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India Beyond 75

Envisioning Smart & Sustainable Agriculture



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MESSAGE



Agriculture is an important sector of the Indian economy employing the largest share of the workforce and providing food and nutrition security to the nation. As the nation enters the landmark 75th year of its independence, it is important to recall the achievements and build a future strategy for sectoral growth. Agriculture sector in India has shown a growth during pandemic which signifies its resilience nature. However, in wake of emerging challenge of climate change, sustainability is going to be a big focus for the coming years. The total GHG emissions from agriculture, non-judicious use of Agri inputs, lack of knowledge about good agriculture practices presents an enormous challenge to agriculture sustainability.

Marginal and small farm sizes constitute more than 85% of the operational holdings in India. It's time to develop impactful programmes to support and empower them with knowledge for sustainable and climate resilient production. The Government of India has brought significant reforms in the agriculture sector which will go a long way in building efficient value chains and ensuring better returns for farmers. With independent India turning 75, Indian agriculture also needs to be transformed and reoriented to be smart and sustainable. Towards this, there is an immense need to promote interventions that help in achieving the sustainable development goals target.

As we embark on a new era of agriculture with enormous pressure to produce more food from less land with shrinking water and other natural resources, there is an urgent need to strengthen the existing agricultural value chain. FICCI's Agriculture Summit "Envisioning Smart & Sustainable Agriculture" aims to bring all key stakeholder and policy makers on a common platform to ideate on implementable strategy for smart and sustainable agriculture. FICCI along with YES Bank is pleased to release this knowledge report on occasion of the Agriculture Summit. The Report highlights priorities and develops segment wise visions with a clear set of recommendations. We hope this Report provides the readers a futuristic roadmap for ensuring sustainable growth of Indian agriculture sector.

T R Kesavan
Chairman, FICCI National Agriculture Committee &
Group President, TAFE Ltd.

MESSAGE



By 2050 the world will be home to another 3 Billion people. The need to scale up agriculture is getting more acute with rising population and decreasing arable land. Today, Farmers are on the front line of climate change – both in terms of the impact felt as well as the potential to achieve measurable improvement. To ensure safe, affordable & enough food and overcome farmers challenges around low productivity & income, it is critical to transform agriculture.

Sustainability is no longer an option – it is imperative that everyone needs to focus on. Sustainable enhancement of farmer income and maintaining natural resources should lie at the heart of India's growth strategy. In the long run real potential of the Indian rural sector can only be unleashed by creating a demand driven Agriculture. However, setting an Agri food ecosystem on a demand driven approach will have to factor an element of sustainability. Soil and water usage in agriculture are already under acute pressure. We need to achieve higher production in agriculture in a manner that also protects the environment. This requires collective responsibility of all relevant stakeholders and preparedness and training of farmers on sustainable agriculture practices.

On June 1 2020, Corteva Agriscience announced its 10-year commitments to advance sustainability throughout the global food system. The goals span a wide range of initiatives for farmers, the land, communities where employees and customers live and work, and in its own operations. Improvements in soil health, on-farm productivity, climate action as well as water stewardship are at the core of these goals. Corteva is collaborating with stakeholders along the entire food supply chain, from farm to table, with sustainability, innovation and responsiveness.

Building long term resilience of our agriculture value chain and Improving farmer incomes through sustainable and good agricultural practices is of paramount importance. I do hope the Report will address some of the key interventions necessary to take Indian agriculture on a sustainable pathway.

Vedika Kapoor
Head Government & Industry Affairs- South Asia
Corteva Agriscience

FOREWORD



Agriculture and allied sectors form the core strength of India's economy as a vehicle of inclusive growth, enhancing rural income and sustaining food and nutritional security of the nation. India has the 2nd largest arable land resource in the world, 20 agro-climatic regions and all 15 major climates that exist in the world. These inherent strengths, coupled with government focus have enabled the country to meet food security needs on the one hand while gainfully employing millions on the other. Over the seven decades since independence, this sector has shown strong resilience against a diverse set of adversities and has remained a key source of income and livelihood for more than 50% of the country's population.

Despite its critical role and significant thrust from the Government to sustainably nurture the sector, challenges persist. The issue of unsustainability and climate change is becoming evident, which if remains unattended, could severely impact growth of the sector. According to the International Panel on Climate Change report, the predicted temperature rise for India is in the range of 0.88–3.16°C by 2050 and 1.56–5.44°C by the year 2080. Studies predict significant negative impact of climate change, envisaging yield reduction by 4.5% to 9.0%, depending on the magnitude and distribution of warming.

Traditional response to agriculture might not be sufficient to mitigate the risks put forth by the future challenges and focus on innovation and technology shall be the key to overcome them. The Government of India has prioritized sustainable agriculture and initiated several measures towards the same. Efforts have been streamlined for developing an end-to-end support system for smart and sustainable agriculture through diverse initiatives, including - schemes such as the National Mission for Sustainable Agriculture, boosting the startup ecosystem, and creating an overall enabling policy environment for innovation and technology to thrive.

Farmers hold the backbone of the agricultural system. Transforming the lives of farmers, enhancing their income, and making them self-reliant is of paramount importance. Realizing this vision requires intensification of efforts across the agriculture value chain and a proactive role by all concerned stakeholders .The Report highlights the transformational journey of Indian Agriculture since India's independence and identifies critical pain points currently faced by the agriculture sector. The report also suggests specific action steps. These steps, if implemented, can significantly contribute to boosting growth of the agricultural sector in a sustainable manner.

Dilip Chenoy
Secretary General
FICCI

FOREWORD



Indian agriculture has witnessed a remarkable transformation over the last seven decades. From being a food deficit nation and a net importer of food grains at the time of independence, the country has come a long way to become one of the global leaders in production of a number of agricultural products - including cereals, pulses, sugarcane, fruits, vegetables, milk, fish and poultry. While sufficiently meeting the nation's food security requirements, the agriculture sector has also transformed into a key contributor to the nation's merchandise exports. In 2020, India exported agricultural products worth USD 42 billion, contributing to about 2.5% of global agricultural exports and about 13% of India's merchandise exports.

While this growth aptly addressed the food security needs of the nation till now, the agriculture sector faces new challenges – as expectations from agriculture diversify beyond food security and self-sufficiency, towards sustainable and climate resilient production.

The Government of India, along with State governments, has taken numerous proactive steps to promote sustainable agriculture and combat climate change. Initiatives such as the National Mission for Sustainable Agriculture, 'Per Drop More Crop' component of Pradhan Mantri Krishi Sinchayee Yojana and the National Innovations in Climate Resilient Agriculture program clearly reflect the keen interest of the government to secure and build sustainability across the agricultural supply chain.

For a country which has to feed 17% of the global population with only 11% of the global arable land, there is an immense need for the private sector, academia and the community at large to partner with the government and develop sustainable agricultural production systems which enable food security for all, in an ecologically sound, economically viable, and socially responsible manner.

YES BANK is pleased to partner with FICCI for the preparation and release of this knowledge report on "India beyond 75: Envisioning Smart & Sustainable Agriculture". This report reviews the transformational journey of Indian agriculture, elaborates the current challenges faced by the sector, identifies need for sustainable & smart agriculture and highlights recommendations to promote sustainability across the agricultural supply chain.

I sincerely hope that this knowledge report contributes to the immense and commendable efforts that are being taken up by all stakeholders in shaping strategic interventions that are instrumental in bringing long term sustainability to the agricultural ecosystem of India.

Prashant Kumar
Managing Director & CEO
YES BANK Ltd.

