seeds are used to make dal. As a rich source of protein, mothbean plays a crucial role as a cheap source of vegetable protein for balancing nutritional deficiency.

Mothbean can withstand high temperatures without compromising flowering and fruit development. The optimal temperature range for growth and development is between 25°C and 37°C. It is primarily cultivated in dry lands of arid zones with annual rainfall ranging from 250 to 500 mm, where proper drainage is essential to prevent waterlogging. In arid regions like western Rajasthan, a single deep ploughing with a mouldboard plough followed by cross-harrowing is sufficient for field preparation during good rainfall years. Alternatively, sweep cultivation with a ferti-seed drill can be used, particularly beneficial for intercropping in wide-spaced crops. Sowing of mothbean should ideally be done at the onset of the monsoon, between the first and second rain showers, typically in the second or third week of July. Delayed sowing can lead to poor germination, increased seedling mortality, and higher susceptibility to pests and diseases. Moreover, late-sown crops may experience moisture stress during the critical flowering stage, resulting in reduced yield and quality. It is primarily cultivated in dry land and rainfed conditions, but one irrigation during the pod formation stage can be beneficial in areas with prolonged dry spells. Mothbean is typically grown as a sole crop, but it can be rotated with mustard in years with favorable rainfall. Mixed cropping with pearl millet, cluster bean, cowpea, green gram, and sesame can be a suitable strategy in risk-prone areas during the monsoon season.

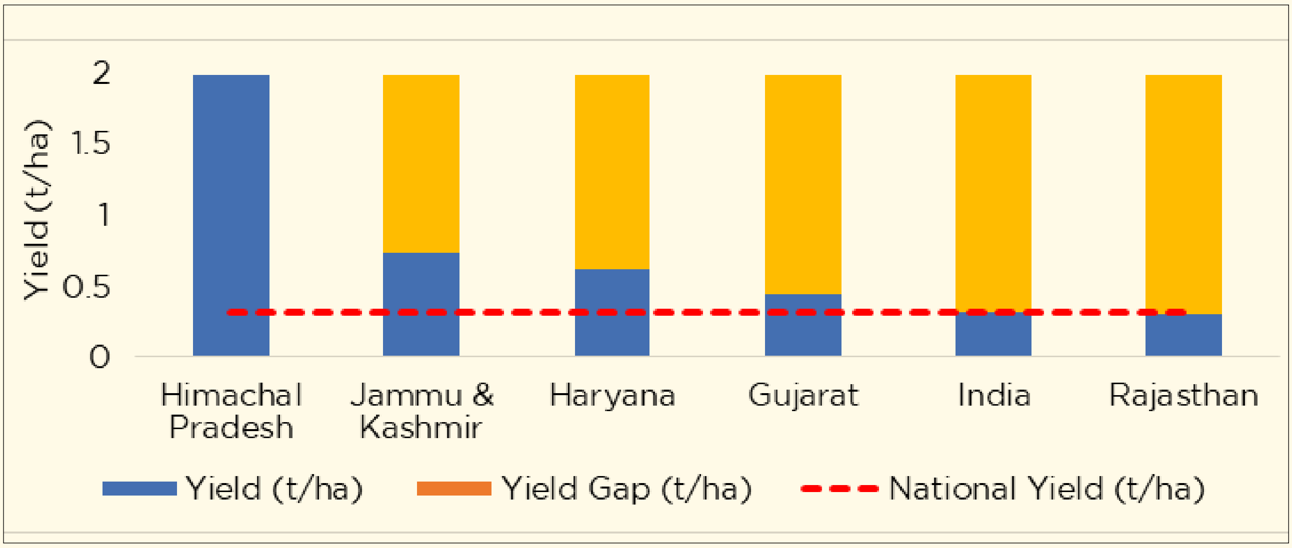
The total area under mothbean cultivation in India spans 1.09 Mha, with a total production of around 0.34 MT. The national average yield is 0.308 t/ha, with Rajasthan being the dominant contributor, accounting for 97.97% of the total area and 96.42% of the production (Table 3.11). Rajasthan's yield is close to the national average at 0.304 t/ha, indicating potential for productivity improvements. Though cultivating only 0.001 Mha, Himachal Pradesh has the highest yield in the country at 1.975 t/ha, more than 1.671 t/ha of yield than Rajasthan (Figure 3.29). Ever highest area and production achieved by Rajasthan in mothbean were 1.39 Mha and 0.43 MT during 2016-17. The productivity peaked at 0.333 t/ha during 2019-20. If Rajasthan matches the national average yield, there is potential to increase mothbean production by 0.005 MT. Additionally, if the state reaches the yield levels of Himachal Pradesh, the highest-yielding state for the mothbean, there is a potential to increase production significantly by 1.78 MT.

Table 3.11: Indian Scenario by Major Mothbean Producing States (2016-17 to 2020-21)

Major Producing States	Area (Mha)	Production (MT)	Yield (t/ha)	Contribution %		Ranking (Yield)
				Area	Production	
Rajasthan	1.067	0.324	0.304	97.98	96.43	5
Gujarat	0.019	0.009	0.44	1.74	2.68	4
Himachal Pradesh	0.001	0.002	1.975	0.09	0.6	1
Jammu & Kashmir	0.001	0.001	0.73	0.09	0.3	2
Haryana	0.001	0.0003	0.623	0.09	0.09	3
India	1.089	0.336	0.309	NA	NA	NA

Source: Authors' computation, data from DES, MoA&FW

Figure 3.29: Yield Gap among Major Mothbean Producing States (2016-17 to 2020-21)



Source: Authors' computation, data from DES, MoA&FW

In addition to the above, India also cultivates several lesser-known but important pulses. Cowpea, horse gram, lathyrus, kidney beans, and clusterbean are some of the other pulses that contribute to India's pulse production and food security.

Cowpea, also known as Lobia/Barbati/Black-eyed pea, originating from Africa and Asia, is renowned for its drought tolerance. Its wide, droopy leaves help conserve soil moisture through shading. Cowpea has diverse uses, including food, feed, forage, green manure, and vegetables. The seeds are a nutritious food source for humans, while the plant material can be used as livestock feed. Both green and dried cowpea seeds are suitable for various culinary applications, such as canning and boiling. Cowpea is primarily cultivated in arid and semi-arid regions of India in states like Punjab, Haryana, Delhi, West Uttar Pradesh, Rajasthan, Karnataka, Kerala, Tamil Nadu, Maharashtra, and Gujarat. While it is not a major pulse crop in India, it plays a significant role in the diets of rural populations.

Horse gram, or kulthi, is an important pulse crop, particularly in South India. Its seeds are used for human consumption as 'dal' or in various culinary preparations like 'rasam.' Additionally, horse gram is a valuable source of fodder for livestock. It can also be used as a green manure crop to improve soil fertility. This crop is often cultivated when the cultivator is unable to sow any other crop with delayed monsoon or in vacant spaces within citrus orchards. Horse gram is primarily cultivated in the states of Karnataka, Andhra Pradesh, Orissa, Tamil Nadu, Madhya Pradesh, Chhattisgarh, Bihar, West Bengal, Jharkhand, and the foothills of Uttarakhand and Himachal Pradesh.

Lathyrus or khesari, originating from South Europe and Western Asia, is considered a drought-tolerant hardy crop and is grown in low-rainfall regions under rainfed conditions during winter when lentil and chickpea are not expected to give good yields. The crop has a unique tolerance ability against stressful environmental conditions, not only drought but also waterlogging and salinity. In addition to use as dal and chapatti, it is usually grown as a fodder crop. Lathyrus leaves about 3648 kg/ha nitrogen economy for the succeeding crop. Lathyrus is primarily cultivated in Chhattisgarh, Bihar, Madhya Pradesh, Maharashtra, and West Bengal.

Kidney bean, is an important pulse crop with high-yielding potential compared to gram and pea. Kidney bean is highly nutritious and traditionally grown in the hilly regions of Maharashtra, Himachal Pradesh, Uttar Pradesh, Jammu & Kashmir, and the Northeastern states. Its cultivation is now expanding to the northern plains during the rabi and summer seasons. To realize the full potential of kidney bean production, focused attention is needed.

India is the native origin of clusterbean or guar, a crop widely cultivated in Rajasthan, Gujarat, Haryana, and Uttar Pradesh. Rajasthan is the leading state in clusterbean cultivation and production in India. While the seeds are consumed as a vegetable, the primary economic value lies in clusterbean gum, a gum extracted from the clusterbean. India is a major exporter of processed clusterbean, accounting for about 90% of global exports.

3.6 Volatility in Pulse Crop Yield- National and State Level: A Decadal Analysis

This section delves into the yield volatility of major pulse crops in India. By examining crop-specific, state-specific, and time-specific patterns and trends, this study measures the extent of yield variation over time. The standard deviation of growth rates is a statistical measure employed to quantify yield volatility. Higher standard deviation values signify greater variability in crop yield across different growth stages, indicating unstable production patterns.

This instability can be attributed to many factors, including climate change, suboptimal input use, infrastructure limitations, and substandard agricultural practices. Identifying the precise factors driving this instability is paramount for developing targeted strategies to enhance the stability and sustainability of pulse production.

To assess national-level yield variability, a comprehensive analysis of seven pulse crops (i.e., pigeonpea, gram, green gram, black gram, lentil, pea, and mothbean) along with total pulses was conducted across five distinct phases (1970-71 to 1979-80, 1980-81 to 1989-90, 1990-91 to 1999-00, 2000-01 to 2009-10, and 2010-11 to 2022-23). For the state-level analysis, the study considered major producing states for each pulse crop. These states were then analyzed for yield volatility over the same five distinct phases to understand trends and patterns in yield volatility. While some data gaps were encountered, these were addressed through substitution from nearby years or noted as unavailable. Understanding these volatility trends is essential for informed decision-making in the pulse sector's agricultural planning and risk management strategies.

3.6.1 National Level Volatility Analysis

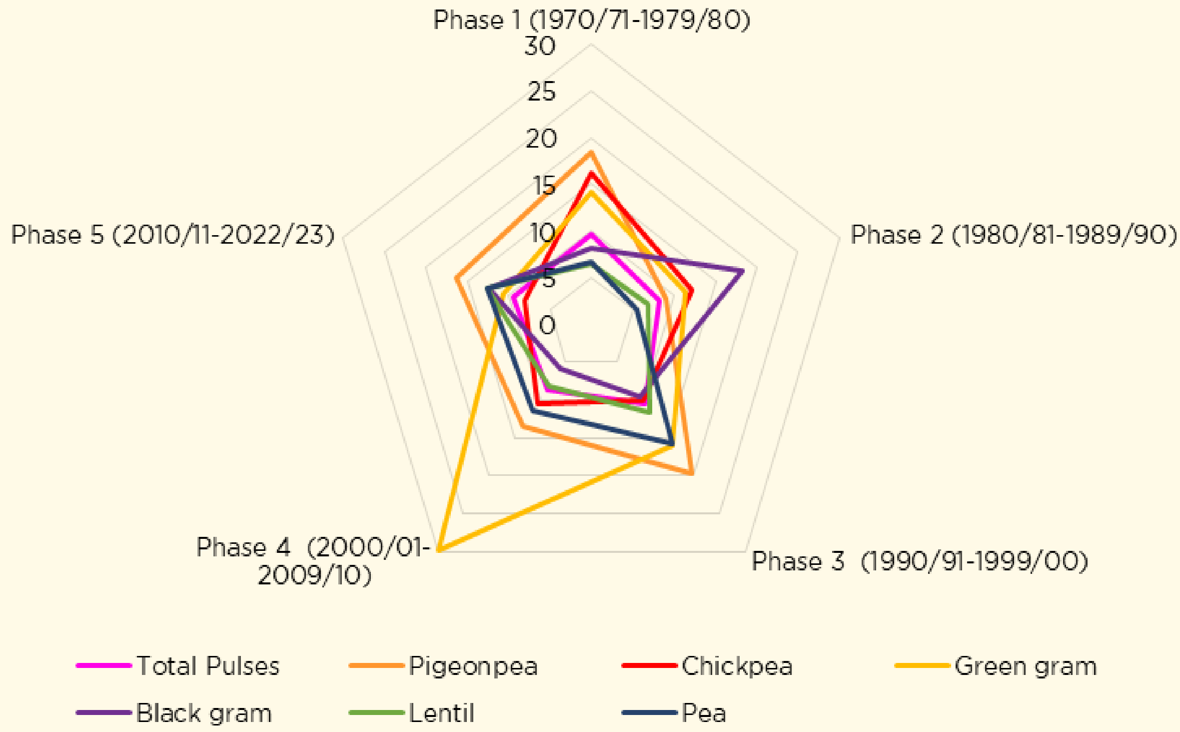
The table (Table 3.12 and Figure 3.30) provides a detailed analysis of yield volatility for major pulse crops across five distinct phases at the national level. Generally, for most pulse crops (except mothbean), the volatility in crop yield ranges from 5% to 20%, while green gram exhibits higher volatility in Phase 4, with a value of 29.9%. However, significant variations among crops and phases highlight the need for continued efforts to improve yield stability through targeted interventions.

Table 3.12: Volatility in Yield of Major Crops across Five Phases (%)

Crop	Phase 1 (1970/71-1979/80)	Phase 2 (1980/81-1989/90)	Phase 3 (1990/91-1999/00)	Phase 4 (2000/01-2009/10)	Phase 5 (2010/11-2022/23)
Total Pulses	9.6	8.3	10.4	8.6	9.4
Pigeonpea	18.4	9.0	19.6	13.5	16.4
Chickpea	16.1	12.2	10.1	10.5	8.1
Green gram	14.1	11.3	15.9	29.9	10.6
Black gram	8.2	18.3	9.6	5.9	12.4
Lentil	6.5	6.8	11.5	8.2	12.6
Pea	6.7	5.5	15.7	11.4	12.6
Mothbean	115.5	180.1	73.8	184.4	24.7

Source: Authors' computation, data from DES, MoA&FW

Figure 3.30: Volatility in Yield of Major Pulse Crops across Five Phases (%)



Source: Authors' computation, data from DES, MoA&FW

The overall phase-wise volatility trend of the total pulse is not much fluctuating. The highest volatility was observed in Phase 3 and the lowest in Phase 2. On average, pigeonpea exhibited higher volatility compared to other major pulse crops. The highest volatility was observed in Phase 3 and the lowest in Phase 2. Chickpea shows a downward trend in volatility, reflecting yield volatility stabilization. The highest volatility was observed in Phase 1 and the lowest in Phase 5. The volatility in the green gram is fluctuating. The highest volatility was observed in Phase 4 and the lowest in Phase 5. In the case of black gram, the highest volatility was observed in Phase 2 and the lowest in Phase 4. Lentil exhibits relatively low volatility compared to other pulses in the initial phases. The highest volatility was observed in the last phase where the lowest in Phase 1. Pea also shows relatively low volatility, like lentil, compared to other pulses in the initial phases, with little more fluctuations than lentil across different phases. The highest volatility was observed in Phase 3 and the lowest in Phase 2. Mothbean consistently exhibits the highest volatility across all phases, with the highest volatility observed in Phase 4 and the lowest in Phase 5, which is a positive sign of decreasing volatility over time.

3.6.2 State-Level Volatility Analysis

Based on the spatial-temporal analysis, phase-wise volatility in pulse crop yield in major producing states is reported in Table 3.13. It is observed that significant variations exist among major producing states and phases for each pulse crop.

Total Pulses: Madhya Pradesh exhibits a relatively stable yield pattern across phases, with the highest volatility observed in Phase 4 and the lowest in Phase 2. Maharashtra shows considerable variation in yield volatility across phases. The highest volatility is observed in Phase 3, and the lowest in Phase 2. Rajasthan exhibits high volatility across all phases compared to other states. However, a significant decrease in volatility is observed in Phase 5, which is lowest among all states. Uttar Pradesh shows moderate stable volatility across phases, with the highest volatility observed in Phase 1 and the lowest in Phase 2. Karnataka exhibits a relatively high yield volatility pattern after Rajasthan, with the highest volatility observed in Phase 1 and the lowest in Phase 2.

Pigeonpea: At the crop-specific level, pigeonpea in Maharashtra exhibited high fluctuations in yield volatility across phases. This state shows the highest volatility in phase 3 and the lowest in phase 2. Karnataka shows a relatively high level of volatility across all phases compared to others, with the highest volatility in phase 3 and the lowest in phase 2. Uttar Pradesh shows lower volatility across phases, with the highest volatility observed in phase 1 and the lowest in phase 3. Gujarat shows a fluctuating trend in volatility across phases, with the highest volatility observed in Phase 2 and the lowest in Phase 5. Jharkhand shows the lowest level of volatility in the last phase, with a huge decline from the previous phase. Madhya Pradesh shows a relatively stable trend in volatility except for the last phase, with the highest volatility observed in phase 5 and the lowest in phase 4.

Chickpea: Madhya Pradesh exhibits relatively lower volatility across most phases compared to other states for chickpea, with the highest volatility observed in Phase 1 and the lowest in Phase 2. Maharashtra demonstrates a higher level of volatility across most phases than other states, with the highest volatility observed in Phase 1 and the lowest in Phase 4. In Rajasthan, the highest volatility was observed in Phase 4, though it declined significantly in the last phase, the lowest among all phases. Gujarat exhibits a fluctuating trend in volatility across phases, with the highest volatility in Phase 1 and the lowest in Phase 5. Uttar Pradesh shows a decreasing trend in volatility over time in the initial three phases but an increasing trend in the later phases, with the highest volatility in Phase 1 and the lowest in Phase 3.

Green gram: Rajasthan consistently showed high volatility across most phases for green gram, with the highest volatility observed in Phase 4 and the lowest in the last phase with a noticeable decline. Madhya Pradesh shows a lower volatility across phases than other states except the last phase, where the highest volatility was observed and the lowest in Phase 4. Maharashtra exhibited the highest volatility in Phase 5, followed by phase 3, and lowest in Phase 1. Karnataka shows a fluctuating trend in volatility across phases, with the highest volatility observed in Phase 1 and the lowest in Phase 2. Bihar shows a decreasing trend in volatility over time, reflecting yield volatility stabilization, with the highest volatility observed in Phase 1 and the lowest in Phase 5.

Black gram: Madhya Pradesh shows relatively low volatility for black gram across phases compared to other states except the last phase, where the highest volatility was observed and the lowest in Phase 1. Andhra Pradesh shows low volatility in the last three phases compared to other states, with the highest volatility observed in Phase 2 and the lowest in Phase 3. Uttar Pradesh shows relatively less fluctuations in volatility, with moderate values across all phases. In this state, the highest volatility was observed in Phase 1 and the lowest in Phase 3. Tamil Nadu shows a fluctuating trend in volatility across phases, with the highest volatility observed in Phase 2 and the lowest in Phase 3. Rajasthan consistently showed high volatility across all phases, with the highest volatility observed in Phase 2 and the lowest in phase 5.

Lentil: Uttar Pradesh shows relatively low yield volatility and a stable trend compared to other states across phases for lentil, with the highest volatility observed in Phase 5 and the lowest in Phase 2. Madhya Pradesh shows a declining trend in volatility in the initial three phases then the trend increases, with the highest volatility observed in Phase 5 and the lowest in Phase 3. West Bengal exhibited the highest volatility in Phase 4 and the lowest in the subsequent phase. Bihar shows a fluctuating trend across phases, with the highest volatility observed in Phase 3 and the lowest in Phase 2. Jharkhand shows a relatively stable volatility, with moderate values across the two phases.

Pea: Uttar Pradesh exhibits relatively low yield volatility and a stable trend for Pea across phases compared to other states, except for Phase 3, where the highest volatility was observed. The lowest volatility was observed in the final phase. Madhya Pradesh shows a fluctuating trend in yield volatility over the initial three phases, with the highest volatility in Phase 3 and the lowest in Phase 2. Jharkhand demonstrates an increase in volatility, with the highest volatility observed in Phase 5. Himachal Pradesh exhibits an increasing trend in yield volatility across phases, with the highest volatility observed in the final phase. Rajasthan consistently showed high volatility across all phases, except for Phase 3 where it exhibited the lowest volatility among all states. The highest volatility for Rajasthan was observed in Phase 1.

Mothbean: For mothbean, Rajasthan consistently exhibited high volatility across all phases, except for the final phase where it was significantly lower. The highest volatility was observed in Phase 2. Himachal Pradesh displayed low yield volatility in phase 4 but increased significantly in the final phase. Gujarat demonstrated a decreasing trend in yield volatility until phase 4, with the highest volatility in phase 2 and the lowest in phase 4.

The analysis of yield volatility across different pulse crops and states over time reveals significant variations. While states and crops have achieved low volatility and relative stability in some cases, others continue to face challenges in terms of yield fluctuations. Factors like climate variability, pest and disease outbreaks, and inadequate management practices contribute to yield volatility. However, implementing improved agricultural practices, such as adopting high-yielding varieties, efficient irrigation systems, and integrated pest management, has led to a decline in volatility in certain regions. To further enhance the stability of pulse production, it is crucial to promote the adoption of advanced technologies, and strengthen extension services. Additionally, targeted interventions that support sustainable agriculture, climate-resilient practices, and market linkages can significantly mitigate yield volatility and ensure food security.

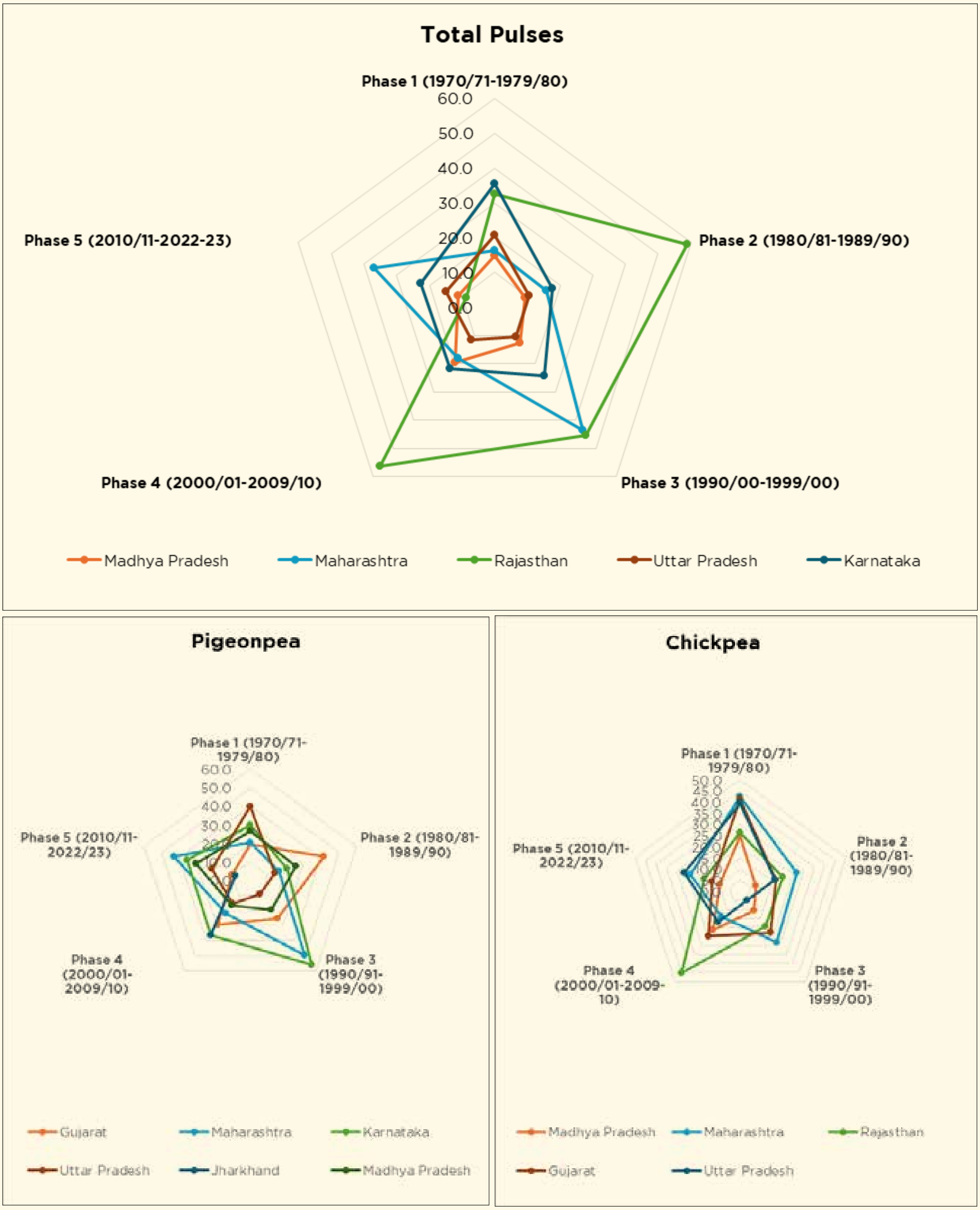
Table 3.13: Phase-wise Volatility in Pulses Crop Yield in Major Pulses-Producing States (%)

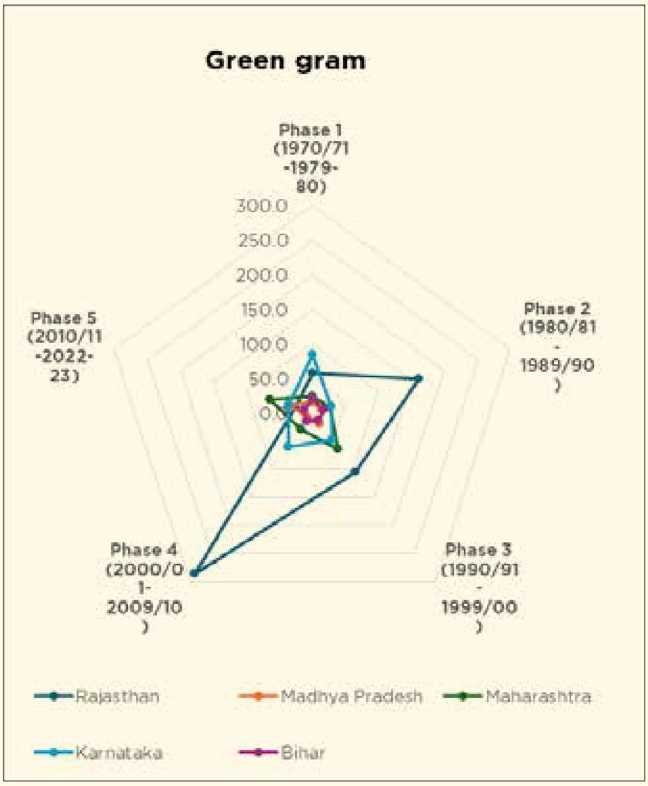
Major Producing States	Phase 1 (1970/71-1979/80)	Phase 2 (1980/81-1989/90)	Phase 3 (1990/91-1999/00)	Phase 4 (2000/01-2009/10)	Phase 5 (2010/11-2022/23)
Total Pulses					
Madhya Pradesh	14.8	9.2	12.6	19.7	11.1
Maharashtra	16.4	15.6	43.5	18.0	36.8
Rajasthan	32.6	58.7	45.3	56.5	8.8
Uttar Pradesh	20.6	10.5	10.6	11.5	14.8
Karnataka	35.5	17.7	24.4	21.8	22.6
Pigeonpea					
Maharashtra	20.8	16.3	49.6	22.0	42.8
Karnataka	30.1	21.2	56.3	36.1	35.5
Uttar Pradesh	40.0	13.8	9.2	15.4	21.6
Gujarat	19.7	41.9	25.3	29.4	10.5
Jharkhand				36.0	8.4
Madhya Pradesh	26.9	26.1	19.6	16.5	30.8
Chickpea					
Madhya Pradesh	24.9	7.1	10.7	21.4	9.9
Maharashtra	42.5	26.7	28.1	14.1	24.0
Rajasthan	26.3	20.0	19.5	45.3	17.4
Gujarat	41.5	16.7	22.9	24.7	13.4
Uttar Pradesh	39.3	16.6	5.0	17.1	26.8
Green gram					
Rajasthan	57.8	160.5	104.9	287.5	26.1
Madhya Pradesh	16.1	14.7	18.3	9.6	34.6
Maharashtra	24.0	26.8	63.5	29.2	64.2
Karnataka	83.8	29.1	48.2	60.1	37.2
Bihar	20.5	17.2	13.6	14.5	12.2

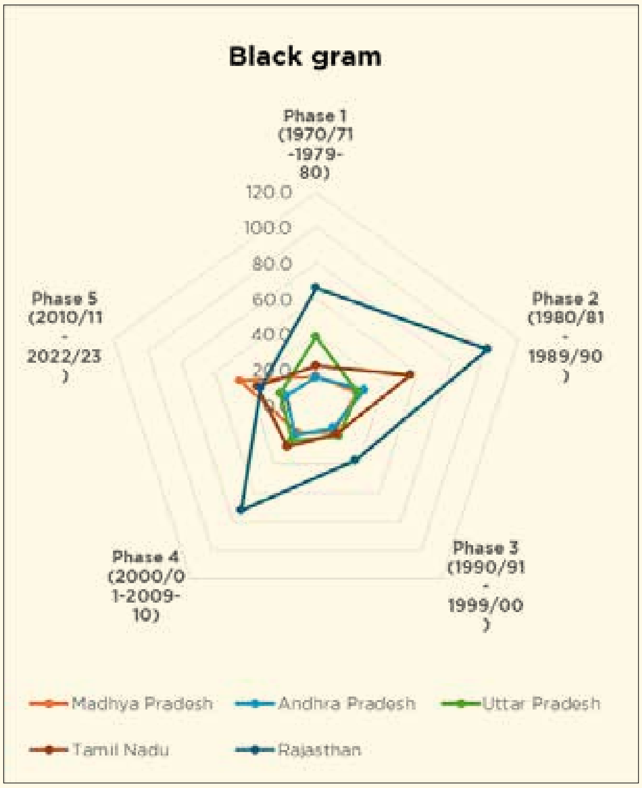
Major Producing States	Phase 1 (1970/71-1979/80)	Phase 2 (1980/81-1989/90)	Phase 3 (1990/91-1999/00)	Phase 4 (2000/01-2009/10)	Phase 5 (2010/11-2022/23)
Black gram					
Madhya Pradesh	16.3	24.3	17.6	18.5	45.2
Andhra Pradesh	16.0	28.2	15.9	20.5	17.7
Uttar Pradesh	38.6	24.5	21.2	23.9	21.4
Tamil Nadu	22.7	55.8	19.1	28.1	35.1
Rajasthan	66.1	101.0	37.7	72.0	32.6
Lentil					
Uttar Pradesh	13.4	11.3	12.4	14.1	18.0
Madhya Pradesh	15.4	7.6	6.5	13.8	24.3
West Bengal	22.5	23.5	17.5	25.4	16.3
Bihar	19.3	9.2	30.7	12.3	19.3
Jharkhand				14.1	14.3
Pea					
Uttar Pradesh	8.0	8.0	23.1	13.4	6.4
Madhya Pradesh	21.8	7.3	24.5	15.0	16.6
Jharkhand				24.5	28.6
Himachal Pradesh			9.3	22.0	42.3
Rajasthan	32.1	23.2	4.4	26.4	19.0
Mothbean					
Rajasthan	161.8	1176.0	91.0	355.4	24.4
Himachal Pradesh				15.5	676.3
Gujarat		316.5	164.5	108.7	144.7

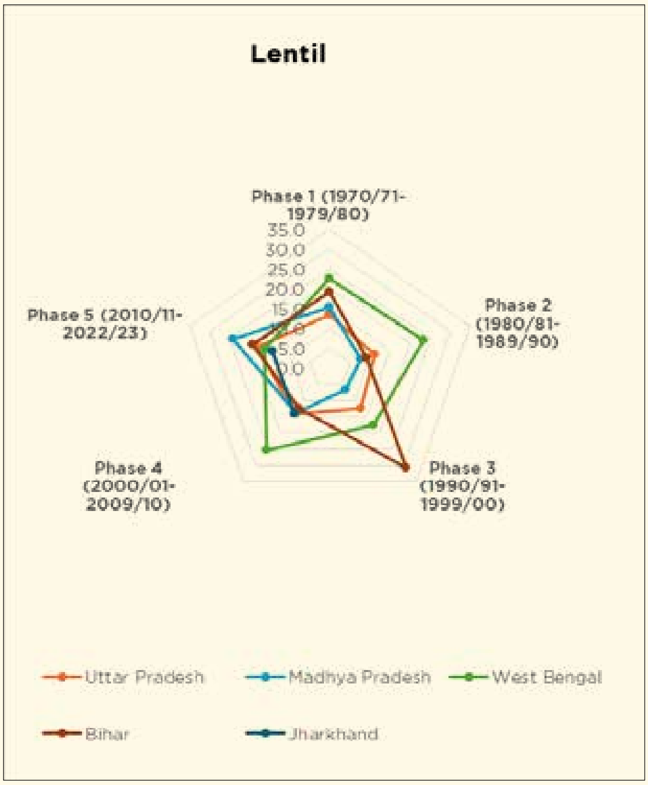
Source: Authors' computation, data from DES, MoA&FW

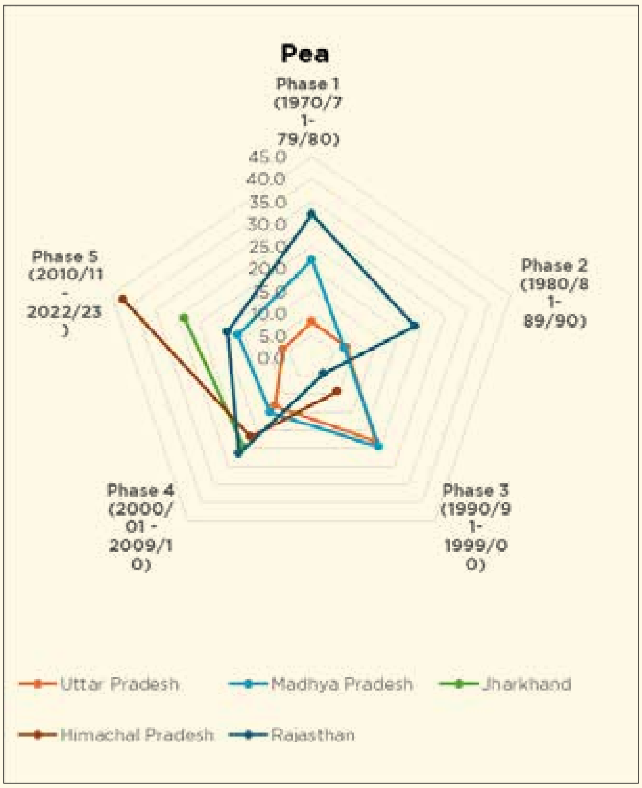
Figure 3.31: Volatility in Yield of Major Pulses in Major Producing States











Author's calculation

3.7 Decomposition of Pulse Crop Production - National and State Level: Decadal Analysis

A decomposition analysis was conducted at national and state levels for major pulse crops cultivated in India to understand the factors driving changes in pulse production. This analysis helps to quantify the relative contributions of changes in area and yield to overall production changes. The additive decomposition approach, which is widely used for its simplicity and interpretability, was employed. The analysis involves comparing the initial ($P0$) and at the nth year production (Pn) levels, considering the changes in area ($A0$ to An) and yield ($Y0$ to Yn) over that specified period. This approach provides valuable insights into the drivers of production growth and helps identify areas for further intervention to enhance pulse production.

For example,

$$P0 = A0 * Y0$$

$$Pn = An * Yn$$

The change in production, area, and yield is represented as:

$$\Delta P = Pn - P0$$

$$\Delta A = An - A0$$

$$\Delta Y = Yn - Y0$$

From above,

$$P + \Delta P = (A + \Delta A) * (Y + \Delta Y)$$

$$P = (A0 * \Delta Y * 100 / \Delta P) + (Y0 * \Delta A * 100 / \Delta P) + (\Delta A * \Delta Y * 100 / \Delta P)$$

Production = Yield effect + area effect + interaction effect

This analysis breaks down production changes into three components: yield effect, area effect, and the interaction effect between area and yield. By analyzing these components for major pulse-producing states and seven key pulse crops (pigeonpea, chickpea, green gram, black gram, lentil, pea, and mothbean), the study provides insights into the specific factors contributing to production over time covering five phases: 1970/71 to 1979/80 (Phase 1), 1980/81 to 1989/90 (Phase 2), 1990/91 to 1999/00 (Phase 3), 2000/01 to 2009/10 (Phase 4), and 2010/11 to 2022/23 (Phase 5).

3.7.1 National Level Decomposition Analysis

The national-level decomposition analysis reveals the dynamic interplay of yield, area, and their interaction in driving pulse production across different phases (Table 3.14).

Total Pulse: At the national level, for total pulses, the overall decomposition analysis suggests that yield was the dominant factor in the initial phase, while the area effect gained prominence from Phase 2 onwards, particularly in Phase 3. The area effect drove the change in production in phase 3. Phase 4 witnessed a more balanced contribution from both area and yield and in the final phase (Phase 5), yield emerged again as the primary driver. The interaction effect, while present, played a relatively minor role across all phases.

Pigeonpea: The yield effect was dominant in the initial phase, contributing significantly to pigeonpea production. However, in the subsequent phase, area expansion gained prominence. Interestingly, yield again became the primary driver of pigeonpea production since the third phase.

Chickpea: The initial phase was dominated by the yield effect, which was the primary driver of production for chickpea. Subsequently, the area effect became more significant, particularly in Phase 3. In Phase 4, area was the primary driver, with yield and their interaction also contributing positively. The final phase witnessed chickpea production primarily driven by yield, with the area and the interaction effect playing supporting roles.

Green gram: In the initial phase, the yield effect played a dominant role in driving green gram production. Subsequently, in Phases 2 and 3, both area and yield contributed to production. In Phase 4, yield was the primary driver of production. The final phase witnessed production was driven by a combination of area, yield, and their interaction.

Black gram: The area effect was initially the primary driver of black gram production. In Phase 2, both area and yield contributed positively to production. Phase 3 was dominated by area effect, while Phase 4 saw contributions from both area and yield. The final phase witnessed a more balanced contribution from both area and yield and a positive interaction effect.

Lentil: The yield effect was dominant in the first phase, contributing significantly to Lentil production. In Phase 2, yield and area and their interaction also contribute positively. Phase 3 production was primarily driven by the area with positive yield and interaction effect. The last two phases witnessed production driven primarily by yield with a positive area and interaction effect.

Pea: In the initial phase, both area and yield contributed positively to production, although the interaction effect had a negative impact. Phase 2 witnessed a more balanced contribution from all three factors—area, yield, and their interaction. The area effect primarily drove production in Phase 3. In the final two phases, the yield effect emerged as the dominant driver of production.

Mothbean: Initially, the yield effect was dominant, contributing significantly to mothbean production. The second phase also witnessed yield dominance. Production was primarily driven by yield in the third phase, while the area effect contributed positively. The fourth phase was primarily yield-driven, while the interaction effect contributed positively. The final phase witnessed production driven by both area and yield, with a negative interaction effect.

Overall, the analysis quantifies the relative contributions of yield, area, and their interaction with changes in pulse production over time. Understanding these dynamics is crucial for developing effective strategies to enhance pulse production further and achieve self-sufficiency.

Table 3.14: Decomposition Analysis of Output for Major Pulse Crops: National Level Analysis (1970/71 to 2022/23)

Crop	Phase 1 (1970/71-1979/80)			Phase 2 (1980/81-1989/90)			Phase 3 (1990/91-1999/00)			Phase 4 (2000/01-2009/10)			Phase 5 (2010/11-2022/23)		
	Y	A	I	Y	A	I	Y	A	I	Y	A	I	Y	A	I
Total pulses	96.6	4.6	-1.2	11.8	81.2	7.0	-47.5	126.9	20.6	48.4	44.6	7.0	71.2	22.1	6.7
Pigeonpea	138.7	-42.7	4.0	26.8	66.1	7.1	147.2	-40.4	-6.8	154.2	-47.1	-7.1	154.0	-43.5	-10.5
Chickpea	77.7	30.7	-8.5	32.5	68.0	-0.6	-380.5	410.9	69.6	24.6	61.3	14.1	62.8	28.4	8.8
Green gram	623.63	-773.31	159.68	40.9	51.7	7.4	46.6	59.6	-6.2	106.0	-9.0	2.9	29.3	55.1	15.7
Black gram	-80.1	205.4	-25.3	51.9	69.3	-21.2	-31.0	126.6	4.3	64.9	36.2	-1.1	43.2	47.1	9.7
Lentil	165.5	-86.4	20.9	53.3	36.6	10.1	11.0	86.5	2.5	98.8	1.1	0.1	93.9	3.8	2.3
Pea	54.0	61.4	-15.4	55.4	33.7	10.8	-16.9	124.3	-7.4	101.1	-17.2	16.1	143.6	-25.9	-17.7
Mothbean	88.4	22.6	-11.0	103.7	-2.4	-1.3	89.6	46.2	-35.8	107.5	-29.6	22.1	50.4	69.7	-20.1

Note- Y stands for Yield, A stands for Area, and I stand for Interaction

Source: Authors' computation, data from DES, MoA&FW

3.7.2 State-Level Analysis

The state-level decomposition analysis reveals distinct patterns in the contributions of yield effect, area effect, and their interaction effect to pulse production across major producing states and phases (Table 3.15).

Total Pulses: In Madhya Pradesh, the yield was initially the primary driver of total pulse production. Subsequently, the area effect gained prominence, particularly in phase 3. In phase 4, a balanced combination of area, yield, and their interaction effect contributed positively. The yield effect once again dominated phase 5. For Maharashtra, the initial phase was characterized by yield dominance, followed by a balanced contribution from area, yield, and their interaction in phase 2. However, yield effects became dominant in phases 3 and 4. A balanced combination of area, yield, and their interaction in the final phase contributed to production growth. In Rajasthan, yield was the primary driver in Phase 1, followed by a shift towards area effect, particularly until Phase 3. In Phase 4, yield regained significance, contributing positively to the interaction effect. The final phase was primarily driven by area effect. While yield dominated the initial phase in Uttar Pradesh, the area effect became more significant in subsequent phases. Phase 4 witnessed contributions from both yield and area. In the final phase, a combination of yield, area, and their interaction effect drove production growth. For Karnataka, a combination of area, yield, and their interaction effect drove production initially. Subsequently, the area became more significant in phase 2. Yield dominance was observed in phase 3. In phase 4, area effect was the primary driver. The final phase witnessed yield as the primary driver of production enhancement.

Pigeonpea: In Gujarat, the area was initially the primary driver of pigeonpea production. The area effect continued with its prominence in phase 2. In phase 3, a balanced combination of area and yield contributed positively. In phases 4 and 5, the yield effect dominated and contributed to the growth of pigeonpea production. For Maharashtra, the initial phase was characterized by yield dominance, followed by a balanced contribution from area and yield in phase 2. However, yield effects again became dominant in phases 3 and 4. In the final phase, the area was the primary driver of production growth. In Karnataka, the yield was the primary driver in phase 1, with some contribution from the area. This was followed by a shift towards area effect in phase 2. In Phase 3, yield regained significance with a minor contribution from area. However, in phase 4, a balanced combination of area and yield contributed to growth in pigeonpea production. The area effect primarily drove the growth in the final phase. While yield dominated the initial phase in Uttar Pradesh, the area effect became significant in phase 3. Phase 4 witnessed contributions from both yield and area. In the final phase, the yield effect drove production growth. For Jharkhand, a combination of yield and the interaction effect drove production in phase 3. Subsequently, the area became significant in phase 4 and was the primary contributor to production growth. For Madhya Pradesh, the yield effect dominated in the initial phases, with the area effect gaining prominence in phase 3. In phase 4, a balanced combination of area and yield contributed positively. The area and interaction effect contributed to growth in pigeonpea production in phase 5.

Chickpea: The area was initially the primary production driver in Madhya Pradesh. In phase 2, a balanced combination of area and yield contributed positively. In Phase 3, the yield effect dominated, following a combination of area and yield contributing to production growth in Phase 4. In the final phase, the yield effect was the primary driver. In Maharashtra, yield was the primary driver in Phase 1, followed by a balanced area contribution and yield in Phase 2. In phase 3, the area effect again gained prominence. A balanced combination of yield and area effect marked phase 4. In phase 5, the area effect was the primary driver of production growth. In Rajasthan, the yield effect was the primary driver of growth in phase 1 and phase 2. However, in subsequent phases, the area effect gained prominence. In phase 3, the area effect dominated production with a minor contribution from the interaction effect. The area continued its dominance in phases 4 and 5, with the yield effect contributing to some growth in phase 5. In Gujarat, the yield effect was the primary driver in phase 1. In phases 2 and 3, the area effect gained prominence. In phase 4, a balanced combination of the area and interaction effect contributed to production growth. In phase 5, both the area and yield contributed to growth in production, with the area effect being the dominant one. In Uttar Pradesh, the yield effect was the primary driver of production growth, with some contribution from the area. In phase 2, a balanced combination of yield and area contributed to production growth. In phase 4, the area effect was the primary driver, and finally, in phase 5, the yield effect gained prominence and contributed positively.

Green gram: In Rajasthan, the yield was the primary driver of the production in phase 1, with some contribution from the area. In phases 2 and 3, the yield was the primary driver with contribution from the interaction effect. In phase 4, a balanced combination of yield and interaction contributed positively. Finally, in phase 5, the area was the dominant contributor to production. In Madhya Pradesh, the yield effect was the primary driver in production in phase 1. Phases 2 and 3 were marked by area as the primary driver. In phase 4, the yield effect regained its prominence. In the final phase, the area and the interaction effect contributed positively. In Maharashtra, a balanced contribution of yield and area contributed positively in phase 1. In phases 2 and 3, the yield effect gained dominance. In phase 4, the area effect was the primary driver of growth in green gram production. In phase 5, the area effect dominated with a minor contribution from the yield effect. In Karnataka, the area effect was the primary growth driver in Phase 1. In phase 2, a balanced combination of the area and the yield effect contributed positively. In phase 3, the area effect contributed primarily to growth. In phase 4, the yield was the primary driver, with a minor contribution from the area. In the final phase, however, a balanced combination of yield and area together steered growth in the production of green gram. In Bihar, in phases 1 and 2, a balanced combination of area and yield contributed positively. In phase 3, area was the primary driver, and in phase 4, yield and area contributed positively. Finally, in phase 5, the yield was the dominant contributor to production.

Black gram: In Madhya Pradesh, yield was the primary driver of production in phase 1, with some contribution from the interaction effect. In phase 2, a balanced combination of yield and area contributed positively. In phase 3, yield was the primary driver in the production of black gram. In phase 4, yield dominated with some contribution from the area. Finally, in phase 5, the area and interaction effects contributed positively. In Andhra Pradesh, the area effect dominated initially in Phase 1; however, in Phase 2, the yield effect gained prominence. In phase 3, the area effect regained its prominence. In phase 4, both area and yield contributed positively, with the area continuing to dominate. In the final phase 5, the yield effect was the primary driver in production. In Uttar Pradesh, the yield effect dominated in phase 1 with a minor contribution from the interaction effect. In phase 2, a balanced combination of yield and area contributed positively. In phases 3 and 4, the area effect was dominant. In phase 5, the yield effect was the primary driver in production with a minor contribution from the interaction effect. In Tamil Nadu, area effect was the primary driver with a minor contribution from yield in phase 1. In phase 2, both yield and area contributed positively. In phase 3, the yield and interaction effect contributed positively. In phase 4, the yield effect was dominant with a minor contribution from the area. In phase 5, both yield and area contributed positively. In Rajasthan, yield and interaction effects contributed positively in phase 1. In phase 2, both area and yield contributed positively. However, in phase 3, the area gained dominance with a minor contribution from the interaction effect. In phase 4, the yield effect was dominant; in the final phase 5, area was the primary driver in production.

Lentil: In Uttar Pradesh, yield was the primary driver of production in phase 1, with some contribution from the interaction effect. In phases 2 and 3, a combination of area and yield contributed positively, with area as the dominant factor. In phases 4 and 5, the yield was the primary driver in the production of Lentil. In Madhya Pradesh, yield was the primary driver in production in phase 1. In phase 2, a combination of yield and area contributed positively. In phase 3, the area was the primary driver in production. In phases 4 and 5, yield regained dominance and was the primary driver in Lentil production. In West Bengal, area was the dominant factor in production in phase 1. However, in phase 2, yield gained prominence. In phase 3, both yield and area contributed positively. In phases 4 and 5, area was the dominant driver in production. In Bihar, in phase 1, yield was the primary driver in production, with a minor contribution from the interaction effect. In subsequent phases, in phases 2, 3, and 4, yield was the primary driver in production. In the final phase, the area was the primary driver in production, with a minor contribution from the interaction effect. In Jharkhand, the area effect was dominant in phases 4 and 5 and has been the primary driver in Lentil production.

Pea: In Uttar Pradesh, the area was the primary production driver in phase 1, with a notable contribution from yield. In phase 2, a combination of area and yield contributed positively, with area as the dominant factor. In phase 3, the area was the primary driver in the production of Pea. In phase 4, yield contributed positively. In phase 5, a combination of yield and area contributed to production, with yield as the dominant factor. In Madhya Pradesh, yield was the primary driver in production in phase 1. In phase 2, yield dominated, with area making some contribution. In phase 3, a balanced combination of area and yield contributed positively. In phase 4, the area dominated with some contribution from yield. In phase 5, yield was the primary factor in production. In Jharkhand, the area contributed positively in phases 4 and 5. In Himachal Pradesh, the area contributed positively in phase 4 with some contribution from yield. In phase 5, the yield was the primary driver in production, with some contribution from area. In Rajasthan, the area and the interaction effect contributed positively in phase 1. In phase 2, yield contributed positively. In phases 3 and 4, area was the primary driver in production. In phase 5, the yield effect dominated production.

Mothbean: In Rajasthan, the area was the primary production driver in phase 1, with a notable contribution from yield. In phase 2, yield contributed positively. In phase 3, the yield was the primary driver in the production of Pea, with some contribution from the area effect. In phase 4, yield contributed positively, with a minor contribution from the interaction effect. In phase 5, a combination of yield and area contributed to production, with area as the dominant factor. In Himachal Pradesh, the area was the primary driver in production in phase 4. In phase 5, yield, area, and the interaction effect contributed positively. In Gujarat, yield was the primary driver, with some contribution from the area in phase 3. In phase 4, yield dominated the contribution to production. In phase 5, the area gained dominance with some contribution from yield.

The analysis highlights the complex interplay of yield, area, and their interaction in shaping pulse production dynamics across different states and phases. While yield improvement is crucial in enhancing production, area expansion and its interaction with yield also play significant roles. Understanding these dynamics is essential for developing effective strategies to enhance pulse production and achieve self-sufficiency.

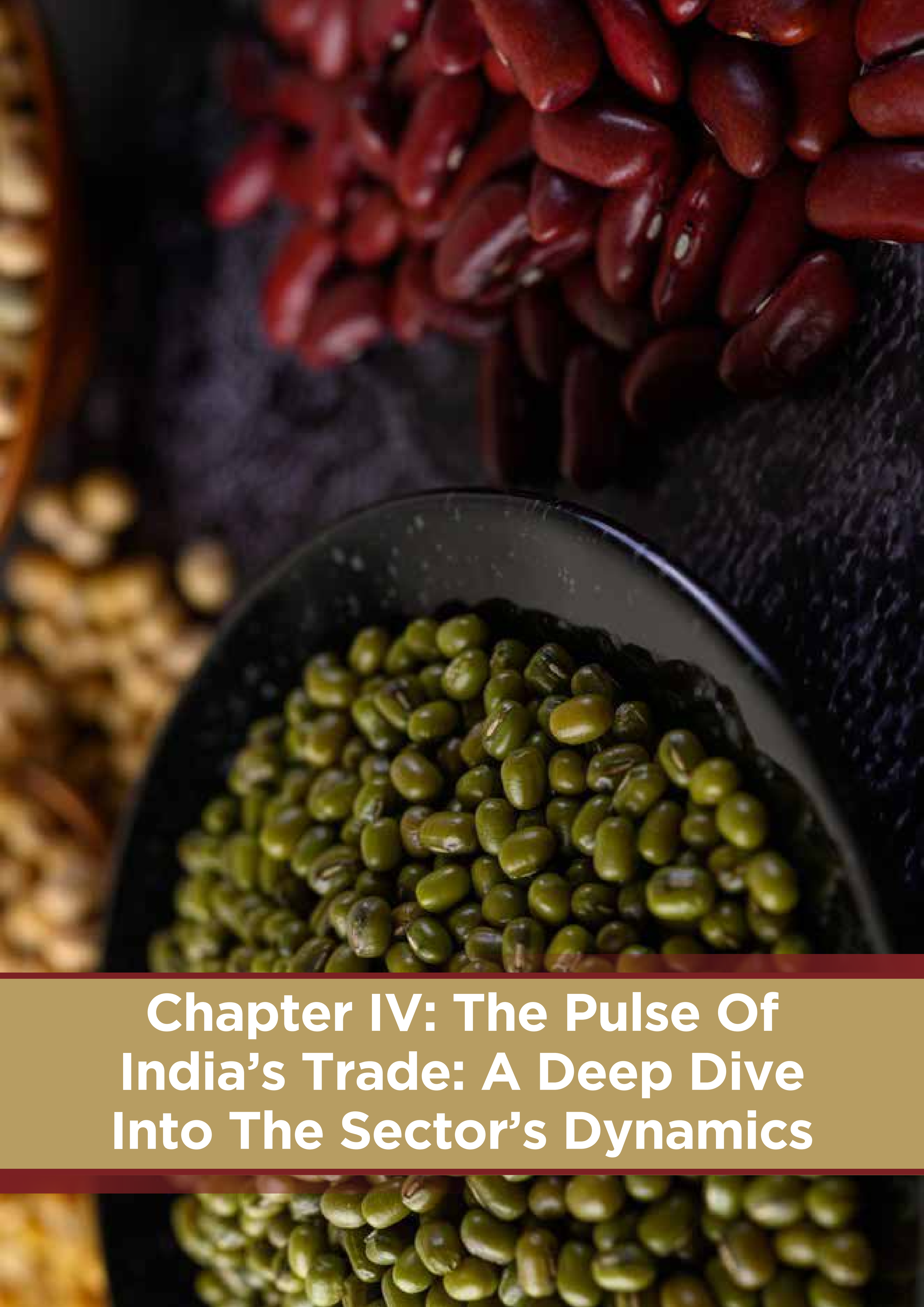
Table 3.15: Decomposition Analysis of Output for Major Pulses by Major Producers: State-Level Analysis (1970/71 to 2022/23)

States	Phase 1 (1970/71-1979/80)			Phase 2 (1980/81-1989/90)			Phase 3 (1990/91-1999/00)			Phase 4 (2000/01-2009/10)			Phase 5 (2010/11-2022/23)		
	Y	A	I	Y	A	I	Y	A	I	Y	A	I	Y	A	I
Total Pulses															
Madhya Pradesh	157.4	-82.6	25.1	20.0	71.8	8.2	-165.8	125.1	50.6	40.5	43.7	15.8	82.2	10.5	7.3
Maharashtra	73.9	20.9	5.2	34.4	39.9	25.7	645.8	-389.5	-156.4	117.4	-11.4	-6.0	42.2	47.8	10.0
Rajasthan	82.5	30.8	-13.4	-28.6	141.9	-13.3	23.0	89.8	-12.8	138.9	-194.9	65.9	-36.6	142.3	-5.7
Uttar Pradesh	72.7	42.6	-15.3	-40.7	159.6	-18.9	-28.3	117.5	10.8	56.3	46.8	-3.2	60.7	31.7	7.6
Karnataka	27.4	62.6	10.0	9.2	85.4	5.3	762.9	-520.4	-142.5	-20.5	124.8	-4.3	89.0	9.9	1.1
Pigeonpea															
Gujarat	18.2	67.7	14.2	8.5	82.8	8.8	42.1	62.5	-4.6	135.1	-13.1	-22.1	456.3	-301.9	-54.4
Maharashtra	86.6	10.3	3.1	47.7	35.6	16.6	93.8	3.1	3.1	101.0	-0.7	-0.3	-96.4	187.1	9.3
Karnataka	64.1	26.7	9.2	8.8	87.4	3.8	77.3	15.1	7.6	46.2	52.1	1.7	29.3	59.9	10.8
Uttar Pradesh	71.3	33.6	-4.9	84.5	18.8	-3.3	-107.2	195.0	12.2	78.1	41.4	-19.5	88.6	9.9	1.5
Jharkhand										60.2	-56.7	96.5	-136.4	39.5	-105.4
Madhya Pradesh	103.0	-5.4	2.4	166.7	-41.1	-25.7	36.0	74.1	-10.1	57.1	33.9	9.0	-544.6	285.4	359.1

States	Phase 1 (1970/71-1979/80)			Phase 2 (1980/81-1989/90)			Phase 3 (1990/91-1999/00)			Phase 4 (2000/01-2009/10)			Phase 5 (2010/11-2022/23)		
	Y	A	I	Y	A	I	Y	A	I	Y	A	I	Y	A	I
Chickpea															
Madhya Pradesh	-246.4	431.0	-84.5	36.3	56.7	7.0	83.2	13.1	3.7	29.6	53.8	16.6	461.3	-212.5	-148.8
Maharashtra	56.9	30.1	13.0	42.9	37.4	19.7	31.1	56.9	12.0	30.4	41.9	27.7	13.0	73.2	13.8
Rajasthan	70.7	39.8	-10.5	64.5	39.8	-4.3	-41.4	124.4	16.9	7.2	90.5	2.3	31.1	66.2	2.7
Gujarat	149.9	-87.0	37.1	-44.1	176.3	-32.1	38.9	81.3	-20.2	6.1	52.5	41.4	9.0	60.9	30.1
Uttar Pradesh	72.6	45.7	-18.3	55.4	51.7	-7.1	-25.4	116.4	9.0	8.6	93.6	-2.2	60.5	27.8	11.7
Green gram															
Rajasthan	94.4	35.0	-29.5	66.5	10.8	22.7	104.5	-16.0	11.5	163.9	-230.3	166.4	-23.1	151.4	-28.3
Madhya Pradesh	95.1	9.1	-4.1	-58.7	139.7	19.0	-5.6	103.9	1.7	138.4	-29.2	-9.2	5.6	29.4	65.1
Maharashtra	47.0	44.2	8.9	60.4	17.1	22.6	102.8	-82.6	-10.1	6.6	96.0	-2.5	23.0	88.7	-11.6
Karnataka	-54.9	194.1	-39.1	33.6	50.0	16.4	-237.5	419.6	-82.1	93.5	21.4	-14.9	53.7	33.4	12.9
Bihar	33.4	51.0	15.6	37.3	48.5	14.2	6.0	95.0	-1.0	47.4	58.7	-6.1	114.8	-11.5	-3.3
Black gram															
Madhya Pradesh	135.6	-52.2	16.6	53.5	76.5	-29.9	127.7	-23.0	-4.7	62.4	24.9	12.7	24.8	45.2	30.0
Andhra Pradesh	-95.5	132.7	-27.2	97.0	-81.8	-5.2	-43.0	135.2	7.8	34.8	73.1	-7.9	124.2	-10.2	-14.1
Uttar Pradesh	144.5	-93.9	49.4	60.9	62.3	-23.3	-6.3	107.5	-1.2	0.0	100.0	0.0	127.1	-39.0	11.9
Tamil Nadu	23.9	57.7	18.5	78.9	57.4	-36.3	41.4	18.7	39.8	80.2	24.4	-4.6	73.5	52.1	-25.6
Rajasthan	176.1	-309.8	233.7	49.7	77.5	-27.2	-643.4	617.3	126.1	150.5	-55.3	4.8	-98.6	348.3	-149.8
Lentil															
Uttar Pradesh	271.7	-289.6	117.9	20.2	64.1	15.7	31.0	66.4	2.6	170.3	-54.8	-15.5	137.6	-27.8	-9.9
Madhya Pradesh	106.9	-10.9	3.9	48.5	44.0	7.5	7.4	88.2	4.4	64.8	28.3	6.9	86.3	4.2	9.4
West Bengal	-244.4	298.1	-43.7	152.9	-26.8	-26.1	52.7	41.4	5.9	-3.6	102.4	1.1	1.8	95.0	3.2
Bihar	199.3	-119.1	19.8	253.8	-130.6	-23.2	299.3	-179.4	-19.9	94.7	5.9	-0.6	-24.5	113.8	10.7

States	Phase 1 (1970/71-1979/80)			Phase 2 (1980/81-1989/90)			Phase 3 (1990/91-1999/00)			Phase 4 (2000/01-2009/10)			Phase 5 (2010/11-2022/23)		
	Y	A	I	Y	A	I	Y	A	I	Y	A	I	Y	A	I
Jharkhand										-6.0	121.6	-15.6	-0.5	101.3	-0.9
Pea															
Uttar Pradesh	43.9	73.1	-17.0	29.5	59.4	11.1	-4.3	105.2	-0.9	149.1	-39.5	-9.6	57.6	31.6	10.8
Madhya Pradesh	111.3	-15.7	4.4	61.9	31.4	6.7	36.9	38.2	24.8	19.4	66.8	13.8	634.4	-140.9	-393.5
Jharkhand										0.4	93.6	5.9	22.4	62.9	14.8
Himachal Pradesh										24.4	58.7	16.9	54.8	37.6	7.5
Rajasthan	-151.9	160.5	91.4	54.5	13.0	32.5	13.4	80.3	6.3	10.5	97.7	-8.2	608.0	-214.8	-293.2
Mothbean															
Rajasthan	96.4	30.4	-26.8	130.9	-18.8	-12.1	94.1	45.6	-39.8	109.7	-45.2	35.5	54.2	66.9	-21.1
Himachal Pradesh										20.7	58.6	20.7	25.7	33.7	40.6
Gujarat							92.5	45.6	-38.0	475.0	-138.6	-236.4	29.0	80.5	-9.5

Source: Authors' computation, data from DES, MoA&FW



Chapter IV: The Pulse Of India's Trade: A Deep Dive Into The Sector's Dynamics

The Pulse Of India's Trade: A Deep Dive Into The Sector's Dynamics

4.1 Global Trade Dynamics: An Overview

This chapter delves into a comprehensive analysis of India's pulse trade, examining historical trends, contemporary patterns, and the challenges faced by the Indian pulse industry. It also explores the role of prices, government policies, and initiatives in boosting domestic production and achieving self-sufficiency in pulse cultivation.

Global pulse production is primarily concentrated in 39 countries, accounting for 90% of the global production, though it's cultivated in 172 countries worldwide. As the world's largest producer, India contributes approximately 28% to the worldwide total. Among the 39 major pulse producers, while eight high-income and eight upper-middle-income countries contribute a significant portion to global pulse production, accounting for 17% and 18%, respectively, most of the production comes from 23 low-income and lower-middle-income countries, particularly those in dryland regions of South Asia and sub-Saharan Africa. Despite facing numerous challenges, such as poverty, climate change, and limited resource access, these countries contribute significantly to global pulse production, accounting for 55% of the total. Eleven low-income countries account for 13% of global pulse production, eight of which are drylands in sub-Saharan Africa, contributing 11% to global production. Similarly, twelve lower middle-income countries account for 43% of global pulse production, eight of which are drylands in South Asia and sub-Saharan Africa, contributing 37% to global production. This highlights the importance of pulses in these regions' food security and sustainable livelihoods.

The global pulse trade has witnessed about 27% growth over the past decade, expanding from 15 MT to 19 MT. It is projected to reach 22 MT by 2033 (OECD-FAO 2024), accounting for approximately 20% of global pulse production (IGC, Rabo Research 2024). Dry pea, chickpea, and lentil dominate international trade, constituting 68% of the total. Despite being a major consumer, Asia relies heavily on imports, accounting for 52% of global consumption but only 43% of production. Interestingly, Africa has expanded its production and consumption over the past decade and has remained largely self-sufficient. These regional disparities highlight the potential for increased trade and investment in the global pulse market.

The global pulse trade is a significant market; about 20% of global pulse production is traded internationally, with Canada as the leading exporter. India and China, on the other hand, are the leading importers of pulses. In 2022, the total export value reached USD 12.5 billion, a notable increase from USD 9.77 billion in 2020. Canada, Myanmar, Australia, Russia, the United States, and Mozambique are the leading exporters of pulses globally, having respective global export shares of 26.6% (4.1 MT), 11.2% (1.72 MT), 10.3% (1.6 MT), 9.4% (1.45 MT), 4.6% (0.69 MT) and 3.3% (0.51 MT). While the largest producer and consumer, India ranked ninth in global exports, accounting for about 2.5% of the worldwide export market. On the import side, China is the largest importer in terms of quantity with 16.6% (2.55 MT) in global imports, followed by India (15.5%, 2.38 MT), Turkey (7.9%, 1.22 MT), Pakistan (7.1%, 1.09 MT), the United Arab Emirates (5.4%, 0.82 MT), and the USA (4.7%, 0.72 MT) (UN Comtrade, as reported by the Importing countries). Regarding import value, India is at the top, followed by China. Looking ahead, Canada is expected to maintain its dominance as the primary exporter, to grow to 5.7 MT by 2033, with Australia and Russia also playing significant roles with 2.8 MT and 2.1 MT of exports by 2033, respectively. While nominal international pulse prices are projected to decrease until 2025, they are expected to increase slightly thereafter. However, in real terms, prices are anticipated to decline (OECD-FAO 2024). These trends underscore the dynamic nature of the global pulse trade and the opportunities and challenges faced by key players.

The significant health and environmental benefits associated with pulses have led governments of pulse-producing countries to support farmers, thereby strengthening market growth. The European Union's Protein Strategy highlights the importance of pulses as a key ingredient in meat substitute products. As consumer awareness of health and sustainability grows, pulses are increasingly being integrated into daily diets as whole foods and as ingredients in processed foods. Urbanization, changing lifestyles, and the demand for convenient and healthy snack foods further fuel the demand for pulses, particularly in ready-to-eat (RTE) products. Additionally, the rising popularity of pulse flour as a healthier alternative to wheat flour drives its use in various food products, including snacks and confectionery. As India's purchasing power grows and dietary preferences evolve, the demand for pulses is expected to increase further, putting pressure on domestic supply.

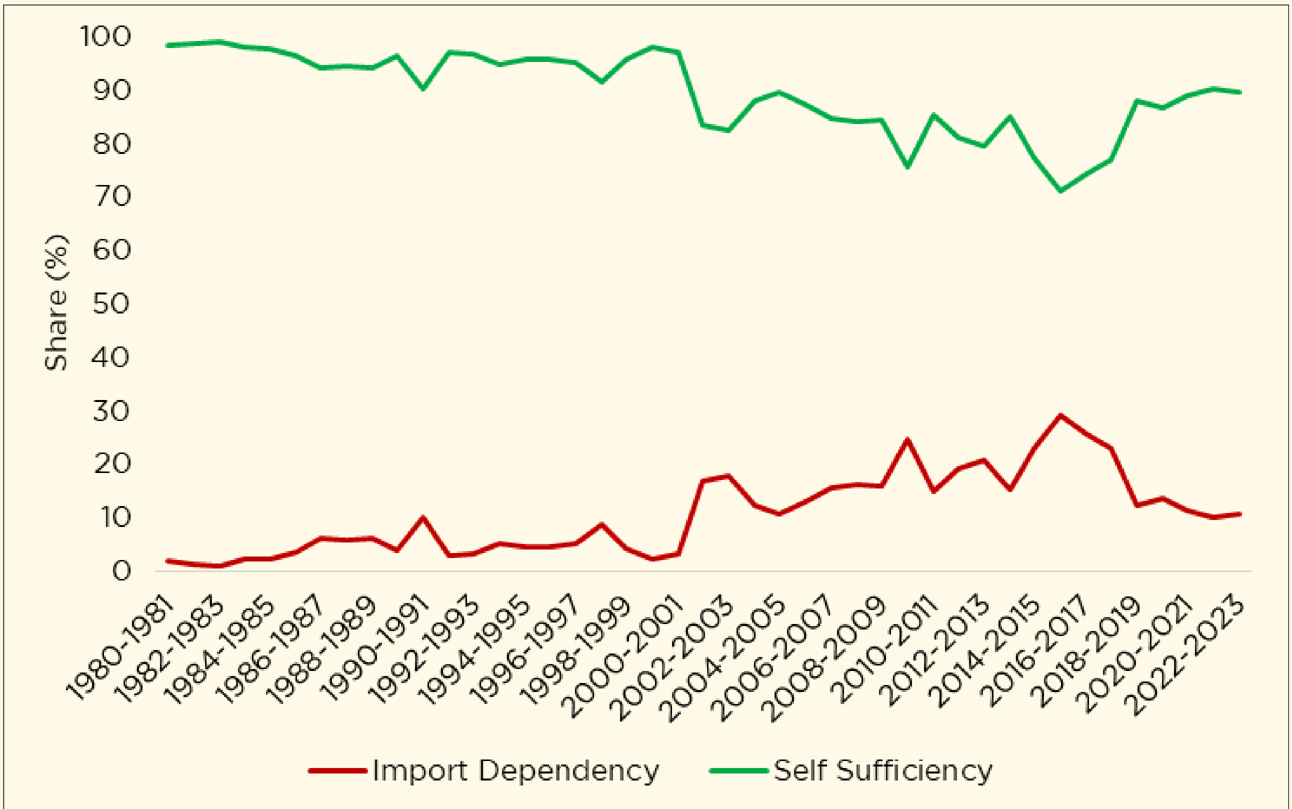
4.2 India: Import-Export Dynamics in the Pulse Sector

As a major producer and consumer, domestic production, consumption patterns, and global market trends influence India's import-export dynamics. While India is a net importer of pulses, it also exports certain pulse varieties to specific markets. The country's import dependence highlights the need for strategic policy interventions to enhance domestic production and reduce reliance on imports.

4.2.1 Import Dynamics

The data reveals a fluctuating trend in India's self-sufficiency in the pulses sector over the past decades (Figure 4.1). While India maintained a high level of self-sufficiency in the initial two decades (1980-81 to 2000-01), exceeding 90%, the increasing gap between domestic production and consumption has led to a gradual decline in self-sufficiency after 2000-01. Pulse imports, minimal in 1980-81 (0.17 MT), surged to nearly 6 MT in 2015-16. This significant rise in imports, coupled with the relatively slow growth in domestic production, has substantially increased India's import dependency, from 1.84% in 1980-81 to approximately 29% in 2015-16. The import of pulses has grown at a rate of 9.82% since 1980–81, while the domestic supply of pulses for consumption has increased by only 1.86% during the corresponding period. Since 2016-17, India has significantly reduced its import dependency on pulses. Import volumes peaked at 6.61 MT in 2016-17 and declined to 2.496 MT in 2022-23. This reduction is reflected in the value of imports, which decreased from $4.2 billion in 2016-17 to $1.94 billion in 2022-23. The import decline can be attributed to factors such as increased domestic production and supportive government policies.

Figure 4.1 Pulses: Share of Imports & Self-Sufficiency over the Years (1980-81 to 2022-23) (%)



Source: Authors' computation, data from DES, MoA&FW; DGCI&S, MoC

The import of certain pulse varieties, mainly yellow/white pea (matar) and chickpea (chana), has declined remarkably in recent years. At their peak, annual yellow/white pea imports exceeded 3 MT, and chickpea imports reached over 1 MT. This surge in yellow/white pea was because yellow/white pea from Canada, Russia, Ukraine, and Lithuania were substituted for chickpea when their prices surged due to lower Indian production. However, government interventions, such as encouraging farmers to expand cultivation during the winter-spring season, supported by a 60% import duty on chickpea imposed in March 2018, and increased robust government procurement at MSP, has led to a significant increase in domestic production after 2016-17. As a result, imports of these pulses have reduced significantly. While this success story highlights the impact of government interventions, similar success has not been replicated for pulses like pigeonpea. The production of pigeonpea in India has experienced a significant decline of nearly 32.04% between 2016-17 and 2022-23. This decrease has directly contributed to the rising prices of pigeonpea. Experts attribute this decline to a shift in farmer preferences towards short-duration varieties of pigeonpea and shifting to more profitable crops like banana, cotton, sugarcane, and soybean. As these crops offer higher returns, farmers are increasingly opting for them, leading to a decrease in pigeonpea cultivation. Further, pigeonpea cultivation requires about eight months. In contrast, crops like lentil, black gram, wheat, bajra, corn, mustard, and cotton have an approximately 50% shorter cultivation period, making them more attractive to farmers. This trend has implications for domestic and consumer prices, highlighting the need for policy interventions to encourage pigeonpea production and ensure a stable supply.

Despite significant government efforts towards self-sufficiency, recent data shows India's import dependency has surged to unprecedented levels in the fiscal year 2023-24 due to external factors like the El Niño weather pattern. Pulse imports soared by 84% year-on-year, reaching a six-year high of 4.739 MT, compared to 2.496 MT in the previous year. This represents a substantial increase of 90% compared to the prior year's imports and accounts for approximately 18.5% of domestic demand. The pulses sowing area has also reduced gradually in the same period, from 30.731 Mha in 2021-22 to 27.505 Mha in 2023-24. In two years, the sowing area was reduced by 10.5% and production by almost 11.2%. Regarding value, India's pulse import expenditure rose by 93% to USD 3.74 billion, up from USD 1.94 billion in 2022-23. Major suppliers of these imported pulses include Canada, Myanmar, Australia, Tanzania, Mozambique, and Russia, collectively accounting for approximately 87% of the total imports. This significant increase in both volume and value highlights the growing reliance on imports to meet domestic demand despite government efforts to encourage self-sufficiency.

India's increased reliance on pulse imports in 2023-24 was primarily driven by a surge in red lentil (masur) and yellow pea and a rise in black gram imports. Despite diplomatic tensions, red lentil imports from Canada more than doubled, reaching 1.2 MT. Canada and Australia accounted for nearly 98% of India's lentil imports. Similarly, yellow pea imports from Russia and Turkey increased significantly. To bridge the production gap, India also imported pigeonpea and black gram. Mozambique, Myanmar, and Tanzania were the primary sources of pigeonpea imports, accounting for nearly 90%, while Myanmar was the leading supplier of black gram, contributing about 96% of total imports (Figure 4.2).

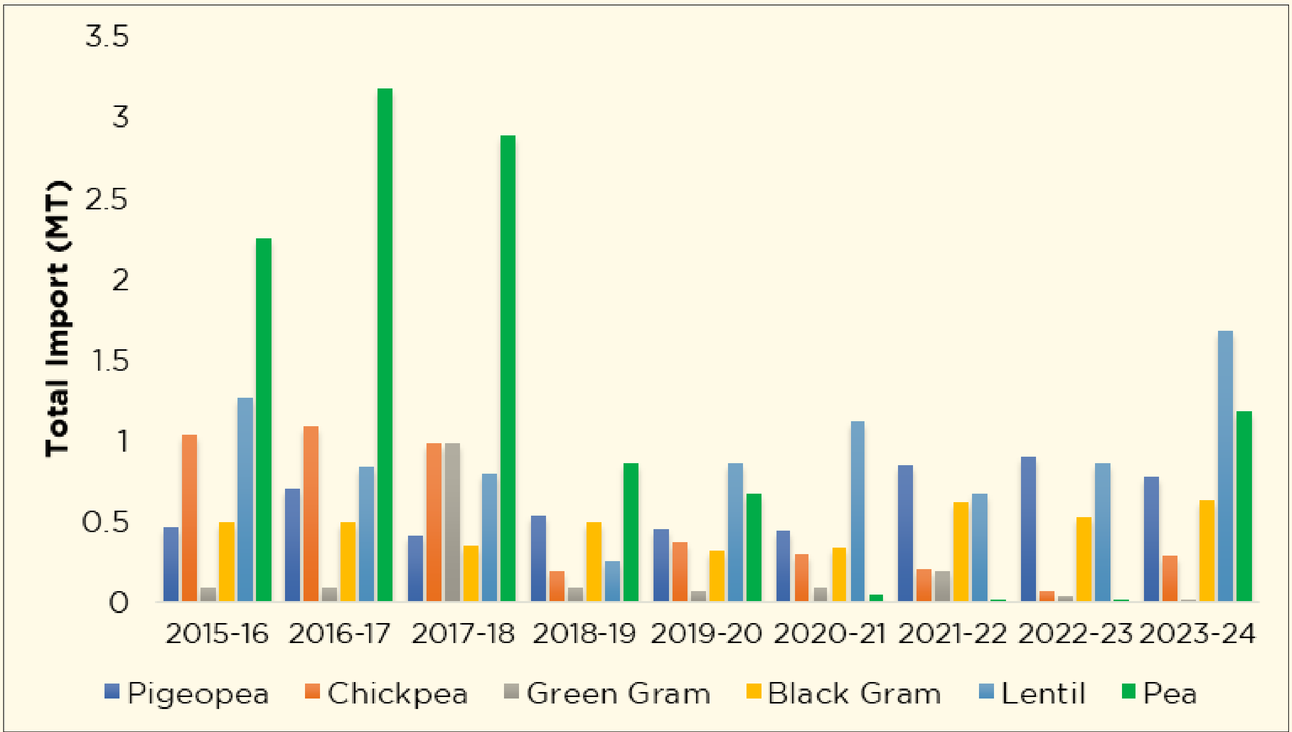
Figure 4.2: Trade of Pulses: Major Import Sources

Crop	Import Sources (in terms of quantity)
Pigeon Pea	Mozambique (38%), Myanmar (24%), Tanzania (23%), Malawi (7%), Sudan (6%)
Green Gram	Mozambique (32%), Tanzania (16%), Myanmar (16%), Afghanistan (11%), Brazil (7%), Argentina (4%), UAE (3%), Kenya (3%), South Africa (3%)
Lentil	Canada (78%), Australia (20%), UAE (1%)
Black Gram	Myanmar (96%), Singapore (3%)
Pea	UAE (65%), Canada (32%), USA (3%)

Source: Authors' computation, data from UPAg, APEDA, and DGCIS, GoI

Among the top imported pulse crops from 2015-16 to 2023-24, pea emerged as the most significant import, averaging 1.23 MT per year. Lentil followed closely, with an average import of 0.92 MT. Pigeonpea, chickpea, black gram, and green gram were the next most imported pulses, with annual averages of 0.61 MT, 0.50 MT, 0.47 MT, and 0.18 MT, respectively. In the latest fiscal year, pea imports substantially increased, followed by lentil, chickpea, and black gram. Conversely, pigeonpea and green gram imports declined compared to the previous year (Figure 4.3).

Figure 4.3: Import by Pulse Crops (2015-16 to 2023-24)



Source: Authors' computation, data from DGCIS, GoI

Imports are crucial in meeting India's pulse deficit and stabilizing domestic prices. In the ever-evolving realm of global trade, these figures reflect a statistical surge in imports and beckon to delve deeper into the economic dynamics at play. The reliance on imports is not without its challenges. Exporters in surplus countries often capitalize on India's import demand by raising prices, making imports less reliable for price stabilization. Despite increased imports, pulse prices in India remained elevated, in double digits, and accelerated in the 2023-24 agricultural year. The government has imposed stock limits on pulses to address this issue and urged states to monitor hoarding activities. The Reserve Bank of India has also highlighted that food price pressures pose challenges in bringing inflation down to the target of 4%, and the price of pulses plays an essential role in inflation numbers. To address this issue, the GoI has implemented a series of measures. To enhance consumer access to affordable pulses, the Government has implemented a program to convert stocks of chana (chickpea), mung (green gram), and masur (lentil) into subsidized "Bharat Dal" for retail distribution. This initiative commenced with the launch of subsidized chana dal and whole chana in the retail market on October 23, 2024. The allocated chana stock is being sold in an 80:20 ratio of dal to whole form, packaged in 1 kg pack. The maximum retail price (MRP) is set at Rs. 70/kg for chana dal and Rs. 58/kg for whole chana. Retail outlets of NAFED, NCCF, Kendriya Bhandar, and other designated channels are distributing Bharat chana dal and whole chana to consumers. Previously, chana dal was sold at subsidized rates of Rs. 60 per kg for 1 kg packs and Rs. 55 per kg for 30 kg packs to improve consumer affordability. The Government also approved converting mung stock into mung dal (Dhuli) and mung dal (Sabut) and masur stock into masur dal for retail distribution. To ensure affordability, the MRP for Bharat mung dal (Dhuli) is set at Rs.107 per kg, and Bharat mung dal (Sabut) at Rs.93 per kg. This pricing strategy incorporates a Rs.1,500 per quintal discount on the issue price (based on the MSP of the mung stock). The MRP for Bharat masur dal has been determined at Rs. 89 per kg, considering prevailing market prices for masur dal. Bharat mung and masur dal are made accessible to consumers through a network of retail outlets, including those operated by NAFED, NCCF, Kendriya Bhandar, Safal, and online e-commerce platforms.

Furthermore, a total of 6.793 MT of pulses has been transferred from the PSS stocks to replenish the buffer stock of the PSF as part of the Pradhan Mantri Garib Kalyan Anna Yojana (PMGKAY/ANB) initiatives. Additionally, 0.488 MT of pulses have been procured under PSF, 0.709 MT has been sourced from imported pulses, and 0.607 MT of pulses have been replenished from PSS. As of 02.12.2024, 0.759 MT (including PMGKAY/ANB) of pulses have been disposed of, while 1.011 MT of pulses is available in the PSF buffer. During the fiscal year 2024-25, the following transactions pertaining to pulses were recorded: 0.441 MT of pulses were transferred from the PSS (DA&FW) to the PSF (DoCA). Additionally, 0.023 MT of pulses were procured through the PSF, while 0.025 MT were obtained from imported sources. Furthermore, 0.055 MT of pulses were replenished from the PSS. As of December 2, 2024, a cumulative total of 0.564 LMT of pulses had been disposed of.[13]

In conjunction with this initiative, the GoI has implemented stock limits on pigeonpea and desi chickpea to curtail hoarding practices. Furthermore, the government has permitted zero-duty imports of a variety of pulses, including pigeonpea, black gram, lentil, and yellow pea, to enhance domestic supply. The integration of these measures, along with substantial progress in Kharif pulse sowing, has contributed to the stabilization of market prices. Notably, in July 2024, prices for chickpea, pigeonpea, and black gram decreased by up to 4% across prominent mandis.

However, enhancing domestic pulse production is essential, given the limitations of relying on imports. The frequent recurrence of price volatility and import dependency underscores the need for a robust domestic pulse production system. While imports can provide temporary relief, they are not a sustainable solution. India must prioritize domestic production to ensure long-term food security and price stability. By increasing the area under cultivation and improving yields, India can reduce import dependence and stabilize domestic prices. This strategic shift requires a comprehensive approach, including promoting advanced agricultural practices, improved seed technology, and supportive policies to incentivize farmers. By promoting sustainable farming practices, and strengthening the domestic value chain, India can achieve self-sufficiency in pulse production and ensure food security for its growing population.

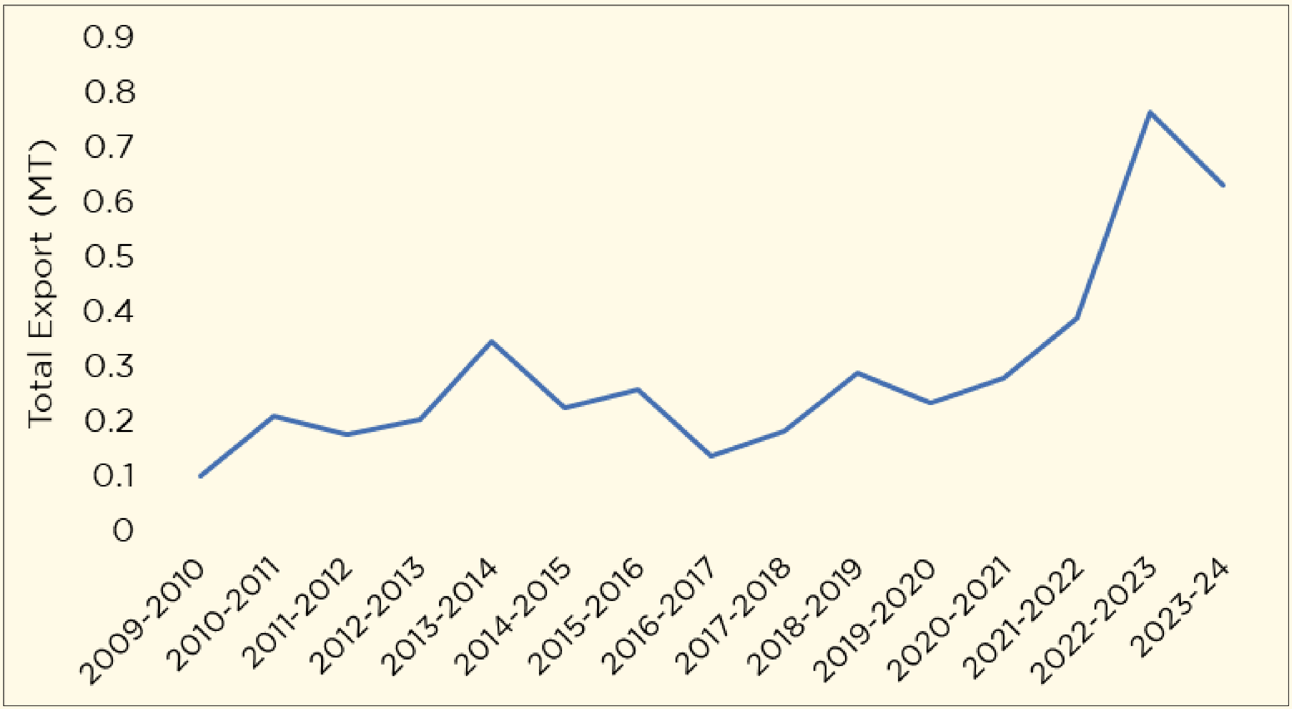
13 *https://pib.gov.in/PressReleaseIframePage.aspx?PRID=2088051#:~:text=Subsequently%2C%20after%20due%20deliberation%2C%20it,which%20regular%20disposal%20was%20undertaken*

4.2.2 Export Dynamics

India's pulse exports have fluctuated over the years, reflecting market conditions and production variations. Starting from 0.10 MT in 2009-10, pulse exports increased to 0.21 MT by 2010-11. Although the export volume declined slightly in the following year, India maintained a relatively steady export trend, reaching a high of 0.35 MT in 2013-14. Exports remained varied from 2014-15 to 2021-22, with the lowest being 0.14 MT in 2016-17. However, the trend took a remarkable upward turn, especially in recent years. In 2021-22, pulse exports reached 0.39 MT, and this surge continued in 2022-23, recording an impressive 0.76 MT— the highest in the period (Figure 4.4). This data highlights India's growing capacity to export pulses, contributing to its position as a key player in the global pulse market.

The country has exported 0.63 MT of pulses worth of Rs. 5,689.40 Crores or USD 686.93 million during 2023-24. Key export destinations include Bangladesh, China, the United Arab Emirates, the USA, and Sri Lanka. Pulses exports from India have witnessed significant exponential growth over the past three financial years (FY). In FY20, they amounted to $211.13 million; in FY23, they surged to $686.93 million. Chickpea is the most exported pulse crop from India (about 44.6% of total pulse export), followed by lentil (19.6%), pea (15.7%), black gram (9%), pigeonpea (6.7%), and green gram (4.4%) in the last three years, respectively. While increased production has contributed to this growth, challenges such as inadequate storage facilities, limited shelf life, variability in seed size, strong domestic demand, and differences in maturity levels continue to impact India's export potential. Addressing these challenges is crucial to enhance further India's position as a global supplier of pulses.

Figure 4.4: Pulse Exports from India: A Growing Trend (2009-10 to 2023-24)



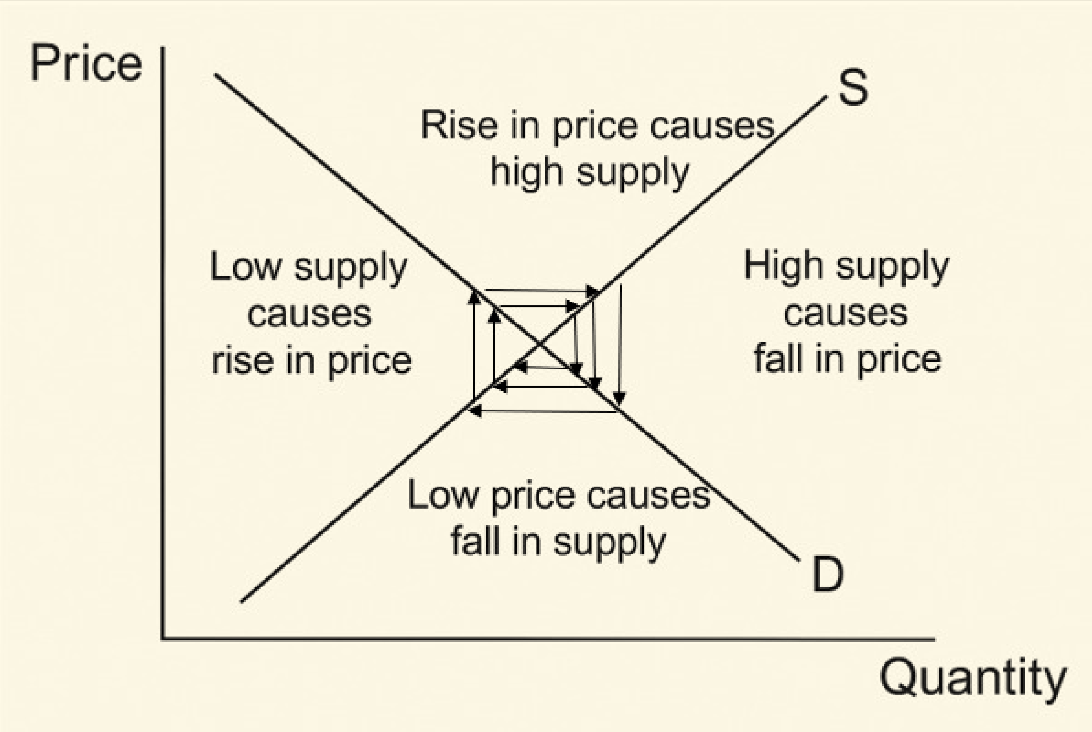
Source: Authors' computation, data from MOAFW, APEDA, and DGCIS, GOI

4.3 Stabilizing Pulse Markets: Why Counter-Cyclical Policies Outperform Reactive Trade Measures

The stability of markets is a complex issue influenced by various factors, including supply and demand dynamics, government policies, global market conditions, and unpredictable weather. Governments often intervene in agricultural markets to stabilize prices and to protect domestic producers and consumers from price fluctuations. However, the effectiveness of these interventions can vary significantly since they are complex and a big challenge for policymakers.

The Cobweb Phenomenon, an economic theory explaining cyclical price fluctuations in agricultural markets, highlights the challenges inherent in this balancing act. Farmers are incentivized to increase production when prices rise, leading to increased supply in the following period; prices can decline, discouraging future production. Conversely, farmers may reduce production when prices are low, leading to potential supply shortages and price increases in the future. This cyclical pattern can destabilize the market and create uncertainty for farmers and consumers (Figure 4.5).

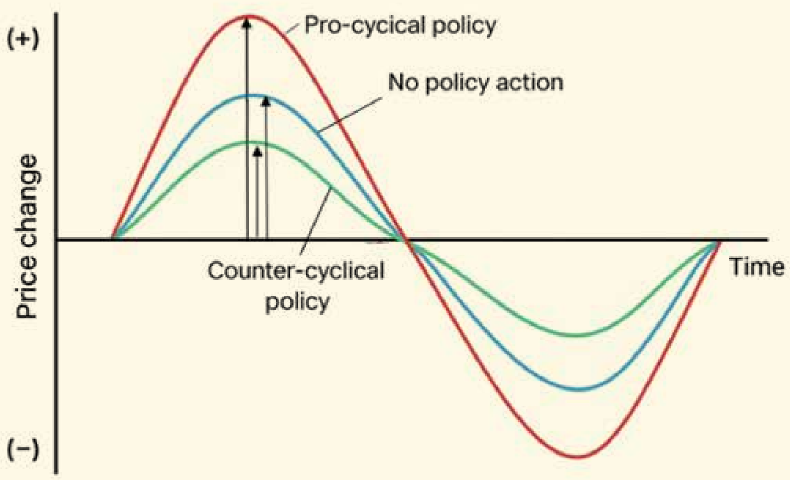
Figure 4.5: The Cobweb Phenomenon: How Supply and Demand Influence Agricultural Markets



Source: Authors' computation

One common approach is implementing reactive trade policies, such as imposing import or export restrictions. While these measures may seem like a quick fix, they can inadvertently exacerbate price volatility. When prices decline, governments may impose import restrictions to protect domestic producers. However, this can lead to reduced production the following year, as farmers perceive the crop as less profitable. Consequently, lower supply can increase prices, prompting export restrictions to keep domestic prices low (Figure 4.6). This cyclical pattern can perpetuate price instability and hinder long-term market development. Reactive Trade Policy can exacerbate the Cobweb phenomenon, while Counter-cyclical policies may offer a more practical approach to stabilizing markets. By implementing policies that offset price fluctuations and focusing on increasing productivity, governments can mitigate the impact of supply and demand shocks, dampen price swings, and reduce uncertainty for farmers. This approach requires careful planning and effective implementation to promote a more sustainable and resilient agricultural sector.

Figure 4.6: Stabilizing Pulse Markets: Reactive Trade Policy Exacerbates the Cobweb Phenomenon



Source: Authors' computation

4.4 Bridging the Gap: Government Strategies to Balance Import Dependence and Domestic Production

India's pulse trade policy has historically aimed to balance domestic supply and demand, ensuring affordable prices for consumers while protecting domestic producers. India has often resorted to import liberalization to address chronic deficits, with low or zero import duties. However, as global demand for pulses increased, India has also implemented import restrictions and tariffs to safeguard domestic interests. The government's strategy has involved ensuring adequate supply, stabilizing prices, and supporting domestic production. While imports can provide temporary relief, a long-term solution is enhancing domestic production through technological advancements, improved agricultural practices, and supportive policies.

India's pulse import policy has significantly changed over the past few decades. During the 1970s and 1980s, pulses imports were strictly regulated through licensing. However, with the onset of economic liberalization in the 1990s, India adopted a more liberal approach to international trade. Between 1988 and 1995/96, pulses were subject to a 10% import duty, which was subsequently reduced to 5% in 1996/97 and completely removed in November 1998. In 1999/2000, the government further relaxed import regulations by withdrawing quantitative restrictions and relying solely on tariff-based measures. However, in response to domestic price pressures, import duties of 5% were reintroduced in 2001 and increased to 10% in 2002/03. During the food price crisis of 2007-2009, the government temporarily reinstated duty-free imports of pulses to alleviate domestic shortages. The period between June 2006 and February 2017 marked a significant phase with low import duties and minimal restrictions. This period coincided with increased global demand for pulses, leading to higher international prices. However, a shortfall in domestic production in India, as witnessed in 2015-2016, due to factors like adverse weather conditions, exacerbated the situation, making it difficult to import certain pulse varieties, such as pigeon pea and black gram, even at inflated prices. This highlighted the complex challenge of balancing import dependence with the need to incentivize domestic production. The GoI has implemented a multifaceted strategy to address this, including a dynamic import policy and farmer-centric Minimum Support Prices (MSPs) for pulse crops. In March 2017, a 10% import duty was imposed on lentil and pigeonpea. Further from November 2017 to March 2018, import duties on chickpea, pea, large chickpea, and lentil were increased to 60%, 50%, 40%, and 30%, respectively. Additionally, export restrictions were lifted on these commodities in November 2017. From 2017-18 onwards, pulses trade policy and import tariffs are detailed in Table 4.1. In addition, GoI announced a significant increase in MSP by declaring bonuses on all major pulse crops during the years 2016-17 and 2017-18. The rise in prices attracted farmers to increase the area under pulse, resulting in a historic 26.6% surge in the area under pulse production, from 23.55 Mha in 2014-15 to 29.81 in 2017-18. Between 2014-15 and 2021-22, the area under pulse cultivation increased by more than 30%, and production surged from 17.15 MT to 27.302 MT in 2021-22. This impressive growth translates to a CAGR of 6.87%, the highest recorded to date. Additionally, the government initiated a robust procurement mechanism at MSP to incentivize farmers and stabilize prices. A careful balance between import restrictions and domestic production incentives from the government highlights the government's commitment to ensuring continued availability for domestic consumption as well as protecting domestic producers. This combination of import duty adjustments, temporary exemptions, and extended free imports highlights the multifaceted nature of India's dynamic import policy.

Table 4.1: Pulses Trade Policy Timelines

Year	Trade Policy and Import Tariffs
During 1970s & 1980s	India follows a protectionist trade policy: the government restricts imports, imposes quantitative restrictions, quotas, tariffs, and various other equally prohibitive trade mechanisms, and puts pulses on a "special list."
1979	Pulses are placed under an open general license, making it possible for any public or private sector entity to import without approval or any restriction.
1980–1990	Import duties on pulses decline.
1989–1994	Imposed a 10% import duty on pulses
1995	Imposed a 5% import duty on pulses

Year	Trade Policy and Import Tariffs
2000	Eliminated import duty on pulses
2001	Reinstated 5% import duty on pulses
2001–2003	Increased import duty to 10%
2006-2017	No import duty (June 2006 to February 2017)
March 2017	10% import duty on lentil and pigeonpea
2017-18	August 2017: 200,000 tons import quota for pigeon pea; 300,000 tons for black gram and green gram (150,000 tons each). November 2017: Import duty on pea increased to 50%; export ban lifted. December 2017: Import duty on lentil and chickpea increased to 30%. February 2018: Import duty on chickpea further increased to 40%. March 2018: Import duty on desi chickpea increased to 60%; 40% on kabuli chickpea.
2018-19	Quota restriction (QR) on: Black gram and green gram: 150,000 tons each Pigeon pea: 200,000 tons Pea: 100,000 tons June 2018: Import duty on kabuli and desi chickpea increased to 60%, and on lentil to 30%
2019-20	QR on pea: 150,000 tons QR on black gram and green gram: 150,000 tons each, increased to 400,000 tons on black gram in December 2019 QR on pigeon pea: 200,000 tons, and increased to 400,000 tons in July 2019 June 2019: Basic import duty on lentil increased to 50%
2020-21	QR on pea and green gram: 150,000 tons each QR on pigeon pea and black gram: 400,000 tons each June 2020: Basic import duty on lentil reduced to 10% (June to August 2020) February 2021: imposed AIDC: chickpea 50%, bengal gram 30%, kabuli chana 50%, Yellow pea 40%, lentil 20%.

Year	Trade Policy and Import Tariffs
2021-22	QR on green gram: 150,000 tons QR on pigeon pea: 400,000 tons QR on black gram: 400,000 tons Import policy: QR removed on green gram, black gram and pigeon pea) up to 31.10.2021, but import duty remained July 2021: Basic import duty on lentil reduced to zero, AIDC lowered from 20% to 10%, Social Welfare surcharge of 10% remained unchanged Dec 2021: Extension of "Free" Import policy for Pigeonpea and Black gram up to 31st Mar 2022 from 31st Dec 2021 February 2022: Import policy for green gram revised from "Free" to "Restricted" (Reference: Gazette ID: CG-DL-E-11022022)
2022-23	March 2022: No QR on black gram and pigeon pea up to 31.03.2023, subject to existing import duties, and further extended up to 31.03.2024. December 2022: Government extended free import of Black gram and Pigeonpea up to March 31, 2024. (DGFT Notification no. 52 /2015-2020) March 2023: Govt. removed Basic Custom Duty of 10% on whole Pigeonpea w.e.f. March 04, 2023 June 2023: Imposition of stock limit on Pulses (Pigeonpea & Black gram) w.e.f. June 02, 2023 till October 31, 2023 September 2023: Govt removes custom duty on certain U.S. origin products, including lentil November 2023: Govt raised Pigeonpea and Black gram Stock limits till 31 December 2023 December 2023: Extension of the nil import duty on Lentil (Masur) (of previous notification) until 31st March 2025. Govt allows duty-free import of Yellow Pea until March 31, 2024. Govt. extends duty-free import of Pigeonpea and Black gram until March 2025
2023-24	May 2024: Revising basic duty on certain pulses like Bengali gram (desi chana) to 40%. Additionally, extensions made to customs duties on other pulses, including Bengal gram, with modifications valid until 31st October 2024 June 2024: The government imposes stock limits on Pigeonpea and Chana (including kabuli chana) till September 30, 2024. July 2024: The Government Excluded kabuli chana from Stock Limit Purview until September 30, 2024

Note: AIDC: Agriculture Infrastructure Development Cess; Quantitativerestrictions do not apply to Governments' import commitments under any
Bilateral or Regional Agreement or Memorandum of Understanding.
Source: Updated by authors using data from DGFT, Ministry of Commerce, GOI.

To incentivize domestic pulse production, the Indian government annually announces Minimum Support Prices (MSPs) for key pulse crops, including pigeonpea, chickpea, green gram, black gram, and lentil. In 2018-19, the government adopted a pre-determined principle to fix MSPs at 1.5 times the cost of production. This policy change aimed to provide a significant return to farmers. Since 2013-14, MSPs for these crops have consistently increased, with substantial percentage and absolute increases over the years (Figure 4.7). Among these, lentil exhibited the maximum increase in MSP, i.e., 127.1%, followed by green gram (92.9%), chickpea (82.3%), pigeonpea (75.6%), and black gram (72.1%), respectively. In terms of absolute increase, green gram had the maximum increase (Rs 4,182/quintal), followed by lentil (Rs 3,750/quintal), pigeonpea (Rs 3,250/quintal), black gram (Rs 3,100/quintal), and chickpea (Rs 2,550/quintal). This significant rise underscores the government's efforts to support and incentivize the production of pulses. This producer-focused approach ensures financial security for farmers, promoting increased pulse cultivation. These initiatives have been vital in motivating farmers to grow pulses and boosting domestic production.

The cost of production varies significantly among pulse crops. Green gram has the highest cost of production at Rs 5788 per quintal, followed by black gram at Rs 4883, pigeonpea at Rs 4761, lentil at Rs 3405, and chickpea at Rs 3400. However, in terms of margin over cost, lentil offers the highest return at 88.7%, followed by chickpea (60.0%), pigeonpea (58.6%), black gram (51.5%), and green gram (50.0%). This information highlights the varying profitability potential of different pulse crops (Figure 4.7).

Figure 4.7: Minimum Support Price (Rs per quintal), Cost of Production (Rs per quintal). and Margin over Cost of Production (%)

Year	Pigeonpea	Chickpea	Green Gram	Black Gram	Lentil
2013-2014	4300	3100	4500	4300	2950
2014-2015	4350	3175	4600	4350	3075
2015-2016	4625	3500	4850	4625	3400
2016-2017	5050	4000	5225	5000	3950
2017-2018	5450	4400	5575	5400	4250
2018-2019	5675	4620	6975	5600	4475
2019-2020	5800	4875	7050	5700	4800
2020-2021	6000	5100	7196	6000	5100
2021-2022	6300	5230	7275	6300	5500
2022-2023	6600	5335	7755	6600	6000
2023-2024	7000	5440	8558	6950	6425
2024-2025	7550	5650	8682	7400	6700
Increase in MSP 2024-2025 Over 2013-14 (%)	75.6	82.3	92.9	72.1	127.1
Increase in MSP 2024-2025 Over 2013-14 (absolute)	3250	2550	4182	3100	3750
Cost of Production (in Rs)*	4761	3400	5788	4883	3405
Margin over Cost (%)*	58.6	60.0	50.0	51.5	88.7

Note: *For rabi crops (i.e., chickpea and lentil) cost of production and margin over cost is based on 2023-24.

Source: CACP, MoA&FW and PIB 2024[14]

14 *https://pib.gov.in/PressNoteDetails.aspx?NoteId=151901&ModuleId=3&reg=3&lang=1*

By acknowledging the historical context, employing a dynamic trade policy focusing on price stabilization and long-term import reduction strategies, and offering producer-centric MSPs, the Government is actively working towards achieving a sustainable balance between import dependence, domestic production encouragement, and consumer welfare. A nuanced approach considering both cultivation economics and import dependence is crucial for success. Policy interventions should encourage the cultivation of high-return pulse crops. These crops offer a strategic advantage due to their favorable return-on-cost ratios. Additionally, exploring measures to reduce the production cost of pulse crops can further enhance profitability and incentivize farmers. By prioritizing high-return crops and implementing strategic import management, India can significantly reduce import reliance and establish a self-sufficient pulses sector. This strategy fosters a win-win situation for producers, consumers, and the nation's food security. Improving storage and warehousing for pulses can address excess production, helping stabilize prices in years of low output.

Chapter V: Demand And Supply Of Pulses In India

Demand And Supply Of Pulses In India

5.1. Introduction

Pulses are a highly nutritious food source, rich in protein, dietary fibre, vitamins, minerals, phytochemicals, and complex carbohydrates. Beyond their caloric contribution, they offer numerous health benefits, including improved digestion, reduced blood glucose levels, minimized inflammation, lower cholesterol, and prevention of chronic diseases like diabetes, heart disease, and obesity. While global consumption patterns vary based on dietary preferences and availability, pulses are generally less prone to wastage than other crops. Their long shelf life and resistance to spoilage make them a valuable food security option, especially for households facing food insecurity.

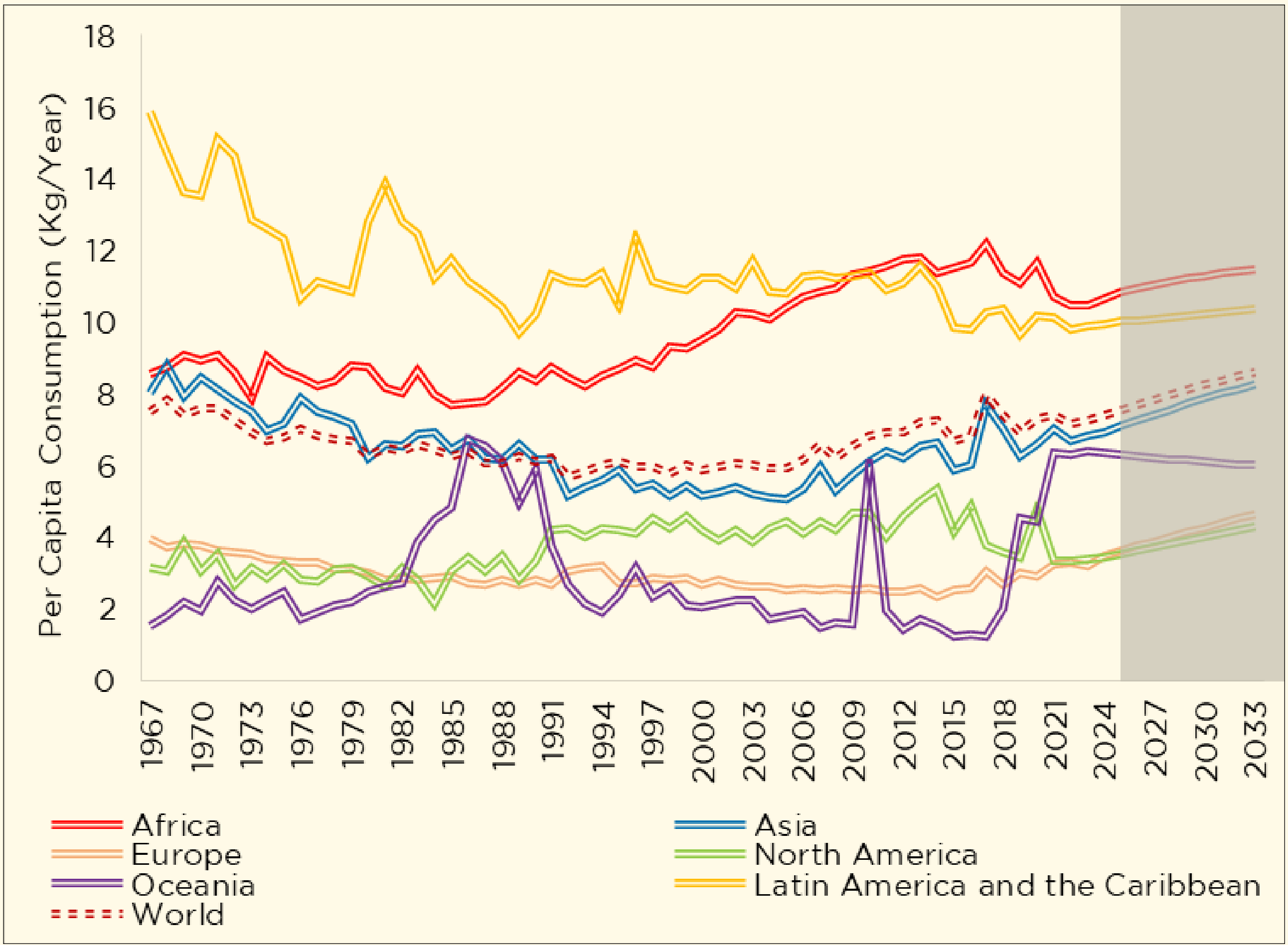
India is the largest cultivator, producer, and consumer, accounting for about 38% of global pulse cultivation, 28% of global production, and 27% of global consumption. Canada, China, and the European Union are the next significant producers, each contributing around 5% to worldwide production. The Asian market accounts for 52% of global consumption but produces only 43% making it the most significant import destination.

Global per capita pulse consumption declined from 7.51 kg/year in 1960 to 5.85 kg/year in 2000 due to slow yield growth, elevated prices, and shifted preferences away from pulses as human diets became richer in animal proteins, sugar, and fats (Figure 5.1). However, with a growing recognition of the nutritional benefits of pulses, global per capita consumption has started to increase after 2000 and reached 7.23 kg/year in 2023 from 5.85 kg/year in 2000 (OECD-FAO 2024). This growth is primarily driven by rising incomes in countries where pulses are a staple food, particularly India, where a significant portion of the population is vegetarian.

Pulses can be processed into various forms, including whole pulses, split pulses, flours, and fractions like protein, starch, and fibre, expanding their applications across meat and snack foods, bakery and beverages, and batter and breading industries. As pulses offer numerous health benefits, including high protein content with a range of essential nutrients and low environmental impact, they are increasingly embraced by health and environmentally-conscious consumers as valuable meat substitutes. This growing demand, coupled with the rising popularity of plant-based diets, is driving the global pulse market. Rapid urbanization and changing lifestyles have led to a surge in demand for convenient and healthy snack foods, further fuelling the demand for pulses as an ingredient in processed foods. The increasing use of pulses in ready-to-eat (RTE) products is also expected to significantly impact their future role in agriculture. As consumer preferences evolve and the demand for sustainable and nutritious food sources grows, pulses are poised to regain prominence in diets worldwide.

The global pulse market is projected to grow continuously, with per capita consumption expected to reach 8.6 kg/year by 2033. This growth is anticipated across almost all regions over the coming decade, with the largest increase expected in Europe, where consumption is projected to increase at a rate of 3% per annum (OECD-FAO 2024).

Figure 5.1: Per Capita Consumption of Pulses by Region (kg/year/capita)



Source: OECD Agriculture Statistics database

The growing recognition of pulses' health and environmental benefits has led governments of pulse-producing countries to support farmers and promote pulse cultivation. The European Union's Protein Strategy, which prioritizes pulses as a major ingredient in meat substitutes, further underscores the increasing importance of pulses in the global food systems. As consumer demand for healthy and sustainable food products continues to rise, pulses are likely to play a pivotal role in agricultural production and diets.

5.2 Trends in Pulse Consumption in India: Rural and Urban India

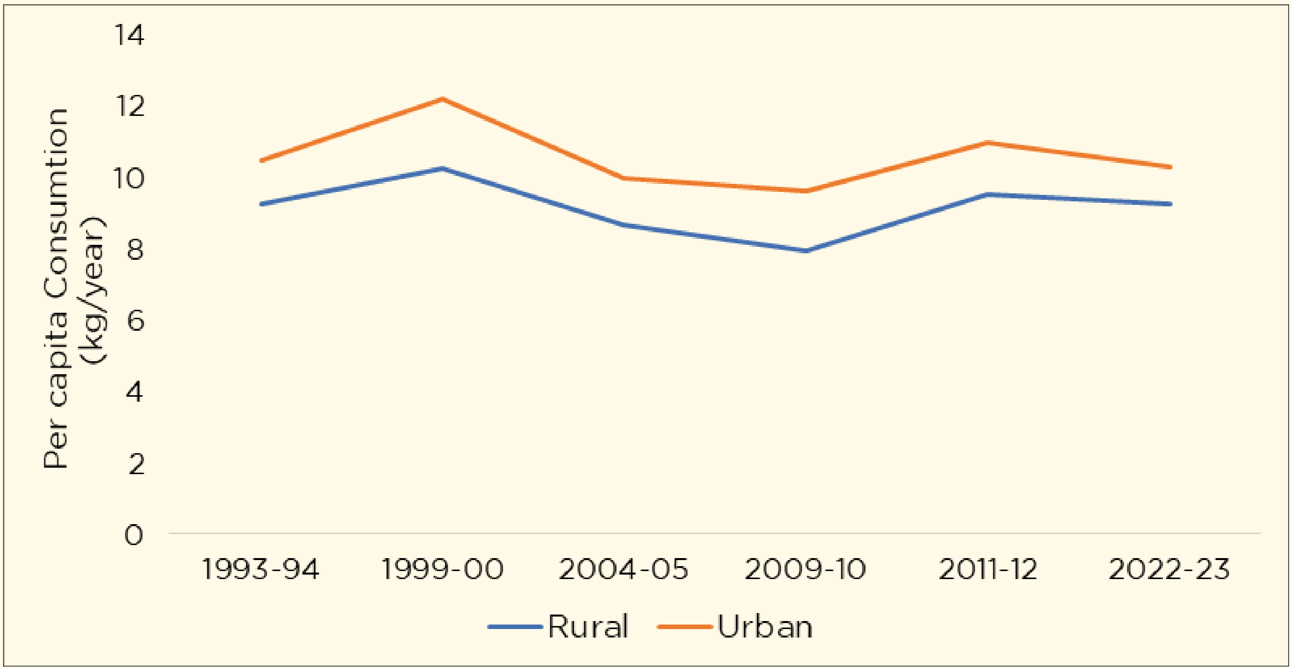
Pulses and pulse products consumption patterns in India exhibit variations between urban and rural areas. Data from the National Sample Survey Organisation (NSSO) indicates a decline in per capita pulse consumption in both rural and urban India over the past decade (Table 5.1 and Figure 5.2).

Table 5.1: Per Capita Consumption of Total Pulse and Different Pulse Crops (kg/year): Rural and Urban (NSSO rounds)

Pulses	Year	Rural	Urban
Pigeonpea	1993-94	2.92	4.02
	1999-00	2.8	4.02
	2004-05	2.56	3.65
	2009-10	1.95	3.16
	2011-12	2.56	3.65
	2022-23	2.62	2.85
Chickpea	1993-94	1.1	1.34
	1999-00	1.34	1.58
	2004-05	0.97	1.34
	2009-10	1.34	1.46
	2011-12	1.46	1.58
	2022-23	2.09	2.36
Green gram	1993-94	1.22	1.58
	1999-00	1.22	1.83
	2004-05	1.1	1.34
	2009-10	0.85	1.22
	2011-12	1.1	1.46
	2022-23	1.2	1.52
Lentil	1993-94	1.46	1.22
	1999-00	1.7	1.58
	2004-05	1.34	1.1
	2009-10	0.97	0.97
	2011-12	1.34	1.1
	2022-23	1.39	1.11
Black gram	1993-94	1.22	1.22
	1999-00	1.1	1.34
	2004-05	0.97	1.1
	2009-10	0.85	1.1
	2011-12	0.97	1.22
	2022-23	0.86	1.21
Total Pulses & Pulses Products	1993-94	9.25	10.46
	1999-00	10.22	12.17
	2004-05	8.64	9.98
	2009-10	7.92	9.6
	2011-12	9.53	10.96
	2022-23	9.25	10.27

Source: Author's compilation from several NSSO rounds, MoSPI, Government of India.

Figure 5.2: Per Capita Consumption of Total Pulses & Pulse Products (kg/year): Rural and Urban (1993-94 to 2022-23)

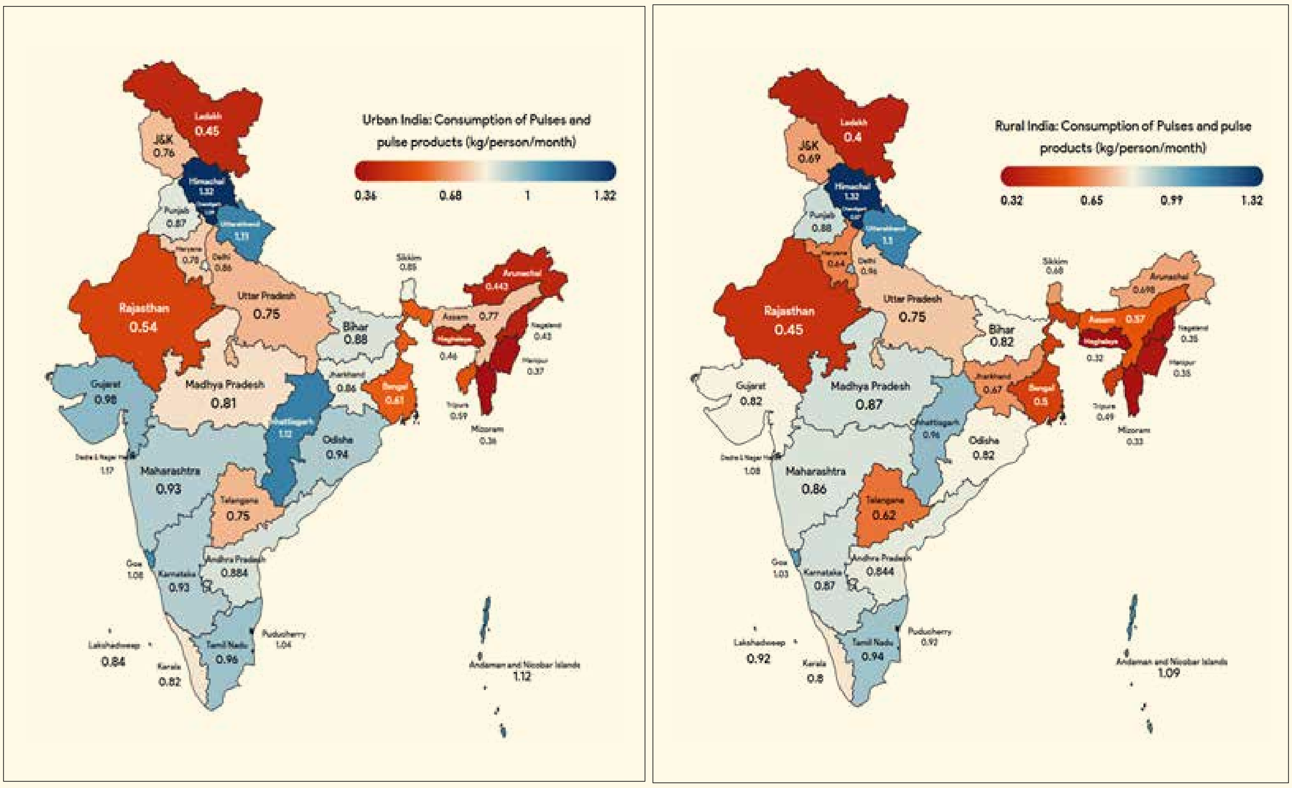


Source: Author's compilation from NSSO rounds

Urban areas witnessed a more pronounced decrease in the last decade, with consumption falling from 10.96 kg/year/capita in 2011-12 to 10.27 kg/year/capita in 2022-23. Rural areas experienced a smaller reduction, from 9.53 kg/year/capita to 9.25 kg/year/capita. Among individual pulses, pigeonpea remains the most popular in both urban (2.85 kg/year) and rural (2.62 kg/year) India. However, its consumption has significantly decreased since 1993-94, from 4.02 kg/year and 2.92 kg/year in urban and rural areas respectively. Interestingly, only chana saw a notable rise in consumption during this period among all the individual pulses, with a substantial increase in urban areas (from 1.34 kg/year to 2.36 kg/year) and in rural areas (from 1.1 kg/year to 2.09 kg/year).

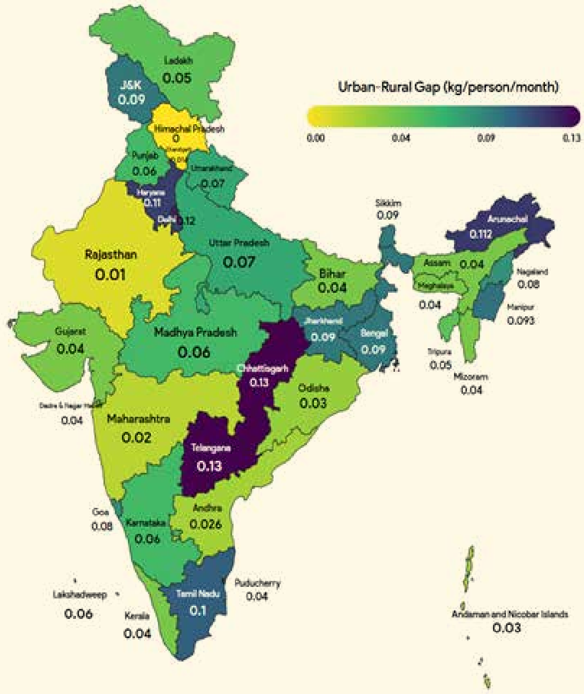
A notable disparity exists in pulse consumption between urban and rural India (Map 5.1). Per capita consumption is consistently higher in urban areas across all states and UTs. Nationally, the urban-rural gap in consumption stands at 0.08 kg/person/month. However, this gap is more pronounced in certain states and UTs, surpassing the national average. Chhattisgarh exhibits the highest disparity, followed by Telangana, Delhi, Arunachal Pradesh, Haryana, Tamil Nadu, Manipur, Jammu & Kashmir, Sikkim, Jharkhand, and West Bengal (Map 5.2). Understanding these urban-rural disparities is crucial for designing targeted interventions to promote pulse consumption and address specific needs.

Map 5.1: Spatial Disparities in Consumption of Pulses and Pulse Products (kg/person/month) across Indian States and UTs: Urban vs Rural (2022-23)



Source: Author's compilation from NSSO rounds and HCES (2022-23), MoSPI, Government of India

Map 5.2: Urban-Rural Disparities in Pulses and Pulse Products Consumption (kg/person/month) across Indian States and UTs (2022-23)

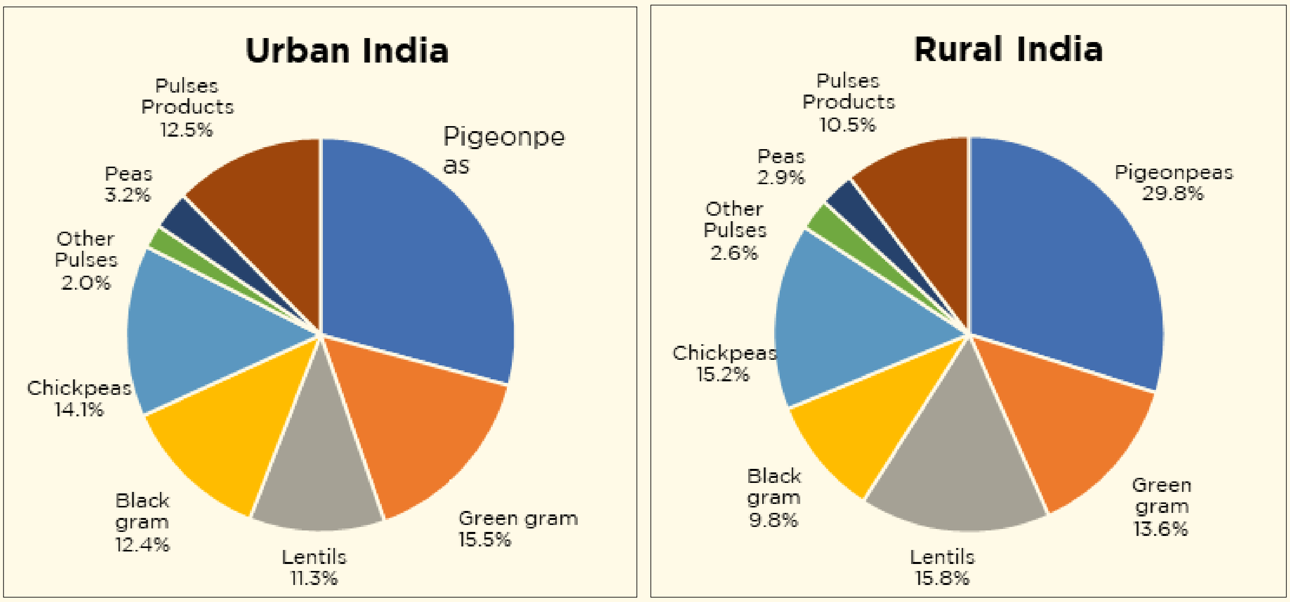


Source: Author's compilation from NSSO rounds and HCES (2022-23), MoSPI, Government of India

This section delves into the consumption trends of different pulse crops in rural-urban sceneries, highlighting the factors influencing these disparities. Pigeonpea remains the most popular pulse in both urban and rural India, constituting about 29.1% and 29.8% of total consumption, respectively, in 2022-23 (Figure 5.3). While popular in both urban and rural areas, chickpea exhibits slightly higher consumption in rural areas (15.2%) compared to urban areas (14.1%). Urban areas exhibit higher consumption of green gram (15.5%) compared to rural areas (13.6%). This could be attributed to its increased usage in urban culinary practices or its higher accessibility and affordability in urban areas. Lentil is more prominent in rural diets, accounting for 15.8% of total pulse consumption, compared to 11.3% in urban areas. This disparity may reflect stronger cultural preferences and affordability considerations in rural areas. Urban areas consume more black gram (12.4%) than rural areas (9.8%), which could be due to its usage in diverse urban culinary preparations. Pea are more popular in urban areas (3.2%) than in rural areas (2.9%), possibly due to their increased usage of urban dishes. Rural areas exhibit higher consumption of other pulses, such as moth, cowpea, horsegram, lathyrus, rajmash, and guar, at 2.6% compared to 2.0% in urban areas, likely due to their availability, affordability, and traditional dietary preferences. Lastly, urban areas show higher consumption of pulse products (12.5%) than rural areas (10.5%), particularly ready-to-eat (RTE) foods, indicating a growing trend towards convenience and processed foods.

Overall, pulses play a crucial role in both urban and rural diets, but with distinct consumption patterns. While some pulses are universally popular, others exhibit variations based on regional and cultural preferences, income levels, lifestyle, and accessibility. Understanding these trends is essential for developing effective strategies to promote pulse consumption and ensure food security.

Figure 5.3: Percentage Share of Consumption by Different Pulse Crops: Rural and Urban India (2022-23)



Source: Author's compilation from MoSPI, Government of India

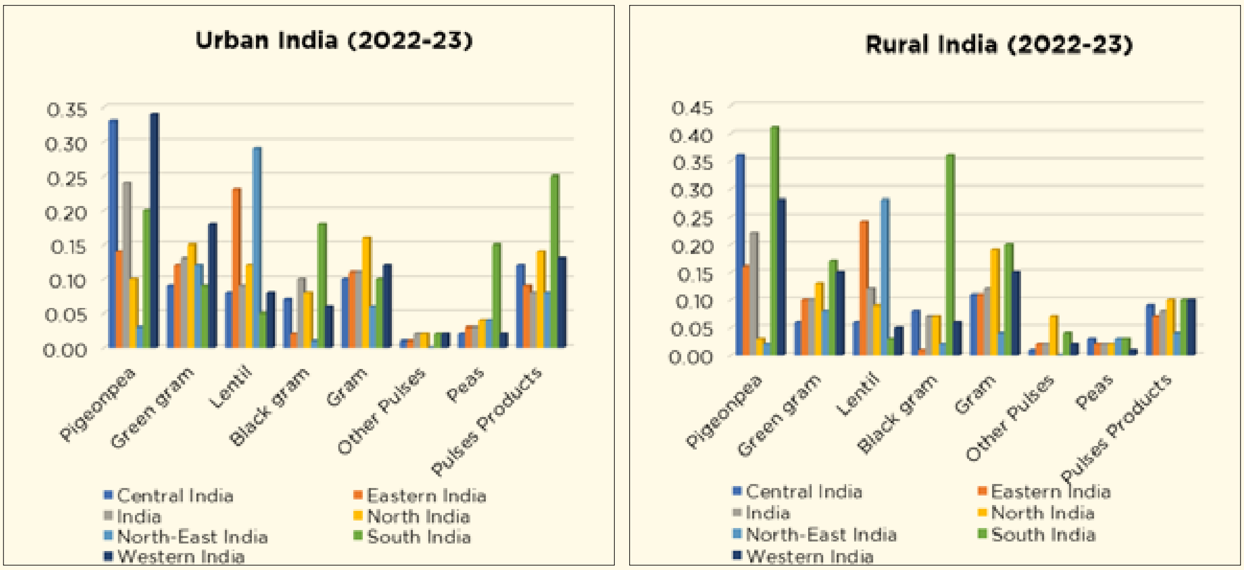
5.2.1 Trends in Pulse Consumption in India: Regional Disparities

Regional variations exist in per capita pulse consumption, with each zone bringing its unique preferences. Pigeonpea is widely consumed in urban areas of Central and Western India, as well as in rural areas of South and Central India. Green gram is particularly popular in urban areas of Western India, while rural areas of South and Western India also strongly prefer it. Lentil is the most favored pulse in both urban and rural areas of North-Eastern and Eastern India. Black gram is commonly consumed in both urban and rural areas of South India. Chickpea are favored in urban and rural areas of North India and rural areas of South India. Other pulses, except pea, are more commonly consumed in rural areas of North India. Pea are most popular in urban areas of South India. Pulse products are especially popular in urban areas of South India, followed by North and Western India (Figure 5.4). This regional disparity in pulse consumption highlights the diverse culinary preferences and dietary habits across different regions of India.

The consumption patterns of various pulse types exhibit significant regional variations, influenced by factors such as income levels, cultural preferences, ease of cooking, and dietary habits. Traditional diets, ease of cooking, and agricultural practices play a crucial role in shaping consumption patterns in rural areas. For instance, in rural South India, pigeonpea and black gram are widely consumed due to their suitability for local agro-climatic conditions and cultural preferences. Similarly, lentil are a staple in North-Eastern and Eastern India. Urban areas, particularly in South India, show a preference for processed pulse products, indicating a shift towards convenience and modern lifestyles. However, traditional pulse consumption patterns persist in North and Western India. Pulse products constitute a significant portion of the total consumption in both these regions (Figure 5.5).

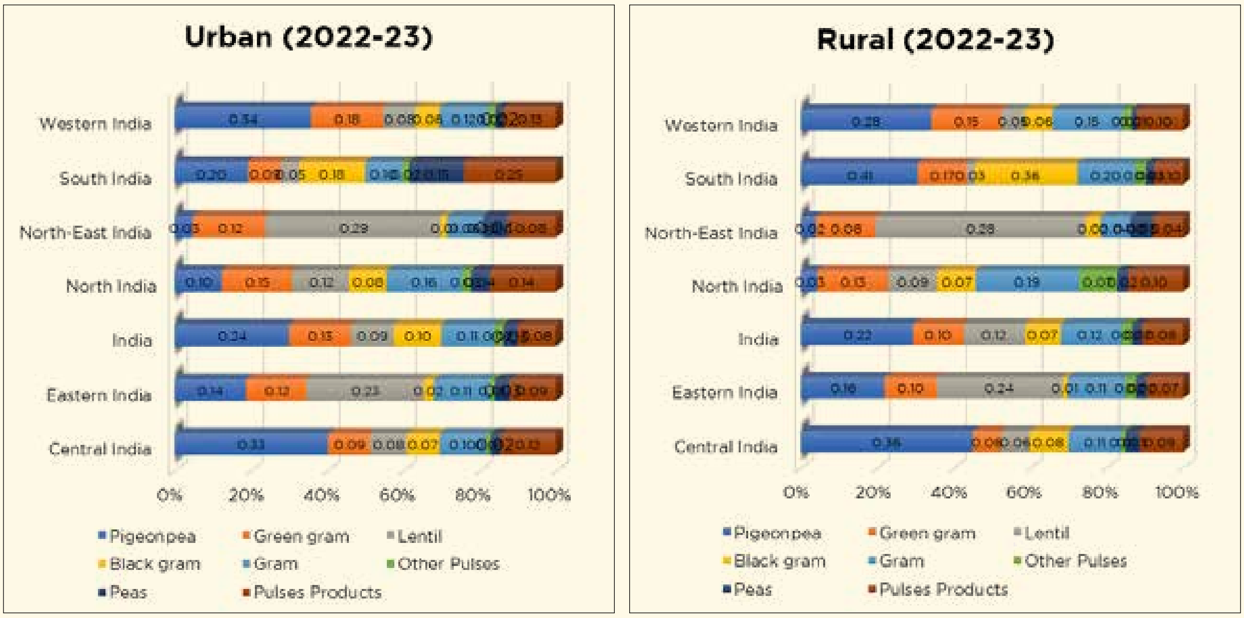
Understanding these regional variations is crucial to developing targeted interventions and promoting the consumption of diverse pulse types. By tailoring strategies to specific regional needs and preferences, it is possible to enhance dietary diversity and improve nutritional outcomes.

Figure 5.4: Crop-wise Per Capita Pulse Consumption (kg/person/month): Regional Disparity (Urban and Rural) (2022-23)



Source: Authors' computation from MoSPI, GoI

Figure 5.5: Share of Crop-wise Pulse Consumption by Region: Urban and Rural India (2022-23)



Source: Crop-wise Per Capita Pulse Consumption (kg/person/month): Regional Disparity (Urban and Rural) (2022-23)

5.3 Trend in Monthly Per Capita Consumption Expenditure (MPCE) Pattern: 1999-2000 to 2022-23

The trend in the average MPCE in India's rural and urban areas since 1999 is shown in Table 5.2. In 1999-2000, the average MPCE in rural areas was ₹486; in urban areas, it was ₹855. Over the years, there has been a significant increase in average MPCE, indicating higher spending power and improved living standards. By 2022-23, the average MPCE in rural areas surged to ₹3,773; in urban areas, it reached ₹6,459, up 164% and 146%, respectively, since 2011-12. Adjusted to 2011-12 prices, the growth is 40% in rural and 33% in urban areas. This substantial rise reflects a notable improvement in purchasing capacity and living standards, which could boost economic growth through higher demand for goods and services. Furthermore, the urban-rural difference in average MPCE has decreased from 84% in 2011-12 to 71% in 2022-23 at current prices and from 84% to 75% at 2011-12 prices (HCESs 2022-23). This shrinking gap suggests economic improvements in rural areas, likely due to effective rural development and better infrastructure. Furthermore, the trend is reflective of higher retail inflation in urban areas, as per capita consumption doesn't vary much between urban and Rural areas.

Table 5.2: Trend in Level of Average Monthly Per Capita Expenditure (1999-00 to 2022-23): Rural and Urban

Period (NSSO)	Average MPCE over different periods (₹)	
	Rural	Urban
1999-00	486	855
2004-05	579	1,105
2009-10	1,054	1,984
2011-12	1,430	2,630
2022-23	3,773	6,459

Source: Author's compilation from NSSO rounds and HCES (2022-23), MoSPI, GoI

Complementing the rise in MPCE (as shown in Table 5.2), Table 5.3 reveals a significant shift in dietary patterns across India. Over the past two decades, there has been a notable decline in the MPCE share of cereals and pulses in both rural and urban areas. In 1999-00, cereals accounted for a substantial portion of the average household expenditure, comprising 22.23% in rural areas and 12.39% in urban areas. However, by 2022-23, this share had significantly decreased to 4.91% and 3.64%, respectively. Similarly, the share of pulses and pulse products declined from 3.94% and 2.95% in 1999-00 to 2.01% and 1.39% in 2022-23 in rural and urban areas, respectively. Interestingly, the rate of decline in the MPCE share of cereals and pulses was more pronounced in rural areas compared to urban areas.

In contrast to the declining trend in cereals and pulses, the share of other food groups in average MPCE has increased in both rural and urban India. The share of 'milk and milk products,' 'fruits,' and 'beverages and processed food' has grown significantly in both rural and urban areas from 2011-12 to 2022-23. While the share of 'egg, fish, and meat' has increased in rural areas, it has remained relatively stable in urban areas. This shift in dietary patterns suggests a growing preference towards more diverse, nutritious, and convenient food items. As incomes rise and lifestyles change, consumers are increasingly opting for processed foods, ready-to-eat meals, and other convenience foods.

Concurrently, the share of food items in the average household expenditure has also declined over the period. In 1999-00, food items accounted for a significant portion of the average MPCE, comprising 59.4% in rural areas and 48.06% in urban areas. However, by 2022-23, this share had decreased to 46.38% in rural areas and 39.17% in urban areas. This trend indicates an evolving consumption pattern in India, with a growing preference for non-food items likely influenced by increasing incomes, urbanization, and lifestyle changes.

Table 5.3: Trend in the Share of Consumption of Cereals, Pulses and Pulse Products and Food items (1999-00 to 2022-23): Rural and Urban

Period	Rural			Urban		
	Share of cereals in average MPCE (%)	Share of pulses and pulse products in average MPCE (%)	Share of food in average MPCE (%)	Share of cereals in average MPCE (%)	Share of pulses and pulse products in average MPCE (%)	Share of food in average MPCE (%)
1999-00	22.23	3.94	59.4	12.39	2.95	48.06
2004-05	17.45	3.1	53.11	9.63	2.14	40.51
2011-12	10.75	2.9	52.9	6.66	2.04	42.62
2022-23	4.91	2.01	46.38	3.64	1.39	39.17

Note: For the years 1999-00 & 2004-05, the percentage shares are based on Mixed Reference Period (MRP) estimates, and for the years 2009-10, 2011-12 and 2022-23, these are based on Modified Mixed Reference Period (MMRP) estimates.

Source: Author's compilation from NSSO rounds and HCES (2022-23), MoSPI, Government of India

Furthermore, a compelling trend is where the average MPCE on all food items increased about 6 times from 1999-00 to 2022-23; it has increased only about 4 times for pulses and pulse products in rural and 3.6 times in urban India, respectively. From 1999-00 to 2022-23, rural MPCE on pulses and pulse products rose from ₹19.1 to ₹75.8; similarly, urban areas exhibited an increase, from ₹25.2 to ₹89.8 (Table 5.4). This data aligns with the observed trend in the above table (Table 5.3).

Table 5.4: Trend in the Level of Average MPCE on Pulses and Pulse Products (1999-2022): Rural and Urban

Period (NSSO)	MPCE of Pulses (₹)	
	Rural	Urban
1999-00	19.1	25.2
2004-05	17.9	23.6
2009-10	35	49
2011-12	41.5	53.7
2022-23	75.8	89.8

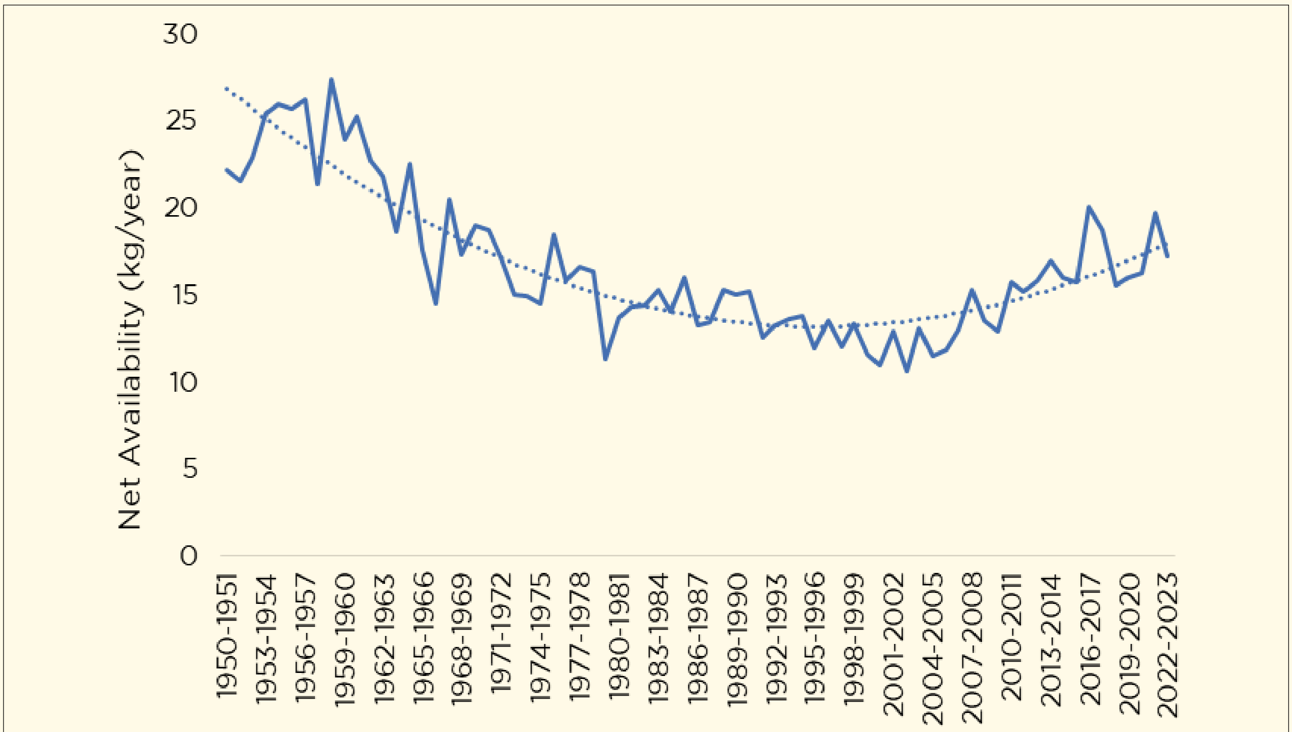
Source: Author's compilation from NSSO rounds and HCES (2022-23), MoSPI, Government of India

5.4 Demand Projections of Pulses by 2030 and 2047 in India

To project future demand for pulses and pulse products, it is essential to understand the country's historical trends in per capita net availability. The per capita net availability of pulses[15] in India has exhibited a complex trajectory over the past several decades. Initially, between 1950-51 and 1970-71, there was a 14.5% decline, from 22.16 kg/year to 18.94 kg/year. Subsequently, a more significant decrease of 40.4% occurred between 1970-71 and 1980-81, reducing availability to 11.28 kg/year. However, a turnaround began in the following decades. Between 1980-81 and 2000-01, a gradual increase of 2.9% was observed, bringing the per capita availability to 11.61 kg/year. A more substantial surge of 48.1% followed between 2000-01 and 2022-23, reaching 17.19 kg/year (Figure 5.6).