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Executive Summary



Agriculture is crucial for ensuring food, nutrition, and livelihood security. The Green revolution brought about significant progress in Indian agricultural productivity, with the country turning from food-deficit to food-sufficient - and eventually to a food-surplus exporting nation. By 2020, agriculture and allied sector accounted for nearly 20% of India's GDP, supporting half of the country's population as its principal source of income. Gross value added (nominal at base price) increased from about INR 100 billion in 1950-51 to about INR 37.8 trillion in 2021. During 2021, while the GVA of entire economy contracted by 7.2%, growth in GVA for agriculture maintained a positive rate of 3.4%.

With a focus on crop based agriculture, chapter one of this report captures the journey of Indian agriculture over the last seven decades since independence, using data to showcase trends in crop based agricultural production, land holding patterns, access to pre-harvest factors of production (including irrigation, seeds, fertilizers, agro-chemicals, farm machinery, credit and insurance) and post-harvest infrastructure. The chapter concludes by capturing key challenges faced by the sector.

From being a subsistence based farming system to a self-sustained, modernized, capital and knowledge intensive one, Indian agriculture has seen a transformative growth in agricultural production – primarily due to increase in yields per hectare across key crops. For instance, the productivity of foodgrains has increased from 0.5 MT/Ha in 1950-51 to 2.4 MT/Ha in 2020-21, while the per capita availability of food grains increased from 144.1 kg/person/year in 1950-51 to feed a population 0.36 Billion then, to 187.1 kg/person/year to feed a population of 1.34 Bn people in 2019-20.This growth in productivity has been driven by better farmers' access to and use of various factors of production. For instance, the percentage of net irrigated area has increased from 20.9 Million hectares in 1950-51 to 69.5 Million hectares in 2019-20[(i)] . Consumption of primary fertilizers increased from 1 Million MT in 1950-51 to 29.3 Million MT in 2019-20[(ii)]. The ratio of Agri-Credit outstanding to Agri-GDP increased from 0.6% in 1950-51 to 51.56% in 2017-18[(iii)] and the flow of institutional credit has increased from about INR 100 Billion in 1990-91 to INR 13.9 Trillion in 2019-20[(iv)]. However, the average farm land holding, which currently stands at about 1.08 Ha, has dropped by about 50% since the early 70s. Small and marginal farmers - holding less than 2 ha of land - increased from 70% in 1970-71 to 86.1% in 2015-16.

(i) MoA&FW, GoI, ICAR
(ii) MoA&FW, GoI

While increase in agricultural production has been driven by increased use of fertilizers, water, agrochemicals and other farm inputs, the increase in productivity due to use of farm inputs has become non-linear – tending towards stagnancy in crop productivity over the last couple of decades. With intensification of inputs use, decreasing per capita arable land and a cereals-dominated agricultural production, India has been witnessing significant stress on its natural resources. As expectations from the sector increase beyond food security and self-sufficiency, towards sustainable and climate resilient production, three overarching challenges have emerged hindering sustainable growth and development of the sector. They include - 1) supply exceeding demand-resulting in bouts of production gluts and high pressure on agri-commodity prices; 2) inefficient use of water, power and other farm inputs coupled with postharvest handling and marketing inefficiencies – resulting in low farm income and unsustainable farm economics and 3) excess and unscrupulous use of water, fertilizers and agrochemicals – leading to degradation of soil and water resources. Compounding these challenges, is the vulnerability of agriculture to climate change related weather-events such as floods, draughts and natural hazards- which are becoming frequent, intense and almost regular in some regions of the country. Addressing these critical challenges is crucial for sustainable growth and development of agricultural sector.

Chapter two delves on the need for and opportunities arising from sustainable and smart agriculture. It reviews the impact of climate change, highlights key initiatives taken by the Government to promote sustainability and assesses the role that smart and digital agriculture can play to boost sustainability.

For sustainable growth of Indian agriculture, it has become vital to promote and develop sustainable agricultural production systems which enable food security for all, in an ecologically sound, economically viable, and socially responsible manner. A long-term vision and strategy need to be framed for achieving sustainability throughout the agricultural value chain. This strategy could be based on three core pillars: promoting holistic ecology, developing efficient markets, and devising policy incentives that enable both farmers as well as the industry to facilitate the first two pillars. The strategy needs to be in alignment with Doubling Farmer's Income Committee's five pillars: Increasing productivity as a route to higher production; reduced cost of production; optimal monetization of the produce; Sustainable production technology; and risk negotiation all along the agricultural value chain. In line with this vision, 5 core themes have been identified for sustainable agriculture development in the report. These include - sustainably boosting productivity; promoting sustainable natural resource management; strengthening food security sustainably; sustainable adaption to climate change; and promoting technology, digitalization and sustainable innovation.

Indian agriculture is particularly vulnerable to climate change, given its growing population density, small and fragmented farm holdings, a predominantly rain-fed agricultural system, Himalayan glacier-fed, river-based irrigation in the north and east and a significantly large livestock population. The overwhelming loss of biodiversity, ground water deficit, pollution of ground water and increase in atmospheric greenhouse gases are serious threats to sustainability. Climate change and its erratic manifestations will have their greatest impact in the most vulnerable areas[v]. According to International Panel on Climate Change report, the predicted temperature rise for India is in the range of 0.88–3.16°C by 2050 and 1.56–5.44°C by the year 2080. Studies showed significant negative impacts of climate change, predicting yield reduction by 4.5% to 9.0%, depending on the magnitude and distribution of warming.[vi] An IARI study suggests that for every one-degree change in temperature, wheat production loss will average at 4-5 Mn MT. Depending on the modeling

(iii) RBI Report of the Internal Working Group to Review Agricultural Credit
(iv) MoA&FW, GoI, Economic Survey, Government of India, Various issues

technique, it has been estimated that rice yields can be impacted by up to 40% while for wheat it can decrease by 52%[vii].

Concerted efforts are required to in-build environmental sustainability and climate adaptation strategies in all government policies as well as in private sector's future business strategy to reduce vulnerability and increase resilience of Indian agriculture. Such sustainable mitigation strategies need to include identification and development of climate resilient varieties, building efficiencies in operating farming systems and efficient water management among others.

The Government of India (GoI) along with state governments has taken numerous proactive steps to combat climate change and to promote sustainable agriculture. For instance, the National Mission for Sustainable Agriculture (NMSA) which focuses on sustainable development of agriculture through use of improved crop seeds, efficient water use efficiency, integrated pest management, improved farm practices, better nutrient management, agricultural insurance, credit support, improved access to markets and Information as well as crop and livelihood diversification. Within NMSA, Rainfed Area Development is a component focusing on Integrated Farming System (IFS) which promotes supplementary farm based livelihood support activities apart from crops/ cropping system (such as animal husbandry, forestry) to provide greater resilience & sustenance to farmer in the wake of extreme climatic events. Other key government initiatives include the 'Per Drop More Crop' component of Pradhan Mantri Krishi Sinchayee Yojana (PMKSY- PDMC) which focuses on enhancing water use efficiency at farm level through Micro Irrigation technologies and 'National Innovations in Climate Resilient Agriculture' (NICRA) anchored by the Indian Council of Agricultural Research (ICAR) that focuses on developing climate resilient technologies through short term and long term research and farm level demonstrations so as to enhance climate resilience across vulnerable areas of the country.

Efforts to promote sustainable agriculture and to combat the impact of climate change will necessitate the use of innovative technology and digitalization. Climate-smart agriculture increasingly leverages digital technologies in the agricultural domain. Digitalisation enables prediction of extreme climatic events in advance to minimize crop loss. Farmers with awareness of weather events can respond by planting more appropriate crops or varieties and in adopting suitable crop management options. Major innovations in response to climate variability will take the form of improved information through monitoring, forecasting and better micro-climate modeling. This report identifies key smart technologies across the value chain and identifies key emerging innovation themes that could play a significant role in enhancing sustainable development of the agricultural sector.