This significant increase in per capita net availability can be attributed to various factors, including rising incomes, urbanization, changing lifestyles, evolving dietary preferences, and a growing awareness of the nutritional benefits of pulses. Understanding these dynamic trends is crucial for developing effective strategies to promote pulse production and consumption, ensuring both food security and dietary diversity in India.

Figure 5.6: Trends in Per Capita Net Availability of Pulses in India (1950-51 to 2022-23)



Source: Authors' computation, data from DES, MoA&FW

Pulses demand projections for household consumption have been worked out using the following three approaches. i.e., (i) Static / Household Approach, using the population projection (Annexure II) and the base year per capita net availability. This approach assumes short-term static behavior of consumption; (ii) Normative Approach, based on the dietary requirement as recommended by the ICMR-National Institute of Nutrition (NIN) and

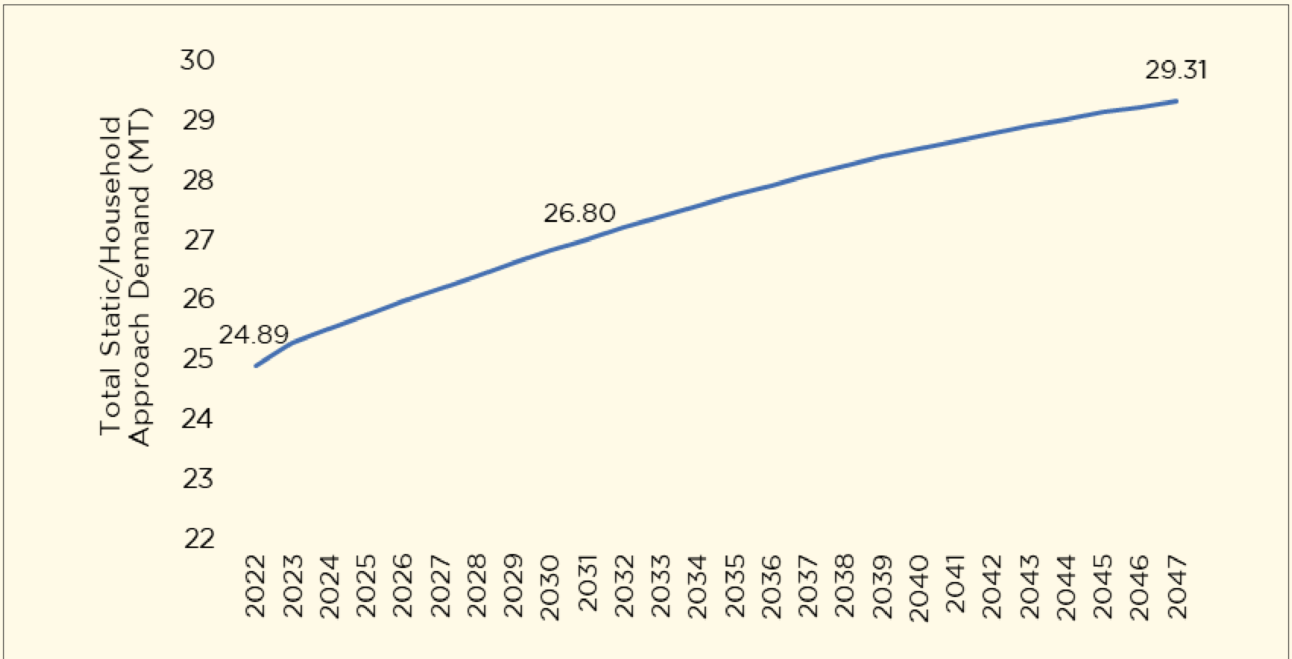
15 *This is per capita net availability for consumption, estimated by Gross Production (-) seed, feed & wastage, (-) exports (+) imports, and (-) change in stocks.*

population projection; (iii) Behavioristic Approach, which considers changes in the behavior of consumption of different food items on account of changing per capita income and prices, measured in terms of income/expenditure elasticities, base year per capita net availability and population projection.

5.4.1 Static/Household Approach

The projected population growth for India, as reported by the World Bank, indicates a substantial increase from 1.41 billion in 2021 to 1.52 billion by 2030 and further to 1.66 billion by 2047. The proportion of the urban population is anticipated to rise from 36% in 2023 to 51% by 2047 (Annexure II). This growth trajectory signifies a significant demographic shift. The rising population will continue driving pulses and pulse products demand in India. The Static/Household Approach estimates projected demand to reach 26.8 MT by 2030 and 29.3 MT by 2047. These projections are based on population growth forecasts and a base year per capita net availability of 17.69 kg/year (the last three-year average per capita consumption), translating to a total demand of 24.89 MT in 2022.

Figure 5.7: Total Household Demand for Pulses and Pulse Products (2022-2047, in MT)



Source: Author's computations

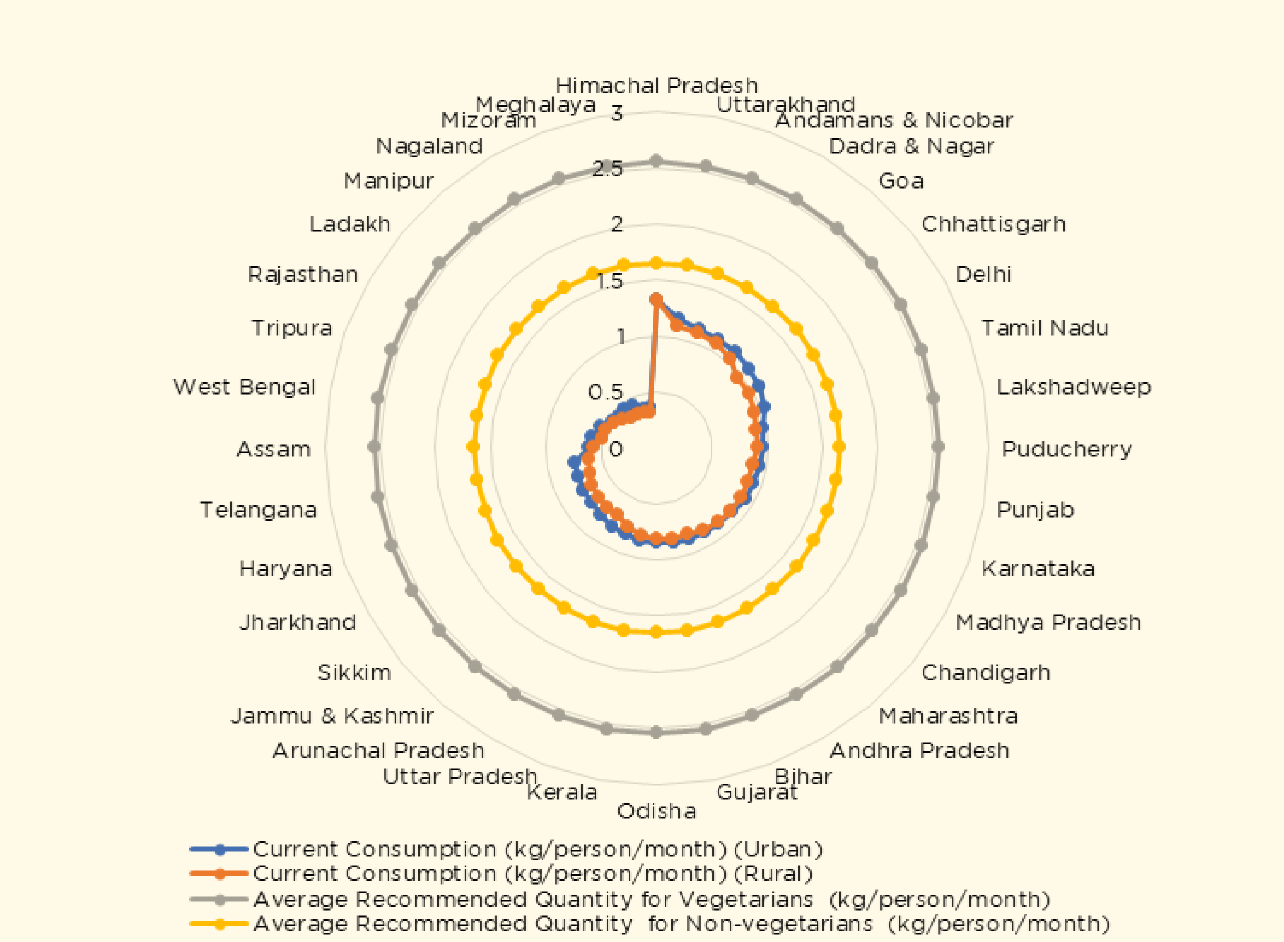
5.4.2. Normative Approach

A balanced diet comprising a variety of nutrient-rich foods, is essential for maintaining good health, preventing all the adverse effects of nutritional deficiencies, and ensuring optimal growth and development. However, modern dietary patterns, influenced by urbanization and globalization, are increasingly shifting towards processed foods, refined carbohydrates, and unhealthy fats, contributing to the rise of non-communicable diseases (NCDs). Ideally, a balanced diet should include cereals (up to 45% of total calories), pulses, eggs, and meat (14-15% of total calories), supplying good quality proteins and essential amino acids through natural food combinations and the remaining calories should be from nuts, vegetables, fruits, and milk. Fat intake should be limited to 30% of total calories, with essential fatty acids sourced from nuts, oilseeds, milk products, and seafood contributing 8-10% of daily caloric intake. In other words, this will ensure 50%–55% of total calories from carbohydrates, 10%–15% from proteins, and 20%–30% from dietary fats (ICMR-NIN 2024). However, the current dietary patterns in India deviate from these recommendations. Cereals, for instance, contribute significantly to the daily diet, i.e., 50-70% of total daily energy intake often exceeding the recommended limit of 45%; while pulses, meat, poultry, and fish contribute only 6-9%, falling short of the recommended 14% of total energy.

The recent Household Consumption Expenditure Survey (HCES) 2022-23 data reveals that the pulse consumption in the average Indian diet remains well below the ICMR-NIN dietary recommended levels, leading to a widening gap between current consumption and the nutritional requirements from pulses across all states and UTs, both in rural and urban areas. The below figure (Figure 5.8) illustrates the significant gap between the current per capita consumption of pulses and the recommended dietary intake set by ICMR-NIN. While Himachal Pradesh exhibits the highest per capita consumption of 1.32 kg/person/month (in both rural and urban), it still falls short of the recommended levels for both vegetarians (2.55 kg/person/month) and non-vegetarians (1.65 kg/person/month). This gap underscores the urgent need for increased awareness among the population regarding the importance of protein consumption, particularly from pulses as an affordable source. Promoting higher pulse intake through education and awareness campaigns will be essential to closing this nutritional gap, improving health outcomes, and ensuring food security for future generations.

Further, despite this shortfall, India's domestic pulse production has struggled to keep pace with demand, necessitating imports to meet consumption needs. As India's population grows and dietary preferences evolve, the demand for affordable and nutritious food sources like pulses is expected to increase. To ensure a stable supply of pulses, addressing challenges such as low productivity, biotic and abiotic stresses, and inadequate infrastructure is crucial. By implementing effective strategies and promoting sustainable agricultural practices, India can strive to increase domestic pulse production and reduce its reliance on imports.

Figure 5.8: Statewise Gap Between Average Actual Consumption of Pulses and Pulse Products and Recommended Quantity of Consumption (kg/person/month) for Vegetarians and Non-Vegetarians set by ICMR-NIN: Urban and Rural India



Source: Author's computations from HCES (2022-23), MoSPI, GoI and ICMR-NIN (2024)

A normative approach has been employed here to project the future demand for pulses in the country based on the ICMR-NIN dietary recommendation. This approach utilizes per capita dietary consumption recommendations provided by ICMR-NIN, segmenting the population into sedentary and moderate activity levels based on research by the ICMR-INDIAB Collaborative Study Group. Dietary pulse requirements, obtained in grams per person per day (g/p/d) from the Working Group Report by ICMR-NIN (2024), are converted to kilograms per person per year (kg/p/year) for further analysis (Table 5.5). By understanding the future demand based on recommended consumption levels and population demographics, effective and efficient strategies may be developed to bridge the production-consumption gap and ensure food and nutritional security. This analysis provides valuable insights into potential demand and a comprehensive assessment of India's future pulse needs, enabling informed decision-making for sustainable and equitable food systems.

Table 5.5: Dietary Requirements of Pulses

Age group			g/p/d	kg/p/yr
0-10 years			58.34	21.29
11-17 years	Male		123.34	45.01
	Female		96.67	35.28
18-59 years	Male	Sedentary	85	31.02
		Moderate	120	43.80
	Female	Sedentary	60	21.90
		Moderate	90	32.85
60<	Male		75	27.37
	Female		70	25.55

Source: ICMR-NIN (2024)

Further, Table 5.5 offers a granular view of pulse demand patterns across various demographic groups in India, revealing the evolving dynamics of dietary habits and lifestyle choices (2022 to 2047). The data showcases total pulse consumption by age, gender, and activity level for 2022, amounting to 43.38 MT. Looking ahead, the Normative Approach projects a rise in pulse demand to 46.33 MT by 2030 and 50.26 MT by 2047 (Table 5.6). This disaggregated approach provides valuable insights to comprehend the specific demand patterns of different demographic groups.

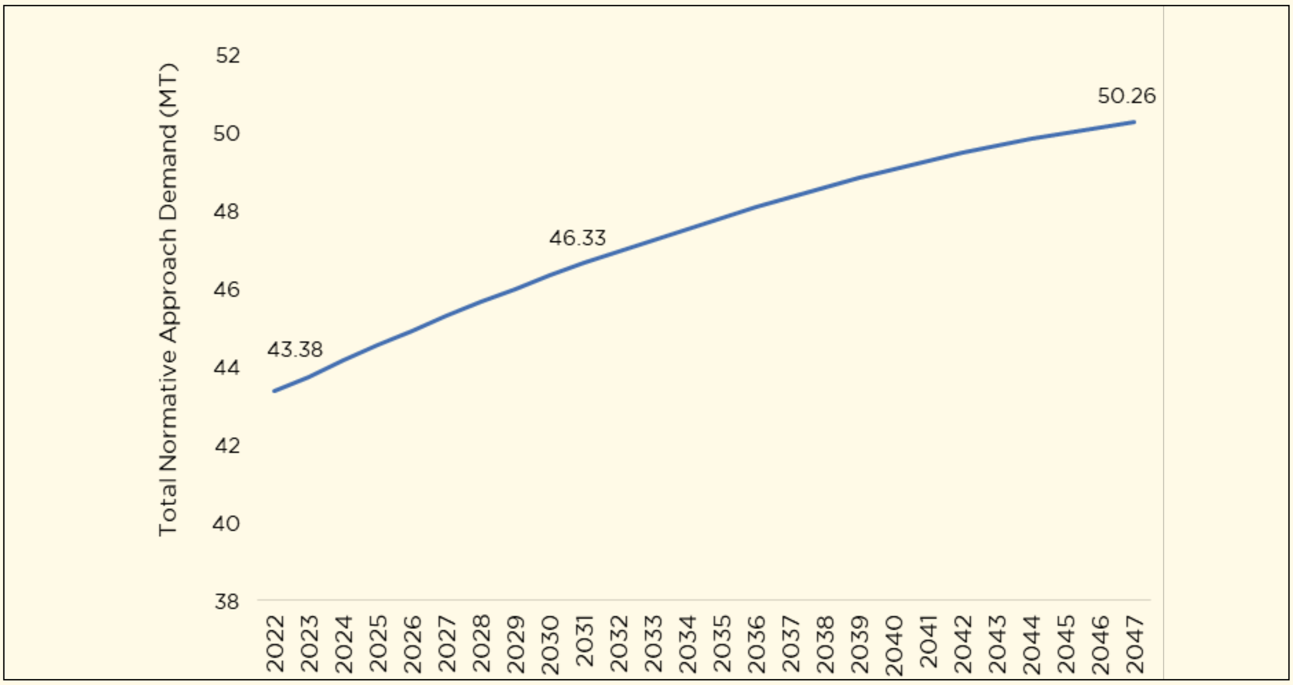
Table 5.6: Projected Demand for Each Group and Total Demand (2022-2047, MT)

Year	Children (0-10)	Male (11-17)	Female (11-17)	Sedentary Male (18-59)	Moderate Male (18-59)	Sedentary Female (18-59)	Moderate Female (18-59)	Male (>60)	Female (>60)	Total
2022	5.50	4.15	2.95	6.12	10.29	5.54	4.88	1.97	1.96	43.38
2023	5.45	4.13	2.94	6.20	10.42	5.61	4.94	2.03	2.02	43.74
2024	5.40	4.11	2.93	6.28	10.55	5.68	5.00	2.11	2.10	44.15
2025	5.36	4.08	2.91	6.35	10.68	5.75	5.06	2.18	2.17	44.54
2026	5.33	4.05	2.89	6.42	10.80	5.81	5.11	2.26	2.25	44.92
2027	5.29	4.01	2.87	6.49	10.92	5.87	5.17	2.34	2.33	45.29
2028	5.26	3.97	2.84	6.56	11.03	5.93	5.22	2.42	2.41	45.65
2029	5.24	3.93	2.82	6.63	11.14	5.98	5.27	2.50	2.49	45.99
2030	5.21	3.88	2.79	6.69	11.24	6.04	5.32	2.59	2.57	46.33
2031	5.20	3.83	2.76	6.74	11.34	6.09	5.36	2.67	2.66	46.64
2032	5.19	3.79	2.73	6.79	11.42	6.13	5.40	2.76	2.74	46.95
2033	5.17	3.75	2.71	6.84	11.49	6.17	5.43	2.85	2.83	47.24
2034	5.15	3.71	2.69	6.88	11.57	6.21	5.47	2.94	2.92	47.53

Year	Children (0-10)	Male (11-17)	Female (11-17)	Sedentary Male (18-59)	Moderate Male (18-59)	Sedentary Female (18-59)	Moderate Female (18-59)	Male (>60)	Female (>60)	Total
2035	5.13	3.68	2.67	6.92	11.63	6.24	5.50	3.03	3.01	47.81
2036	5.11	3.65	2.66	6.95	11.69	6.27	5.52	3.12	3.11	48.08
2037	5.09	3.63	2.65	6.98	11.73	6.30	5.55	3.21	3.20	48.34
2038	5.06	3.62	2.65	7.01	11.78	6.32	5.57	3.30	3.29	48.59
2039	5.03	3.61	2.65	7.03	11.81	6.34	5.58	3.40	3.39	48.83
2040	5.00	3.60	2.64	7.04	11.83	6.36	5.60	3.49	3.49	49.05
2041	4.97	3.58	2.64	7.05	11.85	6.37	5.61	3.60	3.59	49.27
2042	4.94	3.57	2.64	7.06	11.87	6.38	5.62	3.70	3.69	49.47
2043	4.90	3.55	2.63	7.07	11.88	6.39	5.62	3.81	3.80	49.65
2044	4.87	3.54	2.62	7.07	11.88	6.39	5.63	3.92	3.91	49.82
2045	4.83	3.52	2.61	7.07	11.88	6.39	5.63	4.03	4.02	49.98
2046	4.79	3.50	2.60	7.06	11.87	6.39	5.63	4.14	4.13	50.13
2047	4.75	3.48	2.59	7.06	11.86	6.39	5.63	4.25	4.25	50.26

Source: Author's computations

Figure 5.9: Total Normative Demand for Pulses and Pulse Products (2022-2047, in MT)



Source: Author's computations

5.4.3. Behaviouristic Approach

The final approach for demand projection is the behavioral approach, which considers the changing preferences of consumers on different food items with the changes in income (i.e., expenditure) and price. The demand Equation 5.1 is given below:

Where D_t is the household demand for a commodity in year t; D_0 is the per capita consumption of the commodity in the base year, y is growth in per capita income; e is the expenditure elasticity of demand for the commodity; and N_t is the projected population in the year t. Expenditure elasticities are important parameters for projecting future demand. Expenditure elasticity varied widely across locations, income groups, and regions due to changes in production environment, tastes, and preferences.

Understanding the demand structures and consumer behaviour is critical for informing a wide range of development policies. As economic growth progresses, average per capita income typically rises, leading to a decrease in the per capita consumption of staple foods - a trend consistent with Engel's Law (1857) i.e., the proportion of income spent on food declines as average household income rises, and indicative of improved welfare. Furthermore, urbanization drives diversification within the food basket, which, as documented by Kumar (1997) and Rao (2000), enhances the quality of life by contributing to better nutritional status and overall well-being of the population. Consumer demand theory seeks to understand how rational consumers allocate a limited budget across various goods when faced with different prices. This allocation process results in a specific consumption bundle. Changes in income and relative prices lead to adjustments or diversification within this bundle, reflected by the income and price elasticities of demand for different food groups. Accurately estimating these elasticities and their projected changes is vital for future policy decisions. Consequently, the chosen estimation technique is based on a functional form that incorporates realistic assumptions about consumer behavior, a two-stage behaviouristic food demand modelling approach, i.e., the Quadratic Almost Ideal Demand System (QUAIDS) model, builds upon the Almost Ideal Demand System (AIDS) framework (Deaton & Muellbauer, 1980) by incorporating a quadratic expenditure term as it relaxes the linearity assumption of the AIDS in the expenditure function, acknowledging the potential non-linear relationship between income and expenditure. This extension allows for the modelling of non-linearities in Engel curves. Notably, the Engel curve for food exhibits log-linearity and stability over time and across societies both (Banks et al., 1997; Beatty & Larsen, 2005; Blundell et al. 1998; Leser, 1963; Yatchew, 2003). Due to their consistency with consumer theory, exact aggregation properties, and ease of estimation, AIDS-based approaches have become the preferred method for demand system estimation in the literature. The suitability of the QUAIDS framework for modelling consumer preferences has been empirically validated in numerous studies (e.g., Abdulai, 2002; Moro & Sckokai, 2000; Banks et al., 1997; Blundell & Robin, 1999; Fisher et al., 2001; Abdulai & Aubert, 2004; Gould & Villarreal, 2006; Molina & Gil, 2005; Poi, 2002, 2008, and 2012; IMF, 2016).

This framework rests on a two-stage budgeting assumption, where consumers allocate their income sequentially. In the first stage, consumers prioritize broad categories, such as food versus non-food items. This translates to a choice between the budget allocated to food and the remaining budget for all other goods and services. Consequently, the initial stage of QUAIDS involves estimating a first-step budgeting equation. Here, the focus is on how much of the total expenditure is dedicated to food, conditional on the consumption of non-food categories. The non-linear relationship between income and food expenditure, characterized by a decreasing share of income spent on food with rising income, is captured by including a quadratic expenditure term. Notably, as the model only considers two broad expenditure categories - food and non-food - the adding-up restriction on expenditure weights allows for simplified estimation using single-equation least squares regression.

The second stage of the QUAIDS model delves into the intra-food allocation decisions. Here, consumers make simultaneous choices regarding allocating their total food expenditure across specific food items. This stage translates to estimating a system of simultaneous equations within the QUAIDS framework, each representing the demand for a specific food item category. While independent demand equations for individual food items may seem intuitive, can overlook crucial substitution and complementarity effects between different food products. These effects can significantly impact the demand for specific items. To address this limitation, a system of equations approach is employed within the broader food category and allows for estimating demand for various food items while accounting for their interdependencies. The two-stage budgeting framework, therefore, leverages reasonable assumptions about consumer behaviour. These assumptions include the separability of choices regarding food versus non-food consumption and the separability of choices within the food category. This approach balances these simplifications with the ability to capture important characteristics of demand for individual food items through the system of equations.

The two-stage QUAIDS model estimates food expenditure elasticity for specific items. This elasticity measures consumer demand (expenditure) responsiveness for an item to changes in their total food budget. In simpler terms, it reflects the perceived importance of that specific item within consumers' food baskets.

While significant shifts in consumption expenditure and dietary patterns have likely occurred in the past decade, existing elasticity estimates lack this crucial update. To address this gap, this model adopts an alternative approach. It leverages Private Final Consumption Expenditure (PFCE) data from 2013-14 to 2022-23 alongside Consumer Price Index (CPI) data from the same timeframe. This combined dataset allows us to estimate demand/expenditure elasticities for different food items, capturing the recent changes in consumption expenditure patterns and their impact on demand for pulses. While this data has certain limitations and is not a direct replacement for Household Consumption Expenditure Survey (HCES) data, this approach offers valuable insights into the evolving dynamics of pulse consumption in India. Future research efforts could benefit from more granular data on these categories to improve elasticity estimates.

The above data set categorizes expenditure on food into six key groups reflecting the Indian household consumption basket: Cereals and products (c1), Pulses and pulse products (c2), Eggs, Fish, and Meat (c3), Milk and Milk products (c4), Vegetables and Fruits (c5), and Others (Oils and fats + Sugar, jam, honey, chocolate, and confectionery + Non-alcoholic beverages which include Coffee, tea and cocoa, Mineral waters, soft drinks, fruit and vegetable juices, etc.) (c6).

The estimated expenditure elasticities, categorized by food groups in Table 5.7, offer valuable insights into consumer spending patterns. Based on total food expenditure, these elasticities allow for classifying food groups into three distinct categories. The first category encompasses 'high-income elasticity products,' including milk and milk products (i.e., 1.2), eggs, fish and meat (i.e., 1.1), and "Others" (Oils and fats + Sugar, jam, honey, chocolate, and confectionery + Non-alcoholic beverages which include Coffee, tea and cocoa, Mineral waters, soft drinks, fruit and vegetable juices, etc.) (i.e., 1.3). These groups exhibit elasticity greater than 1, indicating that a rise in total food expenditure will lead to a proportionally larger increase in spending on these items. The second category comprises 'unit income elasticity products,' including fruits and vegetables (i.e., 1.0). For these items, expenditure is expected to rise at a rate comparable to the overall increase in food spending. Finally, the third category comprises 'less-than-unity income elasticity products,' primarily cereals and products (i.e., 0.68) and pulses and pulse products (i.e., 0.79). These staples are likely to see a slower rise in expenditure relative to the growth in total food spending.

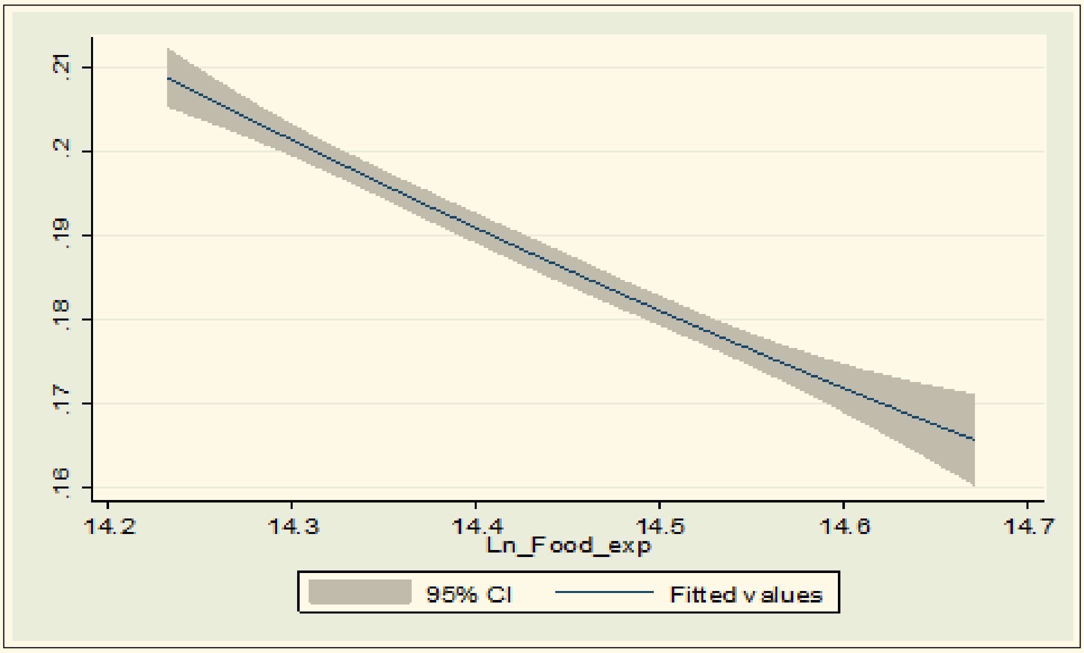
Table 5.7: Food Expenditure Demand Elasticities

Expenditure elasticity: with respect to total expenditure on food	
c1: Cereals and products	0.68
c2: Pulses and products	0.79
c3: Egg, Fish, and meat	1.1
c4: Milk and milk products	1.2
C5: Vegetables and Fruits	1.0
c6: Others (Oils and fats + Sugar, jam, honey, chocolate, and confectionery + Non-alcoholic beverages which include Coffee, tea and cocoa, Mineral waters, soft drinks, fruit and vegetable juices, etc.)	1.3

Source: Authors' estimation

Engel's Law posits a declining income share dedicated to food as incomes rise, and our data (Table 5.7) corroborates this notion. Expenditure on staples like cereals and pulses exhibits a less-than-unity income elasticity, signifying a proportional decrease in consumption with increasing income (Figures 5.10 and 5.11). This trend resonates with Bennett's Law (1941), reflecting a shift from calorie-dense staples to more nutrient-rich and higher-value foods as incomes improve (Figures 5.12 to 5.15). Furthermore, our findings coincide with India's rising personal income and urbanization over the past decade. These factors likely influence households to purchase more processed and packaged foods, potentially impacting overall dietary patterns. Understanding these evolving consumption patterns, with a growing demand for diverse food options, is essential for informing future policy decisions. By recognizing this shift, specific policies can be envisioned that promote balanced dietary choices, boost domestic production of essential food groups, and ensure long-term food security for the nation.

Figure 5.10: Predicted Cereals Expenditure Weights with Total Expenditure on Food

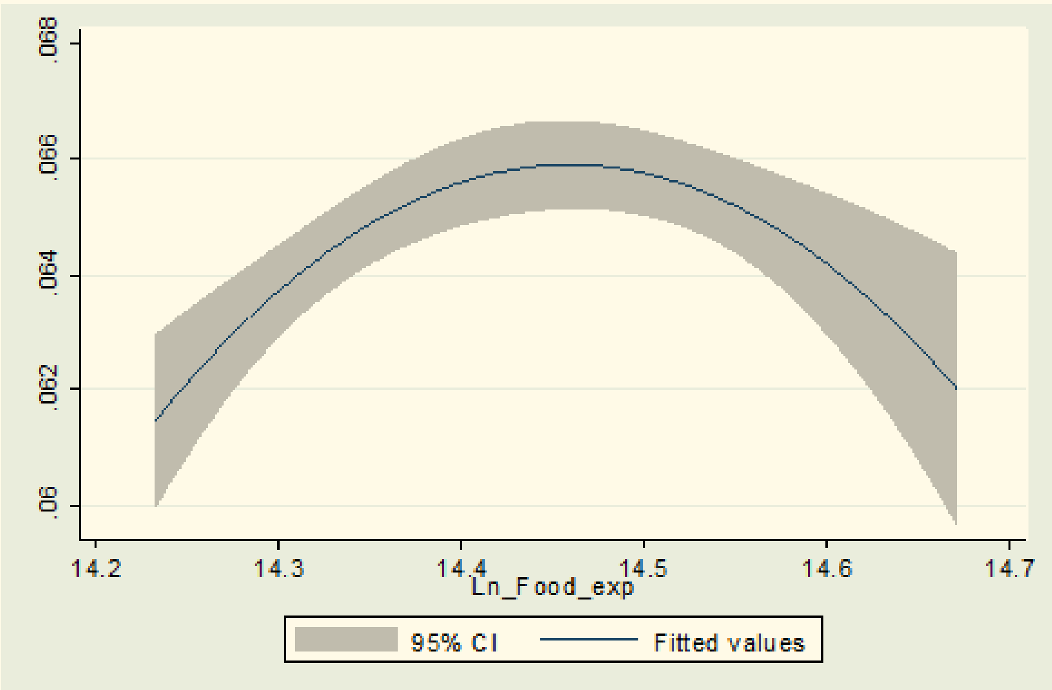


X-axis: Logarithm of total expenditure on food

Y-axis: Cereals and products: predicted weight in the total food budget

Source: Authors' estimation

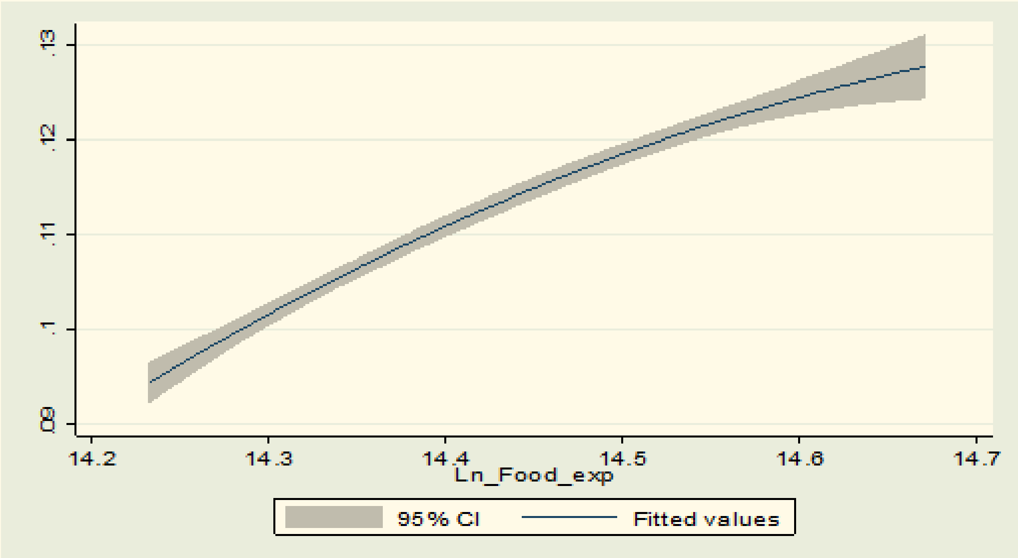
Figure 5.11: Predicted Pulses and Pulse Products Expenditure Weights with Total Expenditure on Food



X-axis: Logarithm of total expenditure on food
Y-axis: Pulses and products: predicted weight in the total food budget

Source: Authors' estimation

Figure 5.12: Predicted Egg, Fish, and Meat Expenditure Weights with Total Expenditure on Food

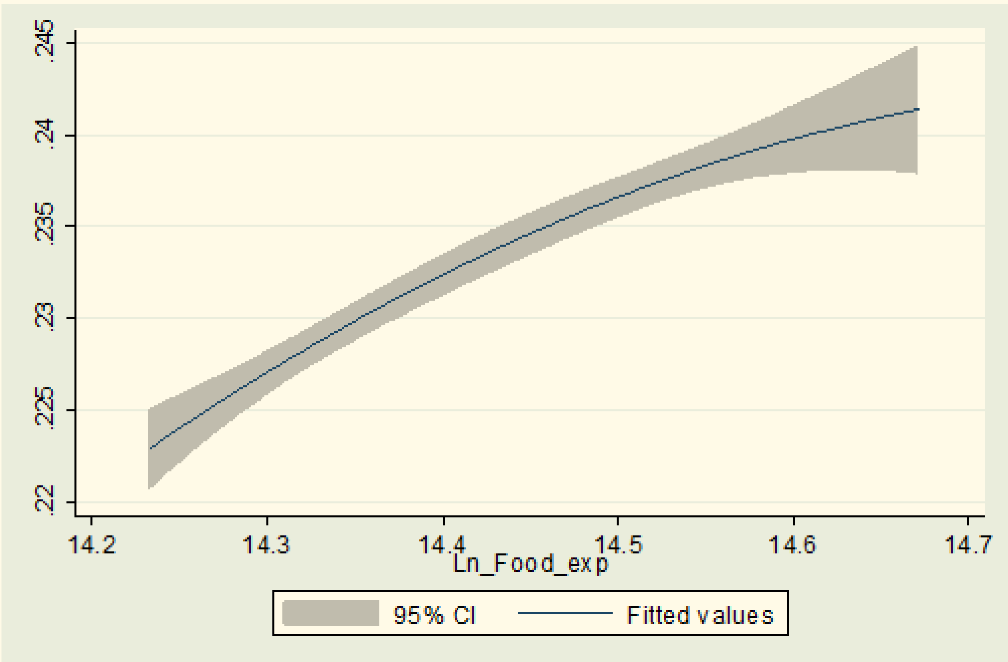


X-axis: Logarithm of total expenditure on food

Y-axis: Egg, Fish, and meat: predicted weight in the total food budget

Source: Authors' estimation

Figure 5.13: Predicted Milk and Milk Products Expenditure Weights with Total Expenditure on Food

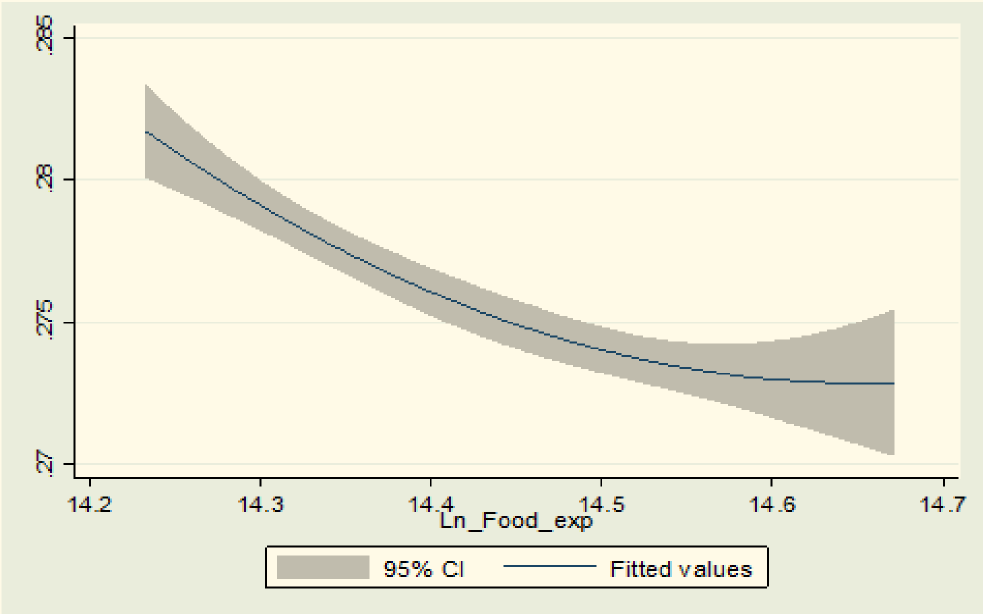


X-axis: Logarithm of total expenditure on food

Y-axis: Milk and milk products: predicted weight in the total food budget

Source: Authors' estimation

Figure 5.14: Predicted Vegetables and Fruits Expenditure Weights with Total Expenditure

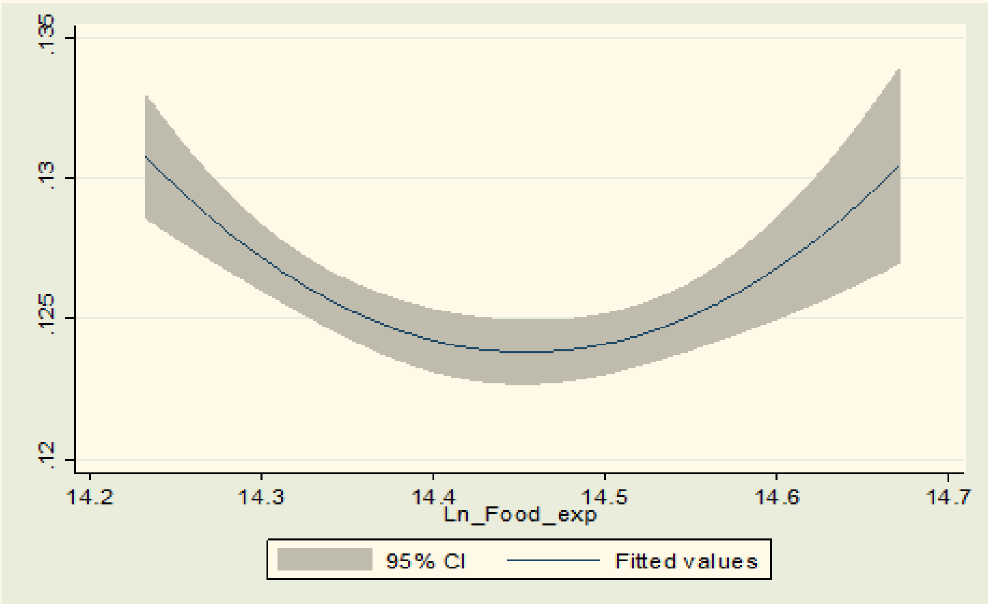


X-axis: Logarithm of total expenditure on food

Y-axis: Vegetables and Fruits: predicted weight in the total food budget

Source: Authors' estimation

Figure 5.15: Predicted Others Expenditure Weights with Total Expenditure on Food



X-axis: Logarithm of total expenditure on food

Y-axis: Others (Oils and fats + Sugar, jam, honey, chocolate, and confectionery + Non-alcoholic beverages which include Coffee, tea and cocoa, Mineral waters, soft drinks, fruit and vegetable juices, etc): predicted weight in the total food budget

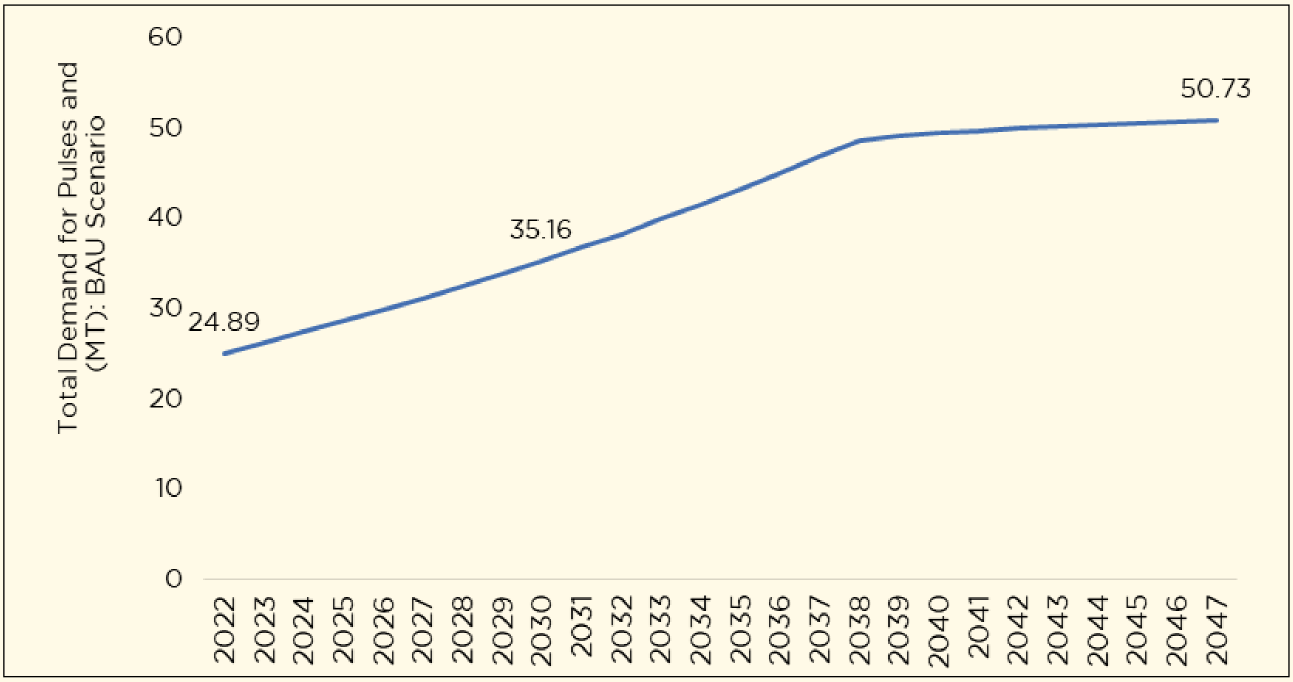
Source: Authors' estimation

In a large segment of the country's population, the intake of micronutrient-dense foods (whole grains, pulses, beans, nuts, fresh vegetables, fruits, etc.) is found to be lower than the recommended levels, low intake of essential nutrients can disrupt metabolism and increase the risk of insulin resistance and associated disorders from a young age. Consumption of pulses would contribute to meeting the recommended daily allowance of proteins and also contribute to fibre and micronutrients. Further, given growing concerns about food and nutrition security, which is key to attaining SDG 2, this behaviouristic approach considers a consumption cap to assess the future demand trajectories based on the maximum required demand for pulse observed in India during the entire period of 2022-2047 as per the ICMR-NIN recommended dietary requirement of pulses across age, gender, and physical activity level, i.e., 30.62 kg/person/year. This consumption cap is then integrated into the demand estimation equation (5.1) to project future pulse demand. The demand estimation utilizes the base year per capita net availability of 17.69 kg/person/year, per capita income growth rate, and expenditure elasticity of pulses derived from the two-stage QUAIDS model.

The two-scenario framework employed in the behaviouristic approach clearly shows India's potential pulses demand trajectory (Figure 5.16 and 5.17). Under the Business as Usual (BAU) scenario (i.e., reflecting the average Net National Income (NNI) per capita growth at constant prices over the past decade), demand for pulses and pulse products is projected to reach 35.16 MT by 2030 and 50.73 MT by 2047 (Figure 5.16). Considering India's aspirations of becoming a developed nation by 2047, this analysis additionally considers the demand for pulses under a High-Income Growth (HIG) scenario. To achieve this ambitious target, economic growth acceleration to 7.6-9.0% is projected to be necessary (RBI, 2023; PTI, 2023). Assuming an estimated 8% annual per capita NNI growth, this HIG scenario projected a demand of 43.76 MT by 2030 and 50.73 MT by 2047 (Figure 5.17).

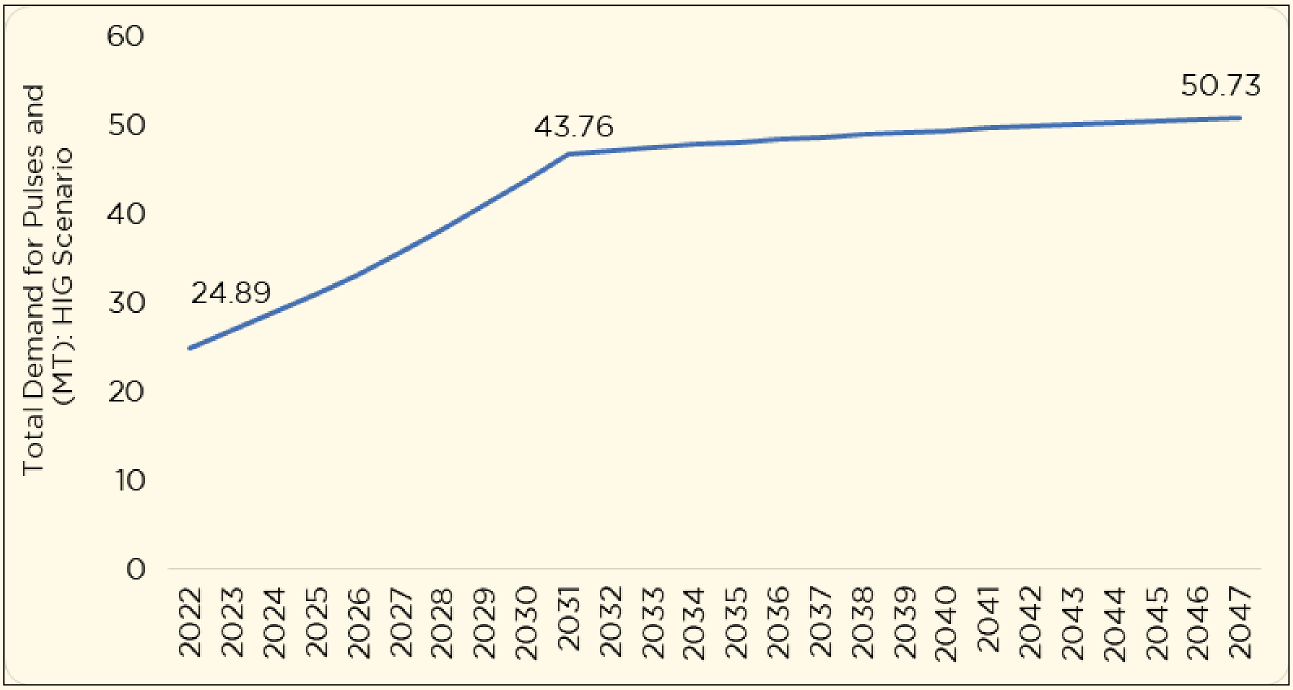
Furthermore, the analysis suggests that India's per capita consumption is expected to reach the maximum required demand for pulse based on the ICMR-NIN recommended dietary requirement by 2039 under BAU Scenario-I and by 2031 under HIG Scenario-II respectively. This represents an eight-year advancement compared to the BAU situation. These projections highlight the significant impact that rapid economic growth can have on pulses demand in India.

Figure 5.16: Total Behaviouristic Demand for Pulses and Pulse Products (MT, 2022-2047): BAU Scenario-I



Source: Authors' estimation

Figure 5.17: Total Behaviouristic Demand for Pulses and Pulse Products (MT, 2022-2047): HIG Scenario-II



Source: Authors' estimation

5.5 Projections of Pulses Production by 2030 and 2047 in India

A comprehensive approach, utilizing various models and techniques, was employed to forecast India's total pulse production under a Business-As-Usual (BAU) scenario. Historical data on pulse production, sourced from the Ministry of Agriculture and Farmers Welfare (MoA&FW), served as the foundation for this analysis. Univariate time series analysis formed the core, utilizing models like Autoregressive Integrated Moving Averages (ARIMA), Generalized Regression Neural Networks (GRNN), Extreme Learning Machines (ELM), Holt's Smoothing, and linear and quadratic trend regressions. The Geometric Mean Growth Rate (GMGR) and Average Annual Growth Rate (AAGR) were also employed. The model exhibiting the best fit or producing the least error for each specific case was then selected to forecast pulse production up to 2047. This rigorous approach ensures the reliability and accuracy of the estimations.

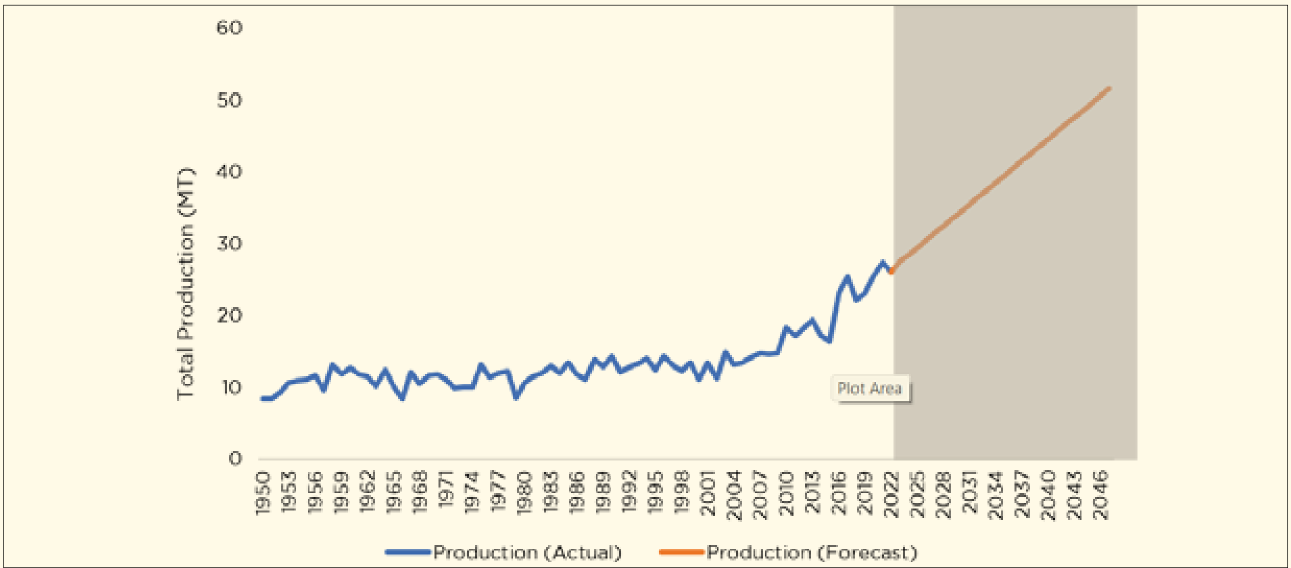
This study expands upon existing pulse production forecasts in India by delving deeper than aggregate historical data. While conventional methods focus solely on aggregate production, this approach takes a more granular look, employing forecasting techniques not only at the aggregate level for total pulses but also at the individual level for major and minor pulses: i.e., chickpea (bengal gram/chana), pigeonpea (arhar/ tur/ red gram), green gram (mung bean), black gram (urdbean/biri/mash), lentil (masur), fieldpea (matar/pea), mothbean (moth), horse gram (kulthi), lathyrus (khesari/grass pea/chicking vetch/teora), and other pulses (i.e., cowpea, rajmash, and guar). This granular approach offers valuable insights into the future production potential of various pulse crops across India.

The following sections present comprehensive national-level projections until 2047. This analysis is categorized to provide granular insights for informed policy decisions. Firstly, aggregated projections for the total pulse production, including all major and minor pulse crops, are presented. Subsequently, disaggregated national-level projections are provided for the individual pulse crop production of each major and major pulse crop.

5.5.1. National Level Projected Production of Total Pulses (based on aggregated data) by 2030 and 2047

Holt's smoothing model emerged as the most suitable method for forecasting national-level total pulse production. This model leveraged historical data from the period 1950 to 2022. The forecast suggests a steady increase in production, reaching an estimated 34.45 MT by 2030 and 51.57 MT by 2047 (Figure 5.18), up from 26.06 MT in 2022.

Figure 5.18: National Level Projected of Total Pulses (based on aggregate level data) by 2030 and 2047

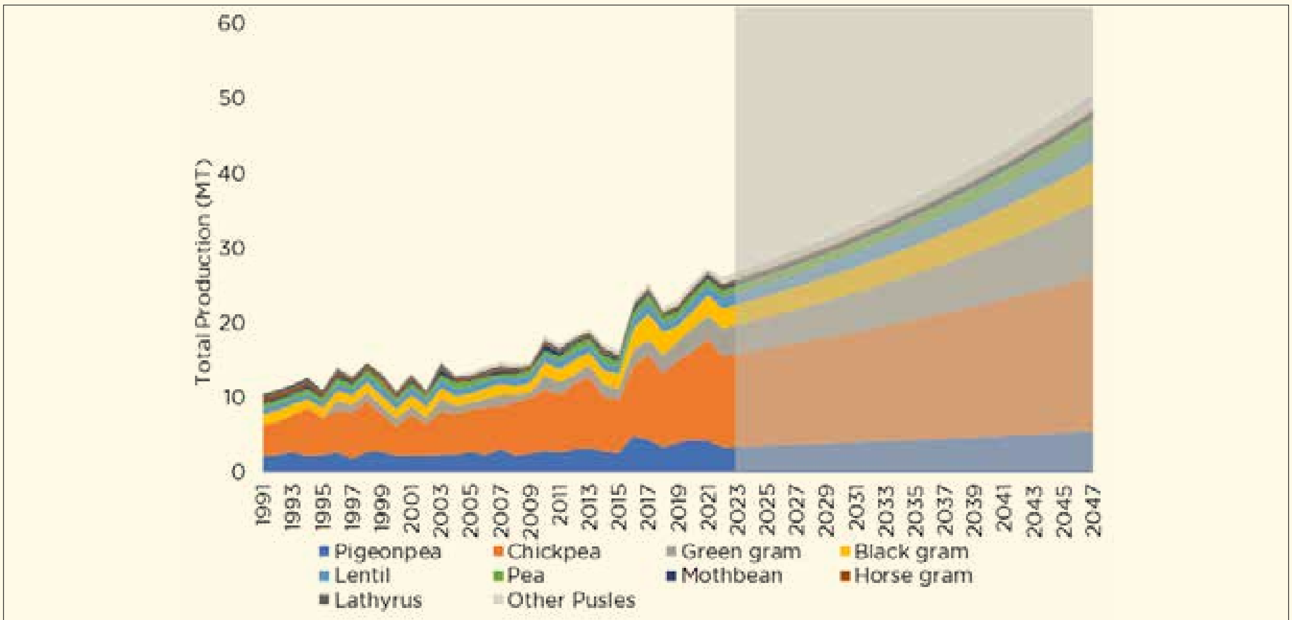


Source: Authors' estimation, data from DES, MoA&FW

5.5.2. National Level Projected Production of Individual Pulse Crops by 2030 and 2047

Building upon the methodology outlined in Section 5.3, this analysis presents disaggregated forecasts for individual pulse crop production in India. A more nuanced and detailed understanding of future trends can be obtained by forecasting each major pulse crop's production individually. Interestingly, the aggregated production estimates derived from these individual forecasts (32.1 MT by 2030 and 50.7 MT by 2047) closely align with the projections based on aggregate data (Figure 5.19). This convergence between the two approaches strengthens the validity and reliability of the overall production forecasts.

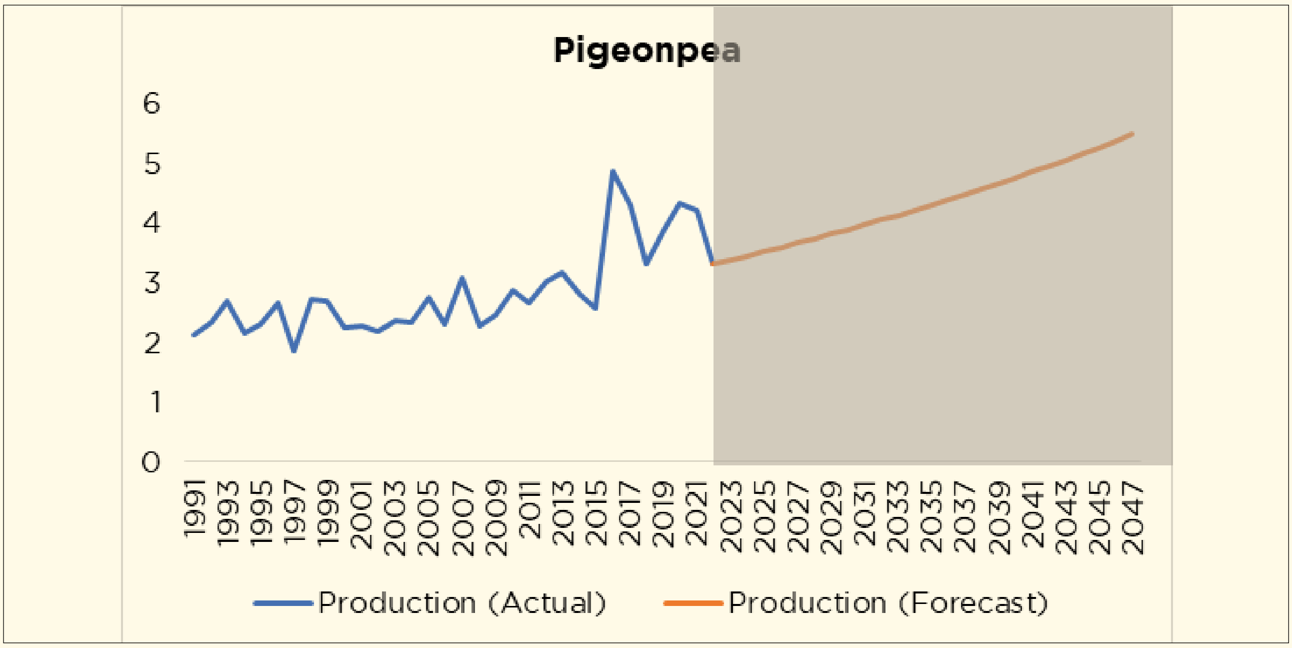
Figure 5.19: National Level Projected Production of Individual Pulse Crops by 2030 and 2047: National Level Projected Production of Individual Pulse Crops by 2030 and 2047

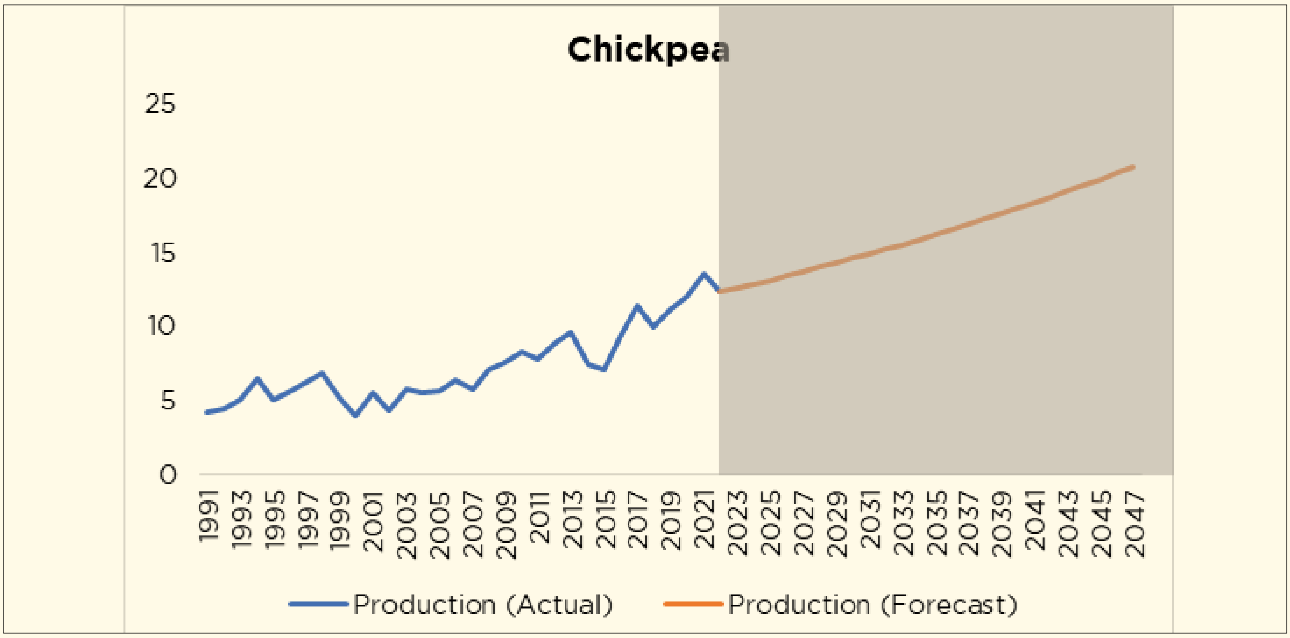


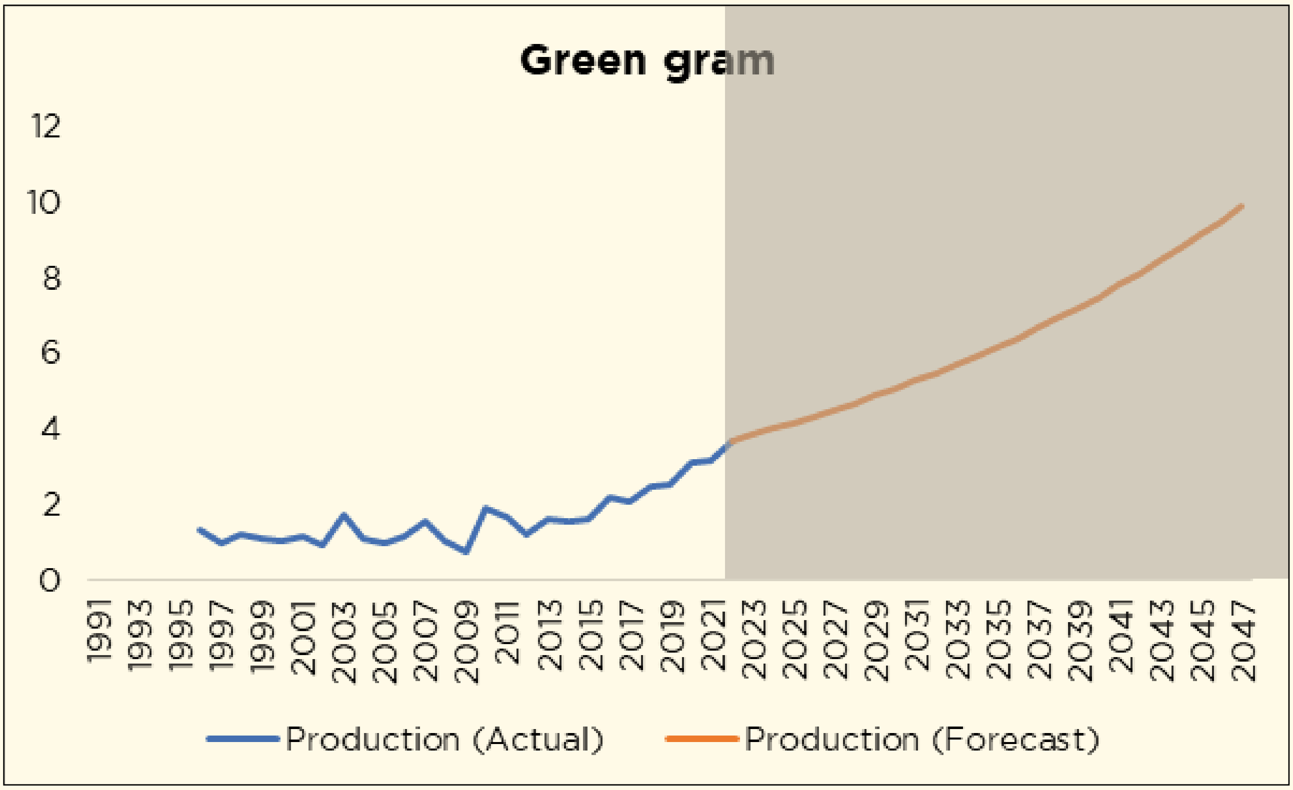
Source: Authors' estimation, data from DES, MoA&FW

To gain deeper insights into the future production potential of each pulse crop, individual crop-wise projections have been presented in Figure 5.20. The projected trends for each crop, including pigeonpea, gram, green gram, black gram, lentil, pea, moth, horse gram, and lathyrus, can help identify specific intervention areas. This granular approach enables the development of targeted strategies to address the unique challenges and opportunities associated with each pulse crop. By strategically allocating resources and implementing tailored support measures, India can work towards optimizing the production potential of different pulse crops and ensuring a sustainable supply of these essential nutrients.

Figure 5.20: National Level Projected Production of Individual Pulse Crops (distinctly) by 2030 and 2047



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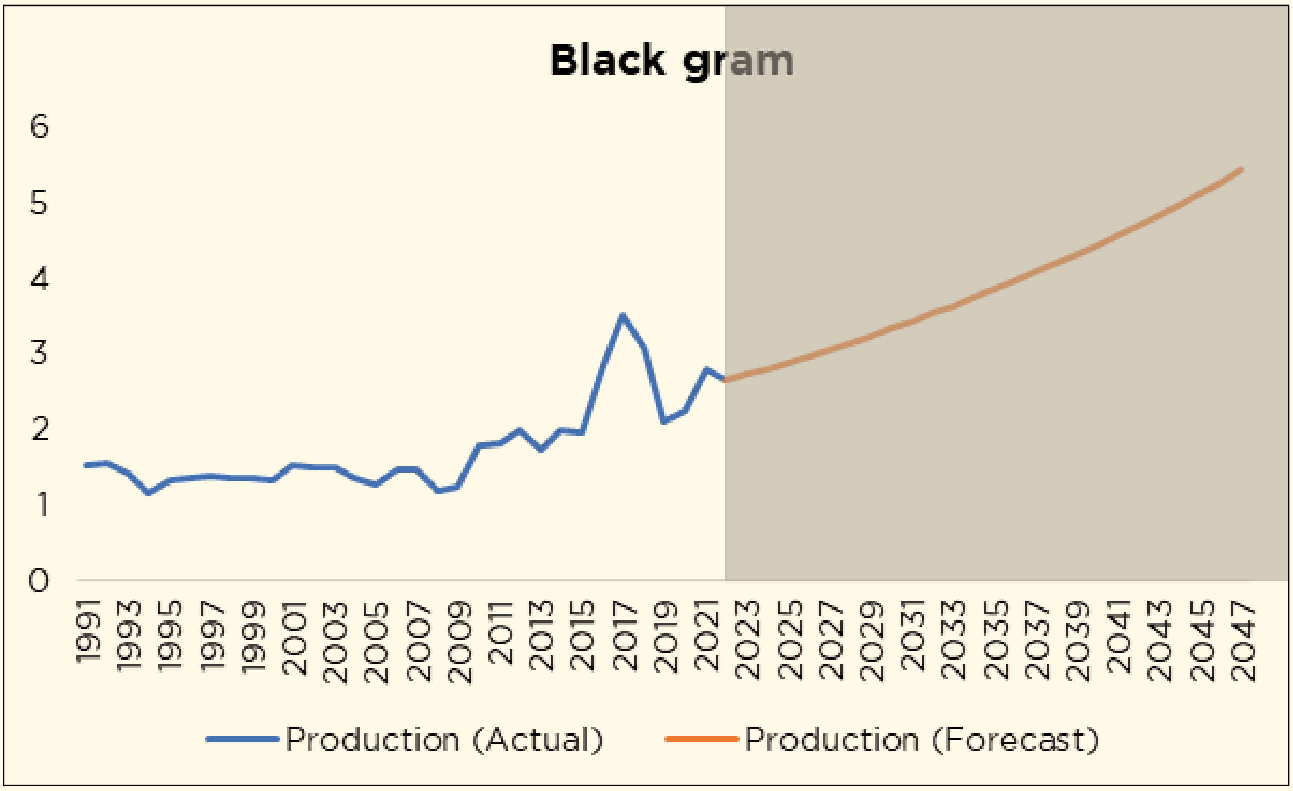
Production (Forecast)


Black gram
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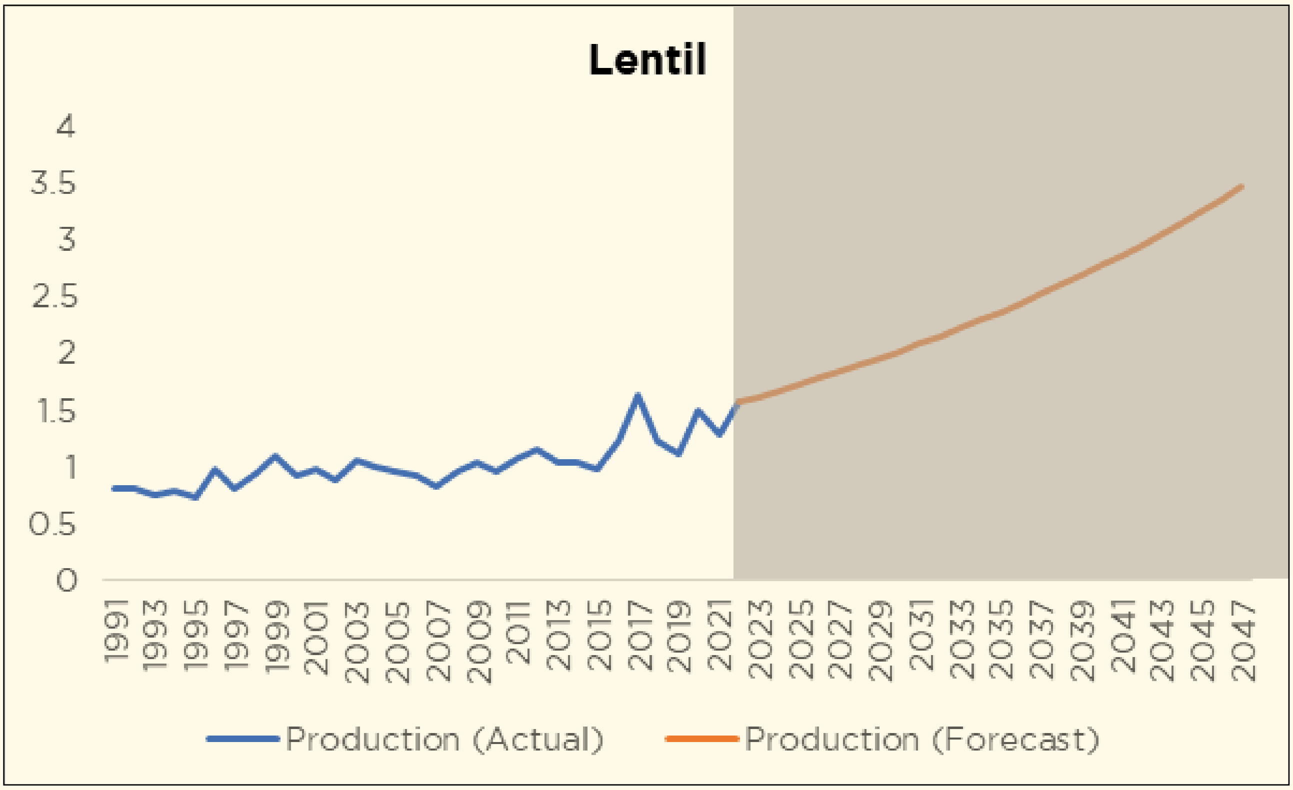
Production (Actual)
Production (Forecast)



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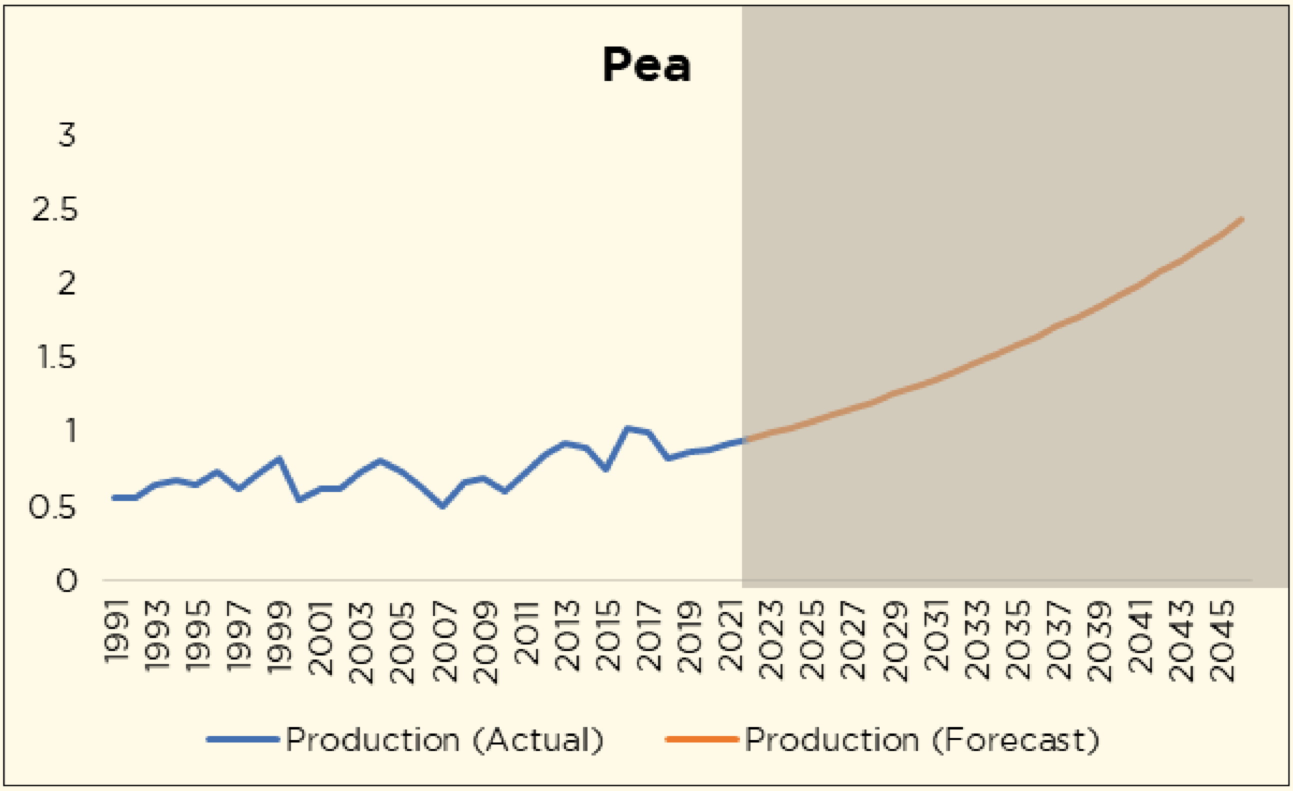
Production (Actual)
Production (Forecast)



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Production (Actual)
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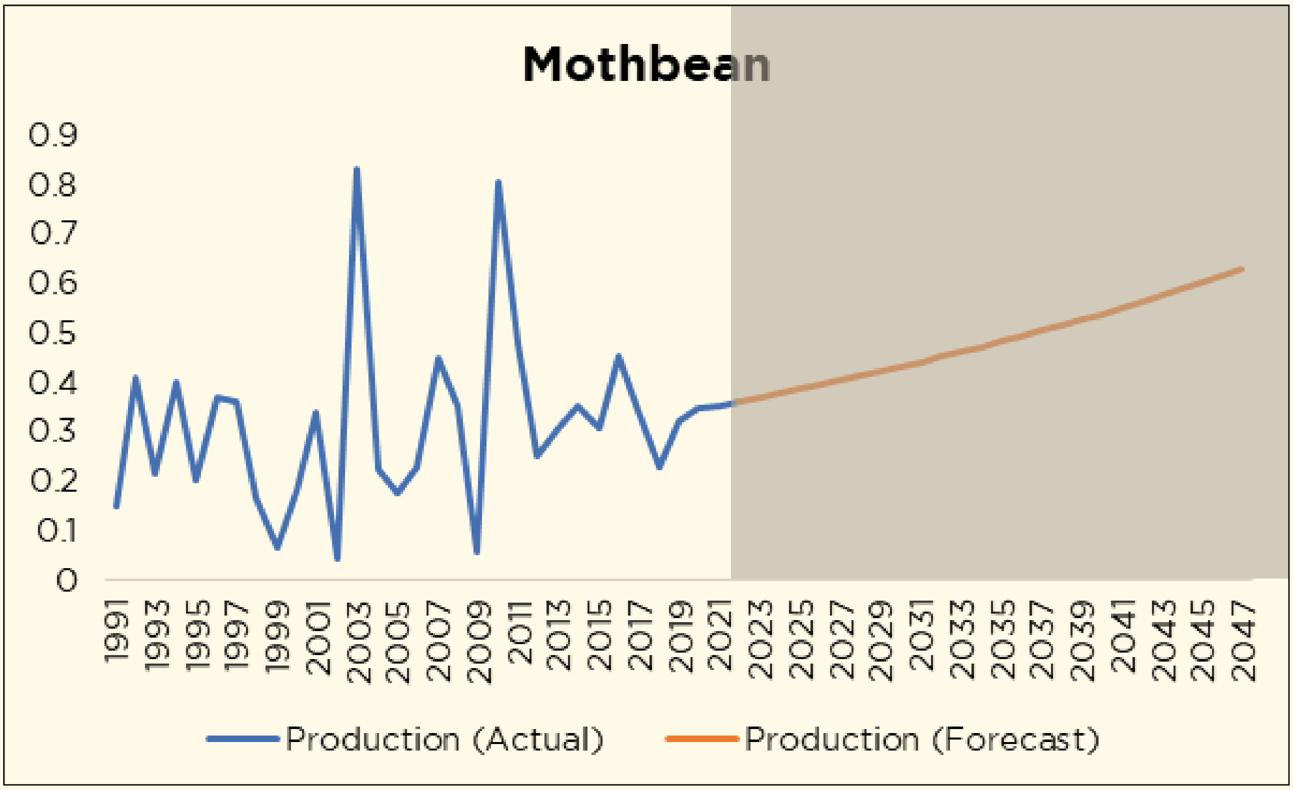
Mothbean
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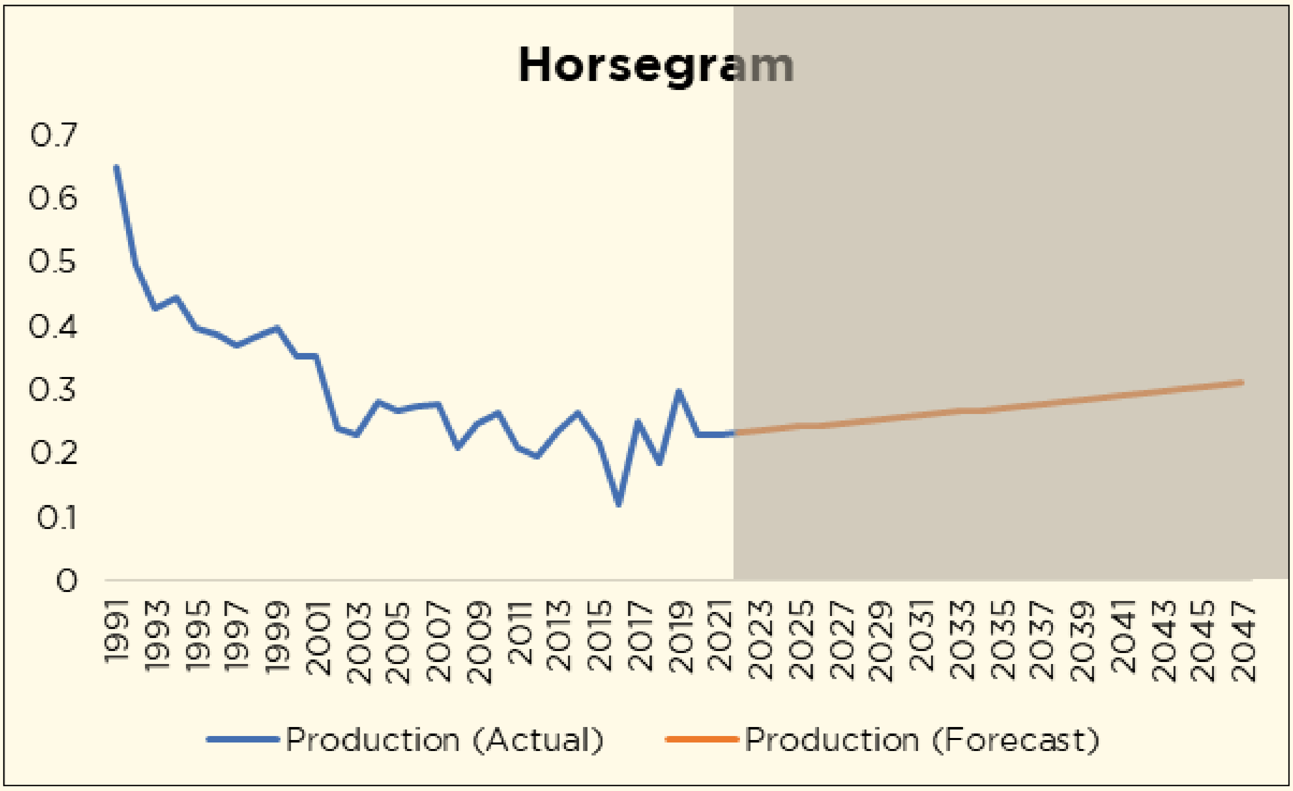
Production (Actual)
Production (Forecast)


Horsegram
0.7
0.6
0.5
0.4
0.3
0.2
0.1
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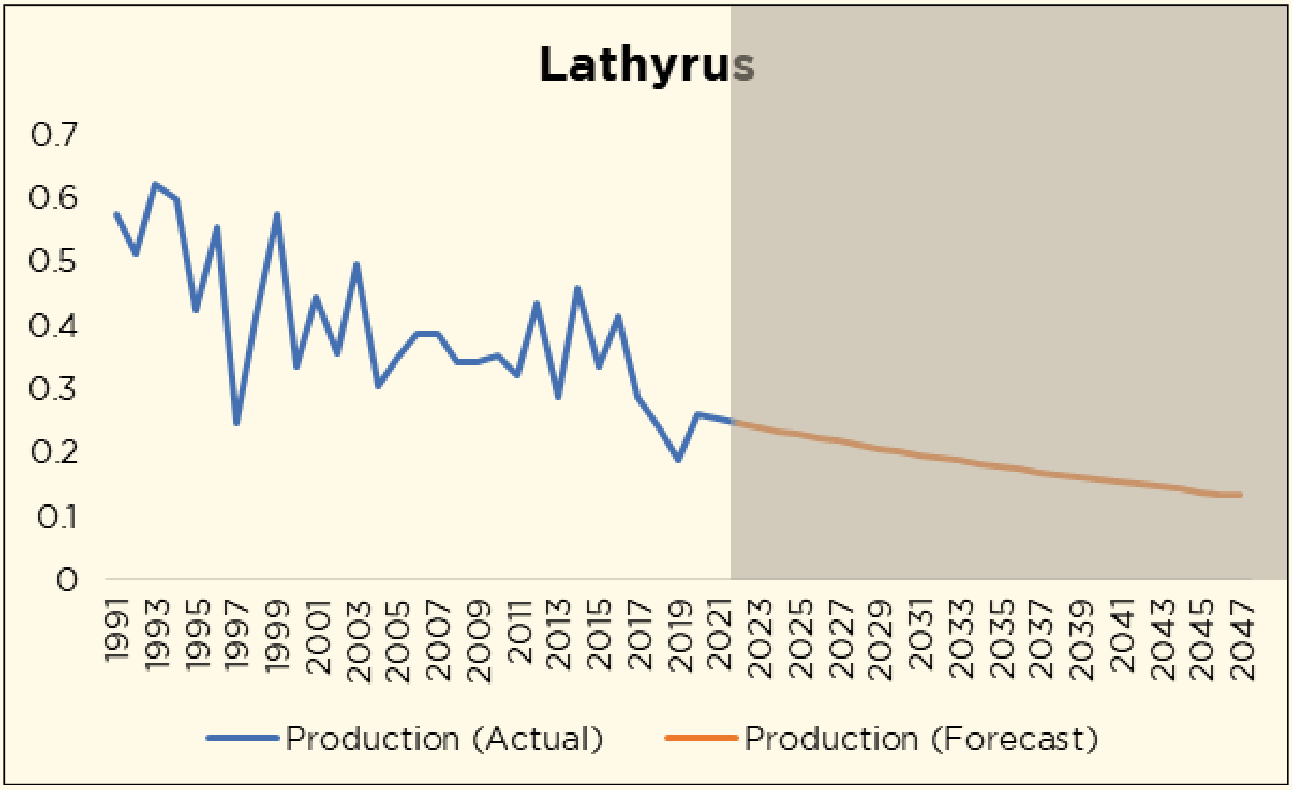
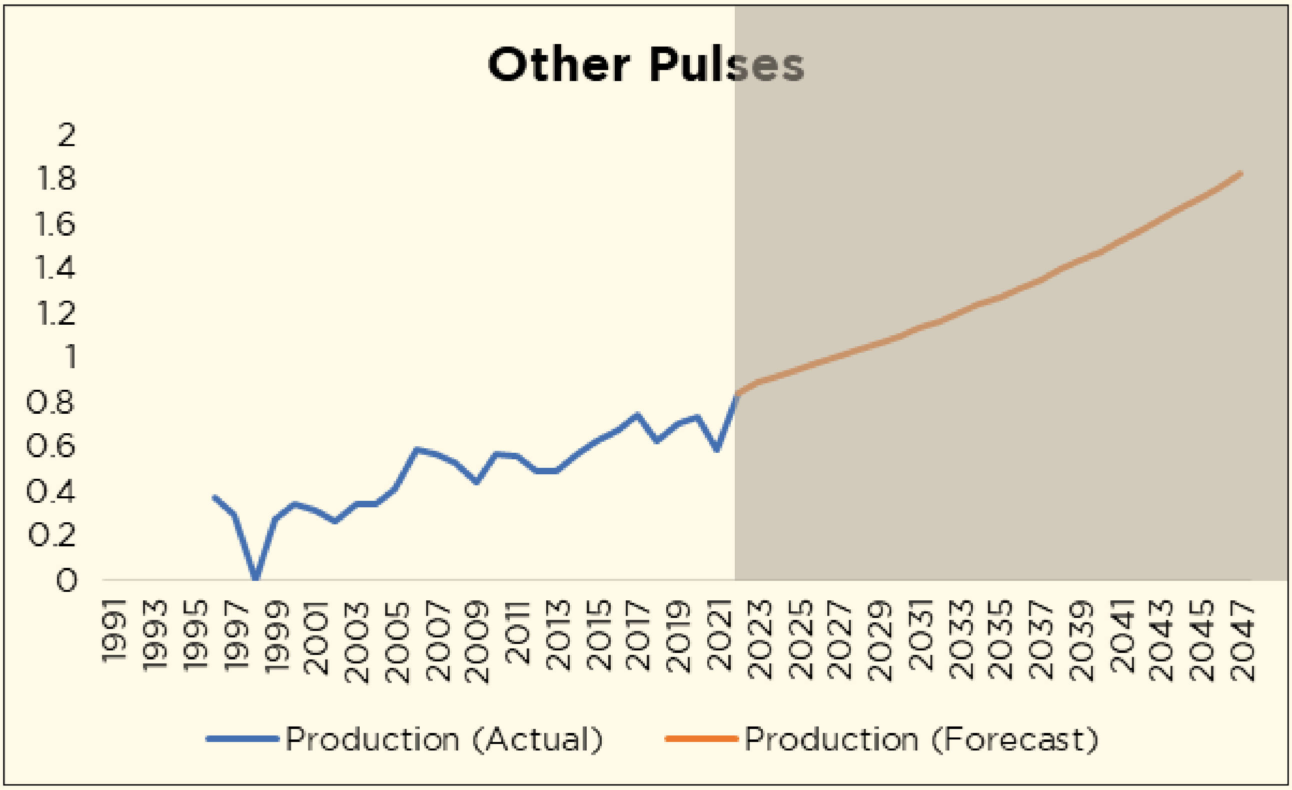
1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015 2017 2019 2021 2023 2025 2027 2029 2031 2033 2035 2037 2039 2041 2043 2045 2047
Production (Actual)
Production (Forecast)





Source: Authors' estimation, data from DES, MoA&FW

5.6 Pulses: Demand-Supply Gap Analysis by 2030 and 2047

A comprehensive approach has been employed to project the future demand-supply gap for pulses, focusing on net consumption availability. This involved considering various factors such as gross production, imports, exports, stock changes, and seed, feed, and wastage. The average percentage share of seed, feed, and wastage of gross production over the past decade (11.2%) was utilized to estimate the supply of pulses, smoothing out short-term fluctuations. By following this multi-step approach, the national-level pulse supply is projected to be 30.6 MT by 2030 and 45.8 MT by 2047 (Table 5.8). However, it is crucial to acknowledge that unforeseen factors could potentially impact these projections.

Table 5.8: Projected Supply at the National Level by 2030-31 and 2047-48

Items	Projected Supply of Pulses (MT)		
	2021-22	2030-31	2047-48
Pigeonpea	3.31	3.46	4.87
Chickpea	12.27	12.88	18.41
Green gram	3.68	4.47	8.75
Black gram	2.63	2.94	4.81
Lentil	1.56	1.79	3.07
Pea	0.95	1.15	2.23
Mothbean	0.36	0.38	0.56
Horse gram	0.23	0.23	0.28
Lathyrus	0.24	0.18	0.12
Other Pulses	0.83	1	1.9
Total (based on aggregated data)	26.06	30.6	45.8

Source: Authors' estimation

Multiple scenarios have been considered to project future demand-supply gaps for pulses. The household/static approach scenario projects a surplus situation. By 2030, a surplus of 3.79 MT is anticipated, increasing to 16.48 MT by 2047 (Table 5.9).

The normative approach scenario, grounded in the recommended dietary intake levels set by ICMR-NIN, presents a contrasting outlook. It reveals a significant demand-supply gap of 15.74 MT by 2030, which is expected to decrease to 4.47 MT by 2047. To bridge this gap, India would need to increase its pulse production substantially, and pulse output would need to grow by a factor of 1.86 times and 2.02 times by 2030 and 2047 from the current supply level, respectively. The substantial gap in the short run starkly contrasts the current gap of 4.739 MT in 2023-24. This divergence highlights the potential impact of promoting healthier consumption habits. Policy interventions that encourage the adoption of ICMR-NIN's recommended intake levels and strategies to boost domestic pulse production are essential to ensure a sustainable and secure future for India's pulse sector.

Under the behaviouristic approach, the BAU scenario estimates a gap of 4.57 MT is projected by 2030, increasing slightly to 4.94 MT by 2047. To bridge this gap, pulse output would need to grow by a factor of 1.41 times and 2.04 times by 2030 and 2047, respectively, from the current supply level. The HIG scenario projects a significant gap of 13.17 MT by 2030, decreasing to 4.94 MT by 2047. To achieve equilibrium, pulse output would need to be amplified by a factor of 1.76 times and 2.04 times by 2030 and 2047, respectively. The behavioral approach highlights the potential impact of different economic growth scenarios on pulse demand and supply. As income levels rise, dietary preferences may shift. To ensure a sustainable and secure future for the pulse sector, it is crucial to consider these diverse scenarios and develop appropriate strategies to address potential challenges and opportunities.

Table 5.9: Projected Demand-Supply Gap of Pulses at the National Level by 2030 and 2047

Year	Household Approach			Normative Approach			Behaviouristic Approach (BAU)			Behaviouristic Approach (HIG)		
	Supply (MT)	Demand (MT)	GAP (MT)	Supply (MT)	Demand (MT)	GAP (MT)	Supply (MT)	Demand (MT)	GAP (MT)	Supply (MT)	Demand (MT)	GAP (MT)
2030	30.59	26.80	(+) 3.79	30.59	46.33	(-) 15.74	30.59	35.16	(-) 4.57	30.59	43.76	(-) 13.17
2047	45.79	29.31	(+) 16.48	45.79	50.26	(-) 4.47	45.79	50.73	(-) 4.94	45.79	50.73	(-) 4.94

Source: Authors' estimation

The projected demand-supply gaps for pulses, particularly under the normative approach, highlight a significant challenge for India's food and nutrition security. To address this, a multi-pronged strategy is necessary. On the supply side, efforts must be made to enhance pulse production. This can be achieved through yield improvement, strategic area expansion, adoption of advanced technologies and efficient and effective farming practices, and the promotion of high-yielding varieties through quality seed supply. Improving processing and marketing infrastructure can also enhance the value chain and incentivize farmers.

On the demand side, promoting healthy consumption practices aligned with ICMR-NIN recommendations is crucial. This involves creating awareness about the nutritional benefits of pulses, encouraging their inclusion in diverse dietary patterns, and addressing consumer preferences and perceptions.

By implementing a comprehensive strategy that addresses both supply and demand-side factors, India can work towards bridging the gap in the pulses sector and ensuring a sustainable future for this vital commodity.

Chapter VI: Strategies and Roadmap to Achieve Self-Sufficiency for Atmanirbharta in Pulses





Strategies and Roadmap to Achieve Self-Sufficiency for Atmanirbharta in Pulses

6.1: Introduction

Achieving self-sufficiency (*Atmanirbharta*) in pulses is a crucial national objective for India. Pulses are vital in ensuring food security, nutritional quality, and soil health. To meet these objectives, a comprehensive strategy is essential to boost pulse production and reduce reliance on imports. This strategy should address various factors, such as encouraging the adoption of advanced technologies, improving seed quality and accessibility, promoting sustainable agricultural practices, enhancing irrigation facilities, and providing adequate market support to farmers. By prioritizing the pulse sector, India can strengthen its food security, improve public health, and contribute to sustainable agriculture.

The pulses' unique properties can significantly advance several Sustainable Development Goals (SDGs). By providing essential nutrients such as protein, fibre, vitamins, and minerals, pulses support the achievement of SDG 2 (Zero Hunger), enhancing resource-use efficiency, which focuses on ending hunger, ensuring food security, improving nutrition, and promoting sustainable agriculture. Moreover, their positive impact on human health aligns with SDG 3 (Good Health and Well-being). Pulses' lower carbon and energy footprints, including their ability to fix nitrogen which helps to enhance soil fertility reducing dependence on synthetic fertilizers and mitigating greenhouse gas emissions, contributes to SDG 13 (Climate Action) and SDG 15 (Life on Land), promoting climate change mitigation and biodiversity conservation through crop rotation, fostering resilient and ecologically balanced agroecosystems. By encouraging sustainable farming practices and responsible consumption, pulses also contribute to SDG 12 (Responsible Consumption and Production).

Like oilseeds, a significant challenge in India's pulse production is the reliance on rainfed agriculture, with nearly 80% of pulse-growing areas dependent on rainfall. This makes the sector vulnerable to unpredictable weather patterns, leading to fluctuating production levels. Additionally, the limited expansion of irrigation coverage, which has increased by only 4% over the past decade (i.e., 23% to 27%), further exacerbates the situation. Stagnant and fluctuating yields and insufficient access to quality inputs also constrain pulse production. Addressing these challenges is crucial to ensure a stable and sustainable pulse supply.

At the same time, the rising demand for pulses is driven by the increasing population, changing dietary preferences, and awareness of their nutritional benefits, which has placed pressure on domestic supply. To overcome these challenges and achieve self-sufficiency, a multi-pronged approach is required to address pulses' production, sustainability, and marketability.

To achieve self-sufficiency, India must adopt a multifaceted strategy focusing on three key pillars: (i) value addition and reducing post-harvest losses in pulses, (ii) expanding the area under pulse cultivation (Horizontal Expansion) and (iii) improving productivity (Vertical Expansion). Figure 6.1 presents an inclusive strategy for accelerating growth and achieving self-sufficiency (*Atmanirbharta*) in the Indian pulses sector.

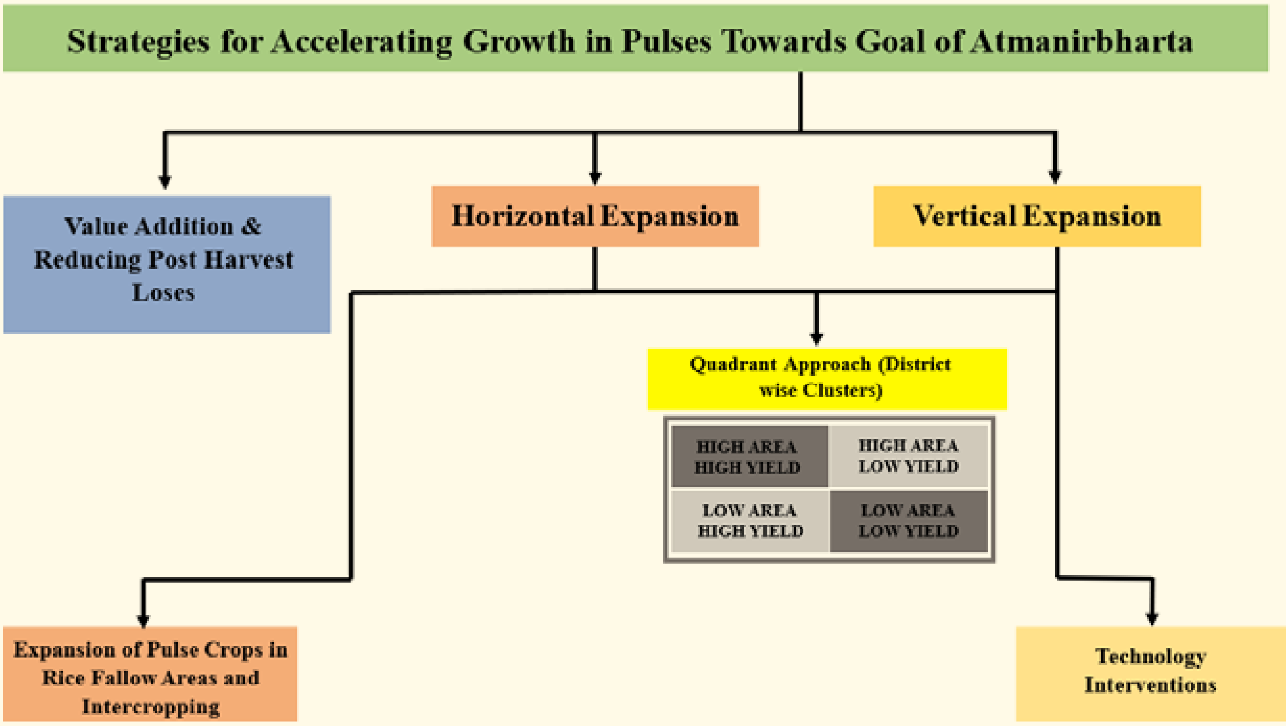


Figure 6.1: Strategies Devised for Accelerating Growth in Pulses

Horizontal and Vertical Expansion Strategies derived from the **district-wise Quadrant Approach** are shown in Table 6.1. This data-driven approach involves developing district-level crop clusters using four quadrants [i.e., **(i) High Area-High Yield (HA-HY), (ii) High Area-Low Yield (HA-LY), (iii) Low Area-High Yield (LA-HY), and (iv) Low Area-Low Yield (LA-LY)**] for pulse crops cultivated in India. The classification is based on districts' average % share of pules cultivated area and yield performance data for the following years: 2020-21, 2021-22, and 2022-23 for specific pulse crops. 'High Area' refers to the district where the % share of pulses cultivated area exceeds the national average for a specific pulse crop, while 'Low Area' falls below this benchmark. Similarly, 'High Yield' is defined by yields surpassing the national average, whereas 'Low Yield' indicates yields below the national average.

HA-HY cluster, with high area and high yields, should prioritize vertical expansion strategies focused on maximizing yield. Drawing insights from global leaders in pulse production may be instrumental in further enhancing these regions' performance. These countries, among global leaders, have achieved significant advancements in seed technology, precision agriculture, irrigation management, and integrated pest management systems apart from using GM-modified varieties. Learning from these leading producers can identify areas for improvement and implement targeted strategies to optimize pulse crop cultivation practices further. **HA-LY cluster**, characterized by high area but lower yields, requires vertical expansion initiatives to close the yield gaps and boost productivity through good agronomic practices. Here, benchmarking against India's top-performing districts can provide valuable guidance. Conversely, **LA-HY cluster**, with smaller cultivated areas but high yields, presents opportunities for horizontal expansion to increase their pulse production footprint. These regions can also learn from national leaders to further improve cultivation practices. Finally, **LA-LY cluster**, with low cultivated areas and yields, needs a comprehensive approach combining horizontal and vertical expansion strategies. Benchmarking against the best-performing districts will be essential for this cluster to identify and implement improvements.

Table 6. 1: Quadrant Strategy for Horizontal and Vertical Expansion

Pulse Crop		**Yield**	
		High	**Low**
Area	**High**	**High Area (**>National average % share area under pulses); **and High Yield (**> National average yield) **(Benchmark: Global Best Performer(s))** **(Strategy: Vertical Expansion)**	**High Area (**>National average % share area under pulses); **and Low Yield (**< National average yield) **(Benchmark: Country Best Performer(s))** **(Strategy: Vertical Expansion)**
	Low	**Low Area (**<National average % share area under pulses); **and High Yield (**> National average yield) **(Benchmark: Country Best Performer(s))** **(Strategy: Horizontal Expansion)**	**Low Area (**<National average % share area under pulses); **and Low Yield (**< National average yield) **(Benchmark: Country Best Performer(s))** **(Strategy: Horizontal + Vertical Expansion)**

In addition, the **Horizontal Expansion Strategy** includes the **Rice Fallow Area Expansion and intercropping Approach**. There is significant potential in utilizing rice fallow lands for pulse cultivation during the non-rice cropping season. By promoting suitable crop rotations, implementing effective management practices, and providing targeted incentives, farmers can be encouraged to grow pulses during these fallow periods, effectively increasing overall land utilization and production capacity. These combined efforts will lead to a geographically expansive and diversified pulse production, contributing significantly to India's self-sufficiency (*Atmanirbharta*) goals.

Complementing the district-wise quadrant strategy, a geographically targeted cluster-based approach holds significant promise for accelerating pulse sector growth. This quadrant analysis will allow for customized interventions and help to optimize the resource allocation by focusing on each cluster separately. In the HA-HY cluster, crop retention programs incentivize farmers to maintain production, ensuring a stable domestic supply. Conversely, strategic diversification initiatives can be introduced in quadrants with lower existing pulse production (particularly the LA-LY cluster). These initiatives involve cultivating higher-yielding varieties of pulse crops, fostering a more geographically diversified production landscape. This targeted strategy, coupled with initiatives like the expansion of fallow land cultivation, improved farming practices, ensuring seed accessibility and quality, market linkages with efficient post-harvest management, and advanced production technologies adoption, holds significant promise for maximizing the impact of the Atmanirbharta strategy and fostering a resilient domestic pulses production system.

6.2 Quadrant Strategy for Diversification and Accelerated Growth

To devise targeted strategies for achieving self-sufficiency in pulses, a district-wise Quadrant Analysis has been conducted for each major pulse crop, including pigeonpea, chickpea, green gram, black gram, lentil, pea, and mothbean. This analysis categorized districts into four clusters based on their recent performance in both horizontal (area) and vertical (yield) dimensions: High Area-High Yield (HA-HY), High Area-Low Yield (HA-LY), Low Area-High Yield (LA-HY), and Low Area-Low Yield (LA-LY). By identifying these clusters, this setting allows tailored interventions to the specific needs of each region. For instance, HA-HY clusters may focus on further optimizing yields, while HA-LY clusters may prioritize improving yield levels. Similarly, LA-HY clusters can explore opportunities for area expansion, and LA-LY clusters may require a combination of area expansion and yield improvement strategies. This data-driven approach provides a valuable framework for guiding future interventions and accelerating progress towards self-sufficiency in pulses.

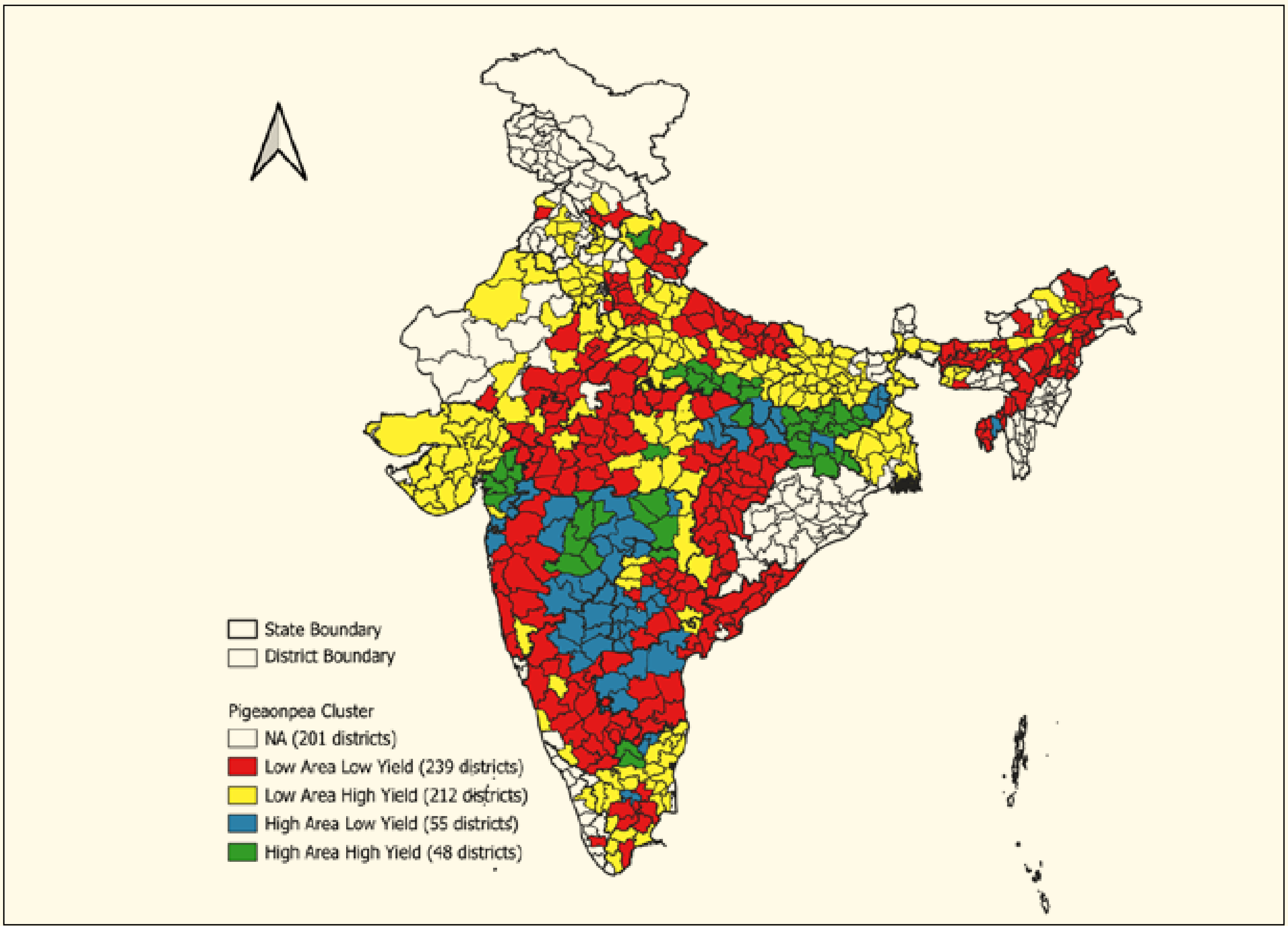
6.2.1 District-wise Quadrant Strategy: Pigeonpea

The district-wise Quadrant Analysis for pigeonpea has identified specific strategies for different regions. The HA-HY cluster, comprising 48 districts across eight states [i.e. Jharkhand (18 districts), Uttar Pradesh (9 districts), Maharashtra (8 districts), Gujarat (6 districts), Madhya Pradesh (3 districts), Tamil Nadu (2 districts), Telangana (1 district), Uttarakhand (1 district)], presents an opportunity to optimize yields through the adoption of advanced agricultural practices and technologies. By benchmarking against global leaders like Malawi and Tanzania, these regions can prioritize best practices and implement them to enhance productivity.

Further, the quadrant analysis exposes opportunities for targeted interventions across other clusters. The LA-HY cluster, encompassing 212 districts spread across 21 states [i.e., Uttar Pradesh (34 districts), Bihar (33 districts), Gujarat (21 districts), Tamil Nadu (22 districts), West Bengal (18 districts), Haryana (17 districts), Madhya Pradesh (13 districts), Rajasthan (13 districts), Punjab (8 districts), Arunachal Pradesh (6 districts), Assam (6 districts), Telangana (4 districts), Meghalaya (4 districts), Maharashtra (3 districts), Karnataka (3 districts), Uttarakhand (2 districts), Andhra Pradesh (1 district), Chhattisgarh (1 district), Himachal Pradesh (1 district), Kerala (1 district), Nagaland (1 district)] amongst others, requires a focus on horizontal expansion to increase the cultivated area by identifying suitable areas for pigeonpea cultivation. These districts may benefit from benchmarking against the national leader(s) to identify areas for further improvement. The HA-LY cluster comprises 55 districts across eleven states [i.e., Maharashtra (13 districts), Telangana (11 districts), Karnataka (7 districts), Jharkhand (6 districts), Andhra Pradesh (5 districts), Gujarat (3 districts), Madhya Pradesh (3 districts), Tamil Nadu (3 districts) Chhattisgarh (2 districts), Tripura (1 district), Uttar Pradesh (1 district)] necessitate vertical expansion initiative to enhance their yield. Benchmarking against the country's top performer(s), these districts can identify and adopt best practices in areas like seed technology, precision agriculture, and pest management. The LA-LY cluster, consisting of 239 districts, spread across 20 states, the majority of districts from Madhya Pradesh (33 districts), Uttar Pradesh (29 districts), Assam (26 districts Chhattisgarh (25 districts), Karnataka (20 districts), Andhra Pradesh (19 districts), Telangana (16 districts), Arunachal Pradesh (12 districts), Maharashtra (10 districts), Nagaland (10 districts), Rajasthan (10 districts)] amongst others presents the utmost challenge. These districts require a comprehensive approach that involves both horizontal and vertical expansion. This dual approach is essential to ensure significant improvements in pulse production in these regions. Benchmarking against the success of the country's best performer(s) will be crucial for these states to identify areas for improvement and implement effective strategies to boost both acreage and productivity.

The spatial distribution of pigeonpea clusters across India, as depicted in Map 6.1, reveals distinct clusters of districts based on their area and yield performance: red for the LA-LY, yellow for the LA-HY, light blue for the HA-LY, and green for HA-HY. This spatial mapping offers valuable insights into the recent performance across districts and regional variations regarding both horizontal (area) and vertical (yield) dimensions of pigeonpea cultivation. It can be used to formulate targeted interventions to enhance area and productivity and address specific challenges different regions face. By focusing on the strengths and weaknesses of each cluster, strategies need to be devised to optimize resource allocation.

Map 6.1: Pigeonpea: District-wise Clusters



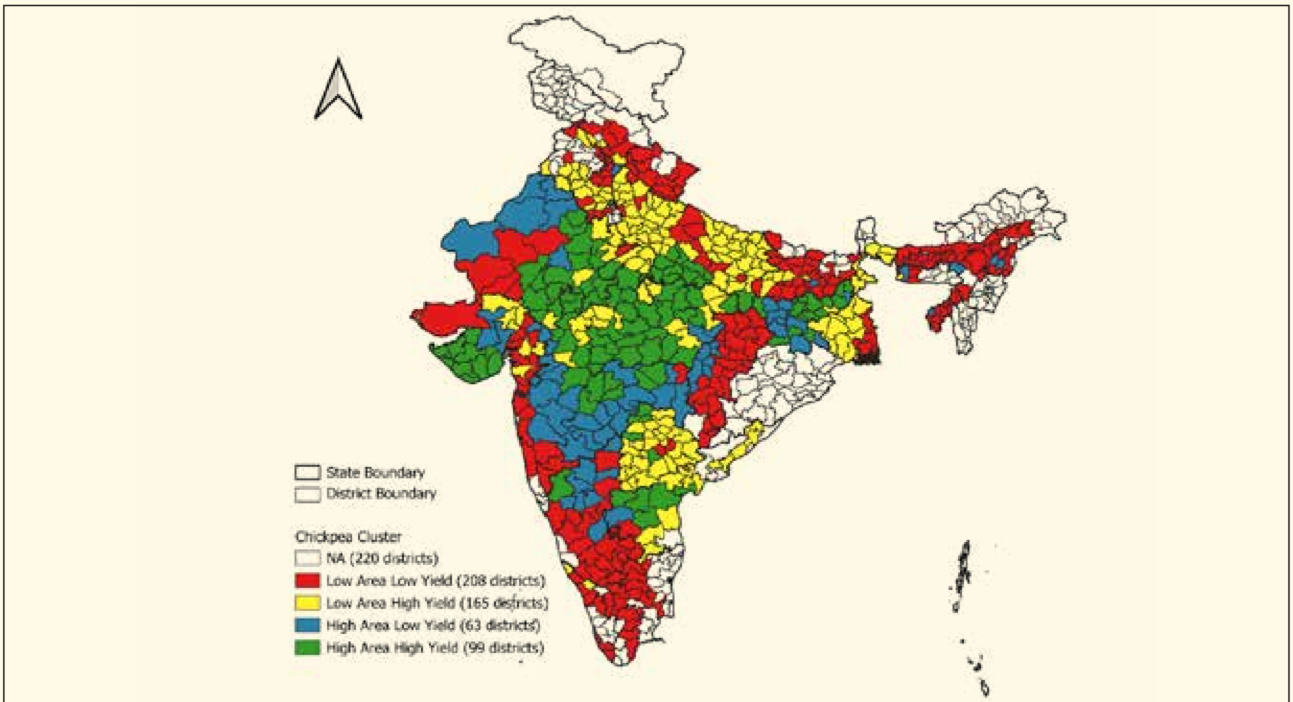
Source: Authors' computation, data from DES, MoA&FW

Note: Based on the average percentage area of pigeonpea to total cropped area: 2.38% and average yield: 0.975 t/ha (2020-21 to 2022-23)

6.2.2 District-wise Quadrant Strategy: Chickpea

The district-wise quadrant analysis for chickpea reveals that the HA-HY cluster comprises 99 districts from Madhya Pradesh (31 districts), Rajasthan (16 districts), Jharkhand (14 districts), Uttar Pradesh (11 districts), Gujarat (10 districts), Maharashtra (7 districts), Andhra Pradesh (5 districts), Telangana (4 districts), Karnataka (1 district). While demonstrating strong performance, these districts under this cluster can further enhance their yield by benchmarking against global leaders like Ethiopia, Mexico, USA, and Myanmar. The LA-HY cluster includes 165 districts from Uttar Pradesh (55 districts), Telangana (26 districts), Madhya Pradesh (18 districts), West Bengal (16 districts), Andhra Pradesh (12 districts), Haryana (9 districts), Gujarat (7 districts), Punjab (6 districts), Rajasthan (5 districts), Bihar (4 districts), Himachal Pradesh (3 districts) Kerala (2 districts), Jharkhand (1 district), Meghalaya (1 district). These districts, characterized by high yields but smaller areas, should focus on horizontal expansion to increase production. Mainpuri from Uttar Pradesh district boasts the highest yield at 2.506 t/ha followed by Guntur (2.39 t/ha) and Kakinada (2.37 t/ha) from Andhra Pradesh. The HA-LY cluster consists of 63 districts, with Chatra (Jharkhand) and Latur (Maharashtra) leading in terms of the percentage of the total cropped area allocated to pulses. These districts need to adopt vertical expansion strategies to improve yields and align with the top-performing districts in India. Finally, the LA-LY cluster, comprising 208 districts, primarily from Assam (29 districts) followed by Bihar (26 districts) and Chhattisgarh (22 districts), Karnataka (20 districts), Tamil Nadu (15 districts), requires a comprehensive approach involving both horizontal and vertical expansion to significantly enhance production and move towards national average levels. The spatial distribution of chickpea clusters across India is depicted in Map 6.2.

Map 6.2: Chickpea: District-wise Clusters



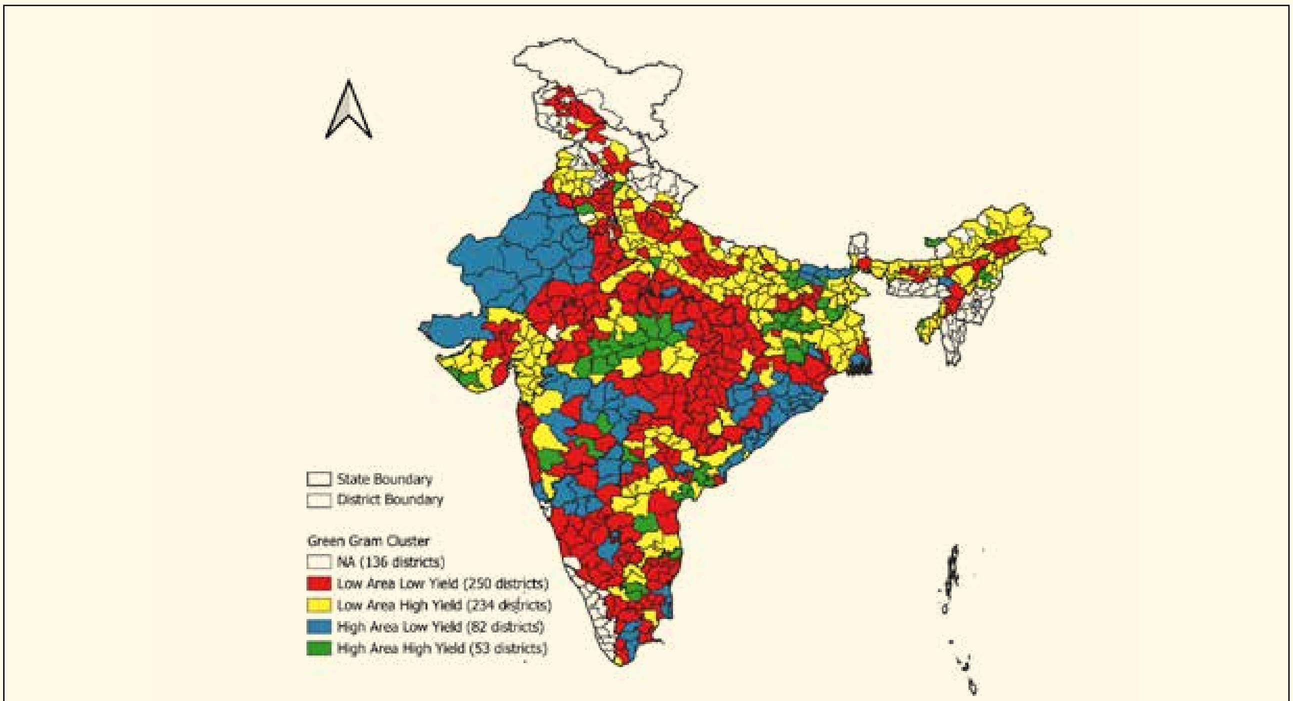
Source: Authors' computation, data from DES, MoA&FW

Note: Based on the average percentage area of chickpea to total cropped area: 4.36% and average yield: 1.157 t/ha (2020-21 to 2022-23)

6.2.3: District-wise Quadrant Strategy: Green Gram

The district-wise quadrant analysis for green gram reveals that the HA-HY cluster, covering 53 districts, mostly from Jharkhand (12 districts), Madhya Pradesh (11 districts), followed by Bihar (6 districts), Andhra Pradesh (5 districts), Maharashtra (3 districts), Tamil Nadu (3 districts) represent the top-performing regions. All the districts under this cluster should aim to compete with global leaders. The LA-HY cluster includes 234 districts, of which 43 districts are from Uttar Pradesh, 25 districts are from Gujarat, 19 districts are from Arunachal Pradesh, 18 districts are from Assam, 17 districts are from West Bengal, 16 districts are from Bihar, 13 districts are from Telangana, 11 districts from Punjab, 10 districts from Andhra Pradesh, 10 districts from Jharkhand, 8 districts from Nagaland, 7 districts from Tripura, 5 districts from Tamil Nadu, 4 districts from Uttarakhand, amongst others. These districts should focus on horizontal expansion to increase the cultivated area. The HA-LY cluster, consisting of 82 districts, is from 15 states. Majority of these districts are from Odisha (17 districts), Rajasthan (16 districts), Maharashtra (12 districts), and Karnataka (9 districts), amongst others. Districts like Nagaur and Puru from Rajasthan top this category when it comes to the percentage of the area of pulses to total cropped area for the green gram but lag in yield. Hence, more efforts are needed to increase such regions' productivity and match the performance of top-performing districts. Finally, LA-LY cluster, encompassing 250 districts, requires significant attention to improve both area and yield. Primarily, districts in Uttar Pradesh (29 districts), Chhattisgarh (26 districts), Madhya Pradesh (26 districts), Tamil Nadu (22 districts), Karnataka (21 districts), and Telangana (15 districts) fall under this category and need targeted interventions to enhance their area and productivity. The spatial distribution of green gram clusters across India is depicted in Map 6.3.

Map 6.3: Green Gram: District-wise Clusters



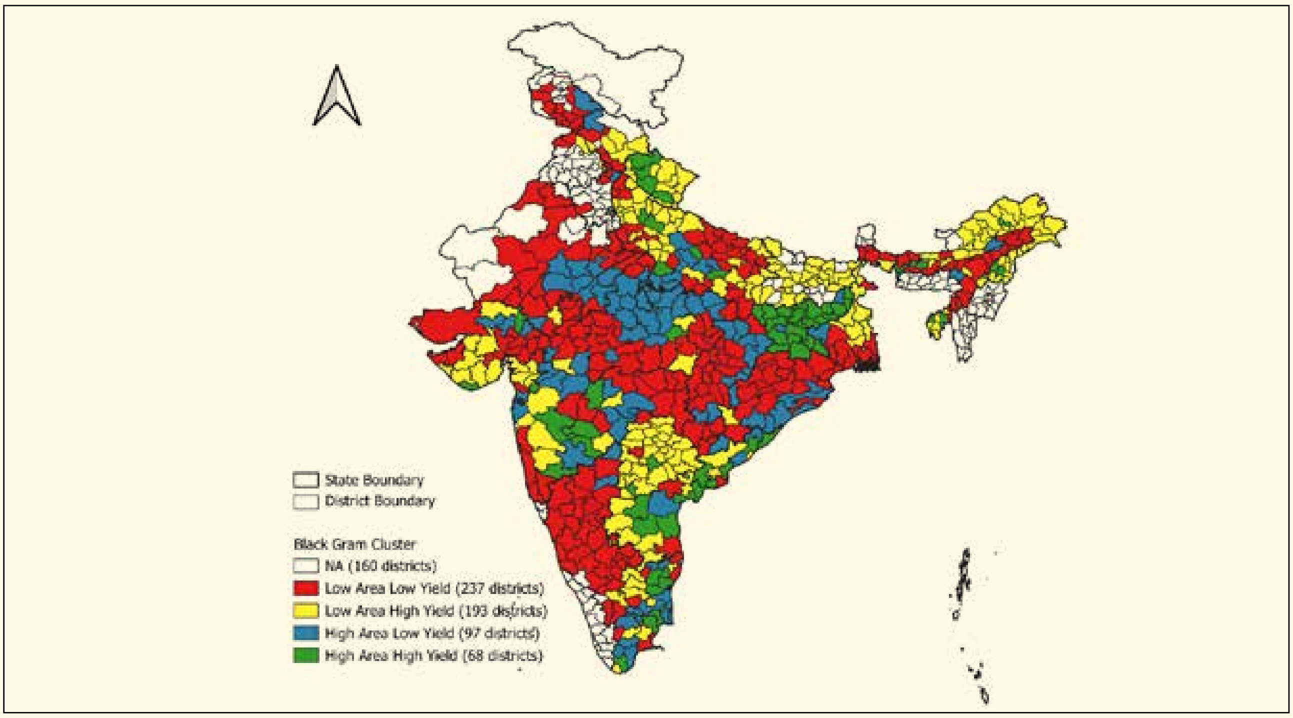
Source: Authors' computation, data from DES, MoA&FW

Note: Based on the average percentage area of green gram to total cropped area: 1.57 % and average yield: 0.678 t/ha (2020-21 to 2022-23)

6.2.4: District-wise Quadrant Strategy: Black Gram

The district-wise quadrant analysis for black gram identified that the HA-HY cluster includes 68 districts, 22 are from Jharkhand, followed by Andhra Pradesh(10 districts), Tamil Nadu (6 districts), Maharashtra (5 districts), Uttar Pradesh (5 districts), Uttarakhand (4 districts), Assam (4 districts), Gujarat (3 districts), Telangana (2 districts), Tripura (2 districts), Nagaland (2 districts), Madhya Pradesh (1 district), Puducherry (1 district), Arunachal Pradesh (1 district) representing the top-performing regions. These districts should aim to compete with global leaders in terms of yield. The LA-HY cluster consisting of 193 districts, of which 32 districts are from Uttar Pradesh, 28 districts from Telangana, and 24 districts from Bihar, 22 districts from Arunachal Pradesh, amongst others, requires a focus on horizontal expansion to increase the cultivated area. Karimnagar and Peddapalli from Telangana have high yields compared to the national average of black gram but lag in the area under cultivation. The HA-LY cluster has 97 districts, of which the majority are from are from Madhya Pradesh (20 districts), Tamil Nadu (13 districts), Maharashtra (9 districts), and Chhattisgarh (8 districts). These districts need to adopt vertical expansion strategies to improve yields. Districts like Chhatarpur and Sagar from Madhya Pradesh occupy the top position in the area under black gram cultivation but lag behind the national average yield, which needs attention to vertical expansion. Finally, the LA-LY cluster encompassing 237 districts, primarily from Uttar Pradesh (29 districts), Karnataka (28 districts), Madhya Pradesh (28 districts), and Odisha (19 districts), necessitates a comprehensive approach involving both horizontal and vertical expansion to enhance production significantly. The spatial distribution of black gram clusters across India is depicted in Map 6.4.

Map 6.4: Black Gram: District-wise Clusters



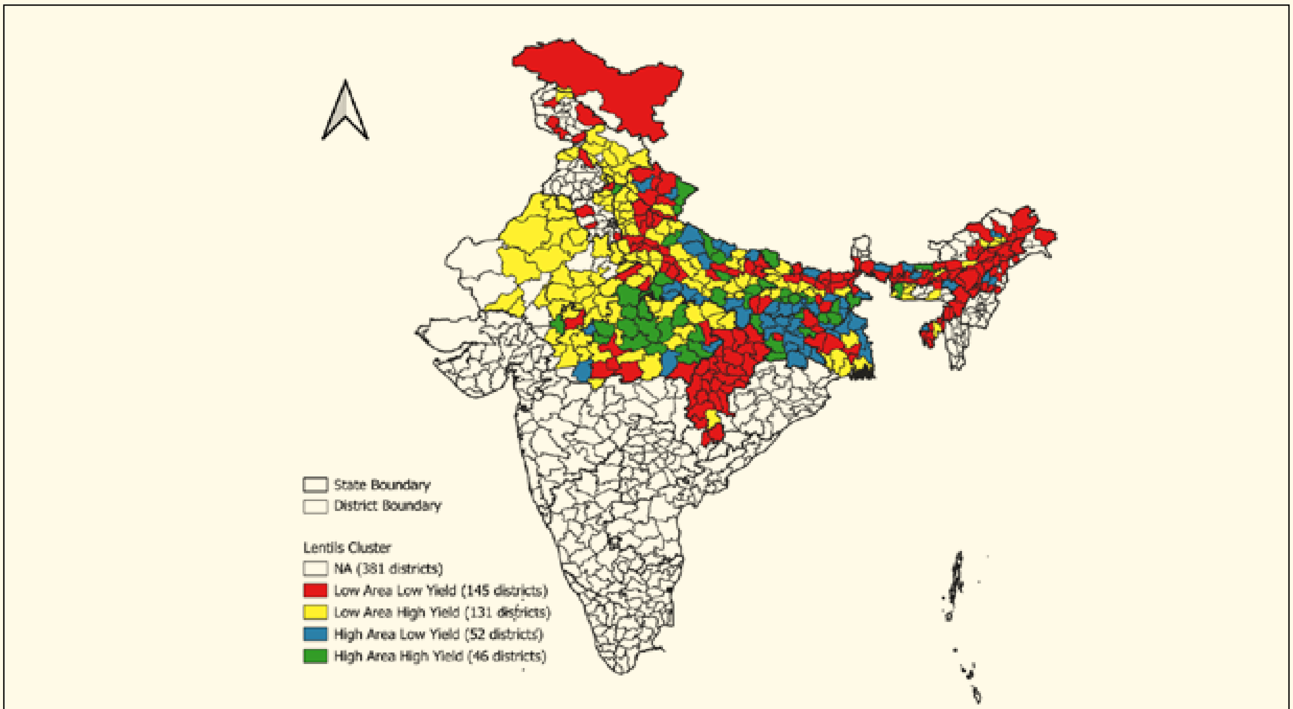
Source: Authors' computation, data from DES, MoA&FW

Note: Based on the average percentage area of black gram to total cropped area: 2.28% and average yield: 0.680 t/ha (2020-21 to 2022-23)

6.2.5: District-wise Quadrant Strategy: Lentil

The district-wise quadrant analysis for lentil has identified specific strategies for different regions. The HA-HY cluster, comprising 46 districts, primarily from Madhya Pradesh (13 districts), followed by Uttar Pradesh (11 districts) and Jharkhand (8 districts), represents the top-performing regions in the country. Jabalpur from Madhya Pradesh takes first place in terms of highest yield at 1.646 t/ha. Sagar from Madhya Pradesh occupies the largest area at 83,107 hectares for the production of lentil in India. These districts should aim to further enhance their yield performance by benchmarking against global leaders like China, Australia, Canada, and Turkey. The LA-HY cluster, consisting of 131 districts, primarily from Uttar Pradesh (32 districts), Madhya Pradesh (24 districts), and Rajasthan (24 districts), requires a focus on horizontal expansion to increase the cultivated area. The HA-LY cluster, with 52 districts, predominantly from Jharkhand (13 districts) and Uttar Pradesh (12 districts), needs to adopt vertical expansion strategies, such as improved seed varieties and advanced agronomic practices, to close the yield gaps and enhance yield gains. Ramgarh and Sahibganj from Jharkhand occupied first place in the HA-LY cluster in terms of percentage area under lentil of total cropped area. Jharkhand, along with states like Assam, Bihar, Uttar Pradesh, Madhya Pradesh, and West Bengal, needs to focus on increasing the yield of lentil. The LA-LY cluster encompasses 145 districts, majorly from Assam (27 districts), Chhattisgarh (25 districts), and Uttar Pradesh (20 districts). These districts deserve maximum attention, as both area expansion and yield expansion strategies offer great scope to increase lentil production. The spatial distribution of lentil clusters across India is depicted in Map 6.5.

Map 6.5: Lentil: District-wise Clusters



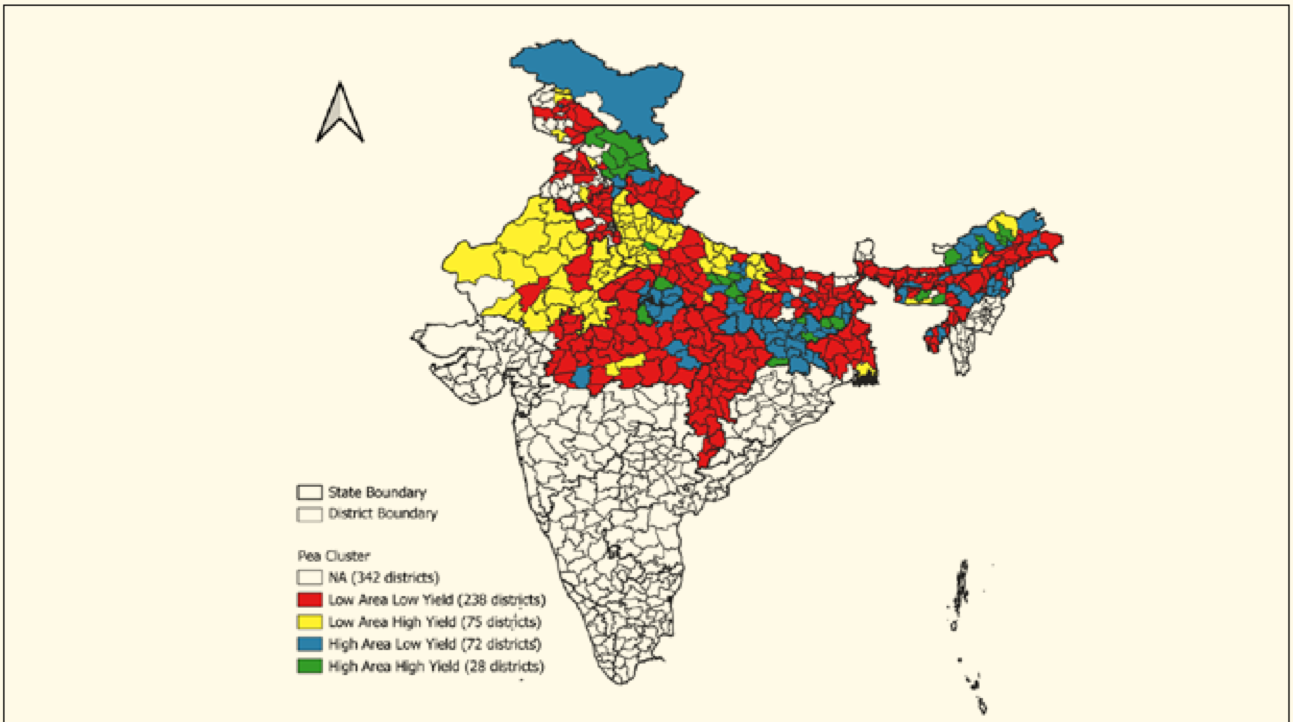
Source: Authors' computation, data from DES, MoA&FW

Note: Based on the average percentage area of lentil to the total cropped area: 1.42% and average yield: 0.912 t/ha (2020-21 to 2022-23)

6.2.6: District-wise Quadrant Strategy: Pea

The district-wise quadrant analysis for pea reveals that the HA-HY cluster covers 28 districts, of which 8 are from Uttar Pradesh, 7 from Himachal Pradesh, and 6 from Arunachal Pradesh, among others representing the top-performing regions. The districts under this cluster should aim to further optimize their production practices and benchmark against global leaders to enhance yield and overall productivity. The LA-HY cluster, including 75 districts, particularly from Uttar Pradesh (37) and Rajasthan (26), requires a focus on horizontal expansion to increase the cultivated area. The HA-LY cluster, with 72 districts in total, includes 19 districts from Jharkhand and 10 from Uttar Pradesh, among others, and needs to prioritize vertical expansion to improve yield. Jhansi from Uttar Pradesh and Chhattarpur from Madhya Pradesh claim the highest area but fail to impress in productivity. Finally, the LA-LY cluster, comprising 238 districts, primarily from Madhya Pradesh (42 districts), Bihar (30 districts), Assam (26 districts), and Chhattisgarh (27 districts), along with West Bengal (20 districts), necessitates a comprehensive approach to enhance both area and yield. The spatial distribution of pea clusters across India is depicted in Map 6.6.

Map 6.6: Pea: District-wise Clusters



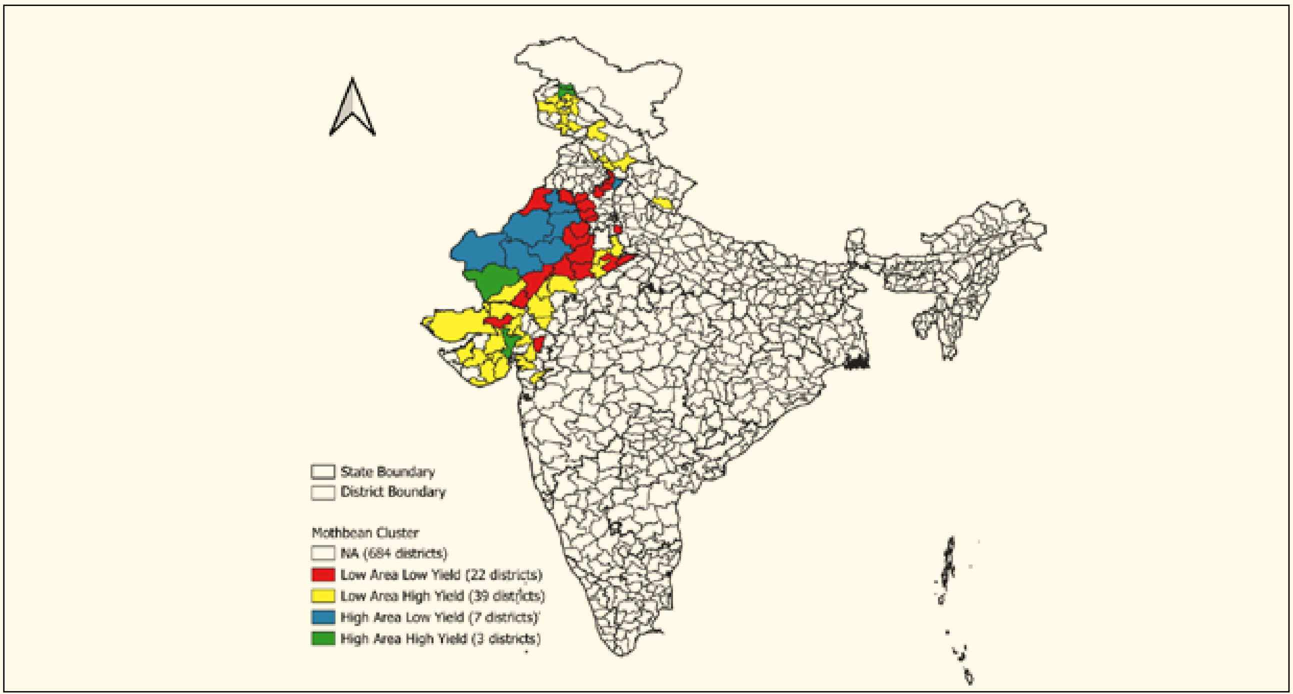
Source: Authors' computation, data from DES, MoA&FW

Note: Based on the average percentage area of pea to total cropped area: 1.03%:and average yield: 1.546 t/ha (2020-21 to 2022-23)

6.2.7: District-wise Quadrant Strategy: Mothbean

Rajasthan is the dominant contributor, accounting for 97.97% of the area and 96.42% of the production in the country. The district-wise quadrant analysis for mothbean reveals that Barmer district in Rajasthan, Bandipore in Jammu & Kashmir, and Ahmadabad in Gujarat are representative of the HA-HY cluster, showcasing the potential for high yield and a large proportion of mothbean area to total cropped area. By replicating the success of these districts, especially that of Barmer, and implementing targeted strategies in other regions, India can significantly enhance mothbeans production and contribute to food security. The HA-LY cluster consists of only 6 districts from Rajasthan and 1 from Haryana. Bikaner and Churu from Rajasthan stand out due to the area involved in mothbean cultivation, which is one of the largest in India, but again yield-wise, it falls behind the national average. Hence, vertical expansion in these regions is crucial to enhancing mothbean production. The LA-HY cluster encompasses 39 districts, with the majority of the districts from Gujarat (15 districts), followed by Jammu & Kashmir (10 districts), and Rajasthan (8 districts), which needs to focus on horizontal expansion. Finally, the LA-LY cluster with 22 districts, primarily comprising districts from Rajasthan (10 districts), Haryana (10 districts), and Gujarat (2 districts), requires a comprehensive approach to enhance both area and yield. The spatial distribution of mothbean clusters across India is depicted in Map 6.7.

Map 6.7: Mothbean: District-wise Clusters



Source: Authors' computation, data from DES, MoA&FW

Note: Based on average percentage area of mothbean to total cropped area: 0.83% and average yield: 0.466 t/ha (2020-21 to 2022-23)

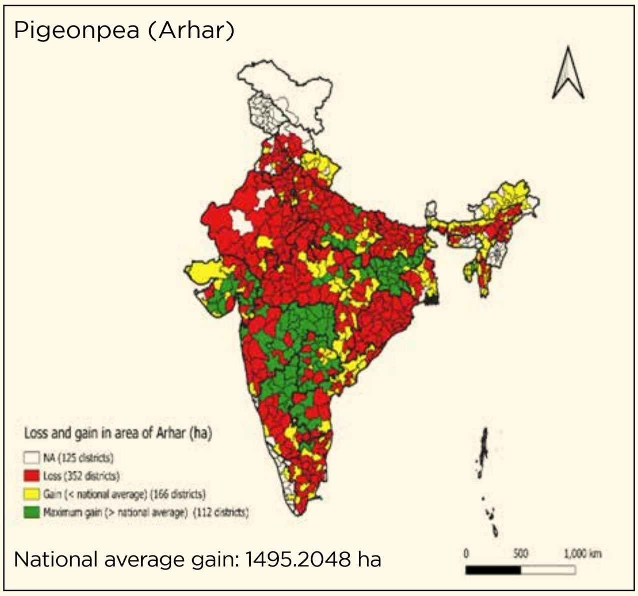
Following establishing district clusters through the quadrant analysis, Annexure III outlines a strategic roadmap for horizontal and vertical expansion across various pulse crops cultivated in India. This data-driven approach categorizes districts into specific clusters based on their area and yield performance, enabling the identification of areas that require either horizontal expansion, vertical expansion, or a combination of both. This strategic framework empowers policymakers and stakeholders to allocate resources effectively and implement targeted interventions to boost pulse production and achieve self-sufficiency.