The third and concluding chapter lists out actionable recommendations that, if implemented, could enhance sustainable growth of the agriculture sector. Sustainable farming requires better farmers' access to right inputs at the right time, efficient farm production techniques and an efficient supply chain to deliver quality produce at reasonable price to the end consumers. Access to quality inputs, finance & insurance, along with improvement of logistics and marketing infrastructure assumes greater significance to provide farmers adopting sustainable farming measures, a sustainable income and a sustained market. Accordingly, this chapter highlights specific recommendations to boost efficiency across critical legs of the supply chain, as well overarching policy recommendations for building an enabling environment for sustainable and inclusive growth of the agriculture sector.

(v) Sustainable Agriculture - ISA article - DM Hegde & SNS Babu July 30 2016.pdf (icar.gov.in)

(vi) Intergovernmental Panel on Climate Change Report (IPCC), 4th Assessment report

(vii) Climate Change and Indian Agriculture: Impact, Adaptation and Vulnerability – Salient Achievements from ICAR Network Project, 2012, Eds. S. Naresh Kumar, Anil Kumar Singh, P.K. Aggarwal, V.U.M. Rao and B. Venkateswarlu. IARI Publication

1

Journey of Indian agriculture – A snapshot



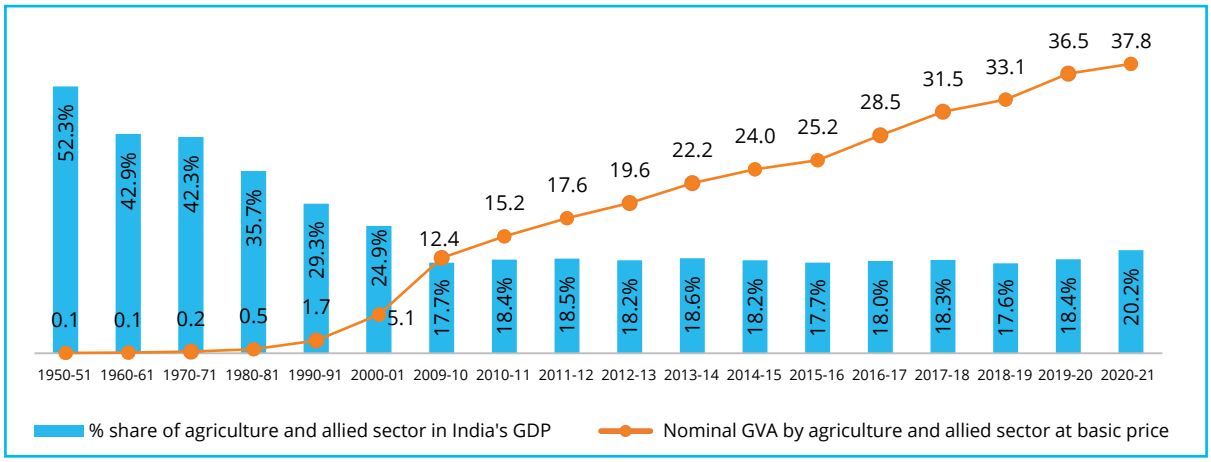
1.1 Introduction

Indian agriculture has witnessed several moments of glory in the last seven decades since independence. With prudent government policies and support, Indian agriculture has transformed from a phase of shortage management during the 50s to a period of surplus management over the last few years. In addition to the major success of green revolution and other key agriculture reforms taken up by various governments, the economic reforms initiated in early 90s have played a significant role in the agricultural growth story – as it opened the economy for private sector participation, liberalized trade and deregulated activities across the agriculture value chains – from supply of seeds to agricultural marketing.

Today, agriculture remains a crucial sector for the Indian economy - as it ensures food security, promotes inclusive growth and enhances rural income and livelihoods. Agriculture and allied sector continue to serve as the principal source of employment and source of livelihood for about 50% of the country's population. While the contribution of agriculture to national GDP has come down from about 52.3% in 1950-51 to about 20.2% in 2020-21, the growing vibrance and importance of the sector can be gauged by the fact that gross value added (nominal at base price) has increased from about INR 100 billion in 1950-51 to about INR 37.8 trillion in 2021[1] (refer exhibit 1).

[1]*Source: National Statistics Office (NSO), DAC&FW*

Exhibit 1: India trends: Annual contribution of agriculture and allied sector to GDP and Nominal GVA of agriculture and allied sector (INR Trillion)

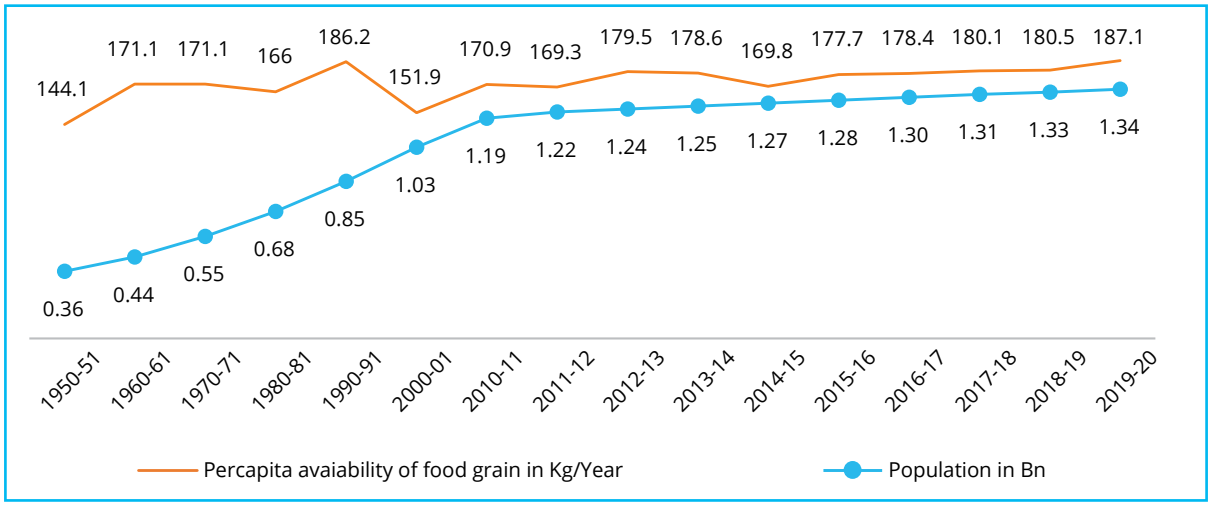


Source: MoA&FW, Agriculture Statistics 2020

The bedrock of this vibrance is the country's inherent agro-climatic strength. India has the 2nd largest arable land resource in the world. In addition, the country has 20 agro-climatic regions and all 15 major climates that exist in the world. The country is home to 46 of the 60 soil types of the world[2] as well. These inherent strengths, coupled with government focus and farmers' enterprise, have enabled the country to meet food security needs on the one hand while gainfully employing millions on the other.

From a food security perspective, a review of trends in population growth and food grain availability (refer exhibit 2) reflects that though population has grown from 0.36 billion in 1950-51 to about 1.34 billion in 2019-20, the per capita availability of food grains per year has constantly increased over these decades, improving from 144 kg to 187.1 kg[3].

Exhibit 2: Trends in India's Population Growth and Per Capita Availability of Food Grains per Year



Source: MoA&FW, Agriculture Statistics 2020

[2]*Source: MoA&FW, FAOSTAT*

[3]*MOA&FW, Agriculture Statistics 2020*

In addition to meeting food security needs, the agriculture sector has also transformed into a key contributor to manufacturing (through food processing) and international trade. Over the last two decades (1990-91 to 2018-19), the GVA by food processing as a percentage of GVA by agriculture has grown from 4.1% to 11.1%[4]. Alongside food processing, agri-exports has also grown significantly. From a net importer of food grains in the 1950s, India has transformed to become the 11th largest exporter of agricultural produce[5]. In 2020[6], India exported agricultural products worth USD 42 Bn, contributing to about 2.5% of global agri exports. India's Agri exports contributed to about 13% of the nation's overall merchandise exports in 2020[7].

While allied sectors such as dairy, fisheries and poultry have played a major role in this transformative development, this chapter focuses on crop based agriculture, capturing the journey of crop production and resultant impact on various sub-sectors that contribute to production and off-take of farm produce.

1.2 Transformation in the crop production ecosystem

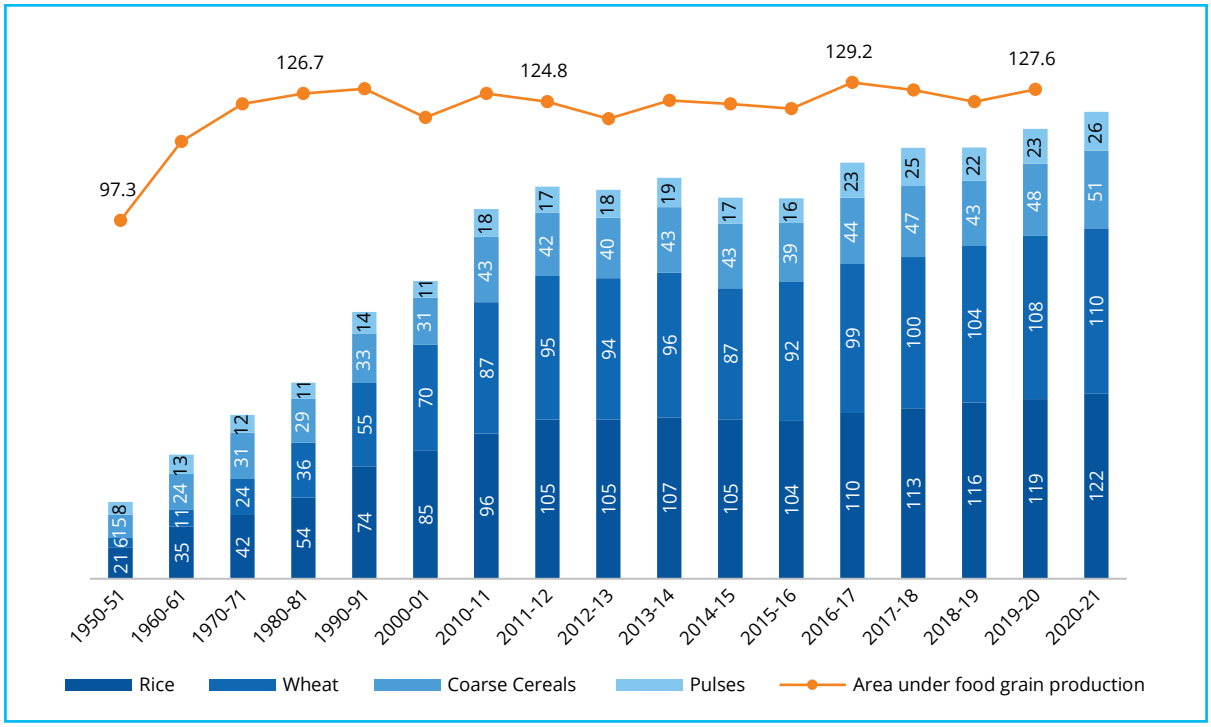
The growth and development of crop-based agriculture can be broadly divided into four phases in terms of time period.

- **The 1950s was a period of shortage and stagnant production** – witnessing limited growth in agricultural production. Food grain production was just 50.8 Mn MT in 1950-51, with a yield of 522 kg/ha[8].
- **The 1960s-1980s was the era of Green Revolution** that witnessed transition from stagnancy to higher food grains production, characterized by introduction of High Yield Variety (HYV) of seeds, increased use of fertilizers and improved irrigation, resulting in a significant spike in production. This led to food self-sufficiency and reduced import of food grains. The food grain production in 1980-81 increased to 126.7 Mn MT, with a productivity of 1.02 MT/Ha.
- **The 1980s-2000s was the initial period of surplus production** during which India achieved food security and started exports of food grains. This period coincided with strong economic reforms and increase in domestic consumption due to high income growth.
- **2000 Onwards began the era of Technological Advancements and Transformation** witnessing better technology adoption, rise in institutional credit for agriculture and assured food security. Introduction of multiple schemes such as the National Food Security Mission (NFSM) to increase the production of commodities, National Horticulture Mission (NHM) to improve fruit and vegetable production, bringing Green Revolution in Eastern India (BREI) and National Mission on Oilseeds & Oil Palm helped diversify the production basket and achieve record production.

In the year 2020-21, total food grain production in the country was estimated to have reached a record 309 Mn MT[9]. Exhibit 3 depicts the growth trends in area and production of food grains over the last seven decades.

[4] *National Accounts Division, Central Statistics Office, MOFPI Annual report 2020-21*
[5] *ITC Trademap, for the year 2020.*
[6] *Calendar year 2020, ITC Trademap*
[7] *Source: ITC Trademap, YES Bank Analysis, Agriculture products include HS Code 1 to 24 and 52 (cotton).*
[8] *Ministry of Agriculture and Farmers Welfare (MoA&FW), GoI*
[9] *MoA&FW, GoI*

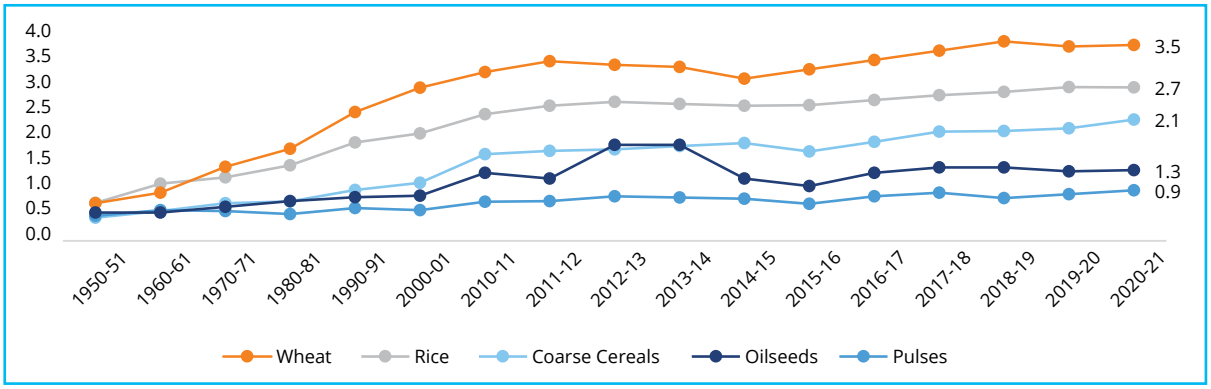
Exhibit 3: Growth Trend in Area (Mn Ha) and Production of Food grains (Mn MT) 1951-2021



Source: MOSPI, RBI, MoA&FW

Growth in area under cultivation drove food grain production till the early 80s. While acreage under food grain production grew by about 30 % during the initial three decades (1950-51 to 1980-81), the growth was just about 1% over the next four decades (1980-81 to 2019-20). Increasing productivity, due to the impact of green revolution, continued to drive production for the next three decades (from 1980-81 to 2010-11). However, the impact of productivity improvement started tapering off gradually over the last decade (refer exhibit 4), as the aftereffects of poor management of natural resources, impacts of climate change and injudicious use of agri inputs played out in the form of inefficient crop production.