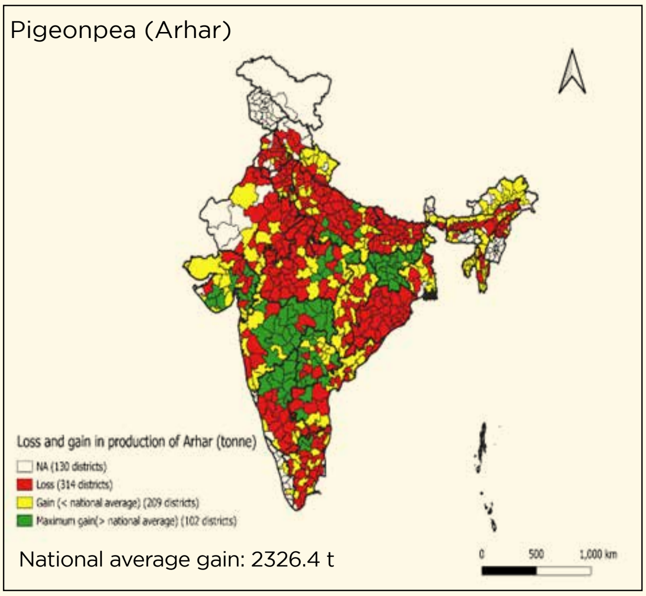
It is crucial to understand pulse cultivation's spatial and temporal dynamics at the district level to devise effective strategies for enhancing pulse production and achieving self-sufficiency. The provided maps (Map 6.8) illustrate the evolution of key pulse crops (pigeonpea, chickpea, green gram, black gram, lentil, pea, and mothbean) over the past two decades (2000-03 to 2020-23). By identifying districts that have experienced significant gains or losses in area, production, and yield, this analysis aims to inform targeted interventions and policy decisions to optimize pulse production as a supplement to the above quadrant analysis. Districts have been categorized into three subgroups[16], based on their performance:

- **Districts with 'Loss':** These districts experienced a decrease ((i.e., <0).
- **Districts with "Gain":** These districts showed a positive change, nevertheless below the national average (i.e., >0 & < national average).
- **Districts with "Maximum Gain":** These districts exhibited significant growth, surpassing the national average (i.e., > national average).

By identifying districts that have experienced significant gains or losses in terms of area, production, and yield, this analysis aims to inform targeted interventions and policy decisions to optimize pulse production. In conjunction with the quadrant analysis, this spatial analysis provides a comprehensive framework for developing effective strategies to enhance pulse production and ensure food security.

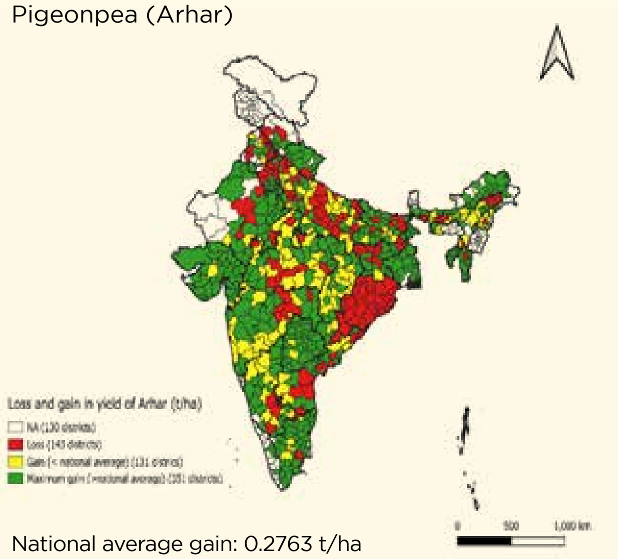
Map 6.8: Evolution of Key Pulse Crops (Pigeonpea, Chickpea, Green Gram, Black Gram, Lentil, Pea, and Mothbean) over the Past Two Decades





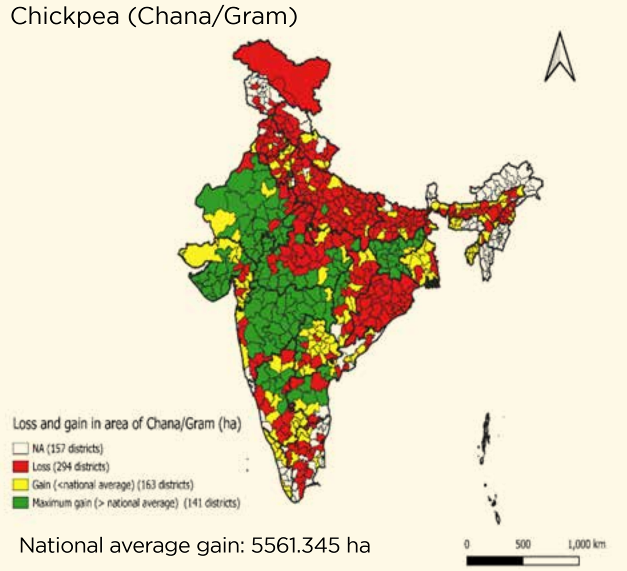
16 *If the national average is negative (i.e., for mothbean area and yield) then the three categories are defined as: (i) 'Maximum Loss': defined as < national average, (ii) 'Loss': defined as > national average and <0, (iii) 'Gain': defined as >0.*

Pigeonpea (Arhar)



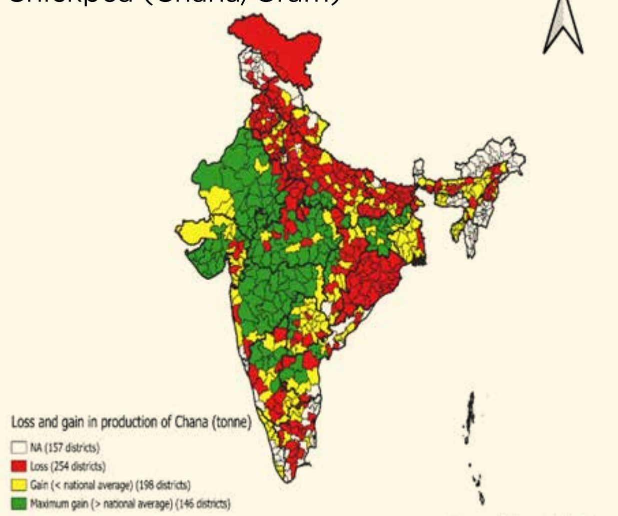
National average gain: 0.2763 t/ha

Chickpea (Chana/Gram)



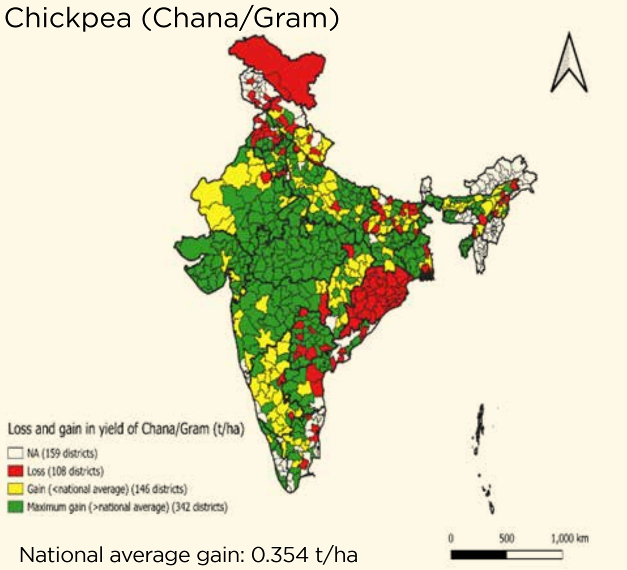
National average gain: 5561.345 ha

Chickpea (Chana/Gram)



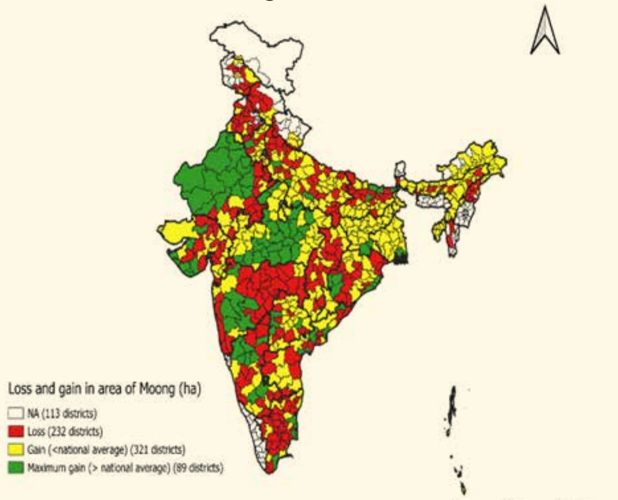
National average gain: 9714.3 t

Chickpea (Chana/Gram)



National average gain: 0.354 t/ha

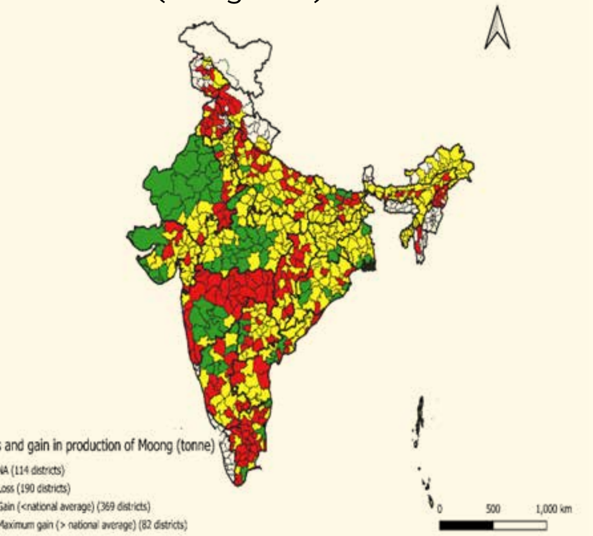
Green Gram (Mungbean)



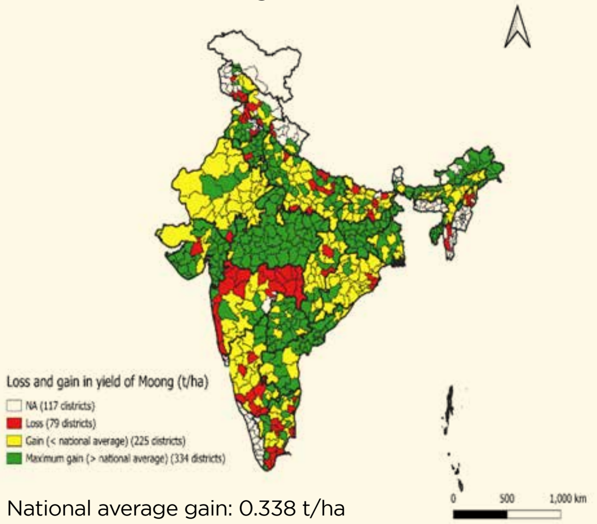
National average gain: 3004.44 ha

Green Gram (Mungbean)

National average gain: 2921.78 t

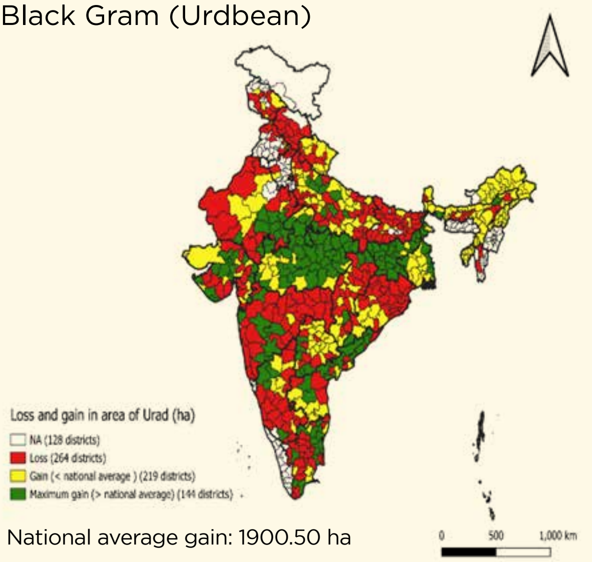


Green Gram (Mungbean)



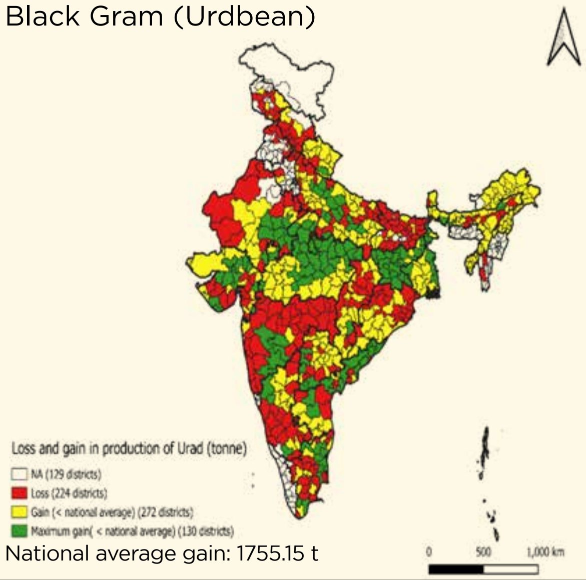
National average gain: 0.338 t/ha

Black Gram (Urdbean)



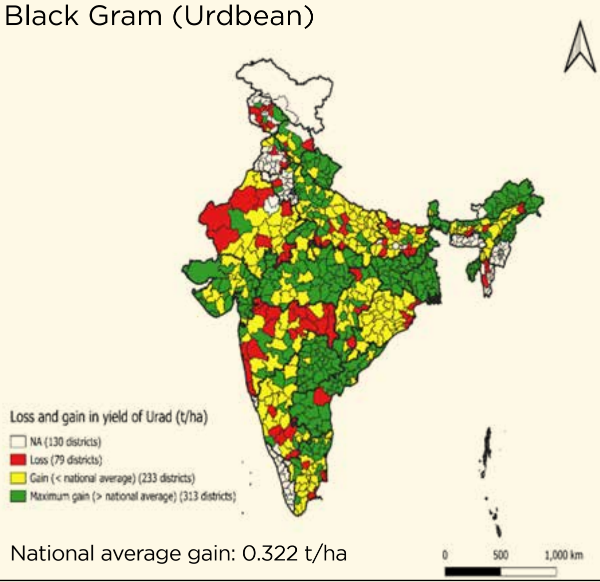
National average gain: 1900.50 ha

Black Gram (Urdbean)



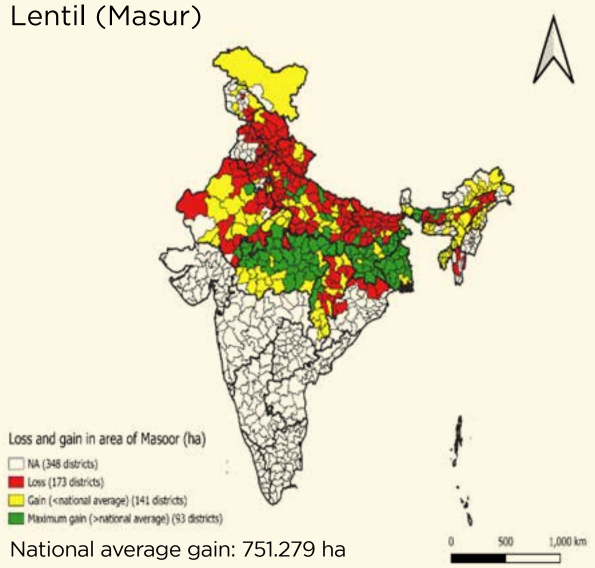
National average gain: 1755.15 t

Black Gram (Urdbean)



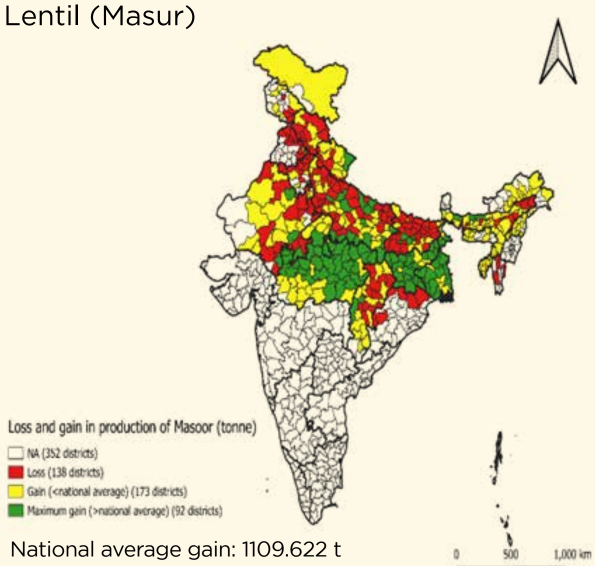
National average gain: 0.322 t/ha

Lentil (Masur)

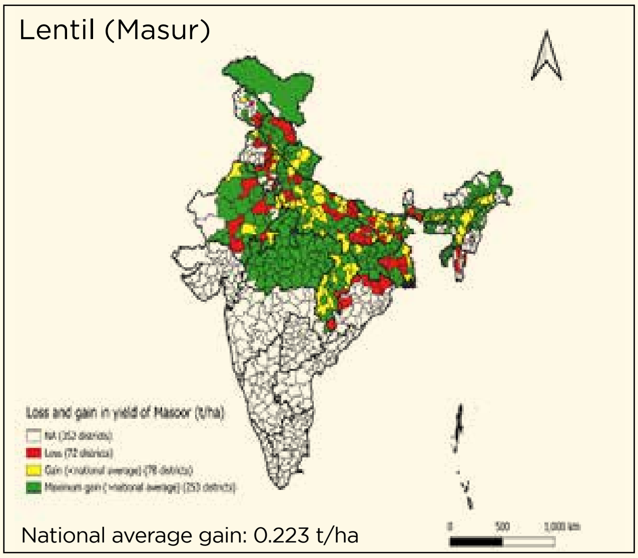


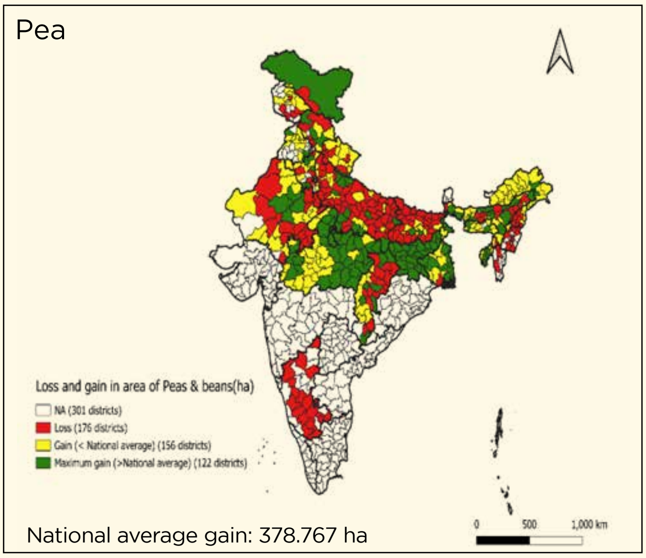
National average gain: 751.279 ha

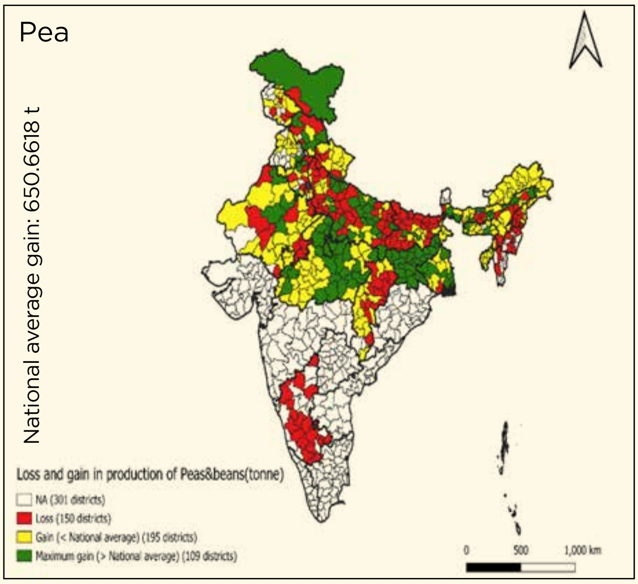
Lentil (Masur)

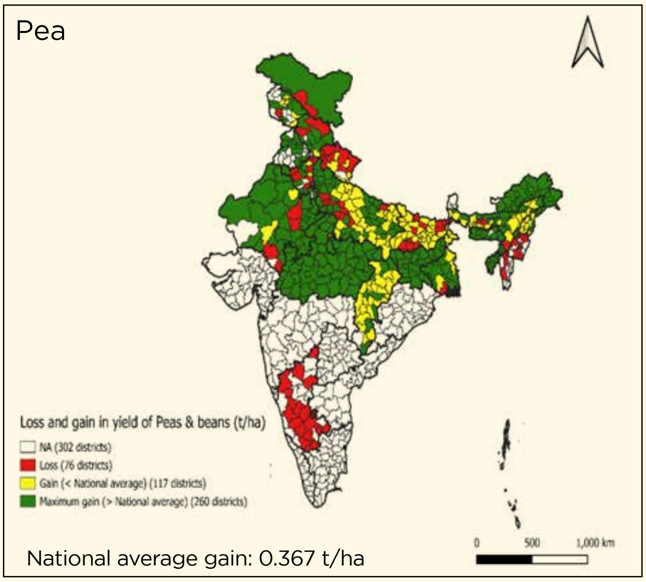


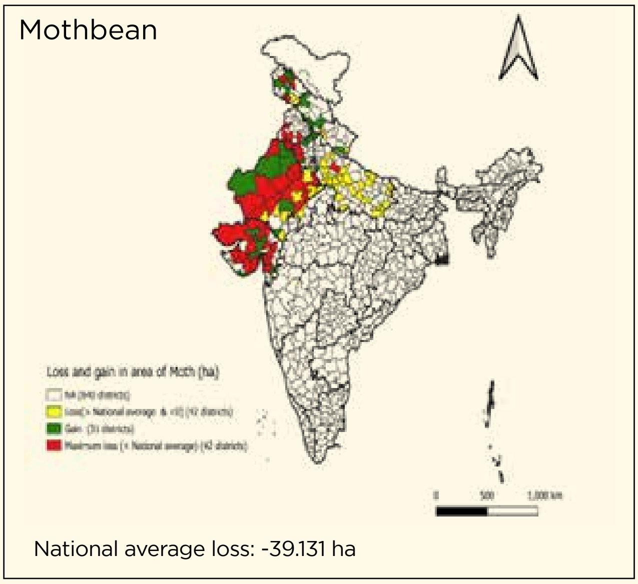
National average gain: 1109.622 t

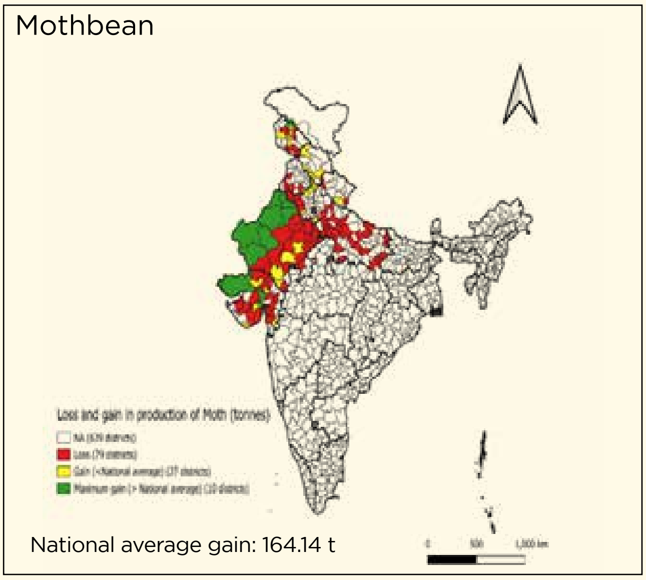

Lentil (Masur)
Loss and gain in yield of Masoor (t/ha)
National average gain: 0.223 t/ha

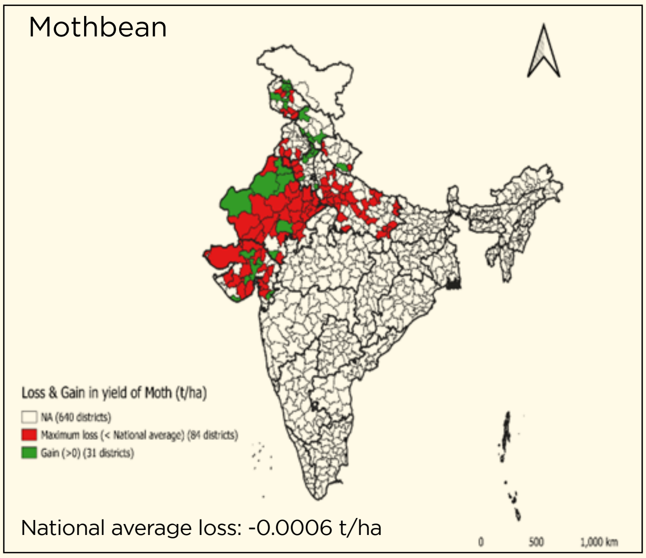

Pea
Loss and gain in area of Peas & beans(ha)
NA (301 districts)
Loss (176 districts)
Gain (< National average) (156 districts)
Maximum gain (>National average) (122 districts)
National average gain: 378.767 ha


Pea
National average gain: 650.6618 t
Loss and gain in production of Peas&beans(tonne)
NA (301 districts)
Loss (150 districts)
Gain (< National average) (195 districts)
Maximum gain (> National average) (109 districts)


Pea
Loss and gain in yield of Peas & beans (t/ha)
NA (302 districts)
Loss (76 districts)
Gain (< National average) (117 districts)
Maximum gain (> National average) (260 districts)
National average gain: 0.367 t/ha


Mothbean
Loss and gain in area of Moth (ha)
National average loss: -39.131 ha


Mothbean
Loss and gain in production of Moth (tonnes)
National average gain: 164.14 t



Source: Authors' computation, data from DES, MoA&FW

By customizing policy measures to tackle the distinct challenges and opportunities within each cluster, this cluster-specific approach has the potential to significantly improve the effectiveness of initiatives aimed at enhancing production and yield in the pulses sector. The identified district clusters utilizing quadrant analysis of seven major pulse crops significantly aid in targeted interventions across different clusters, optimizing resource allocation and policy efforts. To boost domestic pulse production, vertical expansion through the adoption of advanced technologies and efficient farming practices is crucial. By implementing precision agriculture, utilizing drones for monitoring, and optimizing irrigation and nutrient management, yields can be significantly increased. Additionally, climate-resilient, high-yielding varieties biofortified with iron and zinc will enhance productivity and adaptability to changing climatic conditions. To safeguard pulse crops, it is essential to protect them from biotic stresses such as weeds, insect pests, disease-causing agents, and abiotic stresses by adopting advanced technological interventions and effective management practices. Efficient pest and disease management strategies, such as integrated pest management, can minimize crop losses. Moreover, implementing measures to mitigate the impact of abiotic stresses, like drought, heat stress, poor soil conditions, and waterlogging, is critical for optimal crop growth and yield.

By employing underutilized rice fallow areas for pulse cultivation, horizontal expansion can further contribute to increased production. By effectively managing and expanding these areas, India can tap into its untapped potential and achieve self-sufficiency in pulse production.

6.3 Horizontal Expansion

6.3.1 Horizontal Expansion in Rice Fallow Areas

Rice fallows, lowland kharif sown rice areas that remain uncropped during Rabi (winter), represent a significant potential for horizontal expansion in pulse production. These fallows arise due to various factors like early monsoon withdrawal leading to soil moisture stress at planting time of winter crops, waterlogging, excessive moisture in November/December, lack of appropriate varieties of winter crops for late planting, and socio-economic problems (NAAS, 2013; Ali and Kumar, 2009). Strategic research focussing on rice-fallow systems holds immense potential for maximizing total cultivated land (Kar & Kumar, 2009). However, establishing a second crop during the Rabi (winter) season presents challenges due to potential abiotic and biotic stresses encountered in the post-rainy season (Kumar et al., 2018).

Among the states, Madhya Pradesh (MP) and Chhattisgarh have the highest combined area under rice fallow at 4.38 Mha (78.21%), followed by Bihar and Jharkhand with 2.2 Mha (36.85%). West Bengal, Odisha, and Maharashtra also have significant areas under rice fallow, while Assam, Uttar Pradesh, and Andhra Pradesh have comparatively smaller extents. The total rice fallow area across all states amounts to 11.65 Mha.

Since leveraging rice fallows for pulse cultivation presents a significant opportunity to expand India's domestic pulse production, identifying potential crops suitable for pulse cultivation in rice fallows is important. An overview of pulse crops suitable for cultivation in rice fallow areas across various Indian states is provided in Table 6.2. For instance, Madhya Pradesh and Chhattisgarh are well-suited for chickpea, black gram, lentil, grass pea, green gram, and pea, while Bihar and Jharkhand offer a range including chickpea, green gram, lentil, grass pea and pea. West Bengal and Odisha present a varied selection, with black gram, green gram, lentil, grass pea, and pea being suitable choices. Maharashtra suggests chickpea and black gram. Assam prioritizes green gram, black gram, chickpea, pea, and lentil, while Uttar Pradesh offers chickpea, green gram, black gram, lentil, and pea as viable choices. Lastly, Andhra Pradesh recommends green gram and black gram.

Table 6.2: Potential Pulse Crops Suitable for Rice Fallow States

State	Crops
MP + Chhattisgarh	Chickpea, Black gram, Lentil, Green Gram, Pea, Grass pea
Bihar + Jharkhand	Chickpea, Green Gram, Lentil, Pea, Grass pea
West Bengal	Black gram, Green Gram, Lentil, Pea, Grass pea
Odisha	Green Gram, Black gram, Pea, Lentil, Grass pea
Maharashtra	Chickpea, Black gram, Grass pea
Assam	Green Gram, Black gram, Chickpea, Pea, Lentil
Uttar Pradesh	Chickpea, Green Gram, Black gram, Lentil, Pea
Andhra Pradesh	Green gram, Black gram

Source: Author's compilation from research studies

Since rice fallows can accommodate millets, pulses, and oilseed crops, determining the optimal mix of these crops has become a pressing concern, especially with government intervention emphasizing the cultivation of all three. Table 6.3 highlights suitable pulse options for specific regions. The total rice fallow area is divided into three equal parts: one-third for millets, one-third for pulses, and one-third for oilseeds. However, their productivity must be evaluated to effectively compare pulse crops.

Table 6.3: Potential Production of Pulse Crops from Utilized Rice Fallow Areas in Selected Districts

States	Area Under Rice Fallow (Rabi) (Mha)	Fallow Area available for Pulses Cultivation (1/3) (Mha)	Suitable Pulse Crops	Crop-wise Potential Production utilizing Rice Fallow (MT)	Total Pulses Potential Production of state utilizing Rice Fallow (MT)
MP + Chhattisgarh	4.38	1.46	Chickpea	0.32	1.55
			Black Gram	0.38	
			Lentil	0.28	
			Green Gram	0.31	
			Pea	0.26	
Bihar + Jharkhand	2.2	0.73	Chickpea	0.03	0.07
			Green Gram	0.02	
			Lentil	0.02	
			Pea	0	
West Bengal	1.72	0.57	Black Gram	0.14	0.51
			Green Gram	0.09	
			Lentil	0.12	
			Pea	0.16	
Odisha	1.22	0.41	Green Gram	0.04	0.21
			Black Gram	0.04	
			Pea	0.08	
			Lentil	0.05	
Maharashtra	0.63	0.21	Chickpea	0.11	0.16
			Black Gram	0.06	
Assam	0.54	0.18	Green Gram	0.03	0.14
			Black Gram	0.02	
			Chickpea	0.03	
			Pea	0.03	
			Lentil	0.03	
Uttar Pradesh	0.35	0.12	Chickpea	0.03	0.12
			Green Gram	0.02	
			Black Gram	0.02	
			Lentil	0.02	
			Pea	0.03	
Andhra Pradesh	0.31	0.1	Green Gram	0.04	0.09
			Black Gram	0.05	
Total	**11.65**	**3.78**		**NA**	**2.85**

Source: Authors' computation

Utilizing just one-third of the total rice fallow area across ten states for pulse cultivation has the potential to enhance domestic production significantly. Estimates suggest a potential increase of up to 2.85 MT in pulse output. This statistic underscores the immense potential of these currently fallow lands.

Leveraging state-specific crop suitability, significant potential exists for enhancing pulse production across various regions. In Madhya Pradesh and Chhattisgarh, chickpea, black gram, lentil, green gram, and pea cultivation could increase total output to 1.55 MT. Similarly, Bihar and Jharkhand hold the potential to reach 0.07 MT by introducing chickpea, green gram, lentil, and pea. West Bengal also presents promising opportunities. With black gram, green gram, lentil, and pea cultivation, West Bengal's production could rise to 0.51 MT. Odisha's output could reach 0.21 MT by cultivating green gram, black gram, pea, and lentil. By strategically cultivating green gram and black gram in rice fallows, Maharashtra's pulse output could increase to 0.16 MT. Assam, with its suitability for green gram, black gram, chickpea, pea, and lentil, can achieve a production boost of up to 0.14 MT. Uttar Pradesh can leverage rice fallows for pulse production, with chickpea, green gram, black gram, lentil, and pea identified as suitable options, potentially elevating the state's yield to 0.12 MT. Lastly, Andhra Pradesh can also leverage rice fallows for pulse production with green gram and black gram, potentially boosting the state's yield to 0.09 MT.

6.3.2 Horizontal Expansion through Inter-cropping

Moreover, intercropping pulses with sugarcane in regions like Uttar Pradesh and Maharashtra can unlock an additional 3 Mha of cultivable land, potentially yielding 2.4 MT of pulses.[17] Similarly, optimizing the rice-wheat cropping system in states like Uttar Pradesh, Bihar, and Haryana can make space for an additional 4 Mha for pulse cultivation, with the potential to increase production by 2.8 MT[18] (ICAR-IIPR 2024). By implementing these horizontal expansion strategies, India can unlock a substantial 8.05 MT of additional pulse production, contributing towards self-sufficiency. In West Bengal, Assam, Tripura, and Meghalaya, there is an opportunity to introduce super early varieties of lentil, chickpea, grass pea, and pea between kharif rice and boro rice. The potential of intercropping with other crops, such as cotton, millets, cucurbits, and vegetables, may be explored strategically for the horizontal expansion of kharif season pulses, especially for green gram and black gram, in Uttar Pradesh, Bihar, Maharashtra, Andhra Pradesh, and Tamil Nadu. In this direction, pigeonpea can be intercropped with soybean, sorghum, cotton, millets, and groundnut under rainfed upland conditions in Andhra Pradesh, the Malwa Plateau of Madhya Pradesh, the Vidarbha region of Maharashtra, North Karnataka, and Tamil Nadu. Spring/summer pulses (after the harvest of wheat, rapeseed mustard, pea, potato, etc.) are another area that holds great promise for the horizontal expansion of black gram and green gram in western and central Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, and West Bengal. It is also worth noting that western Rajasthan encompasses 7.5 Mha, with a cropping intensity of about 100%, presenting a significant opportunity to expand the area dedicated to pulses, potentially increasing cropping intensity to 130-140%. Since this region relies on rainfed agriculture, incentives for water harvesting initiatives, such as farm ponds and micro-irrigation systems, could be effective. Additionally, Madhya Pradesh allocates 6.6 Mha to soybean cultivation, presenting considerable opportunities for intercropping pulses. Similarly, in Maharashtra, pulses have been successfully intercropped with soybeans on a large scale.

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17 *Considering average productivity 0.8 t/ha.*
18 *Considering average productivity 0.7 t/ha.*

6.4 Technological Interventions: Vertical Expansion in Pulse Crops

The results of Cluster Frontline Demonstration (CFLD)[19] on pulses since 2015-2016 under NFSM conducted on major pulse crops (i.e., Pigeonpea, Chickpea, Greengram, Blackgram, Lentil, Pea, Mothbean, Horsegram) under real farm situations in different agro-ecological conditions of India, revealed a significant yield gap between current farmer practices and Technological Interventions (TI)[20]. This gap ranged from 24% in pea to a substantial 68% in pigeonpea (Table 6.4). By addressing this issue through the widespread use of established and reliable technologies, domestic pulse production could potentially increase by approximately 46.3% (i.e., 12.05 MT). Considering factors like seed, feed, and wastage, the overall supply of pulses could increase by 10.7 MT. Additionally, this increased production will enhance the profitability of pulse crop farmers, promoting a more self-sufficient and resilient agricultural sector. To realize this potential, a dedicated program focusing on adopting advanced technologies, including improved varieties, modern farm machinery, high-quality seeds, and good agronomic practices, is essential. These figures underscore the transformative potential of technological interventions and hold the key to bridging the current demand-supply gap, ensuring India's self-sufficiency in the pulses sector.

Figure 6.2: Technological Interventions

Table 6.4: Gap Between Potential (with Technological Interventions) and Actual Production (MT) for Major Pulses

Pulse Crops	National Average Yield (t/ha) (2017/18-2021/22)	Improved Technology Yield (t/ha)	Potential Increase of Yield Adopting Improved Technology (%)	Actual Production (2021-22) (MT)	Potential Production Adopting Improved Technology (MT)	Gap between Potential and Actual Production (MT)
Pigeonpea	0.837	1.409	68	3.31	5.57	2.26
Chickpea	1.164	1.664	43	12.27	17.54	5.27
Green gram	0.583	0.888	52	3.68	5.61	1.93
Black gram	0.558	0.914	64	2.63	4.31	1.68
Lentil	0.926	1.344	45	1.56	2.26	0.70
Pea	1.222	1.519	24	0.88	1.09	0.21
Other Pulses	NA	NA	NA	1.73	NA	NA
Total	NA	NA	NA	26.06	38.11	12.05

Source: Authors' estimations based on the results of CFLDs under NFSM and NMOOP.

19 *The major objective of Front-Line Demonstrations (FLDs) is to demonstrate the productivity potentials and profitability of the latest and improved pulse production technologies under real farm conditions.*

20 *Use of healthy and disease tolerant seeds, seed treatment, timely sowing, right method of sowing, timely weeding, integrated pest management (IPM), recommended spacing, improved varieties and hybrids, recommended crop sequence, application of gypsum, application of sulphur and boron, spraying of cycocel, integrated nutrient management (INM), integrated weed management (IWM), and integrated water management.*

6.4.1 Abiotic and Biotic Stress Management: Mitigating the Impact on Pulse Production

Effective management strategies for both abiotic and biotic stresses are crucial to ensuring pulses' sustainable and productive cultivation. These stresses, including drought, heat stress, pests, and diseases, can significantly impact yield and quality. A comprehensive approach involving a combination of sustainable agronomic practices, technological innovations, and strategic policy interventions is necessary to address these challenges.

i. **Enhancing Pulse Production with Sustainable Practices:** Adopting economical and sustainable farming practices is crucial for enhancing and sustaining pulse production. These methods effectively tackle biotic and abiotic challenges, reducing reliance on chemical solutions while minimizing environmental impact. Key strategies include implementing integrated pest management (IPM) to control pests and diseases, using biopesticides and biofertilizers to promote natural pest control and improve soil health, engaging in crop rotation and intercropping to break disease cycles and boost soil fertility, and selecting resistant varieties to prevent crop losses. Additionally, it's important to identify safe herbicides for post-emergence applications, particularly for Kharif pulses, where weeds can greatly reduce yield. Focusing on developing pest-resistant varieties, especially for pigeonpea, against threats like the pod borer, webfly, and maruca, as well as hybrids, is also essential. Moreover, integrating new technologies such as drones for spraying crops—particularly for arhar, which is difficult to spray due to its height and dense canopy—can provide significant benefits.

ii. **Mitigating Abiotic and Biotic Stresses:** Reducing the effects of abiotic and biotic stresses requires a comprehensive strategy. Selecting crops wisely, especially those that are drought-resistant, tolerant, early-maturing, and short-duration, can greatly improve resilience. Healthy, disease-free seeds and suitable seed treatments can further reduce the effects of various stresses. Implementing effective crop management practices—like nutrient management, efficient irrigation, and timely weed control—is vital for maximizing growth and yield. Moreover, employing integrated pest and disease management strategies can safeguard crops from pests and diseases, thereby ensuring their full yield potential.

iii. **Improving Soil Health and Water Management:** Improving soil health and water management is essential for sustainable pulse production. Deep ploughing in dryland areas can conserve soil moisture and promote root development, leading to higher yields. Conservation tillage systems minimize soil disturbance and can improve soil health, reduce erosion, and enhance water infiltration.

iv. **Adapting to Climate Change:** In the face of climate change, the development and utilization of climate-resilient crop varieties are increasingly important. These varieties can withstand adverse weather conditions, such as drought, heat stress, and flooding, ensuring stable yields. By implementing these strategies, pulse production can be stabilized and increased, even in challenging environmental conditions.

To further accelerate pulse production and ensure food security, promoting high-performing pulse cultivars is essential. These cultivars, developed through rigorous breeding programs, possess desirable traits such as drought tolerance, heat tolerance, disease resistance, and improved yield potential. By encouraging the adoption of these varieties, India can significantly enhance its pulse production and strengthen its position in the global pulse market. The table below (Table 6.5) presents a selection of promising pulse cultivars that have been identified as particularly well-suited to withstand abiotic and biotic stress conditions in India.

Table 6.5: Promising Pulse Cultivars for Stress Tolerance in India

Pulse Crop	Varieties	Biotic Features	Varieties	Abiotic Features
Pigeonpea	Pusa Arhar 16, GRG 152	Resistant to sterility mosaic (both) and tolerant to wilt, pod-borer	GT 105, Pusa 2018-2, UPAS 120	Escape drought due to short duration
	IPA 203, Pant Arhar 6, Godawari (BDN 2013-41), IPA 15-06,	Resistant to wilt and sterility mosaic	IPH 9-05, Phule Damayanti, KRG 33, Asha, BRG 3,	Suitable for early sowing under delayed monsoon
	KRG 33, TDRG 59, Phule Damayanti,	Resistant to wilt and SMD, Tolerant to pod fly and pod borer		
	Rajendra Arhar 2	Resistant to root knot and cyst nematodes		
Chickpea	Kota Desi Chana 3, Kundan, Samriddhi, Pusa Chickpea 20211, Kanak, SA 1, Pusa 256, Uday, Pusa 372, Pusa G 186	Resistant to wilt, tolerant to Ascochyta blight	ICCV 10, JG 16, Pratao Chana 1, RVG 201, RVG 202, RVG 203, Pusa 1088, Saatvik, Advika, Pusa JG 16, IPC L 4-14	Tolerant to drought stress
	GNG 2461, GJG 0809, CSJ 515, Him Palam Chana 1	Tolerant to Ascochyta blight	HC 7, IPC 2006-77, GNG 2299, Pant Gram 5	Late sown conditions
	PBG 9, Pusa Chickpea 20211, Kota Desi Chana 3	Moderately resistant to wilt and dry root-rot	JG 14, Indira Chana, JG 315, JG 11, RSG 888, GNG 663, Pant G 186	Tolerant to Heat stress
	BDG 72, Co 3	Resistant to wilt and collar rot	Vijay	Delayed Monsoon
	Pusa 1105	Moderately resistant to wilt and dry root-rot	PDG 4	Cold Stress

Pulse Crop	Varieties	Biotic Features	Varieties	Abiotic Features
Green Gram	IPM 410-3, IPM 205-7, SML 2015, ML 1839, LGG 600, MH 1772, LGG 610	Resistant to yellow mosaic	IPM 295-7MH 1762, IPM 512-1, SML 1115	Suitable for drought stress
	IPM 512-1, MH 1142, MH 1142, Pusa 1372	Resistant to yellow mosaic, Cercospora leaf spot and anthracnose		
	MH 1762,	Urdbean leaf circle virus ND Root-knot nematode resistant	IPM 205-7, IPM 409-4, IPM 302-2, IPM 312-20, GM 7	Delayed monsoon
	DGGV 2, GJM 1701	Powdery-mildew resistant	IPM 410-3, IPM 2 14, OBGG 58, VBN 6, LGG 607	Heat tolerant
Black Gram	Pant U 30, IPU 13-1, IPU 10-26, Pant Urd 12, OBG 41, Kota Urd 5	Resistant to yellow mosaic	KPU 18-1, Mash 1190, Mukundra Urd 2, Kota Urd 4	Drought stress
	Mash 1190, Mukundra Urd 2, LBG 787, VBN 9	Powdery-mildew resistant	KUG 878, Kota Urd 5, Pant U 31, Pant U 19	Delayed monsoon
Lentil	LH 17-19, LL 1613, IPL 220,	Resistant to rust and wilt	Pusa Shweta, PDL 1	Salinity stress
	VL Masur 103, DPL 62, LLS 669, HUL 57	Resistant to rust		
	Kota Masur 4, L 4717, Pant L 8,	Resistant to wilt and blight	JL 3, RVL 31, Vamban	Drought Stress
	Pant L 5	Resistant to wilt, rust and blight		
Mothbean	CZMO 18-5, CZMO 18-2, RMO 2251	Resistant to yellow mosaic	CAZRI Moth 3, 1, CZM	Drought resistant and delayed monsoon
			RMO 225, RMO 423, CZMPO 18-5	Heat stress
			CZMO 18-5, CZMO 18-2, RMO 2251	Suitable for rainfed condition

Pulse Crop	Varieties	Biotic Features	Varieties	Abiotic Features
Rajmash	Shalimar Rajmash 3, Shalimar Rajmash 4, Shalimar 1, RKR 1033, Phule Viraj	Resistant to BCMV, Anthracnose	Shalimar Rajmash 3	Moisture Stress
Cowpea	Pant Lobia-3	Resistant to yellow mosaic virus and bacterial blight	Jammu Lobia super 60	Suitable to rainfed conditions
	Pant Lobia-5	Tolerant to aphids, thrips, bruchids and resistant to cowpea yellow mosaic virus	Shalimar Cowpea-2 (SKUA-WCP-149)	Suitable to rainfed conditions
	TPTC 29 (Tirupati cowpea-1)	Moderately resistant to dry root rot and yellow mosaic virus	PGCP 6	Escape drought due to short duration
	DC 15	Tolerant to aphids and pod borer, moderate resistant to dry root rot and yellow mosaic virus		
	Pant Lobia 7 (PGCP 24)	Resistant to cowpea mosaic virus.		
	Jammu Lobia super 60	Resistant to yellow mosaic virus		
	VBN 4 (VCP 14-001)	Resistant to bean common mosaic virus		
	GC 1601 (Gujarat Cowpea 8)	Moderately resistant to cowpea yellow mosaic virus and free from dry root rot		
	Shalimar Cowpea- 2 (SKUA-WCP-149)	Resistant to cowpea mosaic various and ascochyta blight		
	Phule Vithai (Phule CP-05040)	Moderately resistant to color rot and leaf spot		
	Phule Rakhumai (PCP 0306-1)	Moderaltely resistant to cercospora leaf spot		
	CPD 119	Moderately reistant to mosaic, root rot and Cercspora Leaf Spot		

Pulse Crop	Varieties	Biotic Features	Varieties	Abiotic Features
Field pea	IPFD 12-2	Resistant to Powdery mildew		
	IPFD 2014-2	Moderately reistant to pod borer, aphid, leaf miner and nematode		
	Pant Pea 250	Resistant to powdery mildew, rust, Ascophyta blight and root rot diseases		
	Pant Pea 243	Moderately resistant against powdery mildew, rust, Ascophyta blight, and root rot diseases		
	IPF-16-13	Moderately resistant to PM, rust & resistant to pod bearer, aphid and leaf minor		
	HFP 1428	Resistant to powdery mildew, ascochyta blight & root rot and moderately resistant to rust		
	Pant Pea-347 (Pant P 347)	Resistant to powdery mildew & Ascochyta blight and moderately resistant to rust and root & rot diseases.		

Source: Experts' consultations

A key component of this integrated strategy is developing and adopting pulse varieties that are resistant or tolerant to various biotic and abiotic stresses. This can be achieved through the strategic application of biotechnology tools in crop improvement, offering the potential to enhance the genetic resilience of pulse crops. By focusing on developing stress-resistant varieties and integrating them with improved agronomic practices, India can significantly boost pulse productivity and contribute to the nutritional security of its population. To ensure the successful implementation of these strategies, continued research, innovation, and the dissemination of knowledge to farmers are crucial. By empowering farmers with the necessary tools and knowledge, we can mitigate the impact of stresses on pulse crops and ensure sustainable and resilient agriculture.

6.4.2 Pulse Varietal Development through Genetic Diversity and Modern Breeding Techniques

India possesses a vast genetic diversity of pulse crops, with the ICAR–National Bureau of Plant Genetic Resources (NBPGR) holding a collection of around 70,000 accessions of various pulse species. However, much of this genetic wealth remains underutilized. To fully harness these resources, existing breeding programs must be modernized to efficiently extract desirable traits from this genetic pool and develop improved varieties or hybrids. Incorporating modern tools such as genomics can help accelerate the varietal development process, reducing the time required to bring new, high-performing varieties to the field.[21] The major thrusts of pulse-breeding programs include improving genetic potential and enhancing tolerance to biotic and abiotic stresses.

Improvement in the Varietal Replacement Rate (VRR) of major pulse crops in India indicates the percentage of area sown with improved varieties, reflecting the adoption of newer, more productive crop varieties by farmers. Higher VRR is crucial for enhancing yield, as newer varieties often have better resistance to diseases, pests, and adverse climatic conditions.

Table 6.6: Varietal Replacement Rate (VRR) of Major Pulses in India (2018-19 vs 2023-24)

Crop	Varietal Replacement Rate (%)			
	2018-19		2023-24	
	Less than 10 years	Less than 5 years	Less than 10 years	Less than 5 years
Pigeonpea	36.5	3.5	97.2	65.6
Chickpea	54.5	41.4	90.3	41.6
Green gram	68.5	21.1	94.0	37.9
Black gram	32.9	6.3	90.8	59.2
Lentil	53.8	20.4	99.60	57.9

Source: Department of Agriculture & Farmers Welfare, GOI

Table 6.6 shows a significant increase in VRR across all pulse crops from 2018-19 to 2023-24. For instance, the VRR Pigeonpea improved from 36.5% to 97.2% (for varieties less than 10 years old), indicating a widespread adoption of improved varieties. Similarly, Chickpea, Green gram, Black gram, and Lentil also saw increases, with notable improvements in the adoption of varieties less than 5 years old, especially in Pigeonpea and Black gram. These signify efforts to promote newer pulse varieties, aiming to boost production, improve farmer income, and enhance nutritional security in India.

A multi-pronged strategy is essential to enhance the outreach of improved pulse varieties to grassroots farmers. This includes the distribution of seed mini-kits and strengthening agricultural extension services by training local officers and setting up demonstration plots to showcase the benefits of new varieties. Collaborating with KVKs, Farmer Producer Organizations (FPOs), and cooperatives can help in bulk procurement and distribution of seeds, making them more affordable and accessible.

21 https://naas.org.in/Policy%20Papers/policy%20116.pdf

6.4.3 Post-Emergence Herbicide in Pulses: A Pathway to Enhanced Yield and Production

The sensible use of post-emergence herbicides in pulse crops can significantly enhance yields and overall production. By effectively controlling weeds, these herbicides can optimize resource utilization, reduce competition for nutrients and water, and ultimately boost crop productivity.

As depicted in the table (Table 6.7), the application of specific herbicides, such as Imazethapyr, Quizalofop-p-ethyl, Clodinafop-propargyl + sodium acifluorfen, and Topramezone, can lead to substantial yield increases in various pulse crops. For instance, the use of Imazethapyr, Quizalofop-p-ethyl, and Clodinafop-propargyl + sodium acifluorfen in pigeonpea, green gram, and black gram can result in a yield increase of 28.9%, 33.1%, and 37.6% respectively, translating to an additional 1.6 MT, 1.1 MT and 0.75 MT of production. Similarly, applying Topramezone and Quizalofop-p-ethyl in chickpea and lentil can boost yields by 19.6% and 15.2%, leading to an additional 2.7 MT and 0.75 MT of production, respectively. In aggregate, adopting post-emergence herbicides across key pulse crops can potentially increase overall pulse production by an estimated 6.9 MT.

However, it is crucial to use these herbicides responsibly and in accordance with recommended practices to minimize potential environmental impacts. By adopting integrated weed management strategies, including cultural, mechanical, and biological methods, farmers can further optimize herbicide use and maximize the benefits of these technologies.

Table 6.7: Good Agronomic Practices for Yield Optimization: Potential of Post-Emergence Herbicide in Pulses

Crop	Recommendation	Herbicide required ('000 T)	Yield increase (%)	Increase in production (MT)
Pigeonpea	Imazethapyr, Quizalofop-p-ethyl and clodinafop-propargyl + sodium acifluorfen	10.1	28.9	1.6
Green gram		15.6	37.6	0.75
Black gram		3.00	33.1	1.1
Chickpea	Topramezone	0.65	19.6	2.7
Lentil	Quizalofop-p-ethyl	2.84	15.2	0.75
Total Potential Gain In Pulse Production				6.9

Source: ICAR & IIPR 2024

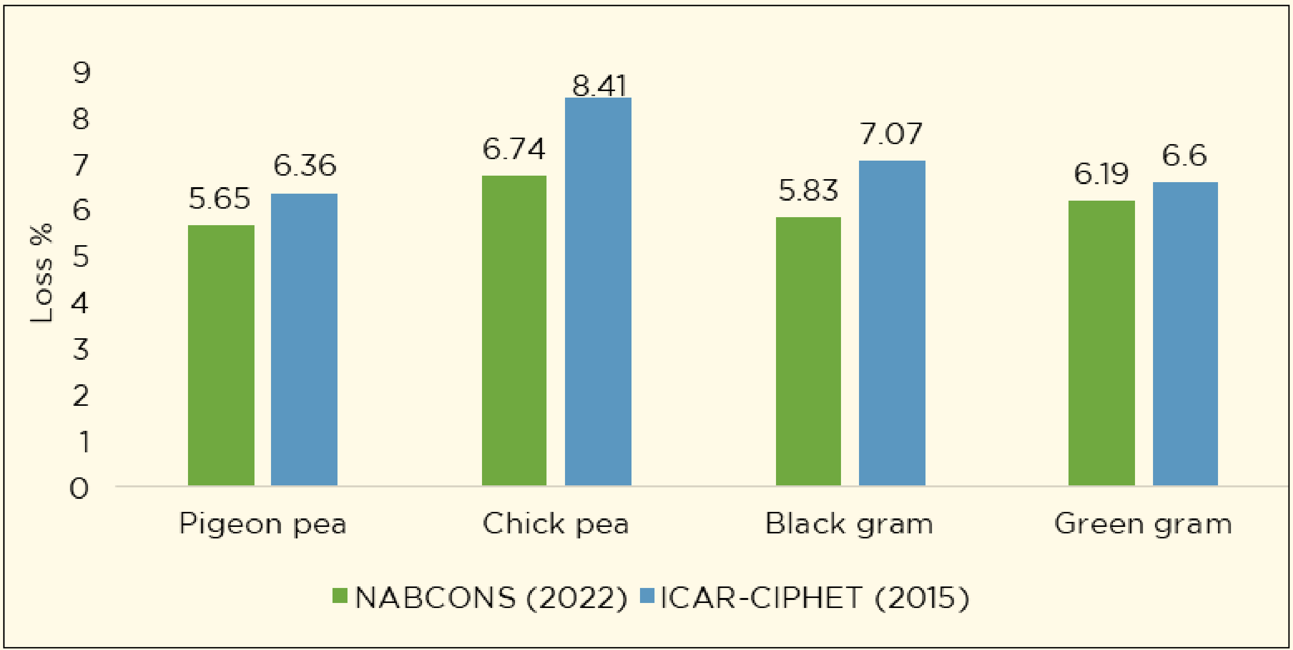
6.4.4 Enhancing Nutritional Quality in Pulses through Nutrition-Sensitive Breeding Programs

The nutrient profile of pulses can be enhanced by integrating nutritional quality traits into breeding programs. Certain genotypes have been found to possess significantly higher nutrient content. For example, some chickpea varieties (such as ICC 5912) and pigeonpea lines (HPL 8, HPL 40) contain 26-27% protein, compared to the 20-22% typically found in commercial varieties. Similarly, lentil varieties L4704 and IPL 220 boast more than double standard commercial types' iron and zinc content. Utilizing such traits through targeted, nutrition-sensitive breeding programs makes it possible to significantly advance efforts toward achieving nutritional security.[22]

6.5 Value Addition and Reducing Post-Harvest Losses in Pulses

Post-harvest losses in pulses occur at various stages, from harvest to consumer consumption. A recent NABCONS study (2022) assessed post-harvest losses across 54 crops/commodities in all 15 agro-climatic zones of India, including major pulse-producing districts. The estimated post-harvest losses in pulses (i.e., pigeon pea, chickpea, black gram, and green gram) ranged from 5.65% in pigeonpea to 6.74% in chickpea (Figure 6.3). These losses are primarily attributed to factors such as shattering of grains during harvesting, spillage during various operations, and mishandling. To minimize these losses and improve the overall efficiency of the pulse value chain, it is crucial to adopt advanced post-harvest technologies and best practices.

Figure 6.3: Post Harvest Loss % in Major Pulses



Source: NABCONS 2022

Pigeonpea: Post-harvest losses in pigeonpea were significant, with 4.67% occurring at the farm level and 0.99% at the market level, totalling 5.65%. Harvesting (1.1%) and threshing (1.84%) were the primary contributors to farm-level losses, while processing (0.35%) and transport (0.27%) accounted for market-level losses. These findings indicate a reduction in post-harvest losses compared to a previous ICAR-CIPHET (2015) study, which reported a 6.36% loss. This improvement can be attributed to factors such as increased use of threshers, improved cultivation practices promoted by ICAR, KVKs, and SAUs, and shorter storage durations at the farm level.

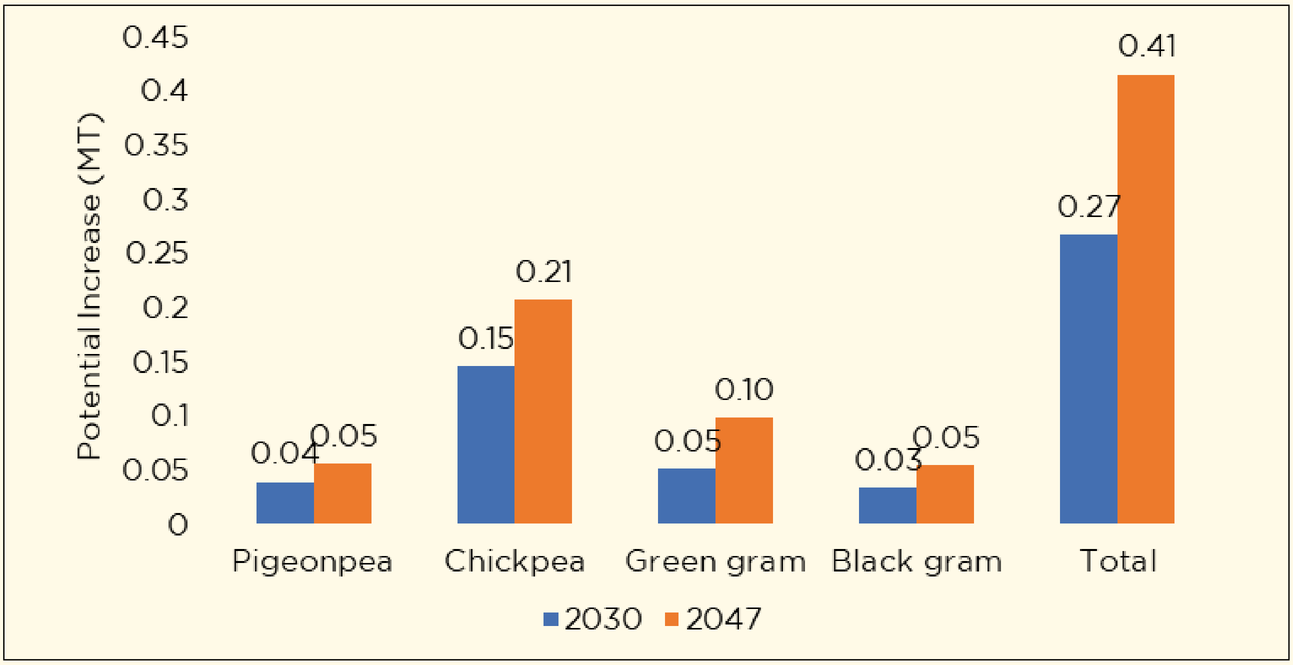
22 https://naas.org.in/Policy%20Papers/policy%20116.pdf

Chickpea: Post-harvest losses in chickpea were estimated to be 6.74%, with 5.89% occurring at the farm level and 0.85% at the market level. Harvesting (1.49%) and threshing (2.00%) were the primary contributors to farm-level losses, while transport (0.30%) accounted for market-level losses. These findings indicate a reduction in post-harvest losses compared to a previous study by ICAR-CIPHET (2015), which reported a loss of 8.41%. The improvement in post-harvest losses can be attributed to factors such as the adoption of improved varieties, increased use of threshers, and enhanced storage capacity in recent years.

Green gram: Post-harvest losses in green gram were estimated at 6.19%, with 5.30% occurring at the farm level and 0.89% at the market level. Harvesting (1.81%) and threshing (1.53%) were the primary contributors to farm-level losses, while wholesaler-level losses accounted for 0.33%. This study found lower post-harvest losses compared to a previous study by ICAR-CIPHET (2015), which reported a loss of 6.60%.

Black gram: Post-harvest losses in black gram were estimated at 5.83%, with 4.95% occurring at the farm level and 0.88% at the market level. Harvesting (1.44%) and threshing (1.17%) were the primary contributors to farm-level losses, while wholesaler (0.24%) and retailer (0.23%) levels accounted for market-level losses. This study found lower post-harvest losses (5.83%) compared to a previous study by ICAR-CIPHET (2015), which reported a loss of 7.07%. The improvement in post-harvest losses can be attributed to factors such as increased storage capacity and the increased use of threshers since 2015.

To minimize post-harvest losses in pulses, a comprehensive approach is essential. This includes exploiting genetic variability to improve milling characteristics, thereby enhancing processing efficiency and reducing waste. Developing pulse varieties with resistance to stored grain pests is crucial to prevent damage during storage. Additionally, the design and dissemination of efficient harvesting and threshing equipment can streamline the post-harvest process, minimizing losses at the farm level. The establishment of advanced and efficient dal mills will improve processing efficiency, while the development of improved storage technologies will help to preserve the quality of pulses over longer periods, ensuring reduced spoilage and better returns for farmers. Reducing post-harvest loss by 1% further, the potential supply of total pulses could increase by 0.27 MT and 0.41 MT in 2030 and 2047, respectively (Figure 6.4). The potential increase in pigeonpea supply by 2030 is estimated to be 0.04 MT, and by 2047, it is projected to reach 0.05 MT. Chickpea production is expected to increase by 0.15 MT in 2030 and 0.21 MT in 2047. The potential increase in green gram production is 0.05 MT in 2030 and 0.10 MT in 2047. Black gram production is projected to increase by 0.03 MT in 2030 and 0.05 MT in 2047.



Source: Authors' computation

Figure 6.4: Potential Increase in Pulses Supply by 2030 and 2047 by Minimizing Post-Harvest Losses

6.6 The Role of Mechanization: A Key to Increased Efficiency and Yield

Mechanization of pulse production offers a promising avenue to enhance productivity, reduce labor costs, and improve overall efficiency. By adopting suitable farm machinery for various operations, such as tillage, planting, harvesting, inter-cultivation, threshing, and processing, farmers can significantly optimize their production processes. The benefits of mechanization are manifold:

- Productivity Gain: Mechanization can lead to a 10-15% increase in productivity (ICAR-IIPR (2024) by improving efficiency and reducing labor requirements.
- Timely Operations: Mechanized operations ensure timely sowing and harvesting, which is crucial for maximizing yields and reducing losses.
- Optimal Plant Population: Mechanized planting techniques help maintain proper plant population, leading to better resource utilization and higher yields.
- Reduced Cost of Production: By reducing labor costs and improving efficiency, mechanization can significantly reduce the overall cost of production.
- Improved Labor Efficiency: Mechanization can alleviate the physical burden on farmers and improve the efficiency of human labor.

To fully realize the potential of mechanization, several key considerations are necessary:

- Development of improved Varieties amenable to machine harvest: Developing pulse varieties that are suitable for mechanized harvesting is essential.

- Modification of Machinery: Adapting existing machinery or developing new machinery specifically designed for pulse crops is crucial.
- Promotion of Custom Hiring: Encouraging the adoption of custom hiring services can make mechanization accessible to small and marginal farmers.
- Leveraging Technology: Using drones and UAVs for spraying can further improve efficiency and precision in crop management.

By embracing mechanization and adopting innovative technologies, India can significantly enhance its pulse production and contribute to food security and rural prosperity.

6.7 Potential Increase in Pulse Production through Strategic Interventions

India's growing reliance on pulse imports, increasing from 2.496 MT in 2022-23 to 4.739 MT in the last fiscal year, necessitates a comprehensive strategy to achieve self-sufficiency. The proposed strategies, encompassing both horizontal and vertical expansion approaches, offer a promising pathway to reduce import dependence. By implementing these strategies effectively, India can significantly boost domestic pulse production, potentially increasing total pulse production by 20.10 MT, as outlined in Table 6.8. This substantial increase can not only have the potential to mitigate the current import dependency of 4.739 MT but also address the projected demand gap of 15.74 MT by 2030 (i.e., the most demanding scenario), estimated through the normative approach utilizing ICMR-NIN dietary requirement and establish India as a self-sufficient nation in the pulse sector.

Table 6.8: Potential Increase in Pulse Production (MT) through Strategic Interventions (MT)

Pulse Crops	Potential Increase in Pulse Production (MT)			
	Horizontal Expansion			Vertical Expansion
	Efficient Rice Fallows Utilization	Sugarcane Intercropping	Rice-wheat Cropping System	Improved Technology & Well-organised Management/Practice
Pigeonpea	NA	NA	NA	2.26
Chickpea	0.52	NA	NA	5.27
Green Gram	0.55	NA	NA	1.93
Black Gram	0.71	NA	NA	1.68
Lentil	0.52	NA	NA	0.70
Pea	0.56	NA	NA	0.21
Sub-total	2.85	2.4	2.8	12.05
Grand Total	20.10			

Source: Authors' estimations

The outlined strategies for increasing domestic pulse production through strategic interventions hold immense potential. By 2030 and 2047, these interventions could lead to a projected pulses supply of 48.44 MT and 63.64 MT (Table 6.9), achieving self-sufficiency under all three demand approaches (i.e., Household/Static, Normative, and Behaviouristic). All the scenarios project a surplus –i.e., 21.64 MT and 34.33 MT under the Household Approach; 2.11 MT and 13.38 MT under the Normative Approach; 13.28 MT and 12.91 MT under the Behavioristic Approach (BAU); and 4.68 MT and 12.91 MT under the Behaviouristic Approach (HIG) by 2030 and 2047 respectively. These estimations highlight the importance of increasing domestic production and considering potential shifts in consumption patterns when formulating long-term strategies for achieving pulse self-sufficiency.

Table 6.9: Projected Pulses Demand-Supply Gap at the National Level by 2030 and 2047 (in MT), adding Potential Increase through Strategic Interventions: Household Approach, Normative Approach, and Behaviouristic Approach (BAU and HIG)

Year	Projected Supply through Strategic Interventions (MT)	Household Approach		Normative Approach		Behavioristic Approach (BAU)		Behavioristic Approach (HIG)	
		Demand (MT)	GAP (MT)	Demand (MT)	GAP (MT)	Demand (MT)	GAP (MT)	Demand (MT)	GAP (MT)
2030	48.44	26.80	21.64	46.33	2.11	35.16	13.28	43.76	4.68
2047	63.64	29.31	34.33	50.26	13.38	50.73	12.91	50.73	12.91

Source: Authors' estimations

To bridge the potential import gap, particularly in the Normative Approach to fulfilling nutritional requirements from pulses consumption for each individual in the country, significant production increase envisioned through strategic interventions needs prioritized implementation. Realizing this ambitious target will necessitate a focused approach that leverages the "Quadrant Strategy" on a district-wise cluster basis. This data-driven strategy involves identifying and exploiting the potential opportunities within each district cluster for specific pulse crops. It emphasizes a scalable approach that prioritizes clusters with LA-LY and those with HA-LY and LA-HY potential. By strategically targeting these clusters and implementing tailored interventions, India can maximize its production potential and effectively address the near-term challenges posed by potential consumption increases.

Over the past five years (2017-18 to 2022-23), India's pulse sector has experienced a modest growth rate of approximately 2.50%. If this trend continues, it will be sufficient to meet the projected demand based solely on population growth, as considered by the Household Approach.

However, achieving self-sufficiency in pulses requires a more ambitious strategy. The Behaviouristic Approach takes into account potential changes in food consumption patterns resulting from factors such as rising income levels, lifestyle changes, and price fluctuations. This necessitates a higher growth rate. Under the Business as Usual (BAU) scenario, a CAGR of 3.82% is required for the period from 2022 to 2030. For the longer term, from 2022 to 2047, a slightly elevated CAGR of 2.70%, compared to recent growth rates, is necessary. The High-Income Growth (HIG) scenario presents an even more challenging outlook. In this case, a significantly steeper CAGR of 6.69% is needed for the 2022-2030 period. For the longer-term goal of self-sufficiency by 2047, a CAGR of 2.70%, which is slightly higher than recent growth rates, will be required from 2022 to 2047.

The Normative Approach adds another layer of complexity. It indicates that additional efforts must be made to accelerate pulse production in order to meet the projected dietary requirements. To meet the anticipated demand by 2030, a significantly higher CAGR of 7.46% is necessary for the period from 2021 to 2030. For the long-term goal of self-sufficiency by 2047, a slightly elevated CAGR of 2.66% compared to recent growth rates is needed for the entire period from 2021 to 2047. These findings highlight the critical need for strategic interventions to accelerate domestic production and bridge the gap between current growth trends and self-sufficiency goals.

Table 6.10: Required CAGR for Self-Sufficiency in Pulses: Considering BAU & Strategic Interventions Scenarios across Normative, Household & Behaviouristic Approaches (BAU and HIG)

Required CAGR	Household Approach		Normative Approach		Behaviouristic Approach			
					BAU		HIG	
	2022-2030	2022-2047	2022-2030	2022-2047	2022-2030	2022-2047	2022-2030	2022-2047
Scenario I: Existing Production Level (without Strategic Interventions)	Recent growth trend of 2.50% would be sufficient		7.46%	2.66%	3.82%	2.70%	6.69%	2.70%
Scenario II: Existing Production Level combined with the Potential Increase through Strategic Interventions	Recent growth trend of 2.50% would be sufficient to meet the projected demand							

Source: Authors' estimations

The proposed strategic interventions, if implemented effectively, hold significant promise for India's pulses sector. These measures could significantly boost domestic production and help achieve self-sufficiency. By combining these gains with the existing production level, India can achieve self-sufficiency in all scenarios, even with the recent growth trend of 2.50%. A more focused and rigorous implementation of the proposed strategic interventions is necessary to accelerate this progress. This more intensive approach has the potential to pave the way for India to achieve *Atmanirbharta* (self-reliance) in its pulses sector, ensuring a secure and sustainable future for its needs.

6.8 Disaggregated Growth Requirements for Achieving Atmanirbharta in Pulse Crops: By 2030 and 2047

Achieving *Atmanirbharta* (self-reliance) in India's pulse sector requires a comprehensive analysis of individual pulse crops, including detailed aggregated demand-supply assessments. This approach recognizes the differences among crops such as pigeonpea, chickpea, greengram, blackgram, lentil, and pea, each with its unique production efficiencies, consumption patterns, and import dependencies. To create effective policy interventions, it is essential to look beyond aggregate data and focus on the specific dynamics of each crop. This involves thoroughly evaluating historical data to quantify domestic production and consumption variations, account for fluctuating import/export volumes, and understand regional dietary preferences that influence pulse demand. Such detailed analysis helps set growth targets tailored to each pulse crop's unique challenges and opportunities, strengthening a self-sufficient national pulse ecosystem.

To quantify the growth trajectories needed for achieving *Atmanirbharta*, a rigorous comparative analysis of recent trends in production, imports, exports, and demand is vital. This framework requires precisely estimating the percentage increase in domestic production needed to meet projected demand. Policymakers can identify critical bottlenecks and design specific interventions by comparing historical growth rates with targeted rates. This comparative analysis serves as an essential framework, offering a strategic roadmap for planning and decision-making to enhance the growth of individual pulse crop production. The primary objective is to formulate a data-driven strategy that effectively drives the pulse sector toward achieving self-sufficiency.

This study uses a multi-faceted, step-by-step analytical approach to estimate the required production growth rates for individual pulse crops to meet projected demand by 2030 and 2047, facilitating self-sufficiency. The estimation is based on the gap between domestic production and demand, explicitly quantifying the percentage increase in production necessary to satisfy domestic demand for each pulse crop, using data from 2015-16 to 2023-24. Considering the observed fluctuations in domestic pulse crop production, imports, and exports, the analysis examines three scenarios for estimating demand for 2030 and 2047:

- Scenario 1 represents the average percentage of production increase needed over the entire period (2015-16 to 2023-24),
- Scenario 2 focuses on the average percentage needed over the last five years (2019-20 to 2023-24), and
- Scenario 3 looks at the average percentage increase required over the last three years (2021-22 to 2023-24), providing a comprehensive and nuanced view.

The resulting data in Table 6.11 delineates the percentage increase in domestic production required to meet domestic demand for six key pulse crops in India: pigeonpea, chickpea, greengram, blackgram, lentil, and pea. The analysis spans from 2015-16 to 2023-24, with three distinct average periods provided to offer a more nuanced understanding of the evolving dynamics within the pulse sector. This detailed presentation of data allows for a granular comparison of required growth rates across different timeframes, enabling policymakers to identify trends, assess the effectiveness of past interventions, and formulate targeted strategies to achieve *Atmanirbharta* in the Indian pulse sector.

Table 6.11: Gap Between Domestic Production and Demand: % of Production Increase that was Required to Meet the Domestic Demand for Individual Pulse Crops (2015-16 To 2023-24)

Year	Pigeonpea	Chickpea	Green gram	Black gram	Lentil	Pea
2015-16	17.91	11.54	5.21	25.24	127.92	301.88
2016-17	14.18	10.59	3.69	17.09	66.5	313.01
2017-18	9.38	7.5	42.16	9.45	48.4	289.21
2018-19	15.72	-0.43	2.96	15.78	19.05	104.61
2019-20	11.28	2.14	2.24	14.57	75.65	77.14
2020-21	9.82	1.14	2.23	14.33	73.54	4.26
2021-22	19.07	0.64	5.3	20.04	50.96	-6.15
2022-23	26.17	-2.38	0.45	18.88	49.5	-16.64
2023-24	21.75	0.74	-0.47	21.19	92.78	117.54
Scenario 1: Average of 2015-16 to 2023-24	16.14	3.5	7.09	17.4	67.15	131.65
Scenario 2: Average of 2019-20 to 2023-24	17.62	0.46	1.95	17.8	68.49	35.23
Scenario 3: Average of 2021-22 to 2023-24	22.33	-0.33	1.76	20.04	64.41	31.58

Source: Authors' computation based on the data from DES, MoA&FW, and MoC&I, GoI

The insights derived from the above table are presented below, with a detailed explanation for each pulse crop.

Pigeonpea: Persistent and Growing Deficit

Pigeonpea demonstrates a consistently significant gap between domestic production and demand. Over the long term, from 2015-16 to 2023-24, an average production increase of 16.14% was required to meet domestic demand. Notably, this gap has widened in recent years, with the average required increase jumping to 17.62% between 2019-20 and 2023-24, and further escalating to 22.33% in the most recent three years (2021-22 to 2023-24). This escalating deficit highlights the urgent need for targeted interventions to boost pigeonpea production and ensure self-sufficiency.

Chickpea: Indicating an Improved Balance

Chickpea demonstrate a gradual transition from a deficit to a surplus, indicating an improved balance. Over the long term (2015-16 to 2023-24), an average production increase of 3.50% was needed, indicating a moderate deficit. However, in recent years, production has improved significantly. The average required increase dropped to 0.46% between 2019-20 and 2023-24 and even turned into a surplus (-0.33%) in the most recent three years. While this improvement is promising, the inherent volatility suggests that careful monitoring and strategic interventions are crucial to maintaining this delicate balance.

Green gram: Marginal Deficit but Narrowing

Green Gram shows a relatively stable and marginal deficit. Over the long term (2015-16 to 2023-24), an average production increase of 7.09% was required. This gap has narrowed in recent years, with the average required increase dropping to 1.95% between 2019-20 and 2023-24 and further to 1.76% in the most recent three years. While the deficit is relatively small, continued efforts are needed to achieve self-sufficiency.

Black gram: Consistent and Growing Shortfall

Black Gram consistently shows a significant deficit, similar to pigeonpea. Over the long term (2015-16 to 2023-24), an average production increase of 17.40% was needed. This deficit has persisted and even slightly increased in recent years, with the average required increase rising to 17.80% between 2019-20 and 2023-24 and further to 20.04% in the most recent three years. This trend highlights the urgent need for targeted interventions to address the growing production shortfall in black gram.

Lentil: Significant Import Dependence

Lentil exhibits a very high deficit, indicating significant import dependence. Over the long term (2015-16 to 2023-24), an average production increase of 67.15% was required. This high deficit has persisted recently, with the average required increase rising to 68.49% between 2019-20 and 2023-24. Although it slightly dropped to 64.41% in the most recent three years, it remains substantially high. This emphasizes the need for substantial efforts to boost domestic lentil production and reduce import reliance.

Pea: Highly Volatile

Pea is characterized by high volatility in the demand-supply gap, with significant surpluses in some years and deficits in others. Over the long term (2015-16 to 2023-24), an average production increase of 131.65% was required, heavily influenced by extreme deficits in the early years. However, the deficit has significantly decreased in recent years, with the average required increase dropping to 35.23% between 2019-20 and 2023-24 and further to 31.58% in the most recent three years. Despite the recent improvement, the inherent volatility necessitates strategies to stabilize production.

The above analysis reveals that lentil, pigeonpea, and black gram are the major concerns, consistently exhibiting production deficits and demanding immediate and substantial efforts to boost domestic output through strategic interventions. Chickpea and green gram show a more balanced production and demand scenario but require continued monitoring. Pea is highly volatile, but its consumption demand is relatively less than other pulse crops. Nevertheless, pragmatic strategies are required to stabilize output and reduce fluctuations. This detailed analysis emphasizes the need for targeted policies and interventions for each pulse crop to achieve *Atmanirbhart*a in India's pulse sector, focusing on boosting production, stabilizing output, and reducing import reliance.

Building on the earlier estimations of the required production increases to meet the domestic demand for individual pulse crops, along with the projected production forecasts under the BAU scenario (outlined in Chapter 5), Table 6.12 shows the anticipated gaps between domestic demand and production for pigeonpea, chickpea, green gram, black gram, lentil, and pea. This analysis, conducted under three distinct scenarios reflecting varying historical production averages, provides critical insights into both the near-term (2030) and long-term (2047) trends and challenges associated with achieving self-sufficiency in India's pulse sector

Table 6.12: Projected Gap between Domestic Demand and Production (MT): 2030 and 2047

Scenario	Year	Pigeonpea	Chickpea	Green gram	Black gram	Lentil	Pea
Scenario 1 (Based on average of 2015-16 to 2023-24)	2030	-0.63	-0.51	-0.36	-0.58	-1.35	-1.71
	2047	-0.88	-0.73	-0.7	-0.94	-2.32	-3.31
Scenario 2 (Based on average of 2019-20 to 2023-24)	2030	-0.69	-0.07	-0.1	-0.59	-1.38	-0.46
	2047	-0.97	-0.09	-0.19	-0.96	-2.37	-0.89
Scenario 3 (Based on average of 2021-22 to 2023-24)	2030	-0.87	0.05	-0.09	-0.66	-1.3	-0.41
	2047	-1.22	0.07	-0.17	-1.09	-2.23	-0.79

Source: Authors' computation

Required vs. Historical CAGR of Pulse Crops Production to Meet the Projected Domestic Demand by 2030 and 2047

The tables below (Table 6.13 and Table 6.14) present the required CAGR of production from 2023 to 2030 and from 2023 to 2047 to meet the projected domestic demand for six pulse crops (pigeonpea, chickpea, green gram, black gram, lentil, and pea), juxtaposed with the historical CAGR under three distinct scenarios. Based on varying historical data periods, these scenarios provide a comparative analysis of past trends and future requirements for achieving self-sufficiency by 2030 and 2047.

To Meet Projected Domestic Demand by 2030

Pigeonpea: For Pigeonpea, the required CAGR consistently exceeds the historical CAGR across all scenarios. Scenario 1, based on long-term trends, necessitates a 4.24% CAGR, while the historical was 3.53%. Scenario 2 shows a required CAGR of 4.43% against a historical of 0.38%, indicating that a significant acceleration is needed. Scenario 3, reflecting recent trends, demands the highest CAGR of 5.01%, compared to a negative historical CAGR of -7.83%, highlighting a critical need for a substantial turnaround in production.

Chickpea: Chickpea shows an encouraging picture. Scenarios 1 and 2 indicate that the required CAGR (2.62% and 2.19%, respectively) is lower than the historical (7.44% and 4.74%), suggesting that current growth rates, if maintained, will have a surplus, exceeding the projected demand. However, Scenario 3 requires a 2.07% CAGR, slightly higher than the historical 1.70%, indicating a need for marginal acceleration.

Green gram: Green Gram demonstrates a positive picture. The required CAGR ranges from 4.28% to 5.04% across the three scenarios, significantly lower than the historical CAGR, ranging from 7.41% to 11.57%. This indicates that recent high growth rates not only meet future demand but will also create a surplus.

Black gram: Black Gram requires a reasonable acceleration in growth. The required CAGR ranges from 5.32% to 5.65% across the scenarios. Scenarios 1 and 2 show a need for slightly higher growth compared to the historical, while Scenario 3 requires a slightly below the historical 6.70%.

Lentil: Lentil presents a significant challenge. The required CAGR is consistently high, ranging from 10.83% to 11.22%, indicating a substantial increase in production is needed. The historical CAGR ranges from 2.52% to 6.45%, highlighting a large gap that needs to be bridged to meet the 2030 demand.

Pea: Pea requires a substantial acceleration in growth. The required CAGR ranges from 8.14% to 17.24%, depending on the scenario. The historical CAGR is consistently low, ranging from 3.62% to 3.98%, indicating a need for a significant boost in production to meet the 2030 demand.

Table 6.13: To Meet Projected Domestic Demand by 2030: Required CAGR (2023-2030) vs Historical CAGR in Three Scenarios

Scenario	CAGR (%)	Pigeonpea	Chickpea	Green gram	Black gram	Lentil	Pea
Based on Scenario 1	Required CAGR (%)	4.24	2.62	5.04	5.32	11.09	17.24
	Historical CAGR (%)	3.53	7.44	11.57	4.22	6.45	3.62
Based on Scenario 2	Required CAGR (%)	4.43	2.19	4.31	5.37	11.22	8.56
	Historical CAGR (%)	0.38	4.74	9.26	-2.41	5.56	3.95
Based on Scenario 3	Required CAGR (%)	5.01	2.07	4.28	5.65	10.83	8.14
	Historical CAGR (%)	-7.83	1.7	7.41	6.7	2.52	3.98

Source: Authors' computation

To Meet Projected Domestic Demand by 2047

Pigeonpea: For Pigeonpea, the required CAGR consistently exceeds the historical CAGR in Scenarios 2 and 3. Scenario 1 requires a 2.67% CAGR, lower than the historical 3.53%. However, Scenario 2 requires 2.73% compared to a historical 0.38%, and Scenario 3 demands 2.89% against a negative historical -7.83%, indicating a significant acceleration is needed, particularly considering recent trends.

Chickpea: Chickpea shows a consistent trend across all scenarios. The required CAGR ranges from 2.11% to 2.27%, significantly lower than the historical CAGR, which ranges from 1.70% to 7.44%. This suggests that current growth trends if maintained, could comfortably meet the projected demand by 2047 and will have a surplus.

Green gram: Green Gram also demonstrates a consistent pattern, with the required CAGR ranging from 4.10% to 4.32% across the three scenarios, all significantly lower than the historical CAGR, which ranges from 7.41% to 11.57%. This indicates that the current growth trajectories are sufficient to meet the projected demand by 2047.

Black gram: Black Gram requires a moderate adjustment in growth. The required CAGR ranges from 3.62% to 3.72% across the scenarios. Scenario 1 and 3 show lower required growth compared to the historical 4.22% and 6.70%, respectively, while Scenario 2 requires a significant turnaround from a negative historical CAGR of -2.41% to a required CAGR of 3.64%. This suggests that while long-term trends are favorable, recent fluctuations necessitate careful monitoring and potential adjustments.

Lentil: Lentil presents a significant challenge. The required CAGR is consistently high, ranging from 5.40% to 5.50%, indicating a substantial increase in production is needed. The historical CAGR ranges from 2.52% to 6.45%, highlighting a large gap that needs to be bridged to meet the 2047 demand.

Pea: Pea requires a substantial acceleration in growth compared to historical trends. The required CAGR ranges from 5.18% to 7.69%, while the historical CAGR is consistently below 4%, indicating a need for a significant boost in production to meet the 2047 demand. Scenario 1 requires a significant increase from the historical 3.62%, while Scenarios 2 and 3 require adjustments from 3.95% and 3.98%, respectively.

Table 6.14: To Meet Projected Domestic Demand by 2047: Required CAGR (2023-2047) vs Historical CAGR in Three Scenarios

Scenario	CAGR (%)	Pigeonpea	Chickpea	Green gram	Black gram	Lentil	Pea
Based on Scenario 1	Required CAGR (%)	2.67	2.27	4.32	3.62	5.47	7.69
	Historical CAGR (%)	3.53	7.44	11.57	4.22	6.45	3.62
Based on Scenario 2	Required CAGR (%)	2.73	2.14	4.1	3.64	5.5	5.3
	Historical CAGR (%)	0.38	4.74	9.26	-2.41	5.56	3.95
Based on Scenario 3	Required CAGR (%)	2.89	2.11	4.1	3.72	5.4	5.18
	Historical CAGR (%)	-7.83	1.7	7.41	6.7	2.52	3.98

Source: Authors' computation

The detailed analysis presented here highlights various challenges and opportunities in India's pulse crops as the country strives to meet projected domestic demand by 2030 and 2047. Notably, Chickpea and green gram demonstrate promising trajectories, with current growth patterns suggesting they are on course to meet future needs. Conversely, Pigeonpea, while exhibiting potential for long-term growth, necessitates a substantial acceleration in production, particularly when considering recent trends. Lentil and pea, emerge as critical areas requiring significant intervention to boost production levels. While not facing the same magnitude of challenges, black gram necessitates vigilant monitoring and strategic adjustments to ensure sustained growth. This detailed comparison of required versus historical growth rate patterns and trends for each pulse crop provides essential insights for crafting targeted strategies to achieve Atmanirbharta in the pulse sector. By clearly delineating the disparities between current and targeted growth rates, this analysis enables the prioritization of interventions and the efficient allocation of resources. Identifying specific percentage increases required for each crop empowers a focused and tailored approach, distinguishing between crops needing rapid acceleration and those requiring incremental improvements. Moreover, the data-driven methodology employed here empowers effective progress tracking towards targets. In conclusion, the findings emphasize the imperative for a dynamic and adaptive strategy capable of responding to evolving market dynamics and technological advancements to secure India's sustainable and self-reliant pulse economy.

Chapter VII: Recommendations and Way Forward

Recommendations and Way Forward

The period after 2004 witnessed a marked acceleration in India's pulse production, largely influenced by targeted government schemes like ISOPOM, NFSM-Pulses, and A3P, indicating crucial lessons for achieving self-sufficiency. The Integrated Scheme of Oilseeds, Pulses, Oil Palm, and Maize (ISOPOM), launched in 2004, consolidated various crop development programs, leading to stabilized production levels and reduced import dependence. The scheme's focus on distributing High Yielding Varieties (HYVs), adopting modern agricultural technologies, and enhancing market interventions contributed to increased cultivation areas and improved yields, with average pulse yields rising to around 0.690 t/ha by the end of the scheme. ISOPOM's integrated approach and better resource allocation highlight the importance of a coordinated framework in boosting pulse production, despite challenges like inadequate infrastructure and limited reach in remote areas.

Complementing these efforts, the Accelerated Pulses Production Programme (A3P), launched in 2010, aimed to accelerate pulse production through cluster demonstrations of advanced agricultural practices. By focusing on large-scale demonstrations, distributing high-quality seeds, and providing financial and technical support to farmers, A3P showcased the potential of modern technologies in increasing pulse yields. While its impact was primarily limited to the demonstration areas, A3P provided valuable lessons for future pulses development efforts, underscoring the need for sustained support and wider adoption of demonstrated technologies to achieve broader self-sufficiency goals.

The National Food Security Mission (NFSM) - Pulses, initiated in 2007, further propelled the growth trajectory by emphasizing area expansion, productivity enhancement, and modern technologies. The mission-mode approach ensured that interventions were effectively implemented and resources reached the intended beneficiaries. The NFSM-Pulses component successfully increased pulse production by over 20% by the end of the Eleventh Plan, demonstrating the effectiveness of a targeted mission-mode approach in achieving specific production targets. The successes of NFSM-Pulses led to its extension and expansion, reinforcing the importance of sustained efforts and consistent implementation for long-term gains in pulse production and productivity. The government has reinvigorated the NFSM-Pulses program from 2016-17 onwards with a clear roadmap to achieve self-sufficiency in the pulse. It is implemented in all 28 states and 2 union territories (J&K and Ladakh), with over 60% of funds allocated to pulses to boost pulse production. Key initiatives under NFSM-Pulses include supporting breeder seed production, establishing 150 Seed Hubs at Indian Council of Agricultural Research (ICAR) institutes, State Agriculture Universities (SAUS), and Krishi Vigyan Kendras (KVKs) to increase quality seed production, and distribution of seed mini-kits of pulses free of cost to the farmers of the varieties notified within 10 years. Additionally, ICAR, KVKs, and SAUs conduct demonstrations on improved agricultural practices. By assisting Central Seed Agencies, the NFSM aims to enhance the availability of quality certified seeds of the latest pulse varieties, thereby contributing to increased production and productivity. These interventions, along with support for cluster demonstrations, improved farm machinery, efficient water tools, plant protection, nutrient management, processing equipment, and farmer training on cropping systems, NFSM-Pulses aims to significantly enhance pulse production and productivity. The Targeting Rice Fallow Area (TRFA) initiative under the NFSM-Pulses program focuses on promoting lentil cultivation in states like Assam, Bihar, Jharkhand, Chhattisgarh, Madhya Pradesh, West Bengal, and Odisha, and green gram and black gram cultivation in Tamil Nadu, Madhya Pradesh, Maharashtra, Jharkhand, Gujarat, West Bengal, and Karnataka.

Achieving self-sufficiency in pulse production is a crucial national priority for India. This goal is vital for ensuring food security, maintaining nutritional balance, and promoting soil health. A well-structured strategic approach is necessary to tackle key challenges while harnessing India's strengths in pulse cultivation. To address this need, NITI Aayog conducted a primary field survey involving 885 farmers across five of the top seven pulse-producing states: Rajasthan, Madhya Pradesh, Gujarat, Andhra Pradesh, and Karnataka (detailed in Annexure IV). The insights gathered from this survey, along with a comprehensive strategy and roadmap presented in earlier chapters and lessons learned from previous strategies (detailed in Annexure I), serve as the foundation for the following recommendations. These recommendations aim to strengthen India's pulse sector, increase domestic production, ensure self-reliance, and promote long-term sustainability.

7.1 Focus on Area Retention of Pulses and Diversification

Crop Clusters and Technology Customization

Crop-wise clustering facilitates both horizontal and vertical expansion efforts for targeted growth in pulse production. States and districts are grouped into four clusters (HA-HY, HA-LY, LA-HY, and LA-LY) based on the area under cultivation and yield performance for each pulse crop, allowing for more tailored growth strategies (refer to Chapter VI for details). Developing customized technology specific to each cluster is essential for yield improvement. Additionally, establishing Agro-Ecological Sub Region (AESR)-based model farms for each crop can support the horizontal dissemination of advanced cultivation practices.

Horizontal Expansion in Rice Fallow Areas

Utilizing just one-third of the total rice fallow area across ten states for pulse cultivation has the potential to enhance domestic production significantly. Estimates suggest a potential increase of up to 2.85 MT in pulse output. This statistic underscores the immense potential of these currently fallow lands. A combination of incentives and strategic planning is necessary to effectively tap into this potential. Providing incentive packages for input costs and guaranteeing remunerative prices can motivate farmers to adopt pulse cultivation in these areas. Identifying suitable areas for pulse cultivation, with the involvement of experts and state governments, is crucial. A phased approach, starting with pilot projects in key states, can help refine strategies and maximize impact.

In short, a systems approach incorporating crop-specific and region-specific cluster strategies is essential to increase the area and production of pulse crops.

7.2 Seed Traceability and Quality Assurance

A significant factor contributing to low pulse productivity is the use of low-quality traditional seed varieties. Seed is a carrier of technological advancements, and the supply of improved varieties can significantly enhance crop performance. A phased approach should be adopted to distribute high-quality seeds and seed treatment kits to farmers in targeted districts with high potential for yield growth and area expansion to address this issue. Given that a significant portion of pulse production is concentrated in specific regions, with 50 districts contributing 50% of the total output and , these districts should be the special focus for raising the production of pulses to attain self-sufficiency in pulses (see annexure).

- **Cluster-Based Seed Village:** To ensure a consistent supply of high-quality seeds, establishing cluster-based seed hubs at the block level, following the "One Block-One Seed Village" model, is crucial. These hubs, facilitated by Farmers' Producer Organizations (FPOs), can guarantee farmers' access to high-quality pulse seeds on time, thereby enhancing seed replacement rates and varietal replacement rates. Implementing end-to-end traceability from breeder to farmer for quality assurance is crucial.

7.3 Strengthening Farmer Producer Organizations (FPOs) and District-Level Value Chain Planning

This can be a game changer in the pulses sector. Through this, the pulse value chain can be easily shortened; it can also add a lot of value to the hands of pulse growers. Identifying the pulses-growing clusters and bringing on a single platform to integrate with the backward and forward linkages will help the farmers substantially reduce production costs.

This will also help capture additional value by processing pulse grains and delivering the product directly to urban consumers through organized retailers. The shortening of the value chain will help the consumers in accessing the produce at a reasonable price, even if the support price of pulses is increased substantially. The by-products of processed pulses are also nutritious feed for livestock, which can also benefit the farmers if the processing mills are set up near these farmers.

7.4 Effective procurement

The procurement of pulses after harvest needs to be strengthened immediately. Most of the pulse growers are currently unable to reach regulated markets to sell their produce; instead, village traders are their main buyers. Therefore, to ensure remunerative prices for these growers, it is essential to bring the procurement centers to the growers' doorstep, particularly during harvest season. Standardizing prices and procurement by using mobile vans or regulating the village traders to make public all the transactions' information may reduce the smallholders' ambiguities and exploitation. In the medium term, it can be facilitated by forming FPOs and linking it with the National Agricultural Market through e-platforms.

7.5 Price Support and Market Interventions

To ensure remunerative prices for pulse producers and incentivize cultivation, providing a price guarantee is crucial and implement the same either by paying the gap between MSP and prices received by the producers in the market or by procurement by public agencies. Both these provisions are already there in the scheme "PM-AASHA" operated by the MoA&FW. Its operational part needs to be strengthened for effective and comprehensive coverage.

7.6 Integrating Pulses into Public Distribution System

Keeping in view the widespread under- and malnutrition among women and children in India, to achieve the target of zero hunger and good health and well-being prescribed in sustainable development goals (SDG), it is necessary to provide pulses to all the poor households at affordable prices. Although this would further increase the demand for pulses, it can be managed if sufficient steps for enhancing domestic production are already taken. Therefore, compulsory inclusion of pulses in the existing schemes, such as the mid-day meal scheme or public distribution system (PDS), shall be ensured so that the minimum pulse consumption by poor households is maintained even during the scarcity in pulse production.

7.7 Customization and Development of Farm Equipment

A collaborative approach to developing small-size multi-crop harvesting farm machines and other farm equipment for plant protection can be of great help to the producers in reducing labor costs.

7.8 Potential of Summer Pulses

To enhance irrigation efficiency, a robust Management Information System (MIS) network is essential, particularly during the reproductive phase of crops. This can ensure timely irrigation and optimal water use. Additionally, opening canals to exploit potential irrigable areas is crucial for mitigating the effects of consecutive droughts. Emphasizing the adoption of early-maturing varieties of crops like rice, potato, wheat, and sugarcane can help prevent pre-harvest sprouting caused by unexpected pre-monsoon rains.

7.9 Resource Requirement for Input Incentive Package

Pulses are a legume crop and they can take nitrogen from the environment and fix it in the soil for use by the plant. The estimates of the amount and value of nitrogen fixed by pulses in the soil in India are presented in Table 7.1. Different pulses fix 58-70 kg of Nitrogen per hectare of area under their cultivation. This way, all five pulses taken together fix 2.91 LT of N in the soil. This quantity is equivalent to 6.48 LT of urea. Pulses, on average, enrich soils by 66 kg N, which is valued at Rs. 3233 per hectare. Based on this, the total value of N fixed in 27 Mha area under cultivation of pulses comes to Rs. 8811 crores. If this much nitrogen is to be applied to soil it will involve a subsidy on urea to the tune of Rs. 7841 crores. These facts highlight the value of ecological services rendered by pulses to society.

To incentivize farmers to increase pulse production, a portion of the ecological services provided by pulse cultivation can be utilized. Implementing incentive packages, such as providing high-quality seeds and seed treatment kits at subsidized rates (e.g., half the MSP), can encourage farmers, particularly in intensive pulse-producing districts, to expand their cultivation (Chand 2024).

Table 7.1 : Quantity and Value of Nitrogen fixed by Pulse Crops in Soil

Crop	Area under crop (000 ha)	Nitrogen fixed/ha (kg)	Price of N in Urea + Subsidy	Value of N per ha (Rs)	Total (Rs. Crore)
Pigeonpea	4900	69	48.9	3373	1653
Chickpea	10740	70	48.9	3422	3676
Black gram	4633	63	48.9	3080	1427
Green gram	5550	61	48.9	2982	1655
Lentil	1412	58	48.9	2836	400
Sum	27236	66	48.9	3235	8811

Source: Chand, 2024

7.10 Bio-fertilization Strategies

To enhance summer crop yields, especially for pulses, several bio-fertilization strategies have proven effective. Field monitoring across various states by DPD, Bhopal, has shown that the use of NPK liquid bio-fertilizers significantly boosts the productivity of summer green gram and black gram. These bio-fertilizers help reduce the leaching of essential nutrients like potassium and nitrogen, as well as mitigate phosphorus fixation in soils, thereby making nutrients more available to plants.

For optimal results, it is recommended to apply NPK liquid bio-fertilizer at a rate of 500 ml per acre, mixed with 50-100 kg of farmyard manure (FYM) or compost, and incorporate it into the soil before sowing. Additionally, using other liquid bio-fertilizers, such as Liquid Rhizobium, Phosphate Solubilizing Bacteria (PSB), and NPK-3 (a combination of Rhizobium, PSB, and Potassium Mobilizing Bacteria) at the same dosage rate further enhances soil nutrient availability by converting fixed phosphorus into a form accessible to crops.

7.11 Advancing Research & Development for Pest-Resistant Pulse Varieties

Pulses, a vital source of protein, are particularly susceptible to pests and diseases. An estimated 30% of pulse crops are lost annually due to these issues, with pests like pod borers, aphids, and pod flies causing severe damage. Prioritizing the development of pest-resistant varieties through the application of modern biotechnology tools is essential to enhance the genetic resilience of pulse crops. Additionally, fostering public-private partnerships can optimize logistics and handling practices, addressing broader challenges within the pulse sector. Integrating pulse crops into farmers' overall cropping systems can further optimize resource utilization and enhance overall productivity.

- **Developing Short-Duration and Pest- and Disease-Resistant Cultivars Specific to Production Regions:** Developing improved cultivars specific to production regions is crucial for breaking the yield barrier. The success of chickpea cultivation in the central and southern regions serves as an excellent example. Focusing on the development of super early varieties without yield penalties with pest- and disease resistance can significantly enhance pulse production and productivity in India.
- **Developing machine-harvestable and herbicide-tolerant varieties for HA-HY regions/districts:** Development of machine-harvestable and herbicide-tolerant varieties of pulses, especially chickpea, lentil, mung bean, and black gram, will allow pulses production at a commercial scale with production efficiency. This will also allow for public-private partnerships for pulse production and market linkages.
- **Climate-resilient varieties to insulate pulse production from seasonal shocks and fluctuations:** Pulses are vulnerable to climate shocks due to their nature of cultivation in marginal areas, and the development of climate-resilient varieties with tolerance to drought, waterlogging, frost, and heat stresses will stabilize not only production but also market prices.

- **Improved varieties enriched with nutrients (protein, iron, zinc):** Pulses varieties biofortified with protein, iron, and zinc content will contribute to nutritional security. In addition, efforts to reduce the anti-nutritional factors such as ODAP in grass pea will contribute to enhanced consumption of pulses in the country.

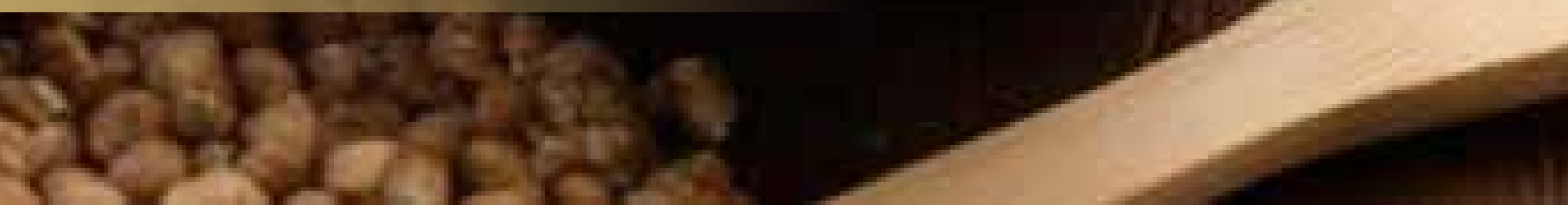
7.12 Robust Early Warning Systems and Proactive Adaptation Strategies

To mitigate the impact of adverse weather conditions like El Niño on pulse production, robust early warning systems, and proactive adaptation strategies are crucial. These systems should monitor weather patterns, predict potential impacts on pulse crops, and disseminate timely advisories to farmers. Additionally, developing climate-resilient varieties, promoting efficient water management practices, and diversifying cropping patterns can help reduce vulnerability to extreme weather events. Utilizing satellite-based yield monitoring or AI-driven predictive models can also stabilize production and decrease dependency on imports.

7.13 Data-Driven Transformation

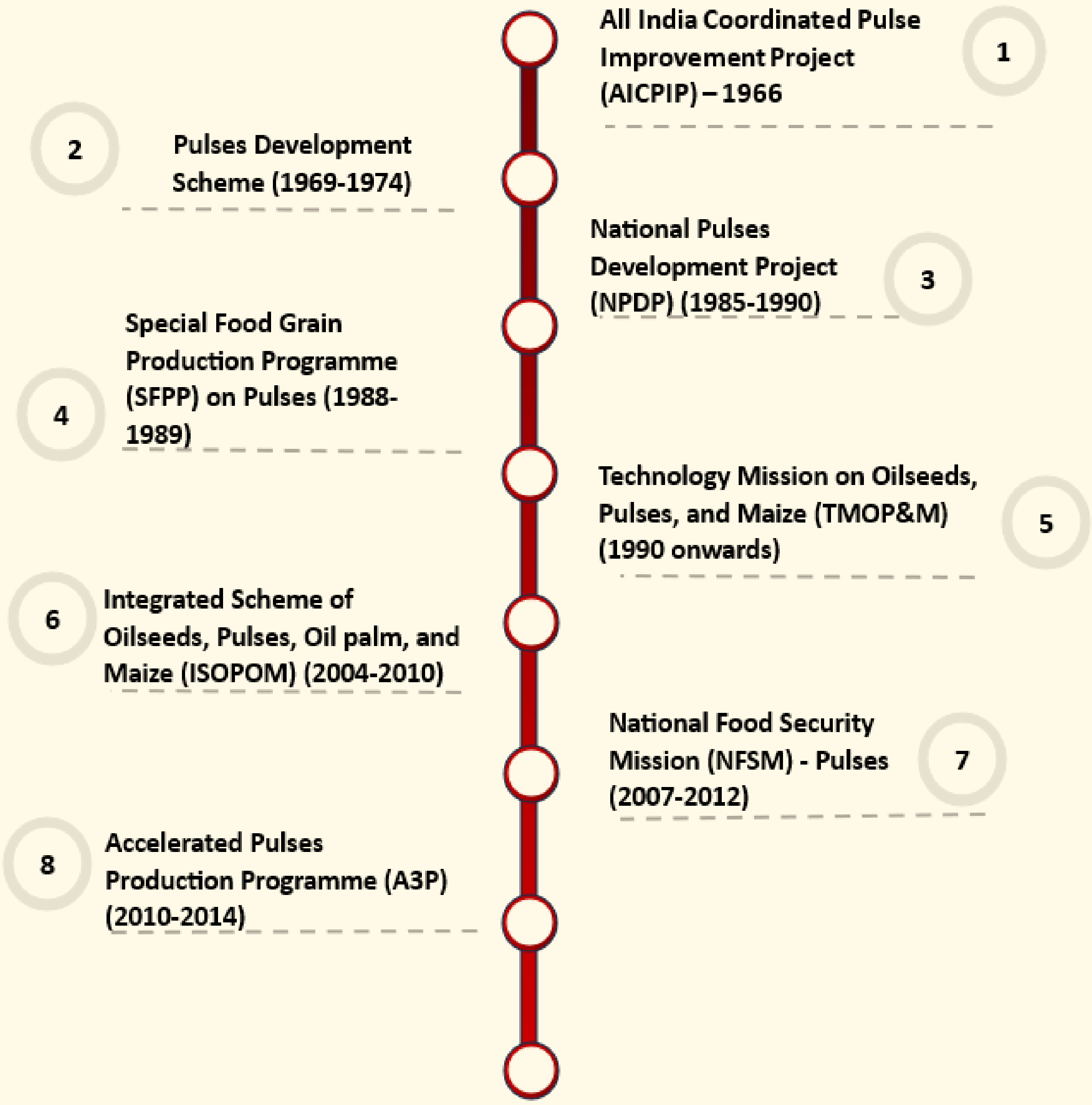
Addressing disparities in pulse crop yields requires a data-driven approach and robust systems to bridge regional gaps. Advancing research and development is essential for the transformation of the pulse sector. A deeper understanding of climate-crop interactions, coupled with the development of innovative solutions, is critical to enhancing the resilience of this sector. Such advancements can provide returns that surpass the benefits offered by input subsidies. Furthermore, implementing comprehensive monitoring systems, leveraging ICT platforms like the SAATHI Portal and Krishi Mapper, will provide real-time insights and facilitate informed decision-making, ultimately ensuring the long-term sustainability and productivity of the pulse sector.

List of Annexures



ANNEXURE-I: Pulses Self-Sufficiency: Lessons from the Past Strategies

As the world's largest producer and consumer of pulses, India still faces a considerable gap between domestic production and demand, necessitating substantial imports. This paradox persists despite the country's favorable agricultural conditions, which support the cultivation of various pulses, including chickpea, pigeon pea, lentil, black gram, and green gram etc.



Source: Author's own compilation

Figure AI.1: Past Strategies Timeline for Pulses Schemes

Pulses are integral to the Indian diet, providing a primary protein source for a large population segment. Over the years, the Indian government has introduced numerous policies and initiatives to enhance pulse production, improve supply chain efficiency, and stabilize prices.

These interventions, while making some headway, have not fully bridged the demand-supply gap. To pave the way for achieving self-reliance in pulses, it is crucial to critically examine past policy approaches, identifying what has worked and where gaps remain. This will serve as a foundation for formulating more effective strategies to ensure sustainable growth in the pulses sector. The chapter delves into the key government interventions in the pulses sector, assessing their objectives, successes, and limitations.

i. **All India Coordinated Pulse Improvement Project (AICPIP) – 1966**

The All India Coordinated Pulse Improvement Project (AICPIP) was launched in 1966 by the Indian Council of Agricultural Research (ICAR) as a government initiative during the early years of India's Green Revolution. This pioneering project aimed to address the country's growing demand for pulses, a critical protein source in the Indian diet. AICPIP sought to enhance the production and productivity of pulses by developing high-yielding and disease-resistant varieties, as well as promoting modern agronomic practices.

Initially, AICPIP focused on breeding improved varieties of major pulses like chickpea, pigeon pea, green gram, black gram, and lentil. These efforts led to the release of numerous High Yielding Varieties (HYVs), which were instrumental in increasing pulse yields Since the inception of AICRP in pulses, a total of 188 varieties have been developed and released in pigeonpea. In the last 10 years alone, 62 superior varieties of pigeonpea have been developed by various NARS partners. These also include 6 hybrids each developed through GMS and CMS-based systems. In green gram, a total of 141 varieties have been developed after 1985. These include 56 varieties developed after 2013. In case of black gram 121 improved varieties have been developed after 1985 including 50 varieties developed in the last 10 years. In arid legumes, a total of 61 varieties have been developed till date. These include 32 varieties of cowpea, 21 each of cluster bean and horse gram and 8 of moth bean. Despite these successes, the project faced limited infrastructure, inadequate irrigation facilities, and dependence on monsoon rains, leading to inconsistent production outcomes, particularly in rain-fed regions.

However, AICPIP laid a crucial foundation for future pulse development programs in India. The project's research and development activities provided valuable insights that guided subsequent efforts in the pulses sector.

The most significant evolution of AICPIP was its transformation into the Directorate of Pulses Research (DPR) in 1984. This upgrade marked a transition from a coordinated project to a dedicated research institution, reflecting the growing importance of pulses in India's agricultural strategy. The DPR, headquartered in Kanpur, Uttar Pradesh, continued the work initiated under AICPIP, focusing on advanced research in pulse crop improvement, disease resistance, and agronomy. The establishment of DPR helped consolidate the gains made under AICPIP and ensured sustained attention to the pulses sector, which remains vital for India's food and nutritional security. In conclusion, the All India Coordinated Pulse Improvement Project was a landmark government initiative that significantly impacted pulse production in India. While it encountered certain limitations, the project laid the groundwork for more extensive future initiatives, forming the Directorate of Pulses Research, which remains vital in boosting pulse productivity nationwide. DPR was elevated to an institute Indian

Institute of Pulses Research (IIPR), along with three All India Coordinated Research Projects (AICRPs) and one All India Coordinated Network Project (AINP) in 1993, later resulted in the merger of the AICRPs and AINP into two distinct AICRPs (Rabi and Kharif Pulses).

ii. Pulses Development Scheme (1969-1974)

The Pulses Development Scheme was launched during the Fourth Five-Year Plan (1969-1974) by the Government of India. It was one of the early efforts to enhance the production of pulses, a staple in the Indian diet, to meet the growing domestic demand. The scheme aimed to introduce improved varieties of pulses and modern production technologies to farmers across the country. Initially, the focus was on increasing the area under pulse cultivation and improving yields through the distribution of High Yielding Varieties (HYVs) of seeds and better agricultural practices.

While the scheme succeeded in raising awareness among farmers about improved pulse varieties and cultivation techniques, its impact was limited due to inadequate infrastructure and resource allocation. During this period, India's pulse production saw a modest increase, with the area under cultivation expanding slightly from around 22 million hectares in the late 1960s to about 23.5 million hectares by 1974. However, due to challenges like inadequate irrigation and reliance on monsoon rains, the yield improvements were not as significant as hoped. The average yield of pulses during this period remained relatively low, hovering around 400-450 kg/ha. Additionally, the reach of the scheme was constrained by the lack of irrigation facilities and dependence on monsoon rains, which often led to inconsistent production outcomes. Despite these challenges, the Pulses Development Scheme set the stage for future interventions in the pulses sector.

In conclusion, although the Pulses Development Scheme was not a transformative success, it was instrumental in laying the groundwork for subsequent pulses development initiatives. The experiences and lessons learned from this scheme informed the design of more focused and comprehensive programs in later years.

iii. National Pulses Development Project (NPDP) (1985-1990)

The National Pulses Development Project (NPDP) was launched during the Seventh Five-Year Plan (1985-1990) as a significant effort to consolidate earlier centrally sponsored schemes aimed at enhancing pulses production in India. The NPDP was conceived in response to the continued shortfall in pulse production, which was inadequate to meet the country's growing demand. The project aimed to increase pulse production through an integrated approach, focusing on the distribution of quality seeds, pest management, and modern agricultural practices.

The NPDP was successful in integrating various pulse development efforts under one umbrella, thereby streamlining the distribution of resources and improving coordination among stakeholders. However, the project's impact was uneven, as the benefits were not uniformly distributed across all regions. The variability in state-level implementation capacities and differences in climatic conditions contributed to the mixed results. During its implementation from 1985 to 1990, the NPDP succeeded in improving yields. The average yield increased from around 540 kg/ha in the early 1980s to about 580 kg/ha by 1990.

In conclusion, the NPDP marked a critical step forward in pulses development, bringing a more coordinated and focused approach to the sector. While it faced challenges in achieving uniform success across the country, it provided valuable insights that shaped future pulses development strategies. The National Pulses Development Project (NPDP), as it was originally conceived, has been discontinued. However, its objectives and strategies were absorbed into subsequent programs such as the Integrated Scheme of Oilseeds, Pulses, Oil Palm, and Maize (ISOPOM) and later into the National Food Security Mission (NFSM)

iv. Special Food Grain Production Programme (SFPP) on Pulses (1988-1989)

The Special Food Grain Production Programme (SFPP) on Pulses was launched in 1988-1989 as a 100% centrally assisted program to supplement the ongoing efforts under the National Pulses Development Project (NPDP). The program was initiated in response to the urgent need to increase pulse production and reduce the country's dependence on imports. SFPP focused on providing immediate support to farmers through distributing high-quality seeds, pest control measures, and other agricultural inputs.

SFPP succeeded in achieving a short-term increase in pulse production, particularly in regions where the program was implemented effectively. However, the program's impact was limited by its short duration and the lack of sustained follow-up efforts. Additionally, the program faced challenges related to the timely distribution of resources and the varying capacities of state governments to implement the program.

In conclusion, while SFPP provided a timely boost to pulse production, its short-term nature and implementation challenges limited its long-term impact. Nevertheless, it highlighted the importance of providing targeted support to farmers and paved the way for more comprehensive programs in the future.

v. Technology Mission on Oilseeds, Pulses, and Maize (TMOP&M) (1990 onwards)

The Technology Mission on Oilseeds, Pulses, and Maize (TMOP&M) was launched in 1990 to integrate pulses development into a broader mission that also included oilseeds and maize. This mission-mode approach was designed to address the challenges in pulses production through a comprehensive strategy that encompassed crop protection, post-harvest technology, input support, and market interventions. The mission aimed to enhance the production and productivity of pulses by adopting modern agricultural technologies and improving market access. The mission contributed to a steady increase in production for pulses, with pulse yields improving from around 580 kg/ha in the early 1990s to approximately 635 kg/ha by the early 2000s.

TMOP&M was successful in increasing pulse production and reducing the country's reliance on imports. The mission's focus on technology adoption and market support contributed to its overall success. However, managing multiple crops under one mission sometimes diluted the focus on pulses, leading to variable outcomes across different regions.

In conclusion, TMOP&M represented a significant advancement in pulse development, demonstrating the benefits of an integrated approach. Although challenges remained in maintaining a consistent focus on pulses, the mission laid a strong foundation for future initiatives in the sector.

vi. Integrated Scheme of Oilseeds, Pulses, Oil Palm, and Maize (ISOPOM) (2004-2010)

Launched in April 2004, the Integrated Scheme of Oilseeds, Pulses, Oil Palm, and Maize (ISOPOM) was an effort to consolidate and streamline various crop development programs into a single, more effective framework. ISOPOM aimed to increase the production of these crops through a coordinated approach that included the distribution of High Yielding Varieties (HYVs) of seeds, the adoption of modern agricultural technologies, and enhanced market interventions.

ISOPOM successfully stabilized production levels and reduced the country's dependence on imports, particularly for pulses and oilseeds. For pulses, the scheme contributed to an increase in the area under cultivation and a modest rise in yield. By the end of the scheme, the average yield of pulses had improved to around 690 kg/ha, and pulse production showed a steady upward trend. The scheme's integrated approach allowed for better resource allocation and focused interventions, contributing to its overall success. However, challenges such as inadequate infrastructure and limited reach in remote areas sometimes limit the scheme's effectiveness.

In conclusion, ISOPOM played a crucial role in consolidating crop development programs, particularly benefiting the pulses sector by providing a focused and integrated approach. While challenges remained, the scheme's successes provided valuable lessons for future interventions.

vii. National Food Security Mission (NFSM) - Pulses (2007-2012)

The National Food Security Mission (NFSM) - Pulses was launched in 2007-08 during the Rabi season as part of a broader mission to address the stagnation in pulses production and meet the growing domestic demand. The NFSM-Pulses is being implemented in 638 districts of 29 states. The mission aimed to increase pulse production by 2 MT by the end of the Eleventh Five-Year Plan through strategies such as area expansion, productivity enhancement, and the adoption of modern technologies.

NFSM-Pulses was successful in achieving its production targets, with pulses production increasing by more than 20% by the end of the Eleventh Plan. The mission-mode approach ensured that interventions were effectively implemented and that resources reached the targeted districts and farmers. However, challenges such as inconsistent fund flow and varying state-level implementation capacities were noted. The NFSM-Pulses component from 2007-2012 was highly successful and has since been continued and expanded under the ongoing National Food Security Mission (NFSM). The success of the mission led to its extension in subsequent Five-Year Plans, with continued efforts to boost pulse production and productivity across India.

In conclusion, NFSM-Pulses was a successful initiative that significantly contributed to increasing pulse production in India. The mission played a vital role in reducing import dependency and stabilizing domestic supply, although the need for better execution and consistency in implementation was highlighted. During 2016-17, new initiatives like distribution of seed mini-kits of newer varieties of pulses free of cost to farmers, production of quality seed, creation of seed hubs at SAU and KVKs, strengthening of bio-fertilizers and bioagent labs at SAUs/ICAR Institutes, cluster front line demonstration by KVKs and enhancing up breeder seed production at ICAR institutes and SAUs have been included under NFSM during 2016-17 for enhancing pulses production and productivity.

viii. Accelerated Pulses Production Programme (A3P) (2010-2014)

The Accelerated Pulses Production Programme (A3P) was launched in 2010 as a centrally sponsored initiative under the National Food Security Mission (NFSM) to accelerate pulses production through a cluster demonstration approach. The program was designed to address the continued shortfall in pulse production by demonstrating improved technologies in high-potential areas. Out of the INR 780.72 crore released under the A3P scheme in 2010/11-2012/13, nearly 80 percent were spent on improving and upgrading technologies of pulses.

A3P focused on conducting large-scale demonstrations of advanced agricultural practices, distributing high-quality seeds, and providing financial and technical support to farmers in targeted regions. The program aimed to showcase the potential of modern technologies in increasing pulse yields and to encourage widespread adoption among farmers. A3P aimed to demonstrate improved technologies for major pulse crops like chickpea, black gram, green gram and lentil in compact blocks covering one million hectares of potential pulse areas.

A3P succeeded in increasing pulses production in the targeted areas, with significant improvements in yields observed in regions where the program was effectively implemented. However, the program faced challenges in scaling up and sustaining its impact beyond the demonstration clusters, and its long-term success depended on the continued support and adoption of the demonstrated technologies.

In conclusion, A3P was a successful initiative that demonstrated the potential of modern agricultural technologies in increasing pulse production. While its impact was limited to the demonstration areas, the program provided valuable lessons for future pulses development efforts.

ANNEXURE-II: Projected Population - All India (2021-2047)

Table AII.1: Projected Population - All India (2021-2047)

Year	Total population(000's)	Rural population(000's)	Urban population(000's)
2011	1257621.19	864287.59	393333.60
2012	1274487.22	871315.93	403171.29
2013	1291132.06	877931.07	413200.99
2014	1307246.51	883907.80	423338.71
2015	1322866.51	889270.55	433595.95
2016	1338636.34	894450.03	444186.31
2017	1354195.68	899185.93	455009.75
2018	1369003.31	903131.48	465871.83
2019	1383112.05	906325.66	476786.39
2020	1396387.13	908684.96	487702.17
2021	1407563.84	909384.77	498179.07
2022	1417173.17	908804.81	508368.36
2023	1428627.66	909121.50	519506.16
2024	1441719.85	910200.99	531518.86
2025	1454606.72	910831.09	543775.63
2026	1467231.21	910989.19	556242.02
2027	1479578.52	910650.99	568927.53
2028	1491671.05	909859.67	581811.38
2029	1503470.60	908592.39	594878.21
2030	1514994.08	906845.16	608148.92
2031	1526208.89	904614.53	621594.36
2032	1537108.04	901913.51	635194.52
2033	1547689.84	898728.01	648961.83
2034	1557919.81	895071.67	662848.14
2035	1567802.26	890950.67	676851.59
2036	1577302.81	886381.09	690921.72
2037	1586438.62	881409.43	705029.19
2038	1595245.78	876077.08	719168.70
2039	1603664.86	870405.14	733259.72
2040	1611676.33	864358.13	747318.20
2041	1619318.36	858012.03	761306.33
2042	1626585.38	851354.79	775230.59
2043	1633430.53	844369.24	789061.29
2044	1639837.77	837055.19	802782.58
2045	1645863.19	829465.67	816397.52
2046	1651513.76	821611.58	829902.18
2047	1656777.05	813494.10	843282.95

Source: World Bank

ANNEXURE-III.1: Tailored Interventions for District-Specific Growth: A Multi-Crop Strategy Matrix based on 2020-21, 2021-22, and 2022-23 Data

Table AIII.1.1: Pigeonpea

Horizontal Expansion [Low Area-High Yield (LA-HY)] 212 districts	Vertical Expansion [High Area-Low Yield (HA-LY)] 55 districts	Horizontal & Vertical Expansion [Low Area-Low Yield (LA-LY)] 239 districts
NTR (Andhra Pradesh), Upper Subansiri (Arunachal Pradesh), Papum Pare (Arunachal Pradesh), Lower Subansiri (Arunachal Pradesh), West Siang (Arunachal Pradesh), Lower Siang (Arunachal Pradesh), Lepa Rada (Arunachal Pradesh), Biswanath (Assam), Sonitpur (Assam), Baksa (Assam), Kamrup Metropolitan (Assam), Sivasagar (Assam), Majuli (Assam), Jamui (Bihar), Gaya (Bihar), Nawada (Bihar), Banka (Bihar), Siwan (Bihar), Sheikhpura (Bihar), Patna (Bihar), Purba Champaran (Bihar), Vaishali (Bihar), Jehanabad (Bihar), Samastipur (Bihar), Begusarai (Bihar), Bhojpur (Bihar), Bhagalpur (Bihar), Muzaffarpur (Bihar), Kaimur (Bhabua) (Bihar), Aurangabad (Bihar), Saran (Bihar), Gopalganj (Bihar), Darbhanga (Bihar), Khagaria (Bihar), Arwal (Bihar), Munger (Bihar), Lakhisarai (Bihar), Rohtas (Bihar), Nalanda (Bihar), Madhubani (Bihar), Sheohar (Bihar), Buxar (Bihar), Pashchim Champaran (Bihar), Kishanganj (Bihar), Sitamarhi (Bihar), Madhepura (Bihar), Bijapur (Chhattisgarh), Ahmadabad (Gujarat), Junagadh (Gujarat), Sabar Kantha (Gujarat), Aravalli (Gujarat), Rajkot (Gujarat),	Prakasam (Andhra Pradesh), Sri Sathya Sai (Andhra Pradesh), Nandyal (Andhra Pradesh), Anantpur (Andhra Pradesh), Palnadu (Andhra Pradesh), Koriya (Chhattisgarh), Balrampur (Chhattisgarh), Tapi (Gujarat), The Dangs (Gujarat), Valsad (Gujarat), Garhwa (Jharkhand), Pakur (Jharkhand), Godda (Jharkhand), Sahibganj (Jharkhand), Dumka (Jharkhand), Ranchi (Jharkhand), Kalaburagi (Karnataka), Vijayapura (Karnataka), Bidar (Karnataka), Yadgir (Karnataka), Raichur (Karnataka), Bagalkote (Karnataka), Koppal (Karnataka), Sidhi (Madhya Pradesh), Umaria (Madhya Pradesh), Shahdol (Madhya Pradesh), Yavatmal (Maharashtra), Washim (Maharashtra), Latur (Maharashtra), Hingoli (Maharashtra), Amravati (Maharashtra), Nanded (Maharashtra), Osmanabad (Maharashtra), Nandurbar (Maharashtra), Solapur (Maharashtra), Aurangabad (Maharashtra), Bhandara (Maharashtra), Palghar (Maharashtra), Jalgaon (Maharashtra), Tiruppattur (Tamil Nadu), Vellore (Tamil Nadu), Karur (Tamil Nadu), Vikarabad (Telangana), Narayanpet (Telangana), Sangareddy (Telangana), Adilabad (Telangana), Mahabubnagar (Telangana),	Kurnool (Andhra Pradesh), Annamayya (Andhra Pradesh), Y.S.R. (Andhra Pradesh), Chittoor (Andhra Pradesh), Alluri Sitharama Raju (Andhra Pradesh), Parvathipuram Manyam (Andhra Pradesh), Bapatla (Andhra Pradesh), Sri Potti Sriramulu Nellore (Andhra Pradesh), Tirupati (Andhra Pradesh), Anakapalli (Andhra Pradesh), Konaseema (Andhra Pradesh), Guntur (Andhra Pradesh), Visakhapatnam (Andhra Pradesh), Srikakulam (Andhra Pradesh), Kakinada (Andhra Pradesh), Vizianagaram (Andhra Pradesh), Eluru (Andhra Pradesh), East Godavari (Andhra Pradesh), Krishna (Andhra Pradesh), Upper Dibang Valley (Arunachal Pradesh), Upper Siang (Arunachal Pradesh), Kamle (Arunachal Pradesh), East Kameng (Arunachal Pradesh), Pakke Kessang (Arunachal Pradesh), Siang (Arunachal Pradesh), Tirap (Arunachal Pradesh), East Siang (Arunachal Pradesh), Longding (Arunachal Pradesh), Lower Dibang Valley (Arunachal Pradesh), Namsai (Arunachal Pradesh), Lohit (Arunachal Pradesh), Dima Hasao (Assam), West Karbi Anglong (Assam), Karbi Anglong (Assam), Goalpara (Assam), Kokrajhar

Horizontal Expansion [Low Area-High Yield (LA-HY)] **212 districts**	**Vertical Expansion [High Area-Low Yield (HA-LY)]** **55 districts**	**Horizontal & Vertical Expansion [Low Area-Low Yield (LA-LY)]** **239 districts**
Navsari (Gujarat), Gir Somnath (Gujarat), Amreli (Gujarat), Jamnagar (Gujarat), Morbi (Gujarat), Surendranagar (Gujarat), Bhavnagar (Gujarat), Botad (Gujarat), Kheda (Gujarat), Patan (Gujarat), Mahesana (Gujarat), Porbandar (Gujarat), Banas Kantha (Gujarat), Anand (Gujarat), Kachchh (Gujarat), Gandhinagar (Gujarat), Gurugram (Haryana), Jhajjar (Haryana), Mahendragarh (Haryana), Faridabad (Haryana), Rohtak (Haryana), Bhiwani (Haryana), Sonipat (Haryana), Hisar (Haryana), Charki Dadri (Haryana), Panipat (Haryana), Panchkula (Haryana), Rewari (Haryana), Yamunanagar (Haryana), Jind (Haryana), Kurukshetra (Haryana), Ambala (Haryana), Sirsa (Haryana), Mandi (Himachal Pradesh), Haveri (Karnataka), Udupi (Karnataka), Kodagu (Karnataka), Palakkad (Kerala), Chhindwara (Madhya Pradesh), Panna (Madhya Pradesh), Jabalpur (Madhya Pradesh), Damoh (Madhya Pradesh), Seoni (Madhya Pradesh), Katni (Madhya Pradesh), Sagar (Madhya Pradesh), Hoshangabad (Madhya Pradesh), Morena (Madhya Pradesh), Balaghat (Madhya Pradesh), Ujjain (Madhya Pradesh), Bhind (Madhya Pradesh), Niwari (Madhya Pradesh), Gadchiroli (Maharashtra), Gondiya (Maharashtra),	Ranga Reddy (Telangana), Jogulamba Gadwal (Telangana), Wanaparthy (Telangana), Yadadri Bhuvanagiri (Telangana), Jangoan (Telangana), Siddipet (Telangana), Dhalai (Tripura), Sonbhadra (Uttar Pradesh)	(Assam), Bongaigaon (Assam), Darrang (Assam), Chirang (Assam), Udalguri (Assam), Kamrup (Assam), South Salmara Mancachar (Assam), Nagaon (Assam), Barpeta (Assam), Morigaon (Assam), Cachar (Assam), Karimganj (Assam), Hailakandi (Assam), Golaghat (Assam), Tinsukia (Assam), Nalbari (Assam), Charaideo (Assam), Dhubri (Assam), Dhemaji (Assam), Lakhimpur (Assam), Dibrugarh (Assam), Jorhat (Assam), Kabeerdham (Chhattisgarh), Surguja (Chhattisgarh), Jashpur (Chhattisgarh), Surajpur (Chhattisgarh), Bametara (Chhattisgarh), Rajnandgaon (Chhattisgarh), Durg (Chhattisgarh), Raigarh (Chhattisgarh), Gaurela-Pendra-Marwahi (Chhattisgarh), Mungeli (Chhattisgarh), Gariaband (Chhattisgarh), Korba (Chhattisgarh), Sukma (Chhattisgarh), Dakshin Bastar Dantewada (Chhattisgarh), Balod (Chhattisgarh), Baloda Bazar (Chhattisgarh), Janjgir - Champa (Chhattisgarh), Bastar (Chhattisgarh), Raipur (Chhattisgarh), Bilaspur (Chhattisgarh), Uttar Bastar Kanker (Chhattisgarh), Kondagaon (Chhattisgarh), Narayanpur (Chhattisgarh), Mahasamund (Chhattisgarh), Dhamtari (Chhattisgarh), Dohad (Gujarat), Mahisagar (Gujarat), Palwal (Haryana),

Horizontal Expansion [Low Area-High Yield (LA-HY)] 212 districts	Vertical Expansion [High Area-Low Yield (HA-LY)] 55 districts	Horizontal & Vertical Expansion [Low Area-Low Yield (LA-LY)] 239 districts
Kolhapur (Maharashtra), South West Garo Hills (Meghalaya), West Garo Hills (Meghalaya), East Garo Hills (Meghalaya), North Garo Hills (Meghalaya), Wokha (Nagaland), Sahibzada Ajit Singh Nagar (Punjab), Malerkotla (Punjab), Ludhiana (Punjab), Jalandhar (Punjab), Moga (Punjab), Barnala (Punjab), Amritsar (Punjab), Sangrur (Punjab), Udaipur (Rajasthan), Pratapgarh (Rajasthan), Dhaulpur (Rajasthan), Alwar (Rajasthan), Pali (Rajasthan), Bharatpur (Rajasthan), Jhalawar (Rajasthan), Tonk (Rajasthan), Ganganagar (Rajasthan), Dausa (Rajasthan), Sikar (Rajasthan), Hanumangarh (Rajasthan), Bikaner (Rajasthan), Ranipet (Tamil Nadu), Erode (Tamil Nadu), Theni (Tamil Nadu), Salem (Tamil Nadu), Tiruvannamalai (Tamil Nadu), Virudhunagar (Tamil Nadu), Perambalur (Tamil Nadu), Namakkal (Tamil Nadu), Ariyalur (Tamil Nadu), Coimbatore (Tamil Nadu), Tiruppur (Tamil Nadu), Thiruvallur (Tamil Nadu), Kanchipuram (Tamil Nadu), Thanjavur (Tamil Nadu), Kallakurichchi (Tamil Nadu), Chengalpattu (Tamil Nadu), Tenkasi (Tamil Nadu), Cuddalore (Tamil Nadu), Viluppuram (Tamil Nadu), Thiruvarur (Tamil Nadu), Tirunelveli (Tamil Nadu), Ramanathapuram (Tamil Nadu),		Solan (Himachal Pradesh), Bilaspur (Himachal Pradesh), Shimla (Himachal Pradesh), Ballari (Karnataka), Tumakuru (Karnataka), Chikkaballapura (Karnataka), Chitradurga (Karnataka), Vijayanagar (Karnataka), Belagavi (Karnataka), Bangalore (Karnataka), Ramanagara (Karnataka), Bengaluru Rural (Karnataka), Kolar (Karnataka), Mysuru (Karnataka), Davanagere (Karnataka), Chamarajanagara (Karnataka), Mandya (Karnataka), Hassan (Karnataka), Gadag (Karnataka), Chikkamagaluru (Karnataka), Dharwad (Karnataka), Shivamogga (Karnataka), Uttara Kannada (Karnataka), Pathanamthitta (Kerala), Raisen (Madhya Pradesh), Betul (Madhya Pradesh), Alirajpur (Madhya Pradesh), Anuppur (Madhya Pradesh), Rewa (Madhya Pradesh), Satna (Madhya Pradesh), Dindori (Madhya Pradesh), Jhabua (Madhya Pradesh), Mandla (Madhya Pradesh), West Nimar (Madhya Pradesh), East Nimar (Madhya Pradesh), Barwani (Madhya Pradesh), Chhatarpur (Madhya Pradesh), Sehore (Madhya Pradesh), Sheopur (Madhya Pradesh), Dewas (Madhya Pradesh), Dhar (Madhya Pradesh), Bhopal (Madhya Pradesh), Vidisha (Madhya Pradesh),

Horizontal Expansion [Low Area-High Yield (LA-HY)] 212 districts	Vertical Expansion [High Area-Low Yield (HA-LY)] 55 districts	Horizontal & Vertical Expansion [Low Area-Low Yield (LA-LY)] 239 districts
Nirmal (Telangana), Kamareddy (Telangana), Khammam (Telangana), Nizamabad (Telangana), Kanpur Dehat (Uttar Pradesh), Pratapgarh (Uttar Pradesh), Jaunpur (Uttar Pradesh), Ballia (Uttar Pradesh), Kanpur Nagar (Uttar Pradesh), Azamgarh (Uttar Pradesh), Chandauli (Uttar Pradesh), Sultanpur (Uttar Pradesh), Ghazipur (Uttar Pradesh), Jalaun (Uttar Pradesh), Amethi (Uttar Pradesh), Auraiya (Uttar Pradesh), Mahoba (Uttar Pradesh), Mau (Uttar Pradesh), Etawah (Uttar Pradesh), Faizabad (Uttar Pradesh), Farrukhabad (Uttar Pradesh), Mathura (Uttar Pradesh), Unnao (Uttar Pradesh), Kannauj (Uttar Pradesh), Bara Banki (Uttar Pradesh), Firozabad (Uttar Pradesh), Mainpuri (Uttar Pradesh), Agra (Uttar Pradesh), Amroha (Uttar Pradesh), Jhansi (Uttar Pradesh), Sambhal (Uttar Pradesh), Budaun (Uttar Pradesh), Shahjahanpur (Uttar Pradesh), Rampur (Uttar Pradesh), Bareilly (Uttar Pradesh), Shamli (Uttar Pradesh), Bijnor (Uttar Pradesh), Pilibhit (Uttar Pradesh), Uttarkashi (Uttarakhand), Dehradun (Uttarakhand), Alipurduar (West Bengal), Puruliya (West Bengal), Birbhum (West Bengal), Paschim Bardhaman (West Bengal), Jhargram (West Bengal), South Twenty Four Pargana (West Bengal), Uttar Dinajpur (West Bengal),		Shajapur (Madhya Pradesh), Harda (Madhya Pradesh), Rajgarh (Madhya Pradesh), Ratlam (Madhya Pradesh), Ashoknagar (Madhya Pradesh), Agar Malwa (Madhya Pradesh), Indore (Madhya Pradesh), Gwalior (Madhya Pradesh), Mandsaur (Madhya Pradesh), Datia (Madhya Pradesh), Neemuch (Madhya Pradesh), Shivpuri (Madhya Pradesh), Tikamgarh (Madhya Pradesh), Guna (Madhya Pradesh), Dhule (Maharashtra), Ahmadnagar (Maharashtra), Ratnagiri (Maharashtra), Sangli (Maharashtra), Nashik (Maharashtra), Raigarh (Maharashtra), Thane (Maharashtra), Pune (Maharashtra), Satara (Maharashtra), Sindhudurg (Maharashtra), South Garo Hills (Meghalaya), Tuensang (Nagaland), Longleng (Nagaland), Kohima (Nagaland), Peren (Nagaland), Phek (Nagaland), Mon (Nagaland), Mokokchung (Nagaland), Dimapur (Nagaland), Zunheboto (Nagaland), Kiphire (Nagaland), Tarn Taran (Punjab), Banswara (Rajasthan), Dungarpur (Rajasthan), Karauli (Rajasthan), Sirohi (Rajasthan), Bhilwara (Rajasthan), Jaipur (Rajasthan), Sawai Madhopur (Rajasthan), Chittaurgarh (Rajasthan), Kota (Rajasthan), Bundi (Rajasthan),

Horizontal Expansion [Low Area-High Yield (LA-HY)] **212 districts**	**Vertical Expansion [High Area-Low Yield (HA-LY)]** **55 districts**	**Horizontal & Vertical Expansion [Low Area-Low Yield (LA-LY)]** **239 districts**
Murshidabad (West Bengal), Maldah (West Bengal), Darjiling (West Bengal), Jalpaiguri (West Bengal), Nadia (West Bengal), Bankura (West Bengal), North Twenty Four Parganas (West Bengal), Dakshin Dinajpur (West Bengal), Hooghly (West Bengal), Medinipur West (West Bengal), Purba Bardhaman (West Bengal)		Madurai (Tamil Nadu), Tiruchirappalli (Tamil Nadu), Dindigul (Tamil Nadu), Pudukkottai (Tamil Nadu), Sivaganga (Tamil Nadu), Thoothukkudi (Tamil Nadu), Medchal Malkajgiri (Telangana), Medak (Telangana), Nagarkurnool (Telangana), Bhadradri Kothagudem (Telangana), Rajanna Sircilla (Telangana), Jagitial (Telangana), Mancherial (Telangana), Suryapet (Telangana), Mahabubabad (Telangana), Warangal Urban (Telangana), Nalgonda (Telangana), Karimnagar (Telangana), Warangal Rural (Telangana), Peddapalli (Telangana), Jayashankar (Telangana), Mulugu (Telangana), North Tripura (Tripura), Khowai (Tripura), Unokoti (Tripura), Gomati (Tripura), West Tripura (Tripura), South Tripura (Tripura), Sipahijala (Tripura), Gautam Buddha Nagar (Uttar Pradesh), Balrampur (Uttar Pradesh), Aligarh (Uttar Pradesh), Rae Bareli (Uttar Pradesh), Hathras (Uttar Pradesh), Sant Kabir Nagar (Uttar Pradesh), Bulandshahr (Uttar Pradesh), Deoria (Uttar Pradesh), Gonda (Uttar Pradesh), Ghaziabad (Uttar Pradesh), Gorakhpur (Uttar Pradesh), Basti (Uttar Pradesh), Ambedkar Nagar (Uttar Pradesh), Shrawasti (Uttar Pradesh), Hapur (Uttar Pradesh), Etah (Uttar Pradesh), Sitapur (Uttar Pradesh), Bahraich (Uttar Pradesh),

Horizontal Expansion [Low Area-High Yield (LA-HY)] 212 districts	Vertical Expansion [High Area-Low Yield (HA-LY)] 55 districts	Horizontal & Vertical Expansion [Low Area-Low Yield (LA-LY)] 239 districts
		Siddharthnagar (Uttar Pradesh), Kasganj (Uttar Pradesh), Lucknow (Uttar Pradesh), Baghpat (Uttar Pradesh), Hardoi (Uttar Pradesh), Kushinagar (Uttar Pradesh), Kheri (Uttar Pradesh), Meerut (Uttar Pradesh), Mahrajganj (Uttar Pradesh), Moradabad (Uttar Pradesh), Lalitpur (Uttar Pradesh), Rudraprayag (Uttarakhand), Chamoli (Uttarakhand), Garhwal (Uttarakhand), Almora (Uttarakhand), Nainital (Uttarakhand), Pithoragarh (Uttarakhand), Champawat (Uttarakhand)