Exhibit 4: Trend in Productivity of Food Grains (MT/ha) from 1950-51 to 2020-21

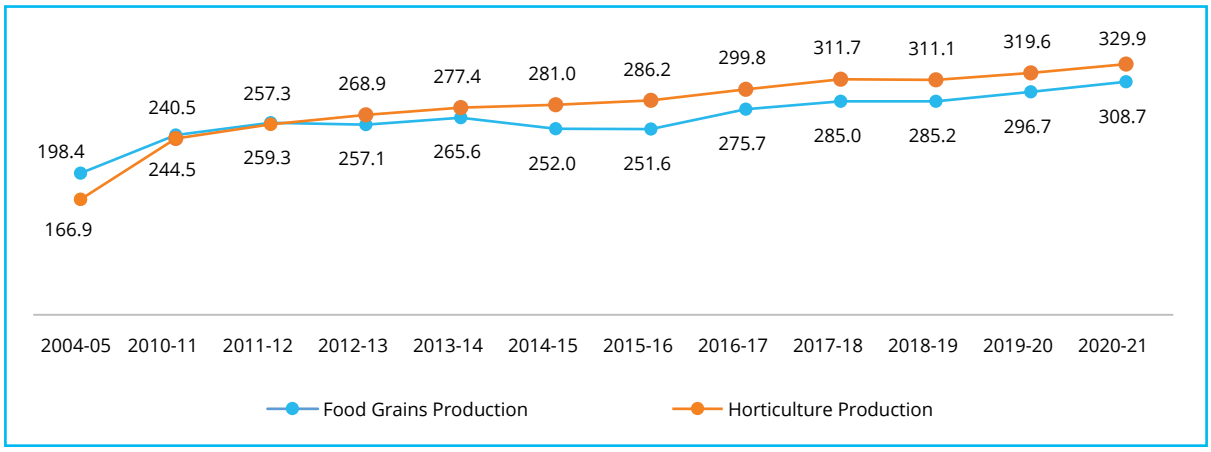


Source: RBI, Ministry of Agriculture & Farmers Welfare, Government of India

With the Indian economy opening up in the 90's, income levels rose, and consumption patterns of people shifted towards high value products. Accordingly, the agricultural system responded

with farmers gradually shifting from traditional, subsistence farming of non-commercial crops to cultivation of commercial and high value crops. While technological interventions drove productivity of certain cash crops such as cotton, better access to irrigation and higher demand for high value crops drove increase in area and production of fruits and vegetables. For instance, over the last 15 years (2004-05 to 2020-21), production of horticulture crops has doubled (from 167 million MT to 330 million MT) overtaking food grain production in 2012-13 (refer exhibit 5).

Exhibit 5: Trend in Growth of Horticultural and Food grain Production (Mn MT) 2004-05 to 2020-21



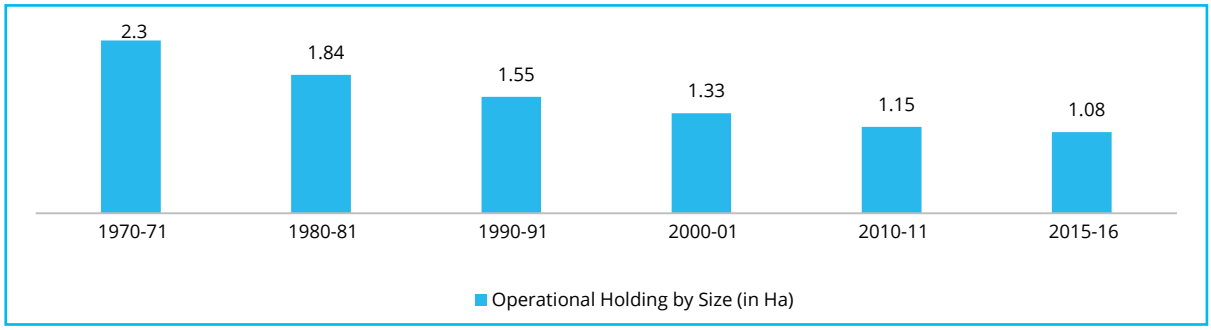
Source: MoA&FW, Agriculture Statistics 2020, PIB, GoI (For 2020-21 data Horticultural Crops)

This transformation in dynamics of agricultural production has come in tandem with significant change in access to various pre-harvest factors of production (such as land holding, irrigation, farm inputs, finance and insurance among others). An overview of changing dynamics across these factors is captured herewith.

Land holding pattern

The average farmland holding, which currently stands at about 1.08 Ha, has dropped by about 50% since the early 70s (refer exhibit 6). Small and marginal farmers - holding less than 2 ha of land increased from 70% in 1970-71 to 86.1% in 2015-16[10]. Around 68.5% of these were marginal farmers holding less than 1 ha of land (refer exhibit 7). Clearly, Indian agriculture is much more dependent on small and marginal holders today than was the case during the early years of independence.

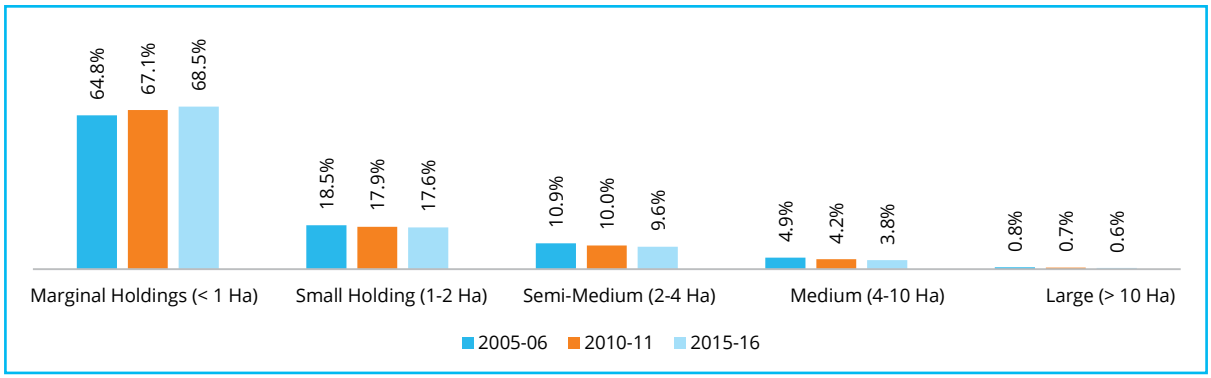
Exhibit 6: Trends in Operational Land Holding Size (Ha)



Source: MOSPI data 77th Survey 2018-19

[10]*Agriculture Census:2015-16 (DoAC&FW, 2019)*

Exhibit 7: Trend in Composition of Land Holding in India based on Holding Category



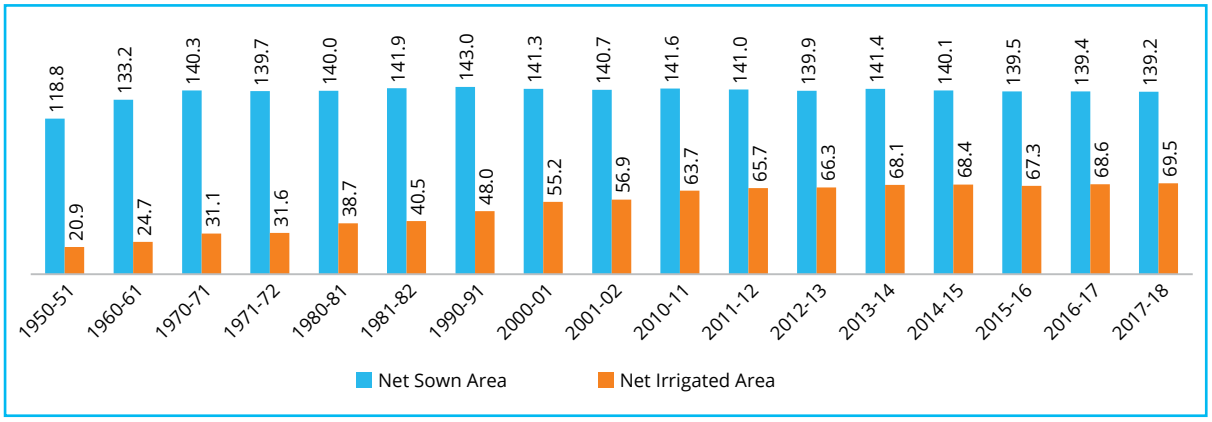
Source: MoA&FW, Agriculture Census 2015-16

Access to irrigation

The net irrigated area has increased from 20.9 Mn Ha in 1950-51 to 69.5 Mn ha in 2019-20 (refer exhibit 8). While this is a significant improvement, close to 53% of cropped area in India is water stressed[11]. Moreover, current irrigation offtake has been skewed to four major crops - Rice, wheat, cotton and sugarcane - which occupy 46% of Gross Cropped Area (GCA) but take up 65% of the Gross Irrigated Area (GIA)[12]. In Maharashtra, for example, while overall irrigation cover is just 19%, sugarcane crop (that occupies 4% of gross cropped area) takes away almost two-thirds of irrigation water of the state.[13]

In addition, the current ground and rainwater management practices are calling for keen focus on conservation and sustainable use. For instance, region wise trend shows that annual groundwater extraction rate in states such as Punjab is 166% - exerting immense pressure on its groundwater resource. Haryana and Rajasthan are other states where the volume of ground water extracted significantly exceeds limits.

Exhibit 8: Trend in Growth of Net Irrigated Area (Mn Ha) in Comparison to Net Sown Area (Mn Ha)



Source: MoA&FW, Agriculture Census 2015-16

[11] *MoA&FW, ICRIER, NABARD*
[12] *MoA&FW, ICRIER, NABARD*
[13] *Indian Council for Research on International Economic Relations (ICRIER), Working Paper No. 358*

To identify best practices related to water management, the Government of India formed the Ministry of Jal Shakti in 2019 and merged all the linked functions under the Ministry of Water Resources and the Ministry of Drinking Water and Sanitation. Some of the major initiatives and schemes structured and promoted centrally by the GoI for ensuring water sustainability in irrigation are National Water Policy 1987 (last updated in 2012), National Water Mission as one of the eight national missions under the National Action Plan on Climate Change (NAPCC), Micro irrigation Fund with NABARD and Pradhan Mantri Krishi Sinchayee Yojana (PMKSY).

Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) is a wholistic scheme for development of irrigation sector to achieve goals of assured or protective irrigation to all area under cultivation. It is being implemented in mission mode with four components namely

(i) Accelerated Irrigation Benefit Programme (AIBP)

(ii) Har Khet ko Pani

(iii) Per Drop More Crop

(iv) Watershed Development.

Access to seeds, fertilizer, and agrochemicals

Seeds, Fertilizers and Agrochemicals are the key agri inputs used by farmers for agricultural production. This section provides a snapshot of dynamics in accessing farm inputs.

Seeds

Crop yield improvement largely depends on quality seeds and higher seed replacement rate. Over the years, several seed cultivation zones have evolved in the country with Indian seed industry perfecting the techniques of quality up-gradation to ensure high standards of physical condition and yield of seeds. Area under high yielding variety seeds has grown at 6.33% per year rising from 6.05 million hectares in 1967-68 to 76 million hectares in 1999-2000[14]. In addition, distribution of certified seed by the government has seen an impressive growth during last couple of decades, increasing from 0.86 Mn MT in 2000-01 to 3.8 Mn MT in 2019-20[15]. Apart from the quality seed availability and its distribution, Seed Replacement Rate plays a significant role in increasing productivity. Although after the enforcement of National Seed Policy (2002) the SRR increased significantly[16], Indian agriculture still has a very low seed replacement ratio of around 15%[17] of India's total cropped area (ranging from about 7% in staple crops to 70% in some vegetables). The ideal SRR is 35% for Self-pollinated crops and 50% in cross-pollinated crops.



[14] *Seednet.gov.in, NITI Aayog Report on Demand and Supply Projection towards 2033*
[15] *Pocket Book of Agricultural Statistics, 2020, MoA&FW, GoI*
[16] *https://krishi.icar.gov.in/jspui/bitstream/123456789/11967/1/Book%201.pdf*
[17] *ICAR, NITI Aayog Report on Demand and Supply Projection towards 2033*

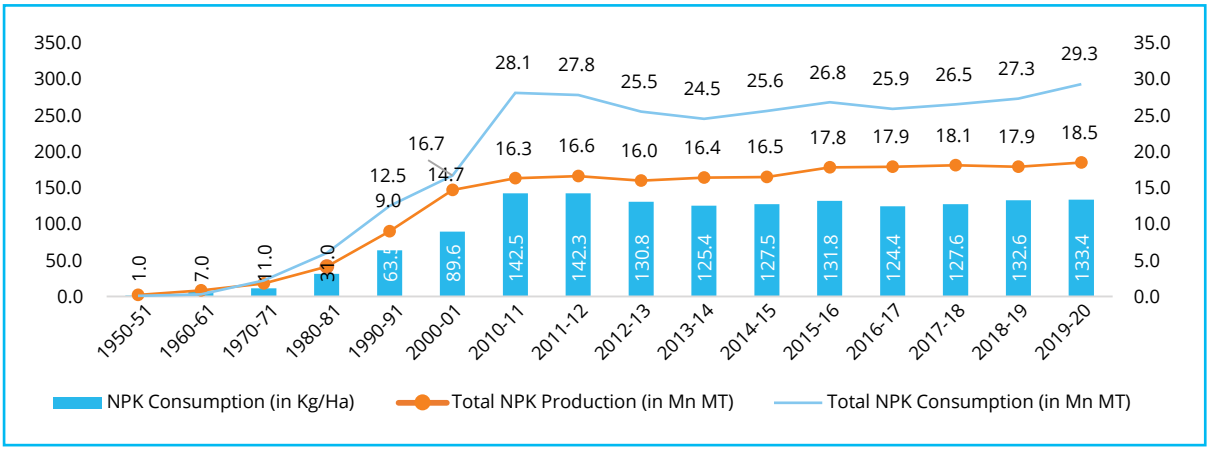
The Government of India carried out a major re-structuring of the seed industry through the National Seed Project Phase-I (1977-78), Phase-II (1978-79) and Phase-III (1990-1991). This project played a critical role in strengthening the seed infrastructure. Introduction of New Seed Development Policy (1988 – 1989) was yet another significant policy milestone for the Indian Seed Industry.

Currently the seed sector is regulated by The Seeds Act, 1966. This Act only covers "notified kinds or varieties of seeds". Thus, regulation of quality is limited to the seeds for varieties that have been officially notified. The new Seeds Bill, 2019 provides for compulsory registration of "any kind or variety of seeds" that are sought to be sold. Enforcing mandatory registration under a new Seed Act, encompassing all varieties and hybrids, is expected to bring greater accountability from the industry.

Fertilizers

As an outcome of green revolution, increased usage of chemical fertilizers has played a significant role in increasing crop productivity. As a result of this, there has been substantial increase in production and consumption of fertilizer over the years. Production of primary fertilizer has increased from around 1 Mn MT in 1950-51 to 18.5 Mn MT in 2019-20 (refer exhibit 9). Consumption increased from around 1 Mn MT in 1950-51 to 29.3 Mn MT in 2019-20[18]. Domestic fertilizer consumption per hectare (in terms of Nitrogen, Phosphorus and Potassium) has increased significantly - from 2.17 kg per hectare in 1961-62 to 134 kg per hectare in 2019-20. India is one of the largest consumers of chemical fertilizers in the world. However, nutrient response ratio is declining due to imbalanced use of fertilizers.