Table AIII.1.2: Chickpea

Horizontal Expansion [Low Area-High Yield (LA-HY)] 165 districts	Vertical Expansion [High Area-Low Yield (HA-LY)] 63 districts	Horizontal & Vertical Expansion [Low Area-Low Yield (LA-LY)] 208 districts
Palnadu (Andhra Pradesh), Annamayya (Andhra Pradesh), Chittoor (Andhra Pradesh), Parvathipuram Manyam (Andhra Pradesh), Sri Potti Sriramulu Nellore (Andhra Pradesh), NTR (Andhra Pradesh), Anakapalli (Andhra Pradesh), Guntur (Andhra Pradesh), Kakinada (Andhra Pradesh), Vizianagaram (Andhra Pradesh), East Godavari (Andhra Pradesh), Krishna (Andhra Pradesh), Patna (Bihar), Bhojpur (Bihar), Rohtas (Bihar), Buxar (Bihar), Vadodara (Gujarat), Chota Udaipur (Gujarat), Surat (Gujarat), Sabar Kantha (Gujarat), Mahesana (Gujarat), Banas Kantha (Gujarat), Gandhinagar (Gujarat), Jhajjar (Haryana), Rohtak (Haryana), Sonipat (Haryana), Hisar (Haryana), Charki Dadri (Haryana), Panipat (Haryana), Jind (Haryana), Sirsa (Haryana), Fatehabad (Haryana), Bilaspur (Himachal Pradesh), Sirmaur (Himachal Pradesh), Una (Himachal Pradesh), Jamtara (Jharkhand), Kasaragod (Kerala), Wayanad (Kerala), Sidhi (Madhya Pradesh), Shahdol (Madhya Pradesh), Rewa (Madhya Pradesh), Jabalpur (Madhya Pradesh), Mandla (Madhya Pradesh), Barwani (Madhya Pradesh), Morena (Madhya Pradesh), Bhopal (Madhya Pradesh), Shajapur (Madhya Pradesh),	Anantpur (Andhra Pradesh), West Karbi Anglong (Assam), Lakhisarai (Bihar), Kabeerdham (Chhattisgarh), Bametara (Chhattisgarh), Rajnandgaon (Chhattisgarh), Durg (Chhattisgarh), Mungeli (Chhattisgarh), The Dangs (Gujarat), Dohad (Gujarat), Mahisagar (Gujarat), Ahmadabad (Gujarat), Surendranagar (Gujarat), Patan (Gujarat), Yamunanagar (Haryana), Latehar (Jharkhand), Palamu (Jharkhand), Chatra (Jharkhand), Pakur (Jharkhand), Gumla (Jharkhand), Lohardaga (Jharkhand), Purbi Singhbhum (Jharkhand), Pashchimi Singhbhum (Jharkhand), Ranchi (Jharkhand), Vijayapura (Karnataka), Bidar (Karnataka), Yadgir (Karnataka), Bagalkote (Karnataka), Koppal (Karnataka), Chitradurga (Karnataka), Gadag (Karnataka), Dharwad (Karnataka), Alirajpur (Madhya Pradesh), Anuppur (Madhya Pradesh), Dindori (Madhya Pradesh), Yavatmal (Maharashtra), Latur (Maharashtra), Hingoli (Maharashtra), Amravati (Maharashtra), Nanded (Maharashtra), Chandrapur (Maharashtra), Osmanabad (Maharashtra), Parbhani (Maharashtra), Nandurbar (Maharashtra), Solapur (Maharashtra), Aurangabad (Maharashtra),	Sri Sathya Sai (Andhra Pradesh), Karbi Anglong (Assam), Biswanath (Assam), Goalpara (Assam), Kokrajhar (Assam), Bongaigaon (Assam), Sonitpur (Assam), Darrang (Assam), Chirang (Assam), Udalguri (Assam), Baksa (Assam), Kamrup (Assam), South Salmara Mancachar (Assam), Nagaon (Assam), Kamrup Metropolitan (Assam), Barpeta (Assam), Morigaon (Assam), Cachar (Assam), Karimganj (Assam), Hailakandi (Assam), Golaghat (Assam), Tinsukia (Assam), Nalbari (Assam), Dhubri (Assam), Dhemaji (Assam), Lakhimpur (Assam), Dibrugarh (Assam), Jorhat (Assam), Majuli (Assam), Hojai (Assam), Jamui (Bihar), Gaya (Bihar), Nawada (Bihar), Banka (Bihar), Siwan (Bihar), Sheikhpura (Bihar), Vaishali (Bihar), Jehanabad (Bihar), Samastipur (Bihar), Begusarai (Bihar), Bhagalpur (Bihar), Muzaffarpur (Bihar), Kaimur (Bhabua) (Bihar), Aurangabad (Bihar), Saran (Bihar), Gopalganj (Bihar), Darbhanga (Bihar), Khagaria (Bihar), Arwal (Bihar), Munger (Bihar), Nalanda (Bihar), Madhubani (Bihar), Pashchim Champaran (Bihar), Kishanganj (Bihar),

Horizontal Expansion [Low Area-High Yield (LA-HY)] **165 districts**	**Vertical Expansion [High Area-Low Yield (HA-LY)]** **63 districts**	**Horizontal & Vertical Expansion [Low Area-Low Yield (LA-LY)]** **208 districts**
Rajgarh (Madhya Pradesh), Agar Malwa (Madhya Pradesh), Indore (Madhya Pradesh), Ujjain (Madhya Pradesh), Bhind (Madhya Pradesh), Gwalior (Madhya Pradesh), Datia (Madhya Pradesh), Tikamgarh (Madhya Pradesh), Niwari (Madhya Pradesh), South West Garo Hills (Meghalaya), Barnala (Punjab), Sangrur (Punjab), Bathinda (Punjab), Fazilka (Punjab), Hoshiarpur (Punjab), Mansa (Punjab), Banswara (Rajasthan), Karauli (Rajasthan), Alwar (Rajasthan), Bharatpur (Rajasthan), Bundi (Rajasthan), Vikarabad (Telangana), Narayanpet (Telangana), Sangareddy (Telangana), Kumuram Bheem Asifabad (Telangana), Mahabubnagar (Telangana), Ranga Reddy (Telangana), Jogulamba Gadwal (Telangana), Wanaparthy (Telangana), Siddipet (Telangana), Medchal Malkajgiri (Telangana), Medak (Telangana), Nagarkurnool (Telangana), Bhadradri Kothagudem (Telangana), Rajanna Sircilla (Telangana), Jagitial (Telangana), Mancherial (Telangana), Suryapet (Telangana), Mahabubabad (Telangana), Warangal Urban (Telangana), Nalgonda (Telangana), Karimnagar (Telangana), Khammam (Telangana),	Bid (Maharashtra), Bhandara (Maharashtra), Dhule (Maharashtra), Gadchiroli (Maharashtra), Ahmadnagar (Maharashtra), Nashik (Maharashtra), Pune (Maharashtra), West Garo Hills (Meghalaya), Zunheboto (Nagaland), Wokha (Nagaland), Ganganagar (Rajasthan), Hanumangarh (Rajasthan), Bikaner (Rajasthan), Ajmer (Rajasthan), Churu (Rajasthan), Jaisalmer (Rajasthan), West Tripura (Tripura	Madhepura (Bihar), Katihar (Bihar), Koriya (Chhattisgarh), Balrampur (Chhattisgarh), Surguja (Chhattisgarh), Jashpur (Chhattisgarh), Surajpur (Chhattisgarh), Raigarh (Chhattisgarh), Gaurela-Pendra-Marwahi (Chhattisgarh), Gariaband (Chhattisgarh), Korba (Chhattisgarh), Sukma (Chhattisgarh), Dakshin Bastar Dantewada (Chhattisgarh), Balod (Chhattisgarh), Baloda Bazar (Chhattisgarh), Janjgir - Champa (Chhattisgarh), Bastar (Chhattisgarh), Raipur (Chhattisgarh), Bilaspur (Chhattisgarh), Uttar Bastar Kanker (Chhattisgarh), Kondagaon (Chhattisgarh), Narayanpur (Chhattisgarh), Mahasamund (Chhattisgarh), Dhamtari (Chhattisgarh), Bharuch (Gujarat), Narmada (Gujarat), Panch Mahals (Gujarat), Tapi (Gujarat), Valsad (Gujarat), Aravalli (Gujarat), Navsari (Gujarat), Kheda (Gujarat), Anand (Gujarat), Kachchh (Gujarat), Gurugram (Haryana), Mahendragarh (Haryana), Mahabubabad (Telangana), Warangal Urban (Telangana), Nalgonda (Telangana), Karimnagar (Telangana),

Horizontal Expansion [Low Area-High Yield (LA-HY)] 165 districts	Vertical Expansion [High Area-Low Yield (HA-LY)] 63 districts	Horizontal & Vertical Expansion [Low Area-Low Yield (LA-LY)] 208 districts
Nizamabad (Telangana), Peddapalli (Telangana), Jayashankar (Telangana), Mulugu (Telangana), Mirzapur (Uttar Pradesh), Bhadohi (Uttar Pradesh), Prayagraj (Uttar Pradesh), Balrampur (Uttar Pradesh), Jaunpur (Uttar Pradesh), Ballia (Uttar Pradesh), Azamgarh (Uttar Pradesh), Aligarh (Uttar Pradesh), Chandauli (Uttar Pradesh), Sultanpur (Uttar Pradesh), Hathras (Uttar Pradesh), Sant Kabir Nagar (Uttar Pradesh), Bulandshahr (Uttar Pradesh), Ghazipur (Uttar Pradesh), Deoria (Uttar Pradesh), Amethi (Uttar Pradesh), Auraiya (Uttar Pradesh), Mau (Uttar Pradesh), Gonda (Uttar Pradesh), Ghaziabad (Uttar Pradesh), Gorakhpur (Uttar Pradesh), Basti (Uttar Pradesh), Ambedkar Nagar (Uttar Pradesh), Shrawasti (Uttar Pradesh), Hapur (Uttar Pradesh), Etawah (Uttar Pradesh), Etah (Uttar Pradesh), Faizabad (Uttar Pradesh), Bahraich (Uttar Pradesh), Siddharthnagar (Uttar Pradesh), Farrukhabad (Uttar Pradesh), Mathura (Uttar Pradesh), Kasganj (Uttar Pradesh), Unnao (Uttar Pradesh), Kannauj (Uttar Pradesh), Bara Banki (Uttar Pradesh), Firozabad (Uttar Pradesh), Baghpat (Uttar Pradesh), Kushinagar (Uttar Pradesh), Mainpuri (Uttar Pradesh), Agra (Uttar Pradesh),		Khammam (Telangana), Nizamabad (Telangana), Peddapalli (Telangana), Jayashankar (Telangana), Mulugu (Telangana), Mirzapur (Uttar Pradesh), Bhadohi (Uttar Pradesh), Prayagraj (Uttar Pradesh), Balrampur (Uttar Pradesh), Jaunpur (Uttar Pradesh), Ballia (Uttar Pradesh), Azamgarh (Uttar Pradesh), Aligarh (Uttar Pradesh), Chandauli (Uttar Pradesh), Sultanpur (Uttar Pradesh), Hathras (Uttar Pradesh), Sant Kabir Nagar (Uttar Pradesh), Bulandshahr (Uttar Pradesh), Ghazipur (Uttar Pradesh), Deoria (Uttar Pradesh), Amethi (Uttar Pradesh), Auraiya (Uttar Pradesh), Mau (Uttar Pradesh), Gonda (Uttar Pradesh), Ghaziabad (Uttar Pradesh), Gorakhpur (Uttar Pradesh), Basti (Uttar Pradesh), Ambedkar Nagar (Uttar Pradesh), Shrawasti (Uttar Pradesh), Hapur (Uttar Pradesh), Etawah (Uttar Pradesh), Etah (Uttar Pradesh), Faizabad (Uttar Pradesh), Bahraich (Uttar Pradesh), Siddharthnagar (Uttar Pradesh), Farrukhabad (Uttar Pradesh), Mathura (Uttar Pradesh), Kasganj (Uttar Pradesh), Unnao (Uttar Pradesh), Kannauj (Uttar Pradesh), Bara Banki (Uttar Pradesh),

Horizontal Expansion [Low Area-High Yield (LA-HY)] **165 districts**	**Vertical Expansion [High Area-Low Yield (HA-LY)]** **63 districts**	**Horizontal & Vertical Expansion [Low Area-Low Yield (LA-LY)]** **208 districts**
Meerut (Uttar Pradesh), Mahrajganj (Uttar Pradesh), Sambhal (Uttar Pradesh), Budaun (Uttar Pradesh), Shahjahanpur (Uttar Pradesh), Moradabad (Uttar Pradesh), Rampur (Uttar Pradesh), Bareilly (Uttar Pradesh), Shamli (Uttar Pradesh), Lalitpur (Uttar Pradesh), Bijnor (Uttar Pradesh), Pilibhit (Uttar Pradesh), Muzaffarnagar (Uttar Pradesh), Saharanpur (Uttar Pradesh), Alipurduar (West Bengal), Puruliya (West Bengal), Birbhum (West Bengal), Paschim Bardhaman (West Bengal), Jhargram (West Bengal), Uttar Dinajpur (West Bengal), Murshidabad (West Bengal), Maldah (West Bengal), Jalpaiguri (West Bengal), Bankura (West Bengal), Dakshin Dinajpur (West Bengal), Hooghly (West Bengal), Medinipur West (West Bengal), Purba Bardhaman (West Bengal), Cooch Behar (West Bengal), Purba Medinipur (West Bengal).		Firozabad (Uttar Pradesh), Baghpat (Uttar Pradesh), Kushinagar (Uttar Pradesh), Mainpuri (Uttar Pradesh), Agra (Uttar Pradesh), Meerut (Uttar Pradesh), Mahrajganj (Uttar Pradesh), Sambhal (Uttar Pradesh), Budaun (Uttar Pradesh), Shahjahanpur (Uttar Pradesh), Moradabad (Uttar Pradesh), Rampur (Uttar Pradesh), Bareilly (Uttar Pradesh), Shamli (Uttar Pradesh), Lalitpur (Uttar Pradesh), Bijnor (Uttar Pradesh), Pilibhit (Uttar Pradesh), Muzaffarnagar (Uttar Pradesh), Saharanpur (Uttar Pradesh), Alipurduar (West Bengal), Puruliya (West Bengal), Birbhum (West Bengal), Paschim Bardhaman (West Bengal), Jhargram (West Bengal), Uttar Dinajpur (West Bengal), Murshidabad (West Bengal), Maldah (West Bengal), Jalpaiguri (West Bengal), Bankura (West Bengal), Dakshin Dinajpur (West Bengal), Hooghly (West Bengal), Medinipur West (West Bengal), Purba Bardhaman (West Bengal), Cooch Behar (West Bengal), Purba Medinipur (West Bengal).

Table AIII.1.3: Green Gram

Horizontal Expansion [Low-Area-High Yield (LA-HY)] 234 districts	Vertical Expansion [High Area-Low Yield (HA-LY)] 82 districts	Horizontal & Vertical Expansion [Low Area-Low Yield (LA-LY)] 250 districts
Nandyal (Andhra Pradesh), Palnadu (Andhra Pradesh), Kurnool (Andhra Pradesh), Annamayya (Andhra Pradesh), Chittoor (Andhra Pradesh), Alluri Sitharama Raju (Andhra Pradesh), Tirupati (Andhra Pradesh), Visakhapatnam (Andhra Pradesh), East Godavari (Andhra Pradesh), Krishna (Andhra Pradesh), Upper Dibang Valley (Arunachal Pradesh), Upper Siang (Arunachal Pradesh), Kamle (Arunachal Pradesh), East Kameng (Arunachal Pradesh), Pakke Kessang (Arunachal Pradesh), Upper Subansiri (Arunachal Pradesh), Siang (Arunachal Pradesh), Papum Pare (Arunachal Pradesh), Lower Subansiri (Arunachal Pradesh), Tirap (Arunachal Pradesh), East Siang (Arunachal Pradesh), Longding (Arunachal Pradesh), Lower Dibang Valley (Arunachal Pradesh), Lower Siang (Arunachal Pradesh), Lepa Rada (Arunachal Pradesh), Namsai (Arunachal Pradesh), Lohit (Arunachal Pradesh), Anjaw (Arunachal Pradesh), Changlang (Arunachal Pradesh), Karbi Anglong (Assam), Biswanath (Assam), Goalpara (Assam), Kokrajhar (Assam), Sonitpur (Assam), Darrang (Assam), Chirang (Assam),	Parvathipuram Manyam (Andhra Pradesh), Anakapalli (Andhra Pradesh), Srikakulam (Andhra Pradesh), Kakinada (Andhra Pradesh), Vizianagaram (Andhra Pradesh), West Karbi Anglong (Assam), Darbhanga (Bihar), Madhubani (Bihar), Kishanganj (Bihar), Araria (Bihar), Saharsa (Bihar), Supaul (Bihar), Kachchh (Gujarat), Purbi Singhbhum (Jharkhand), Kalaburagi (Karnataka), Bidar (Karnataka), Yadgir (Karnataka), Bagalkote (Karnataka), Koppal (Karnataka), Tumakuru (Karnataka), Belagavi (Karnataka), Gadag (Karnataka), Dharwad (Karnataka), Katni (Madhya Pradesh), Yavatmal (Maharashtra), Washim (Maharashtra), Hingoli (Maharashtra), Buldana (Maharashtra), Akola (Maharashtra), Nanded (Maharashtra), Jalna (Maharashtra), Nandurbar (Maharashtra), Jalgaon (Maharashtra), Dhule (Maharashtra), Ahmadnagar (Maharashtra), Sindhudurg (Maharashtra),	Sri Potti Sriramulu Nellore (Andhra Pradesh), NTR (Andhra Pradesh), Konaseema (Andhra Pradesh), Dima Hasao (Assam), Bongaigaon (Assam), Kamrup (Assam), Nagaon (Assam), Barpeta (Assam), Cachar (Assam), Hailakandi (Assam), Golaghat (Assam), Tinsukia (Assam), Charaideo (Assam), Dhemaji (Assam), Dibrugarh (Assam), Jorhat (Assam), Jamui (Bihar), Gaya (Bihar), Nawada (Bihar), Sheikhpura (Bihar), Jehanabad (Bihar), Gopalganj (Bihar), Khagaria (Bihar), Arwal (Bihar), Munger (Bihar), Lakhisarai (Bihar), Koriya (Chhattisgarh), Balrampur (Chhattisgarh), Kabeerdham (Chhattisgarh), Surguja (Chhattisgarh), Jashpur (Chhattisgarh), Surajpur (Chhattisgarh), Bametara (Chhattisgarh), Rajnandgaon (Chhattisgarh), Durg (Chhattisgarh), Gaurela-Pendra-Marwahi (Chhattisgarh), Mungeli (Chhattisgarh), Gariaband (Chhattisgarh), Korba (Chhattisgarh), Sukma (Chhattisgarh), Dakshin Bastar Dantewada (Chhattisgarh), Balod (Chhattisgarh), Baloda Bazar (Chhattisgarh), Janjgir - Champa (Chhattisgarh),

Horizontal Expansion [Low-Area-High Yield (LA-HY)] 234 districts	Vertical Expansion [High Area-Low Yield (HA-LY)] 82 districts	Horizontal & Vertical Expansion [Low Area-Low Yield (LA-LY)] 250 districts
Udalguri (Assam), Baksa (Assam), South Salmara Mancachar (Assam), Kamrup Metropolitan (Assam), Morigaon (Assam), Karimganj (Assam), Nalbari (Assam), Dhubri (Assam), Lakhimpur (Assam), Sivasagar (Assam), Hojai (Assam), Siwan (Bihar), Patna (Bihar), Purba Champaran (Bihar), Begusarai (Bihar), Bhojpur (Bihar), Bhagalpur (Bihar), Kaimur (Bhabua) (Bihar), Aurangabad (Bihar), Saran (Bihar), Rohtas (Bihar), Nalanda (Bihar), Buxar (Bihar), Pashchim Champaran (Bihar), Sitamarhi (Bihar), Katihar (Bihar), Purnia (Bihar), Raigarh (Chhattisgarh), Bastar (Chhattisgarh), Bharuch (Gujarat), Narmada (Gujarat), Vadodara (Gujarat), Panch Mahals (Gujarat), Tapi (Gujarat), Chota Udaipur (Gujarat), The Dangs (Gujarat), Valsad (Gujarat), Surat (Gujarat), Dohad (Gujarat), Mahisagar (Gujarat), Sabar Kantha (Gujarat), Aravalli (Gujarat), Rajkot (Gujarat), Navsari (Gujarat), Gir Somnath (Gujarat), Amreli (Gujarat), Jamnagar (Gujarat), Morbi (Gujarat), Botad (Gujarat), Kheda (Gujarat), Banas Kantha (Gujarat), Anand (Gujarat), Gandhinagar (Gujarat), Devbhumi Dwarka (Gujarat), Rohtak (Haryana), Charki Dadri (Haryana), Bilaspur (Himachal Pradesh),	Anugul (Odisha), Balangir (Odisha), Bargarh (Odisha), Baudh (Odisha), Cuttack (Odisha), Deogarh (Odisha), Dhenkanal (Odisha), Gajapati (Odisha), Ganjam (Odisha), Jagatsinghapur (Odisha), Jajapur (Odisha), Kalahandi (Odisha), Kendrapara (Odisha), Khordha (Odisha), Nayagarh (Odisha), Nuapada (Odisha), Puri (Odisha), Karaikal (Puducherry), Sirohi (Rajasthan), Pali (Rajasthan), Jaipur (Rajasthan), Tonk (Rajasthan), Ganganagar (Rajasthan), Sikar (Rajasthan), Hanumangarh (Rajasthan), Bikaner (Rajasthan), Ajmer (Rajasthan), Barmer (Rajasthan), Churu (Rajasthan), Jaisalmer (Rajasthan), Jalor (Rajasthan), Jhunjhunun (Rajasthan), Jodhpur (Rajasthan), Nagaur (Rajasthan), Madurai (Tamil Nadu), Virudhunagar (Tamil Nadu), Thoothukkudi (Tamil Nadu), Cuddalore (Tamil Nadu), Thiruvarur (Tamil Nadu), Mayiladuthurai (Tamil Nadu),	Raipur (Chhattisgarh), Bilaspur (Chhattisgarh), Uttar Bastar Kanker (Chhattisgarh), Kondagaon (Chhattisgarh), Narayanpur (Chhattisgarh), Mahasamund (Chhattisgarh), Dhamtari (Chhattisgarh), Bijapur (Chhattisgarh), Ahmadabad (Gujarat), Surendranagar (Gujarat), Bhavnagar (Gujarat), Patan (Gujarat), Mahesana (Gujarat), Palwal (Haryana), Gurugram (Haryana), Jhajjar (Haryana), Mahendragarh (Haryana), Faridabad (Haryana), Sonipat (Haryana), Panipat (Haryana), Rewari (Haryana), Jind (Haryana), Kurukshetra (Haryana), Ambala (Haryana), Sirsa (Haryana), Fatehabad (Haryana), Kaithal (Haryana), Karnal (Haryana), Solan (Himachal Pradesh), Shimla (Himachal Pradesh), Mandi (Himachal Pradesh), Chamba (Himachal Pradesh), Una (Himachal Pradesh), Anantnag (Jammu & Kashmir), Bandipore (Jammu & Kashmir), Baramula (Jammu & Kashmir), Badgam (Jammu & Kashmir), Kishtwar (Jammu & Kashmir), Kulgam (Jammu & Kashmir), Pulwama (Jammu & Kashmir), Udhampur (Jammu & Kashmir), Lohardaga (Jharkhand), Vijayapura (Karnataka), Raichur (Karnataka), Ballari (Karnataka), Chikkaballapura (Karnataka),

Horizontal Expansion [Low-Area-High Yield (LA-HY)] 234 districts	Vertical Expansion [High Area-Low Yield (HA-LY)] 82 districts	Horizontal & Vertical Expansion [Low Area-Low Yield (LA-LY)] 250 districts
Kullu (Himachal Pradesh), Sirmaur (Himachal Pradesh), Doda (Jammu & Kashmir), Samba (Jammu & Kashmir), Garhwa (Jharkhand), Palamu (Jharkhand), Godda (Jharkhand), Sahibganj (Jharkhand), Simdega (Jharkhand), Gumla (Jharkhand), Deoghar (Jharkhand), Ranchi (Jharkhand), Giridih (Jharkhand), Jamtara (Jharkhand), Burhanpur (Madhya Pradesh), Betul (Madhya Pradesh), Mandla (Madhya Pradesh), Barwani (Madhya Pradesh), Seoni (Madhya Pradesh), Morena (Madhya Pradesh), Sheopur (Madhya Pradesh), Balaghat (Madhya Pradesh), Bhopal (Madhya Pradesh), Vidisha (Madhya Pradesh), Rajgarh (Madhya Pradesh), Ratlam (Madhya Pradesh), Bhind (Madhya Pradesh), Guna (Madhya Pradesh), Nashik (Maharashtra), Kolhapur (Maharashtra), Pune (Maharashtra), Tuensang (Nagaland), Longleng (Nagaland), Kohima (Nagaland), Peren (Nagaland), Phek (Nagaland), Mon (Nagaland), Mokokchung (Nagaland), Dimapur (Nagaland), Nabarangapur (Odisha), Sambalpur (Odisha), Ludhiana (Punjab), Moga (Punjab), Tarn Taran (Punjab), Barnala (Punjab),	Nagapattinam (Tamil Nadu), Vikarabad (Telangana), Yadadri Bhuvanagiri (Telangana), Khammam (Telangana), Mahoba (Uttar Pradesh), South Twenty Four Pargana (West Bengal)	Chitradurga (Karnataka), Vijayanagar (Karnataka), Bangalore (Karnataka), Ramanagara (Karnataka), Bengaluru Rural (Karnataka), Kolar (Karnataka), Mysuru (Karnataka), Davanagere (Karnataka), Chamarajanagara (Karnataka), Mandya (Karnataka), Hassan (Karnataka), Chikkamagaluru (Karnataka), Haveri (Karnataka), Shivamogga (Karnataka), Uttara Kannada (Karnataka), Udupi (Karnataka), Kodagu (Karnataka), Singrauli (Madhya Pradesh), Sidhi (Madhya Pradesh), Umaria (Madhya Pradesh), Shahdol (Madhya Pradesh), Chhindwara (Madhya Pradesh), Panna (Madhya Pradesh), Alirajpur (Madhya Pradesh), Anuppur (Madhya Pradesh), Rewa (Madhya Pradesh), Satna (Madhya Pradesh), Dindori (Madhya Pradesh), Jhabua (Madhya Pradesh), Chhatarpur (Madhya Pradesh), Dhar (Madhya Pradesh), Shajapur (Madhya Pradesh), Ashoknagar (Madhya Pradesh), Agar Malwa (Madhya Pradesh), Indore (Madhya Pradesh), Ujjain (Madhya Pradesh), Gwalior (Madhya Pradesh), Mandsaur (Madhya Pradesh), Datia (Madhya Pradesh), Neemuch (Madhya Pradesh),

Horizontal Expansion [Low-Area-High Yield (LA-HY)] 234 districts	Vertical Expansion [High Area-Low Yield (HA-LY)] 82 districts	Horizontal & Vertical Expansion [Low Area-Low Yield (LA-LY)] 250 districts
Amritsar (Punjab), Sangrur (Punjab), Bathinda (Punjab), Faridkot (Punjab), Firozpur (Punjab), Mansa (Punjab), Sri Muktsar Sahib (Punjab), Dharmapuri (Tamil Nadu), Krishnagiri (Tamil Nadu), Erode (Tamil Nadu), Pudukkottai (Tamil Nadu), Kanniyakumari (Tamil Nadu), Jogulamba Gadwal (Telangana), Wanaparthy (Telangana), Siddipet (Telangana), Kamareddy (Telangana), Nagarkurnool (Telangana), Bhadradri Kothagudem (Telangana), Rajanna Sircilla (Telangana), Jagitial (Telangana), Mancherial (Telangana), Nalgonda (Telangana), Peddapalli (Telangana), Jayashankar (Telangana), Mulugu (Telangana), Dhalai (Tripura), North Tripura (Tripura), Khowai (Tripura), Unokoti (Tripura), Gomati (Tripura), South Tripura (Tripura), Sipahijala (Tripura), Bhadohi (Uttar Pradesh), Kaushambi (Uttar Pradesh), Fatehpur (Uttar Pradesh), Prayagraj (Uttar Pradesh), Varanasi (Uttar Pradesh), Kanpur Dehat (Uttar Pradesh), Gautam Buddha Nagar (Uttar Pradesh), Pratapgarh (Uttar Pradesh), Jaunpur (Uttar Pradesh), Ballia (Uttar Pradesh), Kanpur Nagar (Uttar Pradesh), Azamgarh (Uttar Pradesh), Aligarh (Uttar Pradesh),		Shivpuri (Madhya Pradesh), Tikamgarh (Madhya Pradesh), Niwari (Madhya Pradesh), Wardha (Maharashtra), Latur (Maharashtra), Amravati (Maharashtra), Nagpur (Maharashtra), Chandrapur (Maharashtra), Solapur (Maharashtra), Aurangabad (Maharashtra), Bid (Maharashtra), Bhandara (Maharashtra), Palghar (Maharashtra), Gadchiroli (Maharashtra), Gondiya (Maharashtra), Ratnagiri (Maharashtra), Sangli (Maharashtra), Raigarh (Maharashtra), Thane (Maharashtra), Baleshwar (Odisha), Bhadrak (Odisha), Jharsuguda (Odisha), Kandhamal (Odisha), Kendujhar (Odisha), Koraput (Odisha), Malkangiri (Odisha), Mayurbhanj (Odisha), Rayagada (Odisha), Sonepur (Odisha), Sundargarh (Odisha), Fazilka (Punjab), Udaipur (Rajasthan), Dungarpur (Rajasthan), Pratapgarh (Rajasthan), Dhaulpur (Rajasthan), Karauli (Rajasthan), Alwar (Rajasthan), Bhilwara (Rajasthan), Sawai Madhopur (Rajasthan), Chittaurgarh (Rajasthan), Bharatpur (Rajasthan), Kota (Rajasthan), Bundi (Rajasthan), Jhalawar (Rajasthan), Dausa (Rajasthan), Baran (Rajasthan),

Horizontal Expansion [Low-Area-High Yield (LA-HY)] 234 districts	Vertical Expansion [High Area-Low Yield (HA-LY)] 82 districts	Horizontal & Vertical Expansion [Low Area-Low Yield (LA-LY)] 250 districts
Chandauli (Uttar Pradesh), Hathras (Uttar Pradesh), Bulandshahr (Uttar Pradesh), Ghazipur (Uttar Pradesh), Deoria (Uttar Pradesh), Auraiya (Uttar Pradesh), Mau (Uttar Pradesh), Gonda (Uttar Pradesh), Ghaziabad (Uttar Pradesh), Gorakhpur (Uttar Pradesh), Basti (Uttar Pradesh), Hapur (Uttar Pradesh), Etah (Uttar Pradesh), Bahraich (Uttar Pradesh), Siddharthnagar (Uttar Pradesh), Farrukhabad (Uttar Pradesh), Mathura (Uttar Pradesh), Kasganj (Uttar Pradesh), Kannauj (Uttar Pradesh), Baghpat (Uttar Pradesh), Hardoi (Uttar Pradesh), Kushinagar (Uttar Pradesh), Mainpuri (Uttar Pradesh), Agra (Uttar Pradesh), Meerut (Uttar Pradesh), Mahrajganj (Uttar Pradesh), Shamli (Uttar Pradesh), Bijnor (Uttar Pradesh), Pilibhit (Uttar Pradesh), Saharanpur (Uttar Pradesh), Almora (Uttarakhand), Champawat (Uttarakhand), Hardwar (Uttarakhand), Udham Singh Nagar (Uttarakhand), Alipurduar (West Bengal), Puruliya (West Bengal), Birbhum (West Bengal), Paschim Bardhaman (West Bengal), Uttar Dinajpur (West Bengal), Murshidabad (West Bengal), Maldah (West Bengal), Darjiling (West Bengal), Nadia (West Bengal),		Rajsamand (Rajasthan), Tiruppattur (Tamil Nadu), Vellore (Tamil Nadu), Karur (Tamil Nadu), Ranipet (Tamil Nadu), Tiruchirappalli (Tamil Nadu), Theni (Tamil Nadu), Tiruvannamalai (Tamil Nadu), Perambalur (Tamil Nadu), Dindigul (Tamil Nadu), Ariyalur (Tamil Nadu), Coimbatore (Tamil Nadu), Tiruppur (Tamil Nadu), Sivaganga (Tamil Nadu), Kanchipuram (Tamil Nadu), Thanjavur (Tamil Nadu), Kallakurichchi (Tamil Nadu), Chengalpattu (Tamil Nadu), Tenkasi (Tamil Nadu), Viluppuram (Tamil Nadu), Tirunelveli (Tamil Nadu), Ramanathapuram (Tamil Nadu), Chennai (Tamil Nadu), Narayanpet (Telangana), Adilabad (Telangana), Kumuram Bheem Asifabad (Telangana), Mahabubnagar (Telangana), Ranga Reddy (Telangana), Jangoan (Telangana), Nirmal (Telangana), Medchal Malkajgiri (Telangana), Medak (Telangana), Suryapet (Telangana), Mahabubabad (Telangana), Warangal Urban (Telangana), Karimnagar (Telangana), Warangal Rural (Telangana), Nizamabad (Telangana), Chitrakoot (Uttar Pradesh), Hamirpur (Uttar Pradesh), Sonbhadra (Uttar Pradesh), Mirzapur (Uttar Pradesh),

Horizontal Expansion [Low-Area-High Yield (LA-HY)] **234 districts**	**Vertical Expansion [High Area-Low Yield (HA-LY)]** **82 districts**	**Horizontal & Vertical Expansion [Low Area-Low Yield (LA-LY)]** **250 districts**
Bankura (West Bengal), Dakshin Dinajpur (West Bengal), Hooghly (West Bengal), Medinipur West (West Bengal), Purba Bardhaman (West Bengal), Cooch Behar (West Bengal), Purba Medinipur (West Bengal), and Howrah (West Bengal)		Banda (Uttar Pradesh), Sultanpur (Uttar Pradesh), Rae Bareli (Uttar Pradesh), Sant Kabir Nagar (Uttar Pradesh), Jalaun (Uttar Pradesh), Amethi (Uttar Pradesh), Ambedkar Nagar (Uttar Pradesh), Shrawasti (Uttar Pradesh), Faizabad (Uttar Pradesh), Sitapur (Uttar Pradesh), Lucknow (Uttar Pradesh), Unnao (Uttar Pradesh), Bara Banki (Uttar Pradesh), Firozabad (Uttar Pradesh), Kheri (Uttar Pradesh), Amroha (Uttar Pradesh), Jhansi (Uttar Pradesh), Sambhal (Uttar Pradesh), Budaun (Uttar Pradesh), Shahjahanpur (Uttar Pradesh), Moradabad (Uttar Pradesh), Rampur (Uttar Pradesh), Bareilly (Uttar Pradesh), Lalitpur (Uttar Pradesh), Muzaffarnagar (Uttar Pradesh), Nainital (Uttarakhand), Jhargram (West Bengal), Jalpaiguri (West Bengal), North Twenty Four Parganas (West Bengal) Top of Form

Table AIII.1.4: Black Gram

Horizontal Expansion [Low Area-High Yield (LA-HY)] 193 districts	Vertical Expansion [High Area-Low Yield (HA-LY)] 97 districts	Horizontal & Vertical Expansion [Low Area-Low Yield (LA-LY)] 237 districts
Sri Sathya Sai (Andhra Pradesh), Anantpur (Andhra Pradesh), Kurnool (Andhra Pradesh), Annamayya (Andhra Pradesh), Chittoor (Andhra Pradesh), Alluri Sitharama Raju (Andhra Pradesh), NTR (Andhra Pradesh), Guntur (Andhra Pradesh), Visakhapatnam (Andhra Pradesh), East Godavari (Andhra Pradesh), Upper Dibang Valley (Arunachal Pradesh), Upper Siang (Arunachal Pradesh), Kamle (Arunachal Pradesh), East Kameng (Arunachal Pradesh), Pakke Kessang (Arunachal Pradesh), Upper Subansiri (Arunachal Pradesh), Siang (Arunachal Pradesh), Papum Pare (Arunachal Pradesh), Lower Subansiri (Arunachal Pradesh), Tirap (Arunachal Pradesh), East Siang (Arunachal Pradesh), Longding (Arunachal Pradesh), Lower Dibang Valley (Arunachal Pradesh), Lower Siang (Arunachal Pradesh), Lepa Rada (Arunachal Pradesh), Namsai (Arunachal Pradesh), Lohit (Arunachal Pradesh), Anjaw (Arunachal Pradesh), Changlang (Arunachal Pradesh), Kra Daadi (Arunachal Pradesh), Kurung Kumey (Arunachal Pradesh),	Prakasam (Andhra Pradesh), Parvathipuram Manyam (Andhra Pradesh), Anakapalli (Andhra Pradesh), West Karbi Anglong (Assam), Lakhimpur (Assam), Majuli (Assam), Koriya (Chhattisgarh), Surguja (Chhattisgarh), Jashpur (Chhattisgarh), Surajpur (Chhattisgarh), Raigarh (Chhattisgarh), Kondagaon (Chhattisgarh), Narayanpur (Chhattisgarh), Mahasamund (Chhattisgarh), Valsad (Gujarat), Aravalli (Gujarat), Patan (Gujarat), Mahesana (Gujarat), Yamunanagar (Haryana), Chamba (Himachal Pradesh), Kishtwar (Jammu & Kashmir), Godda (Jharkhand), Lohardaga (Jharkhand), Bidar (Karnataka), Yadgir (Karnataka), Sidhi (Madhya Pradesh), Narsimhapur (Madhya Pradesh), Raisen (Madhya Pradesh), Panna (Madhya Pradesh), Alirajpur (Madhya Pradesh), Rewa (Madhya Pradesh), Satna (Madhya Pradesh), Damoh (Madhya Pradesh), West Nimar (Madhya Pradesh), Chhatarpur (Madhya Pradesh), Sagar (Madhya Pradesh), Sheopur (Madhya Pradesh), Vidisha (Madhya Pradesh), Harda (Madhya Pradesh), Ashoknagar (Madhya Pradesh), Datia (Madhya Pradesh), Shivpuri (Madhya Pradesh),	Palnadu (Andhra Pradesh), Tirupati (Andhra Pradesh), Konaseema (Andhra Pradesh), Dima Hasao (Assam), Karbi Anglong (Assam), Goalpara (Assam), Kokrajhar (Assam), Chirang (Assam), Udalguri (Assam), Kamrup (Assam), Nagaon (Assam), Kamrup Metropolitan (Assam), Morigaon (Assam), Cachar (Assam), Karimganj (Assam), Hailakandi (Assam), Golaghat (Assam), Tinsukia (Assam), Charaideo (Assam), Dhemaji (Assam), Dibrugarh (Assam), Jorhat (Assam), Sivasagar (Assam), Balrampur (Chhattisgarh), Kabeerdham (Chhattisgarh), Bametara (Chhattisgarh), Rajnandgaon (Chhattisgarh), Durg (Chhattisgarh), Gaurela-Pendra-Marwahi (Chhattisgarh), Mungeli (Chhattisgarh), Gariaband (Chhattisgarh), Korba (Chhattisgarh), Sukma (Chhattisgarh), Dakshin Bastar Dantewada (Chhattisgarh), Balod (Chhattisgarh), Baloda Bazar (Chhattisgarh), Janjgir - Champa (Chhattisgarh),

Horizontal Expansion [Low Area-High Yield (LA-HY)] 193 districts	Vertical Expansion [High Area-Low Yield (HA-LY)] 97 districts	Horizontal & Vertical Expansion [Low Area-Low Yield (LA-LY)] 237 districts
Shi Yomi (Arunachal Pradesh), Biswanath (Assam), Sonitpur (Assam), Darrang (Assam), Baksa (Assam), Nalbari (Assam), Hojai (Assam), Gaya (Bihar), Nawada (Bihar), Siwan (Bihar), Patna (Bihar), Vaishali (Bihar), Jehanabad (Bihar), Samastipur (Bihar), Begusarai (Bihar), Bhagalpur (Bihar), Kaimur (Bhabua) (Bihar), Saran (Bihar), Gopalganj (Bihar), Darbhanga (Bihar), Khagaria (Bihar), Arwal (Bihar), Rohtas (Bihar), Madhubani (Bihar), Pashchim Champaran (Bihar), Kishanganj (Bihar), Madhepura (Bihar), Katihar (Bihar), Purnia (Bihar), Saharsa (Bihar), Supaul (Bihar), Bharuch (Gujarat), Narmada (Gujarat), Tapi (Gujarat), Surat (Gujarat), Junagadh (Gujarat), Rajkot (Gujarat), Amreli (Gujarat), Morbi (Gujarat), Surendranagar (Gujarat), Bhavnagar (Gujarat), Porbandar (Gujarat), Banas Kantha (Gujarat), Shimla (Himachal Pradesh), Mandi (Himachal Pradesh), Kinnaur (Himachal Pradesh), Kullu (Himachal Pradesh), Una (Himachal Pradesh), Barwani (Madhya Pradesh), Katni (Madhya Pradesh), Balaghat (Madhya Pradesh), Washim (Maharashtra), Latur (Maharashtra), Nashik (Maharashtra),	Tikamgarh (Madhya Pradesh), Guna (Madhya Pradesh), Niwari (Madhya Pradesh), Yavatmal (Maharashtra), Hingoli (Maharashtra), Akola (Maharashtra), Nanded (Maharashtra), Nandurbar (Maharashtra), Solapur (Maharashtra), Palghar (Maharashtra), Jalgaon (Maharashtra), Dhule (Maharashtra), Cuttack (Odisha), Gajapati (Odisha), Ganjam (Odisha), Jajapur (Odisha), Kendrapara (Odisha), Malkangiri (Odisha), Nayagarh (Odisha), Nuapada (Odisha), Puri (Odisha), Rayagada (Odisha), Karaikal (Puducherry), Mahe (Puducherry), Dungarpur (Rajasthan), Bhilwara (Rajasthan), Sawai Madhopur (Rajasthan), Kota (Rajasthan), Bundi (Rajasthan), Tonk (Rajasthan), Ajmer (Rajasthan), Baran (Rajasthan), Vellore (Tamil Nadu), Karur (Tamil Nadu), Ranipet (Tamil Nadu), Tiruchirappalli (Tamil Nadu), Virudhunagar (Tamil Nadu), Dindigul (Tamil Nadu), Ariyalur (Tamil Nadu), Thoothukkudi (Tamil Nadu), Tenkasi (Tamil Nadu), Cuddalore (Tamil Nadu), Thiruvarur (Tamil Nadu), Mayiladuthurai (Tamil Nadu), Nagapattinam (Tamil Nadu), Hamirpur (Uttar Pradesh), Kanpur Nagar (Uttar Pradesh), Rae Bareli (Uttar Pradesh), Amethi (Uttar Pradesh),	Bastar (Chhattisgarh), Raipur (Chhattisgarh), Bilaspur (Chhattisgarh), Uttar Bastar Kanker (Chhattisgarh), Dhamtari (Chhattisgarh), Bijapur (Chhattisgarh), Vadodara (Gujarat), Panch Mahals (Gujarat), Chota Udaipur (Gujarat), Dohad (Gujarat), Mahisagar (Gujarat), Ahmadabad (Gujarat), Navsari (Gujarat), Jamnagar (Gujarat), Botad (Gujarat), Kheda (Gujarat), Anand (Gujarat), Kachchh (Gujarat), Gandhinagar (Gujarat), Devbhumi Dwarka (Gujarat), Bhiwani (Haryana), Panchkula (Haryana), Kurukshetra (Haryana), Ambala (Haryana), Solan (Himachal Pradesh), Bilaspur (Himachal Pradesh), Kangra (Himachal Pradesh), Sirmaur (Himachal Pradesh), Anantnag (Jammu & Kashmir), Baramula (Jammu & Kashmir), Doda (Jammu & Kashmir), Jammu (Jammu & Kashmir), Kathua (Jammu & Kashmir), Punch (Jammu & Kashmir), Rajouri (Jammu & Kashmir), Reasi (Jammu & Kashmir), Samba (Jammu & Kashmir), Udhampur (Jammu & Kashmir), Kalaburagi (Karnataka),

Horizontal Expansion [Low Area-High Yield (LA-HY)] 193 districts	Vertical Expansion [High Area-Low Yield (HA-LY)] 97 districts	Horizontal & Vertical Expansion [Low Area-Low Yield (LA-LY)] 237 districts
Thane (Maharashtra), Pune (Maharashtra), Satara (Maharashtra), Tuensang (Nagaland), Longleng (Nagaland), Kohima (Nagaland), Peren (Nagaland), Phek (Nagaland), Mon (Nagaland), Mokokchung (Nagaland), Dimapur (Nagaland), Kiphire (Nagaland), Nabarangapur (Odisha), Sahibzada Ajit Singh Nagar (Punjab), Hoshiarpur (Punjab), Pratapgarh (Rajasthan), Dharmapuri (Tamil Nadu), Krishnagiri (Tamil Nadu), Madurai (Tamil Nadu), Erode (Tamil Nadu), Salem (Tamil Nadu), Perambalur (Tamil Nadu), Sivaganga (Tamil Nadu), Kanchipuram (Tamil Nadu), Kanniyakumari (Tamil Nadu), Vikarabad (Telangana), Narayanpet (Telangana), Sangareddy (Telangana), Kumuram Bheem Asifabad (Telangana), Mahabubnagar (Telangana), Ranga Reddy (Telangana), Jogulamba Gadwal (Telangana), Jangoan (Telangana), Siddipet (Telangana), Nirmal (Telangana), Kamareddy (Telangana), Medchal Malkajgiri (Telangana), Nagarkurnool (Telangana), Bhadradri Kothagudem (Telangana), Rajanna Sircilla (Telangana), Jagitial (Telangana), Mancherial (Telangana),	Mahoba (Uttar Pradesh), Unnao (Uttar Pradesh), Hardoi (Uttar Pradesh), Jhansi (Uttar Pradesh), Lalitpur (Uttar Pradesh), Puruliya (West Bengal)	Vijayapura (Karnataka), Raichur (Karnataka), Bagalkote (Karnataka), Koppal (Karnataka), Ballari (Karnataka), Tumakuru (Karnataka), Chikkaballapura (Karnataka), Chitradurga (Karnataka), Vijayanagar (Karnataka), Belagavi (Karnataka), Bangalore (Karnataka), Ramanagara (Karnataka), Bengaluru Rural (Karnataka), Kolar (Karnataka), Mysuru (Karnataka), Davanagere (Karnataka), Chamarajanagara (Karnataka), Mandya (Karnataka), Hassan (Karnataka), Gadag (Karnataka), Chikkamagaluru (Karnataka), Dharwad (Karnataka), Haveri (Karnataka), Shivamogga (Karnataka), Uttara Kannada (Karnataka), Udupi (Karnataka), Dakshina Kannada (Karnataka), Singrauli (Madhya Pradesh), Umaria (Madhya Pradesh), Burhanpur (Madhya Pradesh), Shahdol (Madhya Pradesh), Chhindwara (Madhya Pradesh), Betul (Madhya Pradesh), Anuppur (Madhya Pradesh), Dindori (Madhya Pradesh), Jhabua (Madhya Pradesh), Mandla (Madhya Pradesh),

Horizontal Expansion [Low Area-High Yield (LA-HY)] 193 districts	Vertical Expansion [High Area-Low Yield (HA-LY)] 97 districts	Horizontal & Vertical Expansion [Low Area-Low Yield (LA-LY)] 237 districts
Suryapet (Telangana), Mahabubabad (Telangana), Warangal Urban (Telangana), Nalgonda (Telangana), Karimnagar (Telangana), Warangal Rural (Telangana), Khammam (Telangana), Nizamabad (Telangana), Peddapalli (Telangana), Jayashankar (Telangana), Mulugu (Telangana), Khowai (Tripura), Unokoti (Tripura), Gomati (Tripura), South Tripura (Tripura), Sipahijala (Tripura), Fatehpur (Uttar Pradesh), Prayagraj (Uttar Pradesh), Varanasi (Uttar Pradesh), Gautam Buddha Nagar (Uttar Pradesh), Jaunpur (Uttar Pradesh), Ballia (Uttar Pradesh), Chandauli (Uttar Pradesh), Hathras (Uttar Pradesh), Bulandshahr (Uttar Pradesh), Ghazipur (Uttar Pradesh), Auraiya (Uttar Pradesh), Ghaziabad (Uttar Pradesh), Ambedkar Nagar (Uttar Pradesh), Hapur (Uttar Pradesh), Etawah (Uttar Pradesh), Farrukhabad (Uttar Pradesh), Kasganj (Uttar Pradesh), Kannauj (Uttar Pradesh), Firozabad (Uttar Pradesh), Baghpat (Uttar Pradesh), Kushinagar (Uttar Pradesh), Mainpuri (Uttar Pradesh), Kheri (Uttar Pradesh), Amroha (Uttar Pradesh), Meerut (Uttar Pradesh), Mahrajganj (Uttar Pradesh), Shahjahanpur (Uttar Pradesh),		East Nimar (Madhya Pradesh), Seoni (Madhya Pradesh), Hoshangabad (Madhya Pradesh), Morena (Madhya Pradesh), Sehore (Madhya Pradesh), Dewas (Madhya Pradesh), Dhar (Madhya Pradesh), Bhopal (Madhya Pradesh), Shajapur (Madhya Pradesh), Rajgarh (Madhya Pradesh), Ratlam (Madhya Pradesh), Agar Malwa (Madhya Pradesh), Indore (Madhya Pradesh), Ujjain (Madhya Pradesh), Bhind (Madhya Pradesh), Gwalior (Madhya Pradesh), Mandsaur (Madhya Pradesh), Neemuch (Madhya Pradesh), Wardha (Maharashtra), Amravati (Maharashtra), Nagpur (Maharashtra), Chandrapur (Maharashtra), Jalna (Maharashtra), Parbhani (Maharashtra), Aurangabad (Maharashtra), Bhandara (Maharashtra), Gadchiroli (Maharashtra), Gondiya (Maharashtra), Ratnagiri (Maharashtra), Raigarh (Maharashtra), Kolhapur (Maharashtra), Sindhudurg (Maharashtra), Anugul (Odisha), Balangir (Odisha), Baleshwar (Odisha), Bargarh (Odisha), Baudh (Odisha), Bhadrak (Odisha), Deogarh (Odisha), Dhenkanal (Odisha),

Horizontal Expansion [Low Area-High Yield (LA-HY)] 193 districts	Vertical Expansion [High Area-Low Yield (HA-LY)] 97 districts	Horizontal & Vertical Expansion [Low Area-Low Yield (LA-LY)] 237 districts
Moradabad (Uttar Pradesh), Rampur (Uttar Pradesh), Bareilly (Uttar Pradesh), Bijnor (Uttar Pradesh), Pilibhit (Uttar Pradesh), Dehradun (Uttarakhand), Rudraprayag (Uttarakhand), Chamoli (Uttarakhand), Almora (Uttarakhand), Pithoragarh (Uttarakhand), Champawat (Uttarakhand), Bageshwar (Uttarakhand), Hardwar (Uttarakhand), Udham Singh Nagar (Uttarakhand), Birbhum (West Bengal), Paschim Bardhaman (West Bengal), Uttar Dinajpur (West Bengal), Murshidabad (West Bengal), Maldah (West Bengal), Nadia (West Bengal), Hooghly (West Bengal), Purba Bardhaman (West Bengal), Cooch Behar (West Bengal)		Jagatsinghapur (Odisha), Jharsuguda (Odisha), Kalahandi (Odisha), Kandhamal (Odisha), Kendujhar (Odisha), Khordha (Odisha), Koraput (Odisha), Mayurbhanj (Odisha), Sambalpur (Odisha), Sonepur (Odisha), Sundargarh (Odisha), Amritsar (Punjab), Gurdaspur (Punjab), Pathankot (Punjab), Banswara (Rajasthan), Udaipur (Rajasthan), Dhaulpur (Rajasthan), Karauli (Rajasthan), Sirohi (Rajasthan), Pali (Rajasthan), Jaipur (Rajasthan), Chittaurgarh (Rajasthan), Bharatpur (Rajasthan), Jhalawar (Rajasthan), Ganganagar (Rajasthan), Dausa (Rajasthan), Hanumangarh (Rajasthan), Churu (Rajasthan), Jalor (Rajasthan), Jodhpur (Rajasthan), Nagaur (Rajasthan), Rajsamand (Rajasthan), Tiruppattur (Tamil Nadu), Theni (Tamil Nadu), Namakkal (Tamil Nadu), Coimbatore (Tamil Nadu), Tiruppur (Tamil Nadu), Thiruvallur (Tamil Nadu), Chengalpattu (Tamil Nadu), Ramanathapuram (Tamil Nadu), Adilabad (Telangana), Medak (Telangana), North Tripura (Tripura), Chitrakoot (Uttar Pradesh), Sonbhadra (Uttar Pradesh),

Horizontal Expansion [Low Area-High Yield (LA-HY)] 193 districts	Vertical Expansion [High Area-Low Yield (HA-LY)] 97 districts	Horizontal & Vertical Expansion [Low Area-Low Yield (LA-LY)] 237 districts
		Mirzapur (Uttar Pradesh), Bhadohi (Uttar Pradesh), Kaushambi (Uttar Pradesh), Banda (Uttar Pradesh), Kanpur Dehat (Uttar Pradesh), Balrampur (Uttar Pradesh), Azamgarh (Uttar Pradesh), Aligarh (Uttar Pradesh), Sultanpur (Uttar Pradesh), Sant Kabir Nagar (Uttar Pradesh), Deoria (Uttar Pradesh), Mau (Uttar Pradesh), Gonda (Uttar Pradesh), Gorakhpur (Uttar Pradesh), Basti (Uttar Pradesh), Shrawasti (Uttar Pradesh), Etah (Uttar Pradesh), Faizabad (Uttar Pradesh), Sitapur (Uttar Pradesh), Bahraich (Uttar Pradesh), Siddharthnagar (Uttar Pradesh), Mathura (Uttar Pradesh), Bara Banki (Uttar Pradesh), Agra (Uttar Pradesh), Shamli (Uttar Pradesh), Muzaffarnagar (Uttar Pradesh), Saharanpur (Uttar Pradesh), Alipurduar (West Bengal), Jhargram (West Bengal), South Twenty Four Pargana (West Bengal), Darjiling (West Bengal), Jalpaiguri (West Bengal), Bankura (West Bengal), North Twenty Four Pargana (West Bengal), Dakshin Dinajpur (West Bengal), Medinipur West (West Bengal), Purba Medinipur (West Bengal), Howrah (West Bengal), Kalimpong (West Bengal) Bottom of Form

Table AIII.1.5: Lentil

Horizontal Expansion [Low Area-High Yield (LA-HY)] 131 districts	Vertical Expansion [High Area-Low Yield (HA-LY)] 52 districts	Horizontal & Vertical Expansion [Low Area-Low Yield (LA-LY)] 145 districts
Kamle (Arunachal Pradesh), Lower Siang (Arunachal Pradesh), Lepa Rada (Arunachal Pradesh), Biswanath (Assam), Darrang (Assam), Siwan (Bihar), Purba Champaran (Bihar), Vaishali (Bihar), Samastipur (Bihar), Begusarai (Bihar), Bhojpur (Bihar), Saran (Bihar), Gopalganj (Bihar), Khagaria (Bihar), Buxar (Bihar), Katihar (Bihar), Kondagaon (Chhattisgarh), Panipat (Haryana), Panchkula (Haryana), Kurukshetra (Haryana), Sirsa (Haryana), Kaithal (Haryana), Karnal (Haryana), Solan (Himachal Pradesh), Bilaspur (Himachal Pradesh), Shimla (Himachal Pradesh), Mandi (Himachal Pradesh), Chamba (Himachal Pradesh), Kangra (Himachal Pradesh), Kinnaur (Himachal Pradesh), Kullu (Himachal Pradesh), Sirmaur (Himachal Pradesh), Una (Himachal Pradesh), Bandipore (Jammu & Kashmir), Singrauli (Madhya Pradesh), Sidhi (Madhya Pradesh), Burhanpur (Madhya Pradesh), Chhindwara (Madhya Pradesh), Rewa (Madhya Pradesh), Jabalpur (Madhya Pradesh), Satna (Madhya Pradesh), Jhabua (Madhya Pradesh), Katni (Madhya Pradesh), Chhatarpur (Madhya Pradesh), Hoshangabad (Madhya Pradesh), Sheopur (Madhya Pradesh),	West Siang (Arunachal Pradesh), West Karbi Anglong (Assam), Chirang (Assam), Barpeta (Assam), Jamui (Bihar), Gaya (Bihar), Nawada (Bihar), Sheikhpura (Bihar), Bhagalpur (Bihar), Aurangabad (Bihar), Madhubani (Bihar), Latehar (Jharkhand), Ramgarh (Jharkhand), Palamu (Jharkhand), Chatra (Jharkhand), Pakur (Jharkhand), Sahibganj (Jharkhand), Saraikela-Kharsawan (Jharkhand), Hazaribagh (Jharkhand), Khunti (Jharkhand), Purbi Singhbhum (Jharkhand), Pashchimi Singhbhum (Jharkhand), Ranchi (Jharkhand), Jamtara (Jharkhand), Anuppur (Madhya Pradesh), West Nimar (Madhya Pradesh), Seoni (Madhya Pradesh), Agar Malwa (Madhya Pradesh), Zunheboto (Nagaland), Wokha (Nagaland), West Tripura (Tripura), Chitrakoot (Uttar Pradesh), Hamirpur (Uttar Pradesh), Sonbhadra (Uttar Pradesh), Mirzapur (Uttar Pradesh), Banda (Uttar Pradesh), Balrampur (Uttar Pradesh), Mahoba (Uttar Pradesh), Shrawasti (Uttar Pradesh),	Upper Dibang Valley (Arunachal Pradesh), Upper Subansiri (Arunachal Pradesh), Siang (Arunachal Pradesh), Papum Pare (Arunachal Pradesh), Lower Subansiri (Arunachal Pradesh), Tirap (Arunachal Pradesh), East Siang (Arunachal Pradesh), Lower Dibang Valley (Arunachal Pradesh), Anjaw (Arunachal Pradesh), Dima Hasao (Assam), Karbi Anglong (Assam), Goalpara (Assam), Kokrajhar (Assam), Bongaigaon (Assam), Sonitpur (Assam), Udalguri (Assam), Kamrup (Assam), South Salmara Mancachar (Assam), Nagaon (Assam), Kamrup Metropolitan (Assam), Morigaon (Assam), Cachar (Assam), Karimganj (Assam), Hailakandi (Assam), Golaghat (Assam), Tinsukia (Assam), Nalbari (Assam), Charaideo (Assam), Dhubri (Assam), Dhemaji (Assam), Lakhimpur (Assam), Dibrugarh (Assam), Jorhat (Assam), Sivasagar (Assam), Majuli (Assam), Hojai (Assam), Banka (Bihar), Muzaffarpur (Bihar), Kaimur (Bhabua) (Bihar), Darbhanga (Bihar), Munger (Bihar), Rohtas (Bihar), Kishanganj (Bihar),

Horizontal Expansion [Low Area-High Yield (LA-HY)] 131 districts	Vertical Expansion [High Area-Low Yield (HA-LY)] 52 districts	Horizontal & Vertical Expansion [Low Area-Low Yield (LA-LY)] 145 districts
Dewas (Madhya Pradesh), Dhar (Madhya Pradesh), Bhopal (Madhya Pradesh), Ratlam (Madhya Pradesh), Indore (Madhya Pradesh), Ujjain (Madhya Pradesh), Bhind (Madhya Pradesh), Gwalior (Madhya Pradesh), Neemuch (Madhya Pradesh), Tikamgarh (Madhya Pradesh), Guna (Madhya Pradesh), Niwari (Madhya Pradesh), South West Garo Hills (Meghalaya), South Garo Hills (Meghalaya), East Garo Hills (Meghalaya), North Garo Hills (Meghalaya), East Khasi Hills (Meghalaya), Sahibzada Ajit Singh Nagar (Punjab), Amritsar (Punjab), Gurdaspur (Punjab), Banswara (Rajasthan), Dhaulpur (Rajasthan), Alwar (Rajasthan), Sirohi (Rajasthan), Bhilwara (Rajasthan), Sawai Madhopur (Rajasthan), Chittaurgarh (Rajasthan), Bharatpur (Rajasthan), Kota (Rajasthan), Bundi (Rajasthan), Jhalawar (Rajasthan), Tonk (Rajasthan), Ganganagar (Rajasthan), Sikar (Rajasthan), Hanumangarh (Rajasthan), Bikaner (Rajasthan), Ajmer (Rajasthan), Baran (Rajasthan), Churu (Rajasthan), Jalor (Rajasthan), Jhunjhunun (Rajasthan), Jodhpur (Rajasthan), Nagaur (Rajasthan), Rajsamand (Rajasthan), Dhalai (Tripura), Bhadohi (Uttar Pradesh), Kaushambi (Uttar Pradesh), Fatehpur (Uttar Pradesh),	Sitapur (Uttar Pradesh), Bara Banki (Uttar Pradesh), Kheri (Uttar Pradesh), Mahrajganj (Uttar Pradesh), Tehri Garhwal (Uttarakhand), Bageshwar (Uttarakhand), Alipurduar (West Bengal), Birbhum (West Bengal), Paschim Bardhaman (West Bengal), Murshidabad (West Bengal), Nadia (West Bengal), North Twenty Four Parganas (West Bengal), Dakshin Dinajpur (West Bengal)	Sitamarhi (Bihar), Madhepura (Bihar), Araria (Bihar), Purnia (Bihar), Saharsa (Bihar), Supaul (Bihar), Koriya (Chhattisgarh), Balrampur (Chhattisgarh), Kabeerdham (Chhattisgarh), Surguja (Chhattisgarh), Jashpur (Chhattisgarh), Surajpur (Chhattisgarh), Bametara (Chhattisgarh), Rajnandgaon (Chhattisgarh), Durg (Chhattisgarh), Raigarh (Chhattisgarh), Gaurela-Pendra-Marwahi (Chhattisgarh), Mungeli (Chhattisgarh), Gariaband (Chhattisgarh), Korba (Chhattisgarh), Dakshin Bastar Dantewada (Chhattisgarh), Balod (Chhattisgarh), Baloda Bazar (Chhattisgarh), Janjgir-Champa (Chhattisgarh), Bastar (Chhattisgarh), Raipur (Chhattisgarh), Bilaspur (Chhattisgarh), Uttar Bastar Kanker (Chhattisgarh), Narayanpur (Chhattisgarh), Mahasamund (Chhattisgarh), Dhamtari (Chhattisgarh), Palwal (Haryana), Hisar (Haryana), Charki Dadri (Haryana), Ambala (Haryana), Baramula (Jammu & Kashmir), Jammu (Jammu & Kashmir), Kathua (Jammu & Kashmir),

Horizontal Expansion [Low Area-High Yield (LA-HY)] 131 districts	Vertical Expansion [High Area-Low Yield (HA-LY)] 52 districts	Horizontal & Vertical Expansion [Low Area-Low Yield (LA-LY)] 145 districts
Varanasi (Uttar Pradesh), Gautam Buddha Nagar (Uttar Pradesh), Pratapgarh (Uttar Pradesh), Jaunpur (Uttar Pradesh), Azamgarh (Uttar Pradesh), Rae Bareli (Uttar Pradesh), Sant Kabir Nagar (Uttar Pradesh), Bulandshahr (Uttar Pradesh), Mau (Uttar Pradesh), Ghaziabad (Uttar Pradesh), Basti (Uttar Pradesh), Hapur (Uttar Pradesh), Etawah (Uttar Pradesh), Siddharthnagar (Uttar Pradesh), Mathura (Uttar Pradesh), Lucknow (Uttar Pradesh), Unnao (Uttar Pradesh), Firozabad (Uttar Pradesh), Baghpat (Uttar Pradesh), Hardoi (Uttar Pradesh), Mainpuri (Uttar Pradesh), Agra (Uttar Pradesh), Meerut (Uttar Pradesh), Budaun (Uttar Pradesh), Bareilly (Uttar Pradesh), Shamli (Uttar Pradesh), Pilibhit (Uttar Pradesh), Muzaffarnagar (Uttar Pradesh), Saharanpur (Uttar Pradesh), Dehradun (Uttarakhand), Nainital (Uttarakhand), Hardwar (Uttarakhand), Jhargram (West Bengal), South Twenty Four Pargana (West Bengal), Medinipur West (West Bengal), Purba Bardhaman (West Bengal), Purba Medinipur (West Bengal)		Kishtwar (Jammu & Kashmir), Rajouri (Jammu & Kashmir), Dhanbad (Jharkhand), Lohardaga (Jharkhand), Giridih (Jharkhand), Leh (Ladakh), Shahdol (Madhya Pradesh), Betul (Madhya Pradesh), East Nimar (Madhya Pradesh), Morena (Madhya Pradesh), Sehore (Madhya Pradesh), Balaghat (Madhya Pradesh), Harda (Madhya Pradesh), Mandsaur (Madhya Pradesh), Datia (Madhya Pradesh), Ribhoi (Meghalaya), Tuensang (Nagaland), Kohima (Nagaland), Peren (Nagaland), Phek (Nagaland), Mon (Nagaland), Mokokchung (Nagaland), Dimapur (Nagaland), Hoshiarpur (Punjab), North Tripura (Tripura), Khowai (Tripura), Unokoti (Tripura), Gomati (Tripura), South Tripura (Tripura), Sipahijala (Tripura), Kanpur Dehat (Uttar Pradesh), Kanpur Nagar (Uttar Pradesh), Aligarh (Uttar Pradesh), Hathras (Uttar Pradesh), Deoria (Uttar Pradesh), Amethi (Uttar Pradesh), Auraiya (Uttar Pradesh), Gorakhpur (Uttar Pradesh), Ambedkar Nagar (Uttar Pradesh), Etah (Uttar Pradesh), Faizabad (Uttar Pradesh),

Horizontal Expansion [Low Area-High Yield (LA-HY)] **131 districts**	**Vertical Expansion [High Area-Low Yield (HA-LY)]** **52 districts**	**Horizontal & Vertical Expansion [Low Area-Low Yield (LA-LY)]** **145 districts**
		Farrukhabad (Uttar Pradesh), Kasganj (Uttar Pradesh), Kannauj (Uttar Pradesh), Kushinagar (Uttar Pradesh), Amroha (Uttar Pradesh), Sambhal (Uttar Pradesh), Moradabad (Uttar Pradesh), Rampur (Uttar Pradesh), Bijnor (Uttar Pradesh), Uttarkashi (Uttarakhand), Rudraprayag (Uttarakhand), Chamoli (Uttarakhand), Garhwal (Uttarakhand), Almora (Uttarakhand), Udham Singh Nagar (Uttarakhand), Puruliya (West Bengal), Uttar Dinajpur (West Bengal), Darjiling (West Bengal), Jalpaiguri (West Bengal), Bankura (West Bengal), Hooghly (West Bengal), Cooch Behar (West Bengal), Howrah (West Bengal)Bottom of Form

Table AIII.1.6: Pea

Horizontal Expansion [Low Area-High Yield (LA-HY)] 75 districts	Vertical Expansion [High Area-Low Yield (HA-LY)] 72 districts	Horizontal & Vertical Expansion [Low Area-Low Yield(LA-LY)] 238 districts
Upper Siang (Arunachal Pradesh), Papum Pare (Arunachal Pradesh), Shi Yomi (Arunachal Pradesh), Una (Himachal Pradesh), Bandipore (Jammu & Kashmir), Jammu (Jammu & Kashmir), Hoshangabad (Madhya Pradesh), Harda (Madhya Pradesh), South Garo Hills (Meghalaya), South West Khasi Hills (Meghalaya), Sangrur (Punjab), Udaipur (Rajasthan), Dhaulpur (Rajasthan), Karauli (Rajasthan), Alwar (Rajasthan), Sirohi (Rajasthan), Bhilwara (Rajasthan), Sawai Madhopur (Rajasthan), Chittaurgarh (Rajasthan), Bharatpur (Rajasthan), Kota (Rajasthan), Bundi (Rajasthan), Jhalawar (Rajasthan), Ganganagar (Rajasthan), Dausa (Rajasthan), Sikar (Rajasthan), Hanumangarh (Rajasthan), Bikaner (Rajasthan), Ajmer (Rajasthan), Baran (Rajasthan), Churu (Rajasthan), Jaisalmer (Rajasthan), Jalor (Rajasthan), Jhunjhunun (Rajasthan), Jodhpur (Rajasthan), Nagaur (Rajasthan), Rajsamand (Rajasthan), Kaushambi (Uttar Pradesh), Gautam Buddha Nagar (Uttar Pradesh), Balrampur (Uttar Pradesh), Ballia (Uttar Pradesh), Aligarh (Uttar Pradesh), Hathras (Uttar Pradesh), Bulandshahr (Uttar Pradesh),	Upper Dibang Valley (Arunachal Pradesh), East Kameng (Arunachal Pradesh), Pakke Kessang (Arunachal Pradesh), Upper Subansiri (Arunachal Pradesh), Longding (Arunachal Pradesh), Lower Siang (Arunachal Pradesh), Namsai (Arunachal Pradesh), Lohit (Arunachal Pradesh), Kurung Kumey (Arunachal Pradesh), Dima Hasao (Assam), West Karbi Anglong (Assam), Biswanath (Assam), Goalpara (Assam), Sonitpur (Assam), Darrang (Assam), Majuli (Assam), Patna (Bihar), Jehanabad (Bihar), Lakhisarai (Bihar), Yamunanagar (Haryana), Sirmaur (Himachal Pradesh), Srinagar (Jammu & Kashmir), Latehar (Jharkhand), Ramgarh (Jharkhand), Garhwa (Jharkhand), Palamu (Jharkhand), Chatra (Jharkhand), Pakur (Jharkhand), Godda (Jharkhand), Sahibganj (Jharkhand), Saraikela-Kharsawan (Jharkhand), Hazaribagh (Jharkhand), Dhanbad (Jharkhand),	Kamle (Arunachal Pradesh), Tirap (Arunachal Pradesh), East Siang (Arunachal Pradesh), Lower Dibang Valley (Arunachal Pradesh), Anjaw (Arunachal Pradesh), Changlang (Arunachal Pradesh), Karbi Anglong (Assam), Kokrajhar (Assam), Bongaigaon (Assam), Chirang (Assam), Udalguri (Assam), Baksa (Assam), Kamrup (Assam), South Salmara Mancachar (Assam), Nagaon (Assam), Kamrup Metropolitan (Assam), Barpeta (Assam), Morigaon (Assam), Cachar (Assam), Karimganj (Assam), Hailakandi (Assam), Golaghat (Assam), Tinsukia (Assam), Nalbari (Assam), Charaideo (Assam), Dhubri (Assam), Dhemaji (Assam), Lakhimpur (Assam), Dibrugarh (Assam), Jorhat (Assam), Sivasagar (Assam), Hojai (Assam), Jamui (Bihar), Nawada (Bihar), Banka (Bihar), Siwan (Bihar), Sheikhpura (Bihar), Purba Champaran (Bihar), Samastipur (Bihar), Begusarai (Bihar), Bhojpur (Bihar), Bhagalpur (Bihar), Muzaffarpur (Bihar), Kaimur (Bhabua) (Bihar), Aurangabad (Bihar), Saran (Bihar), Gopalganj (Bihar), Khagaria (Bihar), Arwal (Bihar), Munger (Bihar), Rohtas (Bihar), Nalanda (Bihar),