Exhibit 9: Trend of Primary Fertilizer Production and Consumption in India 1950-51 to 2019-20 (Mn MT)



Source: MoA&FW, GoI, Fertilizer Association of India

Agrochemicals

The agrochemicals industry plays a significant role in improving agriculture yields by preventing losses incurred due to pests and diseases. With increased farmer focus on boosting productivity,

[18] *MoA&FW, GoI*

especially in commercial crops, use of plant protection chemicals has continued to grow at a healthy pace. Consumption of pesticides has increased from 43.6 thousand MT in 2000-01 to 61.7 thousand MT in 2019-20[19]. However, current domestic consumption of 0.6 Kg/Ha is much lower than Asia average of 3.7 Kg/Ha and world average of 2.6 Kg/Ha[20]. Moreover, agrochemical consumption in India is primarily that of generic and off-patent molecules as premium-priced specialty chemicals are difficult to introduce due to IPR issues as well as unaffordable for a large segment of farmers.

Labor and farm mechanization

The share of workforce employed in the agriculture sector has declined from 70% in 1951 to 42.3% in 2019 and this will further reduce to 25.7% by 2050[21]. Lack of workforce availability and pressing need for improving crop productivity calls for a strong focus on increasing mechanization in agriculture. There is substantial increase in agriculture mechanization in India. Indian tractor industry has emerged as largest in the world and account for about 1/3rd of the total global tractor production[22]. Sale of tractors in India has increased from 3.9 Mn in 2000-01 to 8.8 Mn in 2019-20. However, the level of farm mechanization is just about 40-45% compared to other countries such as US (95%), Brazil (75%) and China (57%)[23].

Keenly aware of the importance of farm mechanization, Government of India (GoI) has executed various schemes and policies supporting mechanization in Indian agriculture. The Sub Mission on Agricultural Mechanization (SMAM) is a significant initiative by GoI in this direction. An ambitious target of increasing the availability of farm power from 2.02 kW/ha (2016–17) to 4.0 kW/ha[24] by the end of 2030 has been set. Seven-year plan[25] which is effective till 2021-22 has identified new targets for SMAM like establishment of 2.8 lakh Custom Hiring Centers, distribution of 19 lakh machineries including multiple equipment threshers, harvesters, tillers. Apart from SMAM, GoI has launched various comprehensive schemes like Rashtriya Krishi Vikas Yojana (RKVY), Mission for Integrated Development of Horticulture (MIDH) and National Food Security Mission (NFSM) having farm mechanization as a significant component.

Access to farm credit and insurance

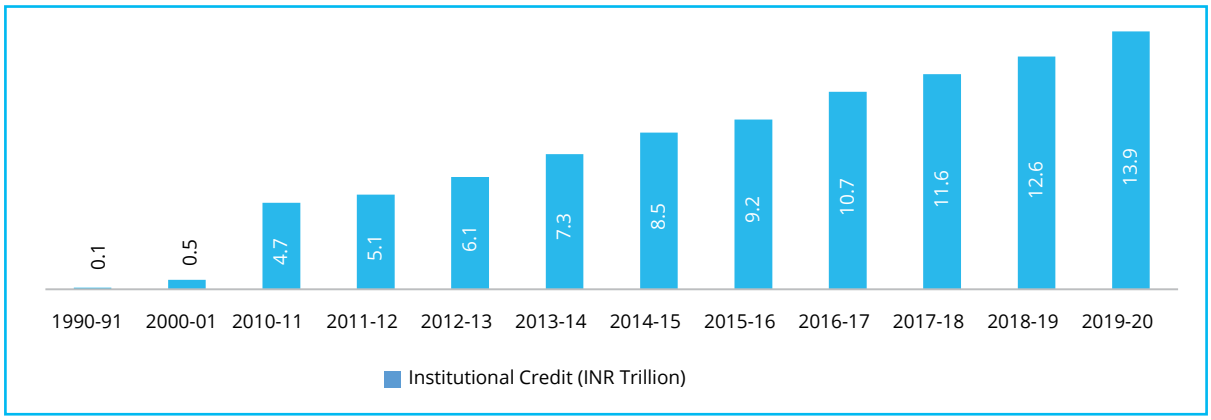
Credit

As per Reserve Bank of India's analysis, the ratio of Agri-Credit outstanding to Agri-GDP increased from 0.6% in 1950-51 to 51.56% in 2017-18[26]. According to the All-India Debt and Investment survey (AIDIS) report, non-institutional sources of agricultural credit declined from 90% in 1951 to 37% in 1981. Over the last three decades, flow of institutional credit has increased from about INR 100 billion in 1990s to INR 13.9 Trillion in 2019-20 (refer exhibit 10). As per NITI Aayog estimates, the Ground Level Credit and Short-Term loan requirement is estimated to touch INR 38 Trillion and INR 28 Trillion respectively by 2032-33[27]. Key policy interventions that drove institutional credit to farmers include nationalization of banks, introduction of RRBs (which expanded the reach of

[19] *MoA&FW (https://eands.dacnet.nic.in/PDF/Pocket%202020%20Final%20web%20file.pdf)*
[20] *FAOSTAT, 2017 data*
[21] *Niti Aayog, Demand and supply projections towards 2033*
[22] *Economic Survey, 2017-18*
[23] *Report on Farm Mechanization: Ensuring Sustainable Rise in Farm Productivity and Income 2019, FICCI*
[25] *Mechanization – Key to higher productivity to double farmers' income, 2017, FICCI*
[26] *RBI Report of the Internal Working Group to Review Agricultural Credit*
[27] *Niti Aayog, Demand and supply projections towards 2033*

formal credit in the country), introduction of Kisan Credit Card and targeted lending under Priority Sector Lending guidelines.

Exhibit 10: Flow of Institutional Credit to Agriculture (in INR Trillion)



Source: MoA&FW, GoI, Economic Survey, Government of India, Various issues

The key challenges faced in agriculture credit are penetration of institutional credit to small and marginal farmers, equitable distribution of credit across regions and high levels of farmer indebtedness. As per latest NSO, MoSPI 77th round of survey on "Land and Livestock Holdings of Households and Situation Assessment of Agricultural Households" 50.2% of agricultural households are indebted with average amount of INR 74,121 loan outstanding per household. Around 70% of the outstanding loans were taken from institutional sources. In some States (such as Kerala, TN, Karnataka, Telangana, Punjab), agricultural credit is higher than their gross value added (GVA) from agriculture.[28]

Insurance

Crop insurance was not available to farmers of Independent India till the 70s. Government of India started a crop insurance scheme on a limited scale in the year 1972-73. A pilot crop insurance programme was initiated in the year 1979 to safeguard farmers by providing cover against decline in crop yield from a threshold level. The crop insurance scheme was modified a number of times over the last four decades. In 2016-17, central government launched a comprehensive "Pradhan Mantri Fasal Bima Yojana (PMFBY)" based on commercial model of crop insurance - subsidized by both state and central governments. As an end to end risk mitigation mechanism for farmers, the scheme extends coverage for the entire cropping cycle from pre-sowing to post-harvest. The average sum insured per hectare has increased from INR 15,100 during the pre-PMFBY Schemes to INR 40,700 under PMFBY. As on January 2021, claims worth INR 900 Bn have been paid out under the Scheme.[29] However, Since the launch of PMFBY till 2019-20, the percentage area covered under insurance has remained constant at around 25-28% of gross cropped area[30].