Horizontal Expansion [Low Area-High Yield (LA-HY)] 75 districts	Vertical Expansion [High Area-Low Yield (HA-LY)] 72 districts	Horizontal & Vertical Expansion [Low Area-Low Yield(LA-LY)] 238 districts
Deoria (Uttar Pradesh), Gonda (Uttar Pradesh), Ghaziabad (Uttar Pradesh), Gorakhpur (Uttar Pradesh), Shrawasti (Uttar Pradesh), Hapur (Uttar Pradesh), Etah (Uttar Pradesh), Faizabad (Uttar Pradesh), Bahraich (Uttar Pradesh), Mathura (Uttar Pradesh), Bara Banki (Uttar Pradesh), Firozabad (Uttar Pradesh), Baghpat (Uttar Pradesh), Kushinagar (Uttar Pradesh), Mainpuri (Uttar Pradesh), Agra (Uttar Pradesh), Amroha (Uttar Pradesh), Meerut (Uttar Pradesh), Mahrajganj (Uttar Pradesh), Sambhal (Uttar Pradesh), Budaun (Uttar Pradesh), Shahjahanpur (Uttar Pradesh), Moradabad (Uttar Pradesh), Rampur (Uttar Pradesh), Bareilly (Uttar Pradesh), Shamli (Uttar Pradesh), Bijnor (Uttar Pradesh), Pilibhit (Uttar Pradesh), Muzaffarnagar (Uttar Pradesh), Saharanpur (Uttar Pradesh), South Twenty Four Pargana (West Bengal)	Khunti (Jharkhand), Gumla (Jharkhand), Lohardaga (Jharkhand), Purbi Singhbhum (Jharkhand), Pashchimi Singhbhum (Jharkhand), Ranchi (Jharkhand), Giridih (Jharkhand), Jamtara (Jharkhand), Leh (Ladakh), Singrauli (Madhya Pradesh), Jabalpur (Madhya Pradesh), Mandla (Madhya Pradesh), West Nimar (Madhya Pradesh), Chhatarpur (Madhya Pradesh), Datia (Madhya Pradesh), Tikamgarh (Madhya Pradesh), Niwari (Madhya Pradesh), West Garo Hills (Meghalaya), Longleng (Nagaland), Kohima (Nagaland), Peren (Nagaland), Phek (Nagaland), Mon (Nagaland), Zunheboto (Nagaland), Wokha (Nagaland), Dhalai (Tripura), West Tripura (Tripura), Hamirpur (Uttar Pradesh), Sonbhadra (Uttar Pradesh), Mirzapur (Uttar Pradesh), Bhadohi (Uttar Pradesh), Pratapgarh (Uttar Pradesh), Azamgarh (Uttar Pradesh), Sant Kabir Nagar (Uttar Pradesh), Mahoba (Uttar Pradesh),	Madhubani (Bihar), Sheohar (Bihar), Buxar (Bihar), Pashchim Champaran (Bihar), Sitamarhi (Bihar), Madhepura (Bihar), Katihar (Bihar), Purnia (Bihar), Saharsa (Bihar), Supaul (Bihar), Koriya (Chhattisgarh), Balrampur (Chhattisgarh), Kabeerdham (Chhattisgarh), Surguja (Chhattisgarh), Jashpur (Chhattisgarh), Surajpur (Chhattisgarh), Bametara (Chhattisgarh), Rajnandgaon (Chhattisgarh), Durg (Chhattisgarh), Raigarh (Chhattisgarh), Gaurela-Pendra-Marwahi (Chhattisgarh), Mungeli (Chhattisgarh), Gariaband (Chhattisgarh), Korba (Chhattisgarh), Sukma (Chhattisgarh), Dakshin Bastar Dantewada (Chhattisgarh), Balod (Chhattisgarh), Baloda Bazar (Chhattisgarh), Janjgir - Champa (Chhattisgarh), Bastar (Chhattisgarh), Raipur (Chhattisgarh), Bilaspur (Chhattisgarh), Uttar Bastar Kanker (Chhattisgarh), Kondagaon (Chhattisgarh), Narayanpur (Chhattisgarh), Mahasamund (Chhattisgarh), Dhamtari (Chhattisgarh), Palwal (Haryana), Gurugram (Haryana), Jhajjar (Haryana), Mahendragarh (Haryana), Faridabad (Haryana), Bhiwani (Haryana), Sonipat (Haryana), Panipat (Haryana), Rewari (Haryana),

Horizontal Expansion [Low Area-High Yield (LA-HY)] 75 districts	Vertical Expansion [High Area-Low Yield (HA-LY)] 72 districts	Horizontal & Vertical Expansion [Low Area-Low Yield(LA-LY)] 238 districts
	Basti (Uttar Pradesh), Jhansi (Uttar Pradesh), Uttarkashi (Uttarakhand), Udham Singh Nagar (Uttarakhand)	Jind (Haryana), Kurukshetra (Haryana), Ambala (Haryana), Sirsa (Haryana), Fatehabad (Haryana), Kaithal (Haryana), Karnal (Haryana), Bilaspur (Himachal Pradesh), Anantnag (Jammu & Kashmir), Badgam (Jammu & Kashmir), Doda (Jammu & Kashmir), Ganderbal (Jammu & Kashmir), Kathua (Jammu & Kashmir), Kishtwar (Jammu & Kashmir), Kulgam (Jammu & Kashmir), Pulwama (Jammu & Kashmir), Punch (Jammu & Kashmir), Udhampur (Jammu & Kashmir), Sidhi (Madhya Pradesh), Narsimhapur (Madhya Pradesh), Umaria (Madhya Pradesh), Burhanpur (Madhya Pradesh), Shahdol (Madhya Pradesh), Raisen (Madhya Pradesh), Chhindwara (Madhya Pradesh), Panna (Madhya Pradesh), Betul (Madhya Pradesh), Alirajpur (Madhya Pradesh), Anuppur (Madhya Pradesh), Rewa (Madhya Pradesh), Satna (Madhya Pradesh), Dindori (Madhya Pradesh), Jhabua (Madhya Pradesh), Damoh (Madhya Pradesh), East Nimar (Madhya Pradesh), Barwani (Madhya Pradesh), Seoni (Madhya Pradesh), Katni (Madhya Pradesh), Sagar (Madhya Pradesh), Morena (Madhya Pradesh), Sehore (Madhya Pradesh), x

Horizontal Expansion [Low Area-High Yield (LA-HY)] 75 districts	Vertical Expansion [High Area-Low Yield (HA-LY)] 72 districts	Horizontal & Vertical Expansion [Low Area-Low Yield(LA-LY)] 238 districts
		Jind (Haryana), Kurukshetra (Haryana), Ambala (Haryana), Sirsa (Haryana), Fatehabad (Haryana), Kaithal (Haryana), Karnal (Haryana), Bilaspur (Himachal Pradesh), Anantnag (Jammu & Kashmir), Badgam (Jammu & Kashmir), Doda (Jammu & Kashmir), Ganderbal (Jammu & Kashmir), Kathua (Jammu & Kashmir), Kishtwar (Jammu & Kashmir), Kulgam (Jammu & Kashmir), Pulwama (Jammu & Kashmir), Punch (Jammu & Kashmir), Udhampur (Jammu & Kashmir), Sidhi (Madhya Pradesh), Narsimhapur (Madhya Pradesh), Umaria (Madhya Pradesh), Burhanpur (Madhya Pradesh), Shahdol (Madhya Pradesh), Raisen (Madhya Pradesh), Chhindwara (Madhya Pradesh), Panna (Madhya Pradesh), Betul (Madhya Pradesh), Alirajpur (Madhya Pradesh), Anuppur (Madhya Pradesh), Rewa (Madhya Pradesh), Satna (Madhya Pradesh), Dindori (Madhya Pradesh), Jhabua (Madhya Pradesh), Damoh (Madhya Pradesh), East Nimar (Madhya Pradesh), Barwani (Madhya Pradesh), Seoni (Madhya Pradesh), Katni (Madhya Pradesh), Sagar (Madhya Pradesh), Morena (Madhya Pradesh), Sehore (Madhya Pradesh), Sheopur (Madhya Pradesh),

Horizontal Expansion [Low Area-High Yield (LA-HY)] 75 districts	Vertical Expansion [High Area-Low Yield (HA-LY)] 72 districts	Horizontal & Vertical Expansion [Low Area-Low Yield(LA-LY)] 238 districts
		Balaghat (Madhya Pradesh), Dewas (Madhya Pradesh), Dhar (Madhya Pradesh), Bhopal (Madhya Pradesh), Vidisha (Madhya Pradesh), Shajapur (Madhya Pradesh), Rajgarh (Madhya Pradesh), Ratlam (Madhya Pradesh), Ashoknagar (Madhya Pradesh), Agar Malwa (Madhya Pradesh), Indore (Madhya Pradesh), Ujjain (Madhya Pradesh), Bhind (Madhya Pradesh), Gwalior (Madhya Pradesh), Mandsaur (Madhya Pradesh), Neemuch (Madhya Pradesh), Shivpuri (Madhya Pradesh), Guna (Madhya Pradesh), South West Garo Hills (Meghalaya), East Garo Hills (Meghalaya), North Garo Hills (Meghalaya), East Jaintia Hills (Meghalaya), West Jaintia Hills (Meghalaya), Ribhoi (Meghalaya), Tuensang (Nagaland), Mokokchung (Nagaland), Dimapur (Nagaland), Kiphire (Nagaland), Ludhiana (Punjab), Jalandhar (Punjab), Tarn Taran (Punjab), Amritsar (Punjab), Firozpur (Punjab), Hoshiarpur (Punjab), Kapurthala (Punjab), Patiala (Punjab), Shahid Bhagat Singh Nagar (Punjab), Pratapgarh (Rajasthan), Pali (Rajasthan), Jaipur (Rajasthan), Tonk (Rajasthan), North Tripura (Tripura), Khowai (Tripura), Unokoti (Tripura), Gomati (Tripura),

Horizontal Expansion [Low Area-High Yield (LA-HY)] 75 districts	Vertical Expansion [High Area-Low Yield (HA-LY)] 72 districts	Horizontal & Vertical Expansion [Low Area-Low Yield(LA-LY)] 238 districts
		South Tripura (Tripura), Sipahijala (Tripura), Chitrakoot (Uttar Pradesh), Banda (Uttar Pradesh), Fatehpur (Uttar Pradesh), Prayagraj (Uttar Pradesh), Kanpur Dehat (Uttar Pradesh), Kanpur Nagar (Uttar Pradesh), Chandauli (Uttar Pradesh), Rae Bareli (Uttar Pradesh), Ghazipur (Uttar Pradesh), Auraiya (Uttar Pradesh), Mau (Uttar Pradesh), Etawah (Uttar Pradesh), Sitapur (Uttar Pradesh), Siddharthnagar (Uttar Pradesh), Farrukhabad (Uttar Pradesh), Lucknow (Uttar Pradesh), Unnao (Uttar Pradesh), Kannauj (Uttar Pradesh), Hardoi (Uttar Pradesh), Kheri (Uttar Pradesh), Tehri Garhwal (Uttarakhand), Dehradun (Uttarakhand), Rudraprayag (Uttarakhand), Chamoli (Uttarakhand), Garhwal (Uttarakhand), Almora (Uttarakhand), Nainital (Uttarakhand), Pithoragarh (Uttarakhand), Champawat (Uttarakhand), Bageshwar (Uttarakhand), Hardwar (Uttarakhand), Alipurduar (West Bengal), Puruliya (West Bengal), Birbhum (West Bengal), Paschim Bardhaman (West Bengal), Jhargram (West Bengal), Uttar Dinajpur (West Bengal),

Horizontal Expansion [Low Area-High Yield (LA-HY)] 75 districts	Vertical Expansion [High Area-Low Yield (HA-LY)] 72 districts	Horizontal & Vertical Expansion [Low Area-Low Yield(LA-LY)] 238 districts
		Murshidabad (West Bengal), Maldah (West Bengal), Darjiling (West Bengal), Jalpaiguri (West Bengal), Nadia (West Bengal), Bankura (West Bengal), North Twenty Four Parganas (West Bengal), Dakshin Dinajpur (West Bengal), Hooghly (West Bengal), Medinipur West (West Bengal), Purba Bardhaman (West Bengal), Cooch Behar (West Bengal), Howrah (West Bengal), Kalimpong (West Bengal) Bottom of Form

Table AIII.1.7:Mothbean

Horizontal Expansion [Low Area-High Yield (LA-HY)] 39 districts	Vertical Expansion [High Area-Low Yield (HA-LY)] 7 districts	Horizontal & Vertical Expansion [Low Area-Low Yield (LA-LY)] 22 districts
Bharuch (Gujarat), Vadodara (Gujarat), Tapi (Gujarat), Rajkot (Gujarat), Gir Somnath (Gujarat), Amreli (Gujarat), Jamnagar (Gujarat), Surendranagar (Gujarat), Bhavnagar (Gujarat), Botad (Gujarat), Kheda (Gujarat), Mahesana (Gujarat), Banas Kantha (Gujarat), Kachchh (Gujarat), Gandhinagar (Gujarat), Solan (Himachal Pradesh), Bilaspur (Himachal Pradesh), Shimla (Himachal Pradesh), Chamba (Himachal Pradesh), Una (Himachal Pradesh), Anantnag (Jammu & Kashmir), Baramula (Jammu & Kashmir), Badgam (Jammu & Kashmir), Ganderbal (Jammu & Kashmir), Jammu (Jammu & Kashmir), Kulgam (Jammu & Kashmir), Pulwama (Jammu & Kashmir), Punch (Jammu & Kashmir), Reasi (Jammu & Kashmir), Udhampur (Jammu & Kashmir), Udaipur (Rajasthan), Dungarpur (Rajasthan), Bhilwara (Rajasthan), Sawai Madhopur (Rajasthan), Bharatpur (Rajasthan), Dausa (Rajasthan), Jalor (Rajasthan), Rajsamand (Rajasthan), Nainital (Uttarakhand)	Yamunanagar (Haryana), Hanumangarh (Rajasthan), Bikaner (Rajasthan), Churu (Rajasthan), Jaisalmer (Rajasthan), Jodhpur (Rajasthan), Nagaur (Rajasthan)	Panch Mahals (Gujarat), Patan (Gujarat), Palwal (Haryana), Bhiwani (Haryana), Hisar (Haryana), Charki Dadri (Haryana), Panchkula (Haryana), Kurukshetra (Haryana), Ambala (Haryana), Sirsa (Haryana), Fatehabad (Haryana), Kaithal (Haryana), Dhaulpur (Rajasthan), Karauli (Rajasthan), Sirohi (Rajasthan), Pali (Rajasthan), Jaipur (Rajasthan), Tonk (Rajasthan), Ganganagar (Rajasthan), Sikar (Rajasthan), Ajmer (Rajasthan), Jhunjhunun (Rajasthan)Bottom of Form

ANNEXURE-III.2: High Area and High Yield (HA-HY) District-Specific Clusters

Table AIII.2.1: High Area and High Yield (HA-HY) District-Specific Clusters

Pulse Crops	HA-HY District-Specific Clusters
Pigeonpea (48 districts)	Bharuch (Gujarat), Narmada (Gujarat), Vadodara (Gujarat), Panch Mahals (Gujarat), Chota Udaipur (Gujarat), Surat (Gujarat), Kodarma (Jharkhand), Latehar (Jharkhand), Ramgarh (Jharkhand), Bokaro (Jharkhand), Palamu (Jharkhand), Chatra (Jharkhand), Saraikela-Kharsawan (Jharkhand), Hazaribagh (Jharkhand), Dhanbad (Jharkhand), Simdega (Jharkhand), Khunti (Jharkhand), Gumla (Jharkhand), Lohardaga (Jharkhand), Purbi Singhbhum (Jharkhand), Pashchimi Singhbhum (Jharkhand), Deoghar (Jharkhand), Giridih (Jharkhand), Jamtara (Jharkhand), Singrauli (Madhya Pradesh), Narsimhapur (Madhya Pradesh), Burhanpur (Madhya Pradesh), Wardha (Maharashtra), Buldana (Maharashtra), Akola (Maharashtra), Nagpur (Maharashtra), Chandrapur (Maharashtra), Jalna (Maharashtra), Parbhani (Maharashtra), Bid (Maharashtra), Dharmapuri (Tamil Nadu), Krishnagiri (Tamil Nadu), Kumuram Bheem Asifabad (Telangana), Chitrakoot (Uttar Pradesh), Hamirpur (Uttar Pradesh), Mirzapur (Uttar Pradesh), Bhadohi (Uttar Pradesh), Kaushambi (Uttar Pradesh), Banda (Uttar Pradesh), Fatehpur (Uttar Pradesh), Prayagraj (Uttar Pradesh), Varanasi (Uttar Pradesh), Tehri Garhwal (Uttarakhand

Pulse Crops	HA-HY District-Specific Clusters
Chickpea (99 districts)	Prakasam (Andhra Pradesh), Nandyal (Andhra Pradesh), Kurnool (Andhra Pradesh), Y.S.R. (Andhra Pradesh), Bapatla (Andhra Pradesh), Junagadh (Gujarat), Rajkot (Gujarat), Gir Somnath (Gujarat), Amreli (Gujarat), Jamnagar (Gujarat), Morbi (Gujarat), Bhavnagar (Gujarat), Botad (Gujarat), Porbandar (Gujarat), Devbhumi Dwarka (Gujarat), Kodarma (Jharkhand), Ramgarh (Jharkhand), Garhwa (Jharkhand), Bokaro (Jharkhand), Godda (Jharkhand), Sahibganj (Jharkhand), Saraikela-Kharsawan (Jharkhand), Hazaribagh (Jharkhand), Dumka (Jharkhand), Dhanbad (Jharkhand), Simdega (Jharkhand), Khunti (Jharkhand), Deoghar (Jharkhand), Giridih (Jharkhand), Belagavi (Karnataka), Singrauli (Madhya Pradesh), Narsimhapur (Madhya Pradesh), Umaria (Madhya Pradesh), Burhanpur (Madhya Pradesh), Raisen (Madhya Pradesh), Chhindwara (Madhya Pradesh), Panna (Madhya Pradesh), Betul (Madhya Pradesh), Satna (Madhya Pradesh), Jhabua (Madhya Pradesh), Damoh (Madhya Pradesh), West Nimar (Madhya Pradesh), East Nimar (Madhya Pradesh), Seoni (Madhya Pradesh), Katni (Madhya Pradesh), Chhatarpur (Madhya Pradesh), Sagar (Madhya Pradesh), Hoshangabad (Madhya Pradesh), Sehore (Madhya Pradesh), Sheopur (Madhya Pradesh), Balaghat (Madhya Pradesh), Dewas (Madhya Pradesh), Dhar (Madhya Pradesh), Vidisha (Madhya Pradesh), Harda (Madhya Pradesh), Ratlam (Madhya Pradesh), Ashoknagar (Madhya Pradesh), Mandsaur (Madhya Pradesh), Neemuch (Madhya Pradesh), Shivpuri (Madhya Pradesh), Guna (Madhya Pradesh), Wardha (Maharashtra), Washim (Maharashtra), Buldana (Maharashtra), Akola (Maharashtra), Nagpur (Maharashtra), Jalna (Maharashtra), Jalgaon (Maharashtra), Udaipur (Rajasthan), Dungarpur (Rajasthan), Pratapgarh (Rajasthan), Pali (Rajasthan), Bhilwara (Rajasthan), Jaipur (Rajasthan), Sawai Madhopur (Rajasthan), Chittaurgarh (Rajasthan), Kota (Rajasthan), Jhalawar (Rajasthan), Tonk (Rajasthan), Dausa (Rajasthan), Sikar (Rajasthan), Baran (Rajasthan), Jhunjhunun (Rajasthan), Rajsamand (Rajasthan), Adilabad (Telangana), Yadadri Bhuvanagiri (Telangana), Nirmal (Telangana), Kamareddy (Telangana), Chitrakoot (Uttar Pradesh), Hamirpur (Uttar Pradesh), Sonbhadra (Uttar Pradesh), Kaushambi (Uttar Pradesh), Banda (Uttar Pradesh), Fatehpur (Uttar Pradesh), Kanpur Dehat (Uttar Pradesh), Kanpur Nagar (Uttar Pradesh), Jalaun (Uttar Pradesh), Mahoba (Uttar Pradesh), Jhansi (Uttar Pradesh)

Pulse Crops	HA-HY District-Specific Clusters
Green Gram (53 districts)	Y.S.R. (Andhra Pradesh), Bapatla (Andhra Pradesh), Guntur (Andhra Pradesh), Eluru (Andhra Pradesh), West Godavari (Andhra Pradesh), West Siang (Arunachal Pradesh), Tawang (Arunachal Pradesh), Majuli (Assam), Banka (Bihar), Vaishali (Bihar), Samastipur (Bihar), Muzaffarpur (Bihar), Sheohar (Bihar), Madhepura (Bihar), Junagadh (Gujarat), Porbandar (Gujarat), Hisar (Haryana), Yamunanagar (Haryana), Kodarma (Jharkhand), Latehar (Jharkhand), Ramgarh (Jharkhand), Bokaro (Jharkhand), Chatra (Jharkhand), Pakur (Jharkhand), Saraikela-Kharsawan (Jharkhand), Hazaribagh (Jharkhand), Dumka (Jharkhand), Dhanbad (Jharkhand), Khunti (Jharkhand), Pashchimi Singhbhum (Jharkhand), Narsimhapur (Madhya Pradesh), Raisen (Madhya Pradesh), Jabalpur (Madhya Pradesh), Damoh (Madhya Pradesh), West Nimar (Madhya Pradesh), East Nimar (Madhya Pradesh), Sagar (Madhya Pradesh), Hoshangabad (Madhya Pradesh), Sehore (Madhya Pradesh), Dewas (Madhya Pradesh), Harda (Madhya Pradesh), Osmanabad (Maharashtra), Parbhani (Maharashtra), Satara (Maharashtra), Zunheboto (Nagaland), Wokha (Nagaland), Yanam (Puducherry), Salem (Tamil Nadu), Namakkal (Tamil Nadu), Thiruvallur (Tamil Nadu), Sangareddy (Telangana), West Tripura (Tripura), Etawah (Uttar Pradesh)
Black Gram (68 districts)	Nandyal (Andhra Pradesh), Y.S.R. (Andhra Pradesh), Bapatla (Andhra Pradesh), Sri Potti Sriramulu Nellore (Andhra Pradesh), Srikakulam (Andhra Pradesh), Kakinada (Andhra Pradesh), Vizianagaram (Andhra Pradesh), Eluru (Andhra Pradesh), Krishna (Andhra Pradesh), West Godavari (Andhra Pradesh), West Siang (Arunachal Pradesh), Bongaigaon (Assam), South Salmara Mancachar (Assam), Barpeta (Assam), Dhubri (Assam), The Dangs (Gujarat), Sabar Kantha (Gujarat), Gir Somnath (Gujarat), Kodarma (Jharkhand), Latehar (Jharkhand), Ramgarh (Jharkhand), Garhwa (Jharkhand), Bokaro (Jharkhand), Palamu (Jharkhand), Chatra (Jharkhand), Pakur (Jharkhand), Sahibganj (Jharkhand), Saraikela-Kharsawan (Jharkhand), Hazaribagh (Jharkhand), Dumka (Jharkhand), Dhanbad (Jharkhand), Simdega (Jharkhand), Khunti (Jharkhand), Gumla (Jharkhand), Purbi Singhbhum (Jharkhand), Pashchimi Singhbhum (Jharkhand), Deoghar (Jharkhand), Ranchi (Jharkhand), Giridih (Jharkhand), Jamtara (Jharkhand), Jabalpur (Madhya Pradesh), Buldana (Maharashtra), Osmanabad (Maharashtra), Bid (Maharashtra), Ahmadnagar (Maharashtra), Sangli (Maharashtra), Zunheboto (Nagaland), Wokha (Nagaland), Yanam (Puducherry), Tiruvannamalai (Tamil Nadu), Pudukkottai (Tamil Nadu), Thanjavur (Tamil Nadu), Kallakurichchi (Tamil Nadu), Viluppuram (Tamil Nadu), Tirunelveli (Tamil Nadu), Wanaparthy (Telangana), Yadadri Bhuvanagiri (Telangana), Dhalai (Tripura), West Tripura (Tripura), Pratapgarh (Uttar Pradesh), Jalaun (Uttar Pradesh), Lucknow (Uttar Pradesh), Sambhal (Uttar Pradesh), Budaun (Uttar Pradesh), Tehri Garhwal (Uttarakhand), Uttarkashi (Uttarakhand), Garhwal (Uttarakhand), Nainital (Uttarakhand)

Pulse Crops	HA-HY District-Specific Clusters
Lentil (46 districts)	Baksa (Assam), Patna (Bihar), Jehanabad (Bihar), Arwal (Bihar), Lakhisarai (Bihar), Nalanda (Bihar), Sheohar (Bihar), Pashchim Champaran (Bihar), Yamunanagar (Haryana), Kodarma (Jharkhand), Garhwa (Jharkhand), Bokaro (Jharkhand), Godda (Jharkhand), Dumka (Jharkhand), Simdega (Jharkhand), Gumla (Jharkhand), Deoghar (Jharkhand), Narsimhapur (Madhya Pradesh), Umaria (Madhya Pradesh), Raisen (Madhya Pradesh), Panna (Madhya Pradesh), Dindori (Madhya Pradesh), Damoh (Madhya Pradesh), Mandla (Madhya Pradesh), Sagar (Madhya Pradesh), Vidisha (Madhya Pradesh), Shajapur (Madhya Pradesh), Rajgarh (Madhya Pradesh), Ashoknagar (Madhya Pradesh), Shivpuri (Madhya Pradesh), West Garo Hills (Meghalaya), Pratapgarh (Rajasthan), Prayagraj (Uttar Pradesh), Ballia (Uttar Pradesh), Chandauli (Uttar Pradesh), Sultanpur (Uttar Pradesh), Ghazipur (Uttar Pradesh), Jalaun (Uttar Pradesh), Gonda (Uttar Pradesh), Bahraich (Uttar Pradesh), Jhansi (Uttar Pradesh), Shahjahanpur (Uttar Pradesh), Lalitpur (Uttar Pradesh), Pithoragarh (Uttarakhand), Champawat (Uttarakhand), Maldah (West Bengal)
Pea and Bean (28 districts)	Siang (Arunachal Pradesh), Lower Subansiri (Arunachal Pradesh), West Siang (Arunachal Pradesh), Lepa Rada (Arunachal Pradesh), Kra Daadi (Arunachal Pradesh), West Kameng (Arunachal Pradesh), Solan (Himachal Pradesh), Shimla (Himachal Pradesh), Mandi (Himachal Pradesh), Chamba (Himachal Pradesh), Kinnaur (Himachal Pradesh), Kullu (Himachal Pradesh), Lahul & Spiti (Himachal Pradesh), Kodarma (Jharkhand), Bokaro (Jharkhand), Dumka (Jharkhand), Simdega (Jharkhand), Deoghar (Jharkhand), East Khasi Hills (Meghalaya), West Khasi Hills (Meghalaya), Varanasi (Uttar Pradesh), Jaunpur (Uttar Pradesh), Sultanpur (Uttar Pradesh), Jalaun (Uttar Pradesh), Amethi (Uttar Pradesh), Ambedkar Nagar (Uttar Pradesh), Kasganj (Uttar Pradesh), Lalitpur (Uttar Pradesh)
Mothbean (3 districts)	Ahmadabad (Gujarat), Bandipore (Jammu & Kashmir), Barmer (Rajasthan)

ANNEXURE-IV: Insights into Pulse Cultivation: A Survey of Indian Farmers

Examining pulse production across India at state and national levels is essential to grasp the complexities within the agriculture sector. This analysis offers a comprehensive look into regional strengths, challenges, and opportunities in pulse farming, which is crucial for creating effective policies and strategies tailored to each region. The state-wise exploration highlights unique regional characteristics and production dynamics. At the same time, the all-India perspective provides a cohesive understanding of the pulse sector's contribution to food security, nutrition, and income for farmers. Given the crop's nitrogen-fixing benefits, achieving self-sufficiency in pulses can address protein security for the population and contribute to sustainable agricultural practices.

This section presents an in-depth study of pulse cultivation in key growing states based on primary survey data from NITI Aayog and lays the groundwork for informed decision-making and sustainable growth in this critical sector.

i. Sampling Framework of Selected Farmers

The survey of pulse production in 5 states was conducted to assess the current status of pulse production in the country. The sampling framework showing selected districts of the sample states is shown in Figure AIV.1. The sample size for the survey was 885 farmers from different states, having different socio-economic profiles, cropping patterns, and land holdings relating to pulse production (Table AIV.1 and Table AIV.2).

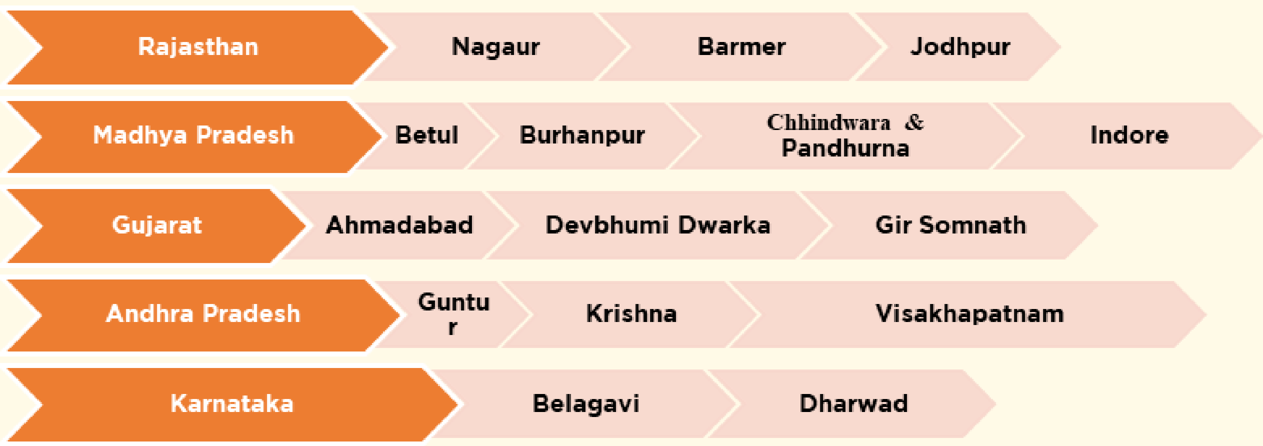


Figure AIV.1: Sampling framework showing selected districts of the sample states

The survey also found a significant variation in pulse production across different states. This variation is due to several factors, including climate, soil type, and irrigation practices. This decline is due to several factors, including the increasing use of fertilizers and pesticides and adopting new agricultural technologies. The survey findings suggest a need to improve pulse production in the country. This can be done by several measures, including developing new pulse varieties, promoting sustainable agricultural practices, and providing better access to credit and inputs for pulse farmers.

Table AIV.1: Sampling Framework with Land Holdings

States/UTs	Marginal (Below 1.0 ha.)	Small (1.00-1.99 ha.)	Semi-medium (2.00-3.99 ha.)	Medium (4.00-9.99 ha.)	Large (10.00 ha. & above)
Madhya Pradesh	51.84	25.44	15.74	5.66	1.32
Rajasthan	43.64	20.12	17.50	13.37	5.37
Karnataka	58.43	23.72	12.74	3.79	1.33
Gujarat	41.45	28.58	20.62	7.92	1.43
Andhra Pradesh	72.85	17.54	8.04	0.71	0.86

The above table illustrates the distribution of land holdings by size category across selected Indian states. Marginal farmers (holding less than 1 hectare) dominate in all states, particularly in Andhra Pradesh (72.85%) and Karnataka (58.43%). Small farmers (1.0-1.99 hectares) also make up a significant portion of states like Gujarat (28.58%) and Madhya Pradesh (25.44%). The proportion of larger landholders (10 hectares and above) is relatively low across all states, with Rajasthan showing the highest percentage (5.37%) for this category. Rajasthan and Gujarat also have a comparatively higher share of medium-sized holdings (4.00-9.99 hectares), highlighting regional variations in landholding patterns across these states.

Table AIV.2: State-wise Distribution of Pulse Crops in Surveyed Districts

Sr No	State	Districts	Pulse Crop(s) in Region Surveyed	No. of Farmers Surveyed
1	Andhra Pradesh	Guntur	Black Gram	65
		Krishna	Black Gram	65
		Visakhapatnam	Black Gram	65
2	Gujarat	Ahmadabad	Chickpea	60
		Devbhumi Dwarka	Chickpea	60
		Gir Somnath	Chickpea, Black Gram	50
3	Karnataka	Belagavi	Pigeonpea	60
		Dharwad	Pigeonpea	60
4	Madhya Pradesh	Betul	Pigeonpea, Chickpea, Green Gram	60
		Chhindwara & Pandhurna	Pigeonpea, Chickpea, Green Gram, Black Gram	60
		Burhanpurkic	Pigeonpea, Green Gram	60
		Indore	Pigeonpea, Green Gram	60
5	Rajasthan	Barmer	Green Gram	50
		Nagaur	Green Gram	60
		Jodhpur	Green Gram	50
Total				**885**

The table AIV.2 provides details of pulse crops surveyed across districts in five states: Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, and Rajasthan. The total number of farmers surveyed is 885, distributed across 13 districts. Andhra Pradesh focuses on Black Gram, with 65 farmers surveyed in each district. Gujarat covers Chickpea and Black Gram across three districts, with the number of surveyed farmers varying between 50 and 60. Karnataka primarily surveys Arhar in two districts, with 60 farmers each. Madhya Pradesh includes diverse pulses such as Arhar, Gram, Moong, and Urd, surveying 60 farmers per district across four districts. Rajasthan focuses on Moong, with farmers surveyed ranging between 50 and 60.

Table AIV.3: Demographic Profile of the Respondents (% of households) – participants

States **Characteristics**		**Madhya Pradesh**	**Rajasthan**	**Karnataka**	**Gujarat**	**Andhra Pradesh**	**Aggregate**
No of Sample (Households)							
Farming experience of the respondents (years)		48.88	50.88	55.09	53.05	49.32	50.91
Age group	18-30 Yrs	3.78	3.09	1.17	1.29	2.69	3.56
	31-40 Yrs	19	12.54	6.76	8.89	15.74	12.59
	41-50 Yrs	31.79	33.41	23.08	29.25	37.02	29.96
	51-60 Yrs	31.13	30.89	31.53	35.98	30.25	33.84
	61-65 Yrs	7.49	10.1	25.88	12.92	7.94	12.24
	66 Yrs & Above	6.8	9.97	11.58	11.67	6.35	7.80
Education status	Illiterate	0.13	5.4	14.3	7.78	11.4	7.04
	Up to primary	30.23	30.77	42.36	27.78	36.12	27.64
	up to secondary	35.51	40.42	21.33	23.28	41.83	41.12
	up to graduate	22.64	8.51	8.67	19.22	6.45	11.87
	above graduate	11.49	14.9	13.34	21.94	4.2	12.32
Main occupation	Farming	86.89	77.3	86.1	80.3	77.2	81.06
Self-business **6.9** **12.4**				9.89	13.4	10.2	10.28
	Salaried/ pensioners	1.4	3.2	3.4	2.4	5.2	3.77
	wage earners	2.1	5	0	2.1	1.5	2.29
	Others	2.71	2.1	0.61	1.8	5.9	2.60

ii. Farmers' Socio-economic Profile

The socio-economic factors furnish a base for further planning and development of the agriculture sector. The standard of living of people depends upon their socio-economic status. The socioeconomic status of farmers can be assessed or quantified through various parameters like age-wise distribution of farmers, their educational status, their size of land holdings, their farming experience, etc. Table AIV.3 presents a brief overview of the demographic profile of the respondents. It can be clearly seen from the statistics that there are wide variations in the socio-economic profile of the households across the sample states.

The table outlines farming households' demographic and socio-economic attributes across various Indian states. On average, respondents have 50.91 years of farming experience. Karnataka (55.09 years) has the highest experience, while Madhya Pradesh (48.88 years) has the lowest depicting that the farmers are highly experienced, suggesting a deep understanding of traditional agricultural practices.

The farming population is aging, and the low representation of youth indicates potential challenges for future agricultural sustainability. Very few young respondents (18-30 years) are engaged in farming, with Karnataka and Gujarat reporting the least. The aggregate is 3.56%, reflecting a declining interest in agriculture among youth. Most of the farmers fall into the 31-60 age group (76.39% aggregate).

The majority of farmers possess basic education, which can support modern agricultural practices. However, higher education levels are still limited. The overall illiteracy rate is 7.04%. Karnataka has the highest rate (14.3%), while Madhya Pradesh (0.13%) has the lowest. A significant proportion of farmers have completed primary (27.64%) and secondary education (41.12%). Around 24.19% of respondents are graduates or above, with Gujarat having the highest share of above-graduates (21.94%).

iii. Holding Size

The details of the respondents' average size of land holdings are given in Table AIV.4. It is discernible from the table that the landholding patterns and agricultural metrics across five states. Karnataka has the largest owned area (11.2 acres) but a smaller net operated area (9.3 acres), indicating some land may be left uncultivated, while its gross cropped area (16.2 acres) and high cropping intensity (135.3%) reflect efficient land use through multiple cropping. Rajasthan shows a significant gap between its owned area (6.1 acres) and net operated area (5.1 acres), suggesting land may be leased out or fallow, yet it achieves the highest cropping intensity (135.9%) due to intensive farming.

Madhya Pradesh has consistent figures for owned and net operated area (7.1 acres), with moderate cropping intensity (131.3%) and the highest irrigation coverage (81.7%), supporting stable agricultural output. Andhra Pradesh shows a higher net operated area (7.2 acres) than owned, likely due to leased land, and its high gross cropped area (13.5 acres) reflects effective land use despite a lower cropping intensity (119.2%). Gujarat reports the smallest owned area (5.1 acres) and gross cropped area (8.6 acres) alongside the lowest irrigation coverage (59%), which restricts cropping intensity (122%).

Table AIV.4: Average Size of Land Holdings of the Respondents (in acres)

States	Owned area	Net operated area	Gross cropped area	Cropping intensity (%)	Area irrigated (%)
Rajasthan	6.1	5.1	12.8	135.9	65.2
Madhya Pradesh	7.1	7.1	9.7	131.3	81.7
Gujarat	5.1	5.6	8.6	122%	59
Andhra Pradesh	6.4	7.2	13.5	119.2	81.2
Karnataka	11.2	9.3	16.2	135.3	71.6

iv. Knowledge of MSP to the Farmers

The survey on pulse cultivation in various states provided valuable insights into farmers' awareness and engagement with Minimum Support Price (MSP) policies. Among the surveyed farmers, a substantial 94.2% on aggregate were found to be aware of the MSP provided by the government. This high level of awareness indicates that the majority of farmers are well-informed about the government's MSP initiatives, reflecting the successful dissemination and accessibility of this important information.

v. Constraints Faced by Farmers in Growing Pulses

The opinion and suggestions of farmers regarding the cultivation of pulses in each state is presented in Table AIV.5 and are summarized below.

Table AIV.5: Constraints Faced by Farmers in Growing Pulses

Constraint Type	Issue	Rajasthan	Madhya Pradesh	Gujarat	Andhra Pradesh	Karnataka	Aggregate
Production Constraints	Non-availability of suitable varieties	25	27	28	29	26	27
	Poor crop germination	42	45	47	46	43	45
	Lack of irrigation facilities	29	25	28	27	30	28
	Poor quality of soils	54	50	48	47	53	50
	High input costs (diesel, fertilizer, etc.)	82	79	81	78	84	81
	Timely availability of seed	25	27	28	29	26	27
	Poor-quality supply of inputs	60	62	58	55	61	59

Constraint Type	Issue	Rajasthan	Madhya Pradesh	Gujarat	Andhra Pradesh	Karnataka	Aggregate
Marketing Constraints	High mandi charges	55	58	54	50	57	55
	Uneven bargaining power with intermediaries	63	65	64	66	62	64
	Low, fluctuating prices at harvest	80	82	78	81	79	80
Information Access	Lack of awareness of pulse technologies	70	69	68	65	71	69
	Poor extension services	61	62	60	58	63	61
	Lack of price and market info	72	71	73	70	69	71
Infras-tructure & Institutional	Lack of institutional credit	65	64	66	63	67	65
	Irregular power supply	83	85	82	78	80	82
	Poor marketing system/ access	74	76	75	73	71	74
	Lack of processing facilities	69	68	67	64	70	68
	Lack of transport means	62	66	63	60	65	63
	Inadequate storage	76	73	75	71	77	74
	Poor road infrastructure	68	67	64	69	65	67
	High transportation costs	80	79	77	75	82	79
Natural Constraints	Extreme temperature variations	73	72	74	68	71	72
	Excessive rains	65	64	63	60	66	64

State-wise Summary of the Survey is Given Below:

a). Rajasthan:

i. Nearly 60% of pulse farming relies on rain-fed systems, making production vulnerable to irregular rainfall and drought. Farmers proposed promoting water conservation techniques like rainwater harvesting and implementing Furrow Irrigated Raised Bed (FIRB) systems to reduce water stress.

ii. Government procurement at MSP has supported some farmers (such as those in Nagaur), but many districts lack this benefit, impacting income stability. Farmers suggested expanding MSP-based procurement initiatives to more districts to support a larger number of pulse growers.

iii. The high price of quality seeds and bio-fertilizers discourages regular adoption of resilient, high-yield varieties. Farmers mentioned that subsidies or financial assistance for these inputs would enable them to use improved seed varieties.

iv. Farmers were worried about unpredictable weather and yield variability. They propose expanding crop insurance schemes to manage pulses farming risks, thereby promoting sector investment.

v. Inadequate local storage facilities and high transportation costs lead to significant post-harvest losses and reduce profitability.

vi. There are no processing units or storage facilities available at the farm level, which affects farmers' ability to manage their produce efficiently.

vii. Essential nutrients like zinc, iron, and boron are often lacking in Rajasthan's soils, affecting pulse crop productivity. Farmers themselves suggested that access to balanced micronutrient fertilizers at subsidized prices and more soil testing facilities would help address this issue.

b) Madhya Pradesh:

i. Chickpea and lentil crops are frequently affected by pests like pod borers and wilt diseases, leading to significant crop losses each season. Farmers suggested promoting pest-resistant seed varieties and increasing access to bio-pesticides to manage these issues effectively.

ii. The decline in pulses (Moong, Arhar) cultivation in Indore over the past decade is primarily due to crop losses from wild boar and pig attacks and a shift to high-value crops like Garlic and Onion. Farmers with access to irrigation prefer short-duration, high-return crops over long-duration pulses like Arhar.

iii. Farmers demand regular electricity supply, proper storage facilities at the village level, strengthening of extension and market intelligence services, and the establishment of more regulated market/purchase centres.

iv. Farmers expressed a need for short-duration pulse varieties that could better suit the local growing conditions.

v. Farmers reported that maximum labour is required during harvesting, threshing, bagging, transportation, and other field operations, increasing production costs.

They expressed a need for more mechanized solutions and labour-efficient practices to reduce labour dependency and lower costs.

vi. The decline in pulse cultivation is further driven by issues such as the timely availability of seeds and fertilizers, with hoarding and cartelization by merchants contributing to shortages. Additionally, farmers are hesitant to use nano-urea and prefer selling gram as a horticultural crop for better financial returns instead of classifying it as a pulse.

vii. Limited storage facilities and weak market linkages often force farmers into distressed sales, contributing to income instability. Farmers suggested establishing better local storage facilities and strengthening market linkages to reduce post-harvest losses and allow for more profitable sales.

viii. Farmers also face competition from banana, cotton, and sugarcane crops, while dal mills in the district have shut down. There is a significant price discrepancy between seeds and produce of the same crop.

c) Andhra Pradesh:

i. Crops like pigeonpea and chickpea face frequent attacks from pests, such as pod borers, leading to yield losses. Farmers suggested implementing improved pest management strategies and developing pest- and disease-tolerant crop varieties to enhance crop resilience and productivity.

ii. In Krishna District (Kharif), major crops include paddy and sugarcane. Pulse area is limited, with Blackgram grown in 1,500 Ha. Groundnut is cultivated in 500 Ha.

iii. In regions like Krishna district, delayed release of water for Kharif crops leads to late paddy harvests, which in turn pushes the Black gram sowing season beyond the optimal period. Farmers recommended advancing the release of canal water to early June to allow for a timely paddy harvest and ensure Black gram can be sown within the ideal window.

iv. Quality seeds and fertilizers are often costly and located at distant distribution centres, increasing transportation expenses for farmers. Farmers proposed establishing nearby input centres to provide certified seeds and fertilizers at affordable prices, enabling timely sowing and improved crop care.

v. Farmers experience considerable price volatility, which affects income stability and discourages pulse production. Farmers suggested implementing a Minimum Support Price (MSP) along with direct procurement programs to stabilize income and encourage continued cultivation.

vi. Many farmers rely solely on rain-fed agriculture, which limits productivity, especially during dry spells. Farmers advocated for community-based irrigation systems and water harvesting methods to ensure water availability during critical growth stages.

vii. In Guntur District, Blackgram has traditionally been a prominent crop during the Kharif and late Kharif seasons, but in recent years, Maize has started replacing it. The district faces significant challenges, including a lack of mechanization in pulse cultivation, which increases dependence on manual labor. This labor shortage is pushing farmers to shift towards more labor-efficient crops like Paddy and Maize.

viii. In Visakhapatnam District, the cultivation of pulses is severely impacted by limited irrigation facilities and a lack of access to High Yielding Varieties (HYV) or short-duration varieties. These factors restrict the ability of farmers to maximize yield potential, particularly during the critical growing seasons, thereby affecting pulse crop productivity.

d). Karnataka:

i. The dominance of commission agents in the marketing chain often reduces farmers' profit margins. Farmers advocated for improved market access and the development of direct sales channels to secure better prices and enhance profitability in pulse farming.

ii. The rising costs of essential inputs, such as seeds, fertilizers, and pesticides, strain farmers financially, reducing their capacity to invest in high-quality resources.

iii. Continuous cultivation without adequate soil restoration measures has led to declining soil fertility in pulse-growing regions.

iv. With irregular weather and other uncertainties, many farmers are vulnerable to crop losses without adequate insurance options. Farmers suggested expanding crop insurance coverage tailored to pulse farming to protect against income loss during adverse seasons.

e). Gujarat:

i. In Gir Somnath District, pulses such as Green Gram (Moong) and Black Gram (Urad) are sown in very limited areas during the Kharif season, with a higher focus on crops like Groundnut, Soyabean, and Cotton. Wheat and Chickpea dominate the Rabi season, with Chickpea grown in significant areas. The district also grows pulses during the summer season, with notable areas under Black Gram and Green Gram.

ii. Farmers face challenges, including water issues, pest infestations, labor shortages, and inadequate seed availability, which affect pulse yields.

iii. In the Gujarat region, farmers grow black gram, green gram, and chickpea but encounter several constraints that hinder productivity, such as water scarcity, especially during the rabi season, and pest infestations in green gram.

iv. There is also a labor shortage for harvesting, which impacts pulse production across districts. To address these issues, it is recommended to construct more check dams to stabilize groundwater levels, develop high-yield and pest-resistant crop varieties, and ensure timely seed availability.

v. Farmers propose constructing more check dams to stabilize groundwater levels, developing pest- and fungus-resistant seed varieties, and creating high-yield, mechanically harvestable crops to improve irrigation, reduce crop losses, and address labor shortages.

vi. They also recommend ensuring timely seed availability, increasing procurement quantities for efficient processing, and appointing additional Gram Sevaks to enhance agricultural extension services and streamline administrative workloads.

ANNEXURE-V: Top 111 Districts contributing 75% of total pulse production

Table AV.1: Top 111 Districts contributing 75% of total pulse production

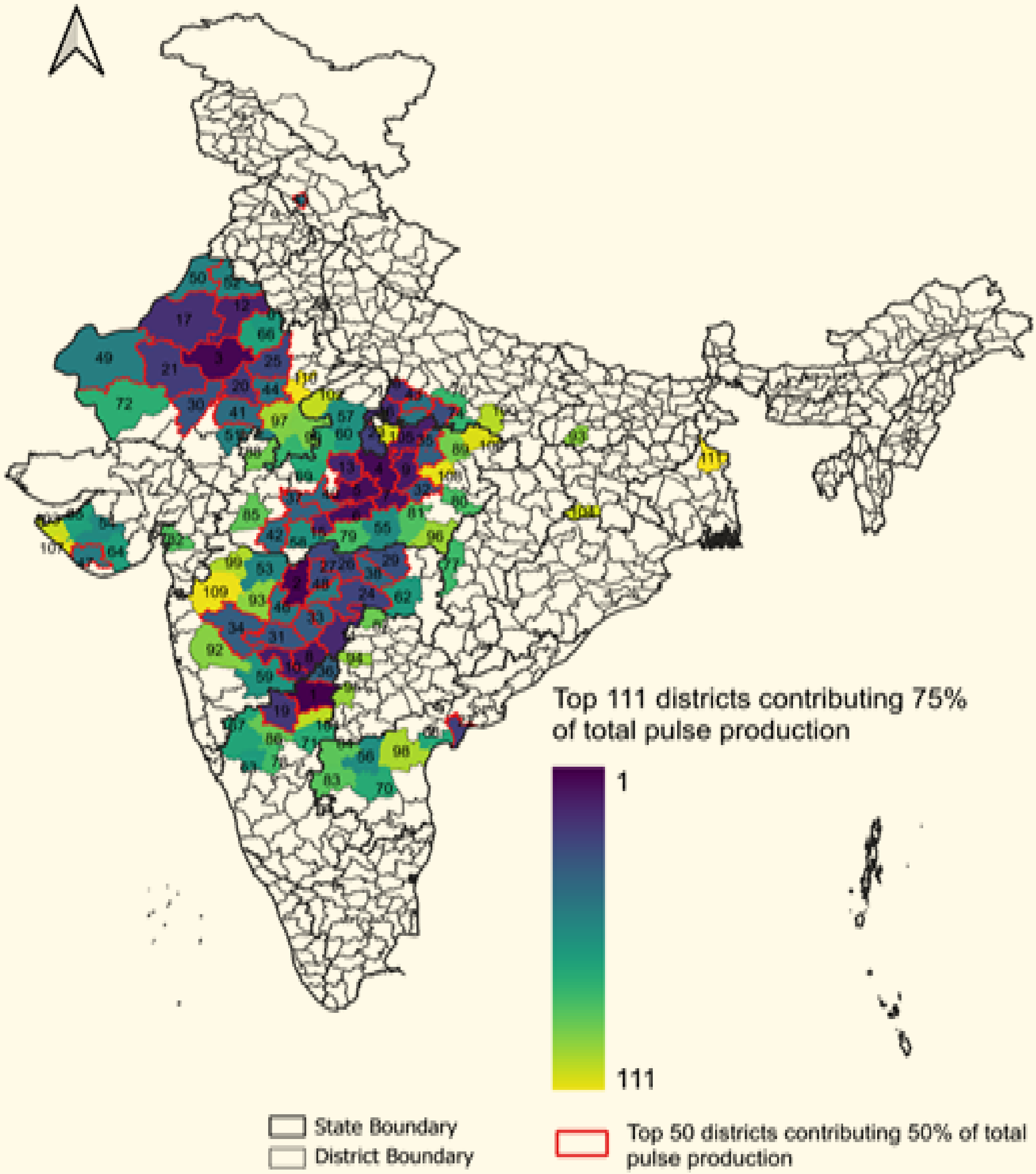
Sl. No	District	State
1.	Kalaburagi	Karnataka
2.	Buldana	Maharashtra
3.	Nagaur	Rajasthan
4.	Sagar	Madhya Pradesh
5.	Raisen	Madhya Pradesh
6.	Hoshangabad	Madhya Pradesh
7.	Narsimhapur	Madhya Pradesh
8.	Latur	Maharashtra
9.	Damoh	Madhya Pradesh
10.	Osmanabad	Maharashtra
11.	Chhatarpur	Madhya Pradesh
12.	Churu	Rajasthan
13.	Vidisha	Madhya Pradesh
14.	Nanded	Maharashtra
15.	Harda	Madhya Pradesh
16.	Jhansi	Uttar Pradesh
17.	Bikaner	Rajasthan
18.	Jalaun	Uttar Pradesh
19.	Vijayapura	Karnataka
20.	Ajmer	Rajasthan
21.	Jodhpur	Rajasthan
22.	Krishna	Andhra Pradesh
23.	Lalitpur	Uttar Pradesh
24.	Yavatmal	Maharashtra
25.	Jaipur	Rajasthan
26.	Amravati	Maharashtra
27.	Akola	Maharashtra
28.	Banda	Uttar Pradesh
29.	Nagpur	Maharashtra
30.	Pali	Rajasthan
31.	Bid	Maharashtra
32.	Jabalpur	Madhya Pradesh
33.	Parbhani	Maharashtra
34.	Ahmadnagar	Maharashtra
35.	Panna	Madhya Pradesh
36.	Bidar	Karnataka
37.	Dewas	Madhya Pradesh

Sl. No	District	State
38.	Wardha	Maharashtra
39.	Hingoli	Maharashtra
40.	Sehore	Madhya Pradesh
41.	Bhilwara	Rajasthan
42.	West Nimar	Madhya Pradesh
43.	Hamirpur	Uttar Pradesh
44.	Tonk	Rajasthan
45.	Mahoba	Uttar Pradesh
46.	Jalna	Maharashtra
47.	Junagadh	Gujarat
48.	Washim	Maharashtra
49.	Jaisalmer	Rajasthan
50.	Ganganagar	Rajasthan
51.	Chittaurgarh	Rajasthan
52.	Hanumangarh	Rajasthan
53.	Jalgaon	Maharashtra
54.	Rajkot	Gujarat
55.	Chhindwara	Madhya Pradesh
56.	Nandyal	Andhra Pradesh
57.	Shivpuri	Madhya Pradesh
58.	East Nimar	Madhya Pradesh
59.	Solapur	Maharashtra
60.	Ashoknagar	Madhya Pradesh
61.	Jhunjhunun	Rajasthan
62.	Chandrapur	Maharashtra
63.	Dharwad	Karnataka
64.	Amreli	Gujarat
65.	Jamnagar	Gujarat
66.	Sikar	Rajasthan
67.	Belagavi	Karnataka
68.	Bapatla	Andhra Pradesh
69.	Rajgarh	Madhya Pradesh
70.	Y.S.R.	Andhra Pradesh
71.	Raichur	Karnataka
72.	Barmer	Rajasthan
73.	Guna	Madhya Pradesh
74.	Chitrakoot	Uttar Pradesh
75.	Jhalawar	Rajasthan
76.	Fatehpur	Uttar Pradesh

Sl. No	District	State
77.	Rajnandgaon	Chhattisgarh
78.	Gadag	Karnataka
79.	Betul	Madhya Pradesh
80.	Dindori	Madhya Pradesh
81.	Seoni	Madhya Pradesh
82.	Bharuch	Gujarat
83.	Anantpur	Andhra Pradesh
84.	Kurnool	Andhra Pradesh
85.	Dhar	Madhya Pradesh
86.	Bagalkote	Karnataka
87.	Adilabad	Telangana
88.	Mandsaur	Madhya Pradesh
89.	Satna	Madhya Pradesh
90.	Baran	Rajasthan
91.	Kota	Rajasthan
92.	Pune	Maharashtra
93.	Aurangabad	Maharashtra
94.	Kamareddy	Telangana
95.	Vikarabad	Telangana
96.	Balaghat	Madhya Pradesh
97.	Bundi	Rajasthan
98.	Prakasam	Andhra Pradesh
99.	Dhule	Maharashtra
100.	Prayagraj	Uttar Pradesh
101.	Yadgir	Karnataka
102.	Sheopur	Madhya Pradesh
103.	Devbhumi Dwarka	Gujarat
104.	Simdega	Jharkhand
105.	Tikamgarh	Madhya Pradesh
106.	Rewa	Madhya Pradesh
107.	Porbandar	Gujarat
108.	Katni	Madhya Pradesh
109.	Nashik	Maharashtra
110.	Sawai Madhopur	Rajasthan
111.	Murshidabad	West Bengal

Source: Authors' Computation

Map AV.1: Top 111 Districts contributing 75% of total pulse production



Source: Authors' Computation

ANNEXURE-VI: List of Reviewers

Table AVI.1: List of Reviewers

S.No	Reviewer Name	Designation
1.	**Smt. Subha Thakur**	Additional Secretary, Crops, Admn. & Seeds, Department of Agriculture & Farmers' Welfare (DA&FW)
2.	**Dr. Praveen Kumar Singh**	Agriculture Commissioner, Department of Agriculture & Farmers' Welfare (DA&FW)
3.	**Dr. J.S. Sandhu**	Professor Chair, Guru Gobind Singh Chair, Patanjali University, Uttarakhand
4.	**Dr. Shiv Kumar Agrawal**	Regional Coordinator, South Asia & China Programme, International Center for Agricultural Research in the Dry Areas (ICARDA)
5.	**Dr. GP Dixit**	Director, ICAR-Indian Institute of Pulses Research (IIPR), Kanpur
6.	**Dr. Aditya Pratap**	Project Coordinator All India Coordinated Research Projects (AICRP) (Kharif Pulses), ICAR
7.	**Dr. A.K. Shivhare**	Jt. Director, Directorate of Pulses Development (DPD), Bhopal
8.	**Dr. Shailesh Tripathi**	Project Coordinator, AICRP All India Coordinated Research Projects (AICRP) (Rabi Pulses), ICAR
9.	**Dr. C. Bharadwaj**	Principal Scientist (Genetics), Indian Agricultural Research Institute (IARI)
10.	**Dr. Anita Babbar**	Principal Scientist (Chickpea), Jawaharlal Nehru Krishi Vishwavidyalaya (JNKVV), Jabalpur
11.	**Prof. S.K. Jain**	Professor (Plant Breeding & Genetics), Rajasthan Agricultural Research Institute, Durgapura, Jaipur
12.	**Dr. Prakash Gangashetty**	Senior Scientist (Pigeonpea), International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
13.	**Mr. Bimal Kothari**	Chairman, India Pulses Grains Association (IPGA)

REFERENCES

i. Abdulai, A. (2002). Household demand for food in Switzerland: A quadratic almost ideal demand system. Swiss Journal of Economics and Statistics, 138(1), 1–18.

ii. Abdulai, A., & Aubert, D. (2004). A cross-section analysis of household demand for food and nutrients in Tanzania. Agricultural Economics, 31(1), 67–79.

iii. Agricultural & Processed Food Products Export Development Authority (APEDA). (n.d.). India import of principal commodities. Retrieved from https://agriexchange.apeda.gov.in/importtoindia/18headgenReportmonth.aspx#content

iv. Agricultural Statistics at a Glance 2022, Government of India, Ministry of Agriculture & Farmers Welfare, Department of Agriculture & Farmers Welfare, Economics & Statistics Division

v. Ahlawat, I. P. S., Sharma, P., & Singh, U. (2016). Production, demand and import of pulses in India. Indian Journal of Agronomy, 61(4, IAC Special Issue), S33–S41.

vi. Anand, R., Kumar, N., & Tulin, M. V. (2016). Understanding India's food inflation: The role of demand and supply factors. International Monetary Fund.

vii. Annual Report 2022-23, DPD/Pub./TR/46/2022-23, Government Of India Ministry of Agriculture & Farmers Welfare (Department of Agriculture & Farmers Welfare) Directorate of Pulses Development Vindhyachal Bhavan, Bhopal-462004 (Madhya Pradesh)

viii. Anjana, R. M., Pradeepa, R., Das, A. K., Deepa, M., Bhansali, A., Joshi, S. R., Joshi, P. P., Dhandhania, V. K., Rao, P. V., Sudha, V., Subashini, R., Unnikrishnan, R., Madhu, S. V., Kaur, T., Mohan, V., Shukla, D. K., & ICMR– INDIAB Collaborative Study Group (2014). Physical activity and inactivity patterns in India - results from the ICMR-INDIAB study (Phase-1) [ICMR-INDIAB-5]. *The International Journal of Behavioural Nutrition and Physical Activity*, *11*(1), 26. https://doi.org/10.1186/1479-5868-11-26

ix. Area, production, and yield of pulses in the world: FAOSTAT - 1961-2022 Pulses APY Global Data

x. Banks, J., Blundell, R., & Lewbel, A. (1997). Quadratic Engel curves and consumer demand. The Review of Economics and Statistics, 79(4), 527–539.

xi. Beatty, T. K., & Larsen, E. R. (2005). Using Engel curves to estimate bias in the Canadian CPI. Canadian Journal of Economics, 38(2), 482–499.

xii. Blundell, R., Pashardes, P., & Weber, G. (1998). What do we learn about consumer demand patterns from micro data? The American Economic Review, 79(4), 570–597.

xiii. Blundell, R., & Robin, J.-M. (1999). Estimation in large and disaggregated demand systems: An estimator for conditionally linear systems. Journal of Applied Econometrics, 14(3), 209–232.

xiv. CACP consolidated crop wise data 2021-22, https://desagri.gov.in/document-report-category/cost-of-cultivation-production-estimates/

xv. Chand, R. (2024). Raising pulse production for self-sufficiency, nutrition, sustainability, and farmers' income. Unpublished manuscript.

xvi. Crop-wise pulses global scenario: 2020-22, FAO

xvii. Decomposition analysis of output for Pulses crops – National level: Department of Agriculture & Farmers Welfare & Directorate General of Commercial Intelligence and Statistics

xviii. Decomposition analysis of output for Pulses crops – State level: Department of Agriculture & Farmers Welfare & Directorate General of Commercial Intelligence and Statistics

xix. DES, MoA&FW. https://desagri.gov.in/#

xx. Directorate of Pulses Development. (2022). *Annual report 2022-23*. https://dpd.gov.in/Final%20%20Annual%20Report%20(2022-23)%20with%20Preface%20(As%20on%2020.02.2024).pdf

xxi. Fisher, G., Pollak, R. A., & Wales, T. J. (2001). Consumer demand in the United States: Prices, income, and consumption behavior. Econometrica, 69(1), 105–122.

xxii. FAOSTAT, FAO. https://www.fao.org/faostat/en/#home.

xxiii. FAO, The Global Economy of Pulses, 2019

xxiv. FAOSTAT. (n.d.). https://www.fao.org/faostat/en/#rankings/countries_by_commodity

xxv. Food and Agriculture Organization (FAO). (2021). Crop-wise pulses global scenario: 2020-21.

xxvi. GOI (2024). Ministry of Commerce and Industry. TRADESTAT: Export and Import Data Bank https://tradestat.commerce.gov.in/eidb/default.asp

xxvii. Gould, B. W., & Villarreal, H. J. (2006). An assessment of the demand for meat in Mexico. Agricultural Economics, 34(1), 75–86.

xxviii. GOVERNMENT OF INDIA Ministry of Commerce. (n.d.).

xxix. Government of India, Ministry of Statistics & Programme Implementation, National Sample Survey Office. (2024). Survey on Household Consumption Expenditure: 2022-23 (Report No. 591).

xxx. *Home | Department of Agriculture & Farmers Welfare | MOA & FW | Government of India, India*. (n.d.). https://agriwelfare.gov.in/en/whatsnew/16

xxxi. ICMR-NIN Expert Group on Nutrient Requirement for Indians. (2024). Nutrient requirements and recommended dietary allowances for Indians (RDA)

xxxii. ICMR-NIN, Dietary Guidelines for Indians. Expert Committee Members-2024. https://main.icmr.nic.in/sites/default/files/upload_documents/DGI_07th_May_2024_fin.pdf

xxxiii. Indian Council of Agricultural Research (2022-23). Annual Report 2022-23. https://icar.org.in/sites/default/files/2023-07/ICAR-Annual-Report-2022-23-English.pdf

xxxiv. Indian Institute of Pulses Research. (n.d.). AICRP on Kharif pulses. https://iipr.icar.gov.in/aicrp-kharif-pulses/

xxxv. Indian Council of Agricultural Research - Indian Institute of Pulses Research. (2024). ICAR-IIPR official website. Retrieved from https://iipr.icar.gov.in/

xxxvi. IndiaStat. (2018). State and season-wise area, production, and productivity of total pulses in India (2010-2011 to 2017-2018). https://www.indiastat.com/table/agriculture/state-season-wise-area-production-productivity-tot/924122

xxxvii. IndiaStat. (2011). State and season-wise area, production, and productivity of total pulses in India (2006-2007 to 2010-2011). https://www.indiastat.com/table/agriculture/state-season-wise-area-production-productivity-tot/706855 xxxviii. IndiaStat. (2009). State and season-wise area, production, and productivity of total pulses in India (2003-2004 to 2008-2009). https://www.indiastat.com/table/agriculture/state-season-wise-area-production-productivity-tot/79805

xxxix. IFPRI Discussion Paper 02113. India's Pulse Policy Landscape and Its Implications for Trade. https://ebrary.ifpri.org/utils/getfile/collection/p15738coll2/id/135842/filename/136053.pdf

xl. India import OF principle commodities. (n.d.). https://agriexchange.apeda.gov.in/importtoindia/18headgenReportmonth.aspx#content

xli. Indian Journal of Agronomy 61 (4th IAC Special issue): S33__S41 (2016) Production, demand and import of pulses in India I.P.S. AHLAWAT, PURUSHOTTAM SHARMA AND UMMED SINGH

xlii. Jha, S. N., Vishwakarma, R. K., Ahmad, T., Rai, A., & Dixit, A. K. (2015). *Report on assessment of quantitative harvest and post-harvest losses of major crops and commodities in India.* All India Coordinated Research Project on Post-Harvest Technology, ICAR-CIPHET.

xliii. Kar, G., & Kumar, A. (2009). Evaluation of post-rainy season crops with residual soil moisture and different tillage methods in rice fallow of eastern India. Agricultural Water Management, 96, 931–938.

xliv. Kumar, S., & Ali, J. (2009). Decision making of agrarian communities: exploring the impact of e-governance initiatives in India. International Journal of Electronic Governance, 2(2-3), 156-169.

xlv. Leser, C. E. V. (1963). Forms of Engel functions. Econometrica, 31(4), 694–703.

xlvi. Malo, Mousumi & Hore, Jayita. (2020). PULSE PRODUCTION IN INDIA: MAJOR CONSTRAINTS AND WAY FORWARD.

xlvii. Molina, J. A., & Gil, A. (2005). The demand for meat in Spain: An analysis by type of product. Food Policy, 30(5–6), 521–533.

xlviii. Moro, D., & Sckokai, P. (2000). Heterogeneous preferences in household food consumption in Italy. European Review of Agricultural Economics, 27(3), 305–323.

xlix. M, S., Lazarus, T. P., Vijayan, A., & F, T. (2020). Demand: Supply gap in pulses in India: An analysis. *www.phytojournal.com*. https://www.phytojournal.com/special-issue/2020.v9.i2S.11753/demand-supply-gap-in-pulses-in-india-an-analysis

l. NABCONS. (2022). Study to determine post-harvest losses of agri produces in India.

li. National Academy of Agricultural Sciences (NAAS). (2013). Annual report 2013-14. NAAS.

lii. National_Pulses_Scenario_Normal_&_EH_APY_(28.02.2024)

liii. National Food Security Mission. (n.d.). Brief on National Food Security Mission (NFSM). https://nfsm.gov.in/ReadyReckoner/NFSM_Brief.pdf

liv. National wise volatility in pulses crop yield in major pulses-producing states (in %): Department of Agriculture & Farmers Welfare - MoA& FW lv. OECD/FAO (2021). *OECD-FAO Agricultural Outlook 2021-2030*, OECD Paris. https://doi.org/10.1787/19428846-en.

lvi. OECD/FAO (2024). *OECD-FAO Agricultural Outlook 2024-2033*, OECD Paris/FAO, Rome. https://doi.org/10.1787/4c5d2cfb-en.UNSTAT.

lvii. Observer Research Foundation. (2020, December 9). The state of India's pulses sector. https://www.orfonline.org/research/the-state-of-india-s-pulses-sector/

lviii. Phase-wise volatility in pulses crop yield in major pulses-producing states (in %): Department of Agriculture & Farmers Welfare - MoA& FW

lix. Poi, B. P. (2008). Demand system estimation: Update. Stata Journal, 8(4), 554–556.

lx. Poi, B. P. (2002). From the help desk: Demand system estimation. Stata Journal, 2(4), 403–410.

lxi. Poi, B. P. (2012). Easy demand-system estimation with QUAIDS. Stata Journal, 12(3), 433–446.

lxii. Policy Brief 53. Technology and Policy Options for Sustaining Pulses Revolution https://niap.icar.gov.in/pdf/pb53.pdf

lxiii. Press Trust of India. (2023). India's GDP grows at 8.4% in Q3; economy to expand at 7.6% in FY24: Govt data. Retrieved from https://www.ptinews.com/story/business/india-s-gdp-grows-at-8-4-pc-in-q3-economy-to-expand-at-7-6-pc-in-fy24-govt-data/1325129

lxiv. Production, Markets and Trade: A Detailed Analysis of Factors Affecting Pulses Production in India Poornima Varma Centre, https://desagri.gov.in/wp-content/uploads/2024/04/2019-20-Production-Markets-and-Trade-Factors-Affecting-Pulses-in-India.pdf

lxv. Press Information Bureau. (2012, June 1). Union Agriculture Minister emphasises on pulses production. https://pib.gov.in/newsite/PrintRelease.aspx?relid=87121

lxvi. Roy, D., Boss, R., Pradhan, M., & Ajmani, M. (2022). *India's pulse policy landscape and its implications for trade*. IFPRI Discussion Paper 02113. International Food Policy Research Institute.

lxvii. Singh, Pushpa & Shahi, Brajesh & Singh, K.. (2016). Trends of Pulses Production, Consumption and Import in India: Current Scenario And Strategies. SSRN Electronic Journal. 10.2139/ssrn.2780102.

lxviii. Singh, A. (2021).International Journal of Engineering and Management Research (IJEMR) https://doi.org/10.31033/ijemr.11.4.36

lxix. Statista. (2024, April 15). Import value of pulses into India FY 2011-2023. https://www.statista.com/statistics/625066/import-value-of-pulses-india/

lxx. Szczebyło, Agata & Halicka, Ewa & Jackowska, Małgorzata & Rejman, Krystyna. (2019). Analysis of the Global Pulses Market and Programs Encouraging Consumption of This Food. Zeszyty Naukowe SGGW w Warszawie - Problemy Rolnictwa wiatowego. 19(34). 85-96.

lxxi. TPCI - Trade Promotion Council of India. (2024, April 30). Rising pulses imports: Trends and Implications - India Business and Trade. https://www.indiabusinesstrade.in/blogs/rising-pulses-imports-trends-and-implications/

lxxii. Top producing countries of major pulses and the yield comparison with India: FAOSTAT - 1961-2022 Pulses APY Global Data

lxxiii. https://unstats.un.org/unsd/classifications/Econ/Structure/Detail/EN/1074/01701

lxxiv. What do we know about the future of pulses in global and regional agri-food systems? CGIAR. (2023, December 18). CGIAR. https://www.cgiar.org/news-events/news/what-do-we-know-about-the-future-of-pulses-in-global-and-regional-agri-food-systems/

lxxv. Yatchew, A. (2003). Semiparametric regression for the applied econometrician. Cambridge University Press.

lxxvi. Yield of major pulses (in tonnes/hectare): FAOSTAT - 1961-2022 Global Yield Data

NITI Aayog hosted an expert consultation on "Pulses for Prosperity: Strategy for Accelerating Growth in Pulses", September 20, 2024

Glimpse of Primary Survey Conducted by NITI Aayog in 5 States

Field visit to Nagaur, Barmer and Jodhpur, Rajasthan



Field and KVK visit to Betul and Chhindwara, Madhya Pradesh



Field and KVK Visit to Indore and Khargone, Madhya Pradesh

Field visit to Guntur, Palnadu and Krishna, Andhra Pradesh

Field visit to Belgaum, Karnataka

NOTES

सत्यमेव जयते

NITI Aayog