Access to markets and post-harvest infrastructure

The marketable surplus of agriculture in India has shown a healthy rise due to increased productivity at farm level. Rising marketed surplus called for efficient marketing system to enable fast and effective movement of goods from producers to consumers. Essential Commodities

[28] *Commission of Agriculture Cost and Prices, Kharif 2021 Report, RBI (https://www.rbi.org.in/Scripts/PublicationReportDetails.aspx?UrlPage=&ID=942)*
[29] *Economic Survey 2020-21, GoI*
[30] *MoA&FW (https://eands.dacnet.nic.in/PDF/Pocket%202020%20Final%20web%20file.pdf)*

Act, 1955 and The Agriculture Produce Marketing Laws in 1960s started the formalization of agriculture marketing in India. Under these Acts, farmers are required to sell their produce at state-owned mandis. The APMC system led to the establishment of over 7,000 regulated markets in the country. These regulated markets were in addition to thousands of rural periodic markets or haats where farmers could sell their goods. However, with growing supply, there was need for increasing the off-take avenues for farmers – such that they could sell directly to market, without much government regulation. To address these requirements, various policy measures were taken - including amendments to the APMC act and roll out of the Model APMC Act of 2003, launch of an online trading platform-National Agriculture Market (eNAM) in 2016 and the landmark three farm Acts of 2020. E-NAM envisioned integrating all the existing APMCs in the country to create a pan-Indian electronic market for farm produce. Currently about 1.7 crore farmers are registered in e-NAM, 1,000 mandis in 18 states and 3 UTs are already integrated and a trade value of INR 1.22 Trillion has been carried out through e-NAMs as on March, 2021[31].

In addition to building marketing infrastructure, various governments have focused on developing the right storage and logistics infrastructure. The total storage capacity available with FCI and State Government agencies for storage of food grains as on January 2021 was about 80.7 Mn MT[32]. Of the total capacity, 65.7 Mn MT was covered storage and about 15 Mn MT (18.6%) was CAP (cover and plinth) storage. In addition, India has a 37.43 Mn MT capacity of Cold storages across states[33]. However, increased production and procurement due to open-ended procurement policy is leading to huge stocks and acute shortage of scientific storage infrastructure. While the Government of India is focusing intensively on creation of post-harvest infrastructure, including by providing subsidies and interest subvention incentives through various schemes such as the Agriculture Infrastructure Development Fund, Mission for Integrated Development of Horticulture (MIDH) and Pradhan Mantri Kisan SAMPADA yojana among others, farmers continue to face acute shortage in storage infrastructure.

Indian Council of Agricultural Research (ICAR) assessment of crop loss in 2016 revealed that about 3.9% to 6% cereals, 4.3% to 6.1% pulses, 2.8% to 10.1% oilseeds, 5.8% to 18.1% fruits, and 6.9% to 13% vegetables were lost during harvesting, post-harvesting activities, handling and storage.[34]



[31] *e-NAM Website (https://enam.gov.in/web/eNam-mandi-status)*
[32] *Food Corporation of India*
[33] *NCCD*
[34] *https://pib.gov.in/newsite/PrintRelease.aspx?relid=136922*

Indian agriculture has transformed significantly over the years as seen from the growth trends in overall production of agri commodities and enhancement in different components of agri value chain. Currently India is the second largest producer of wheat, rice, F&V, sugarcane, cotton and oilseeds and largest producer of spices globally. This transformation was driven technological innovations, institutional engineering, and government support in providing right incentives to the sector. However, the changing socio-economic as well as agro-climatic situation has unfolded new challenges that need to be identified and addressed so as to continue growing sustainably.

Exhibit 11: Estimate of current market sizes for select sub-sectors

Sector	Market size in 2020
Seeds	~INR 222.4 Bn (USD 3 Bn)
Fertilizer	~INR 926.7 Bn (USD 12.5 Bn)
Agrochemicals	~INR 444.8 Bn (USD 6 Bn)
Farm Equipment	~INR 915.3 Bn (USD 13 Bn)#
Agri Warehousing	~INR 70.4 Bn (USD 1 Bn)#
Cold Chain	~INR 300.0 Bn (USD 4 Bn)
Food Processing	~INR 19,496.8 Bn (USD 263 Bn)

Source: Industry sources, FICCI
** Converted basis average USD: INR exchange rate of 74.1322 in 2020 and 70.4059 in 2019*
 # 2019

1.3 Current challenges faced by agriculture sector

While Indian agriculture has grown leaps and bounds over the last seven decades, aptly addressing the food security and socio-economics of the nation till now, the sector faces new challenges – as demand for the sector increases beyond food security and self-sufficiency, towards sustainable, climate resilient production. To achieve sustainable production, there is a need to identify critical challenges across the supply chain and innovatively address them so as to improve efficiency, reduce wastage and increase farm income while also providing for sustainable use of natural resources such that these scarce resources are conserved for future use.

Current challenges faced by agriculture sector can be broadly classified into three areas as follows:

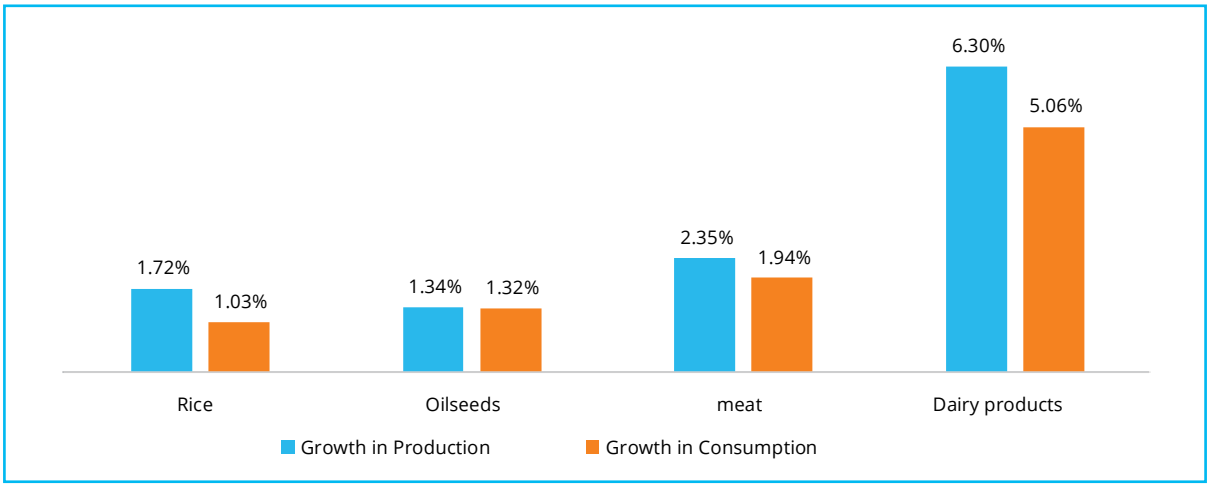
I. Demand-Supply mismatch
II. Inefficiencies across the supply chain and
III. Sustainability and climate related challenges

I. The challenge of demand-supply mismatch

While efforts put in by the Indian Government to improve production and address post-harvest challenges have resulted in stable growth in supply of agricultural produce, the growth in domestic consumption is not at par with that of production for many key agricultural commodities (refer exhibit 12). As per the estimates of the Committee on Doubling Farmers' Income (2019), at the all-India level, farmers are unable to sell about 40% of the total fruits and vegetables produced in the market or lose around INR 630 Bn every year for not being able to sell their produce[35].

[35] *Report of the Committee on Doubling Farmers' Income*

Exhibit 12: Growth in Production and Consumption of Select Agri Commodities (2010-19)



Source: OECD-FAO Agricultural Outlook 2020-2029

Supply exceeding demand, is resulting in bouts of production gluts and high pressure on commodity prices - both for staples as well as for seasonal perishable produce such as fruits and vegetables. The emerging surplus of food in India is calling for a close look at alternative opportunities for off-take of produce, such as promoting domestic consumption of high value and healthy food produce, value addition through processing and enhancing exports – so as to maximize farm income and protect the livelihoods of farmers dependent on these commodities.

In light of this transformation in demand-supply dynamics, policy makers are keen on re-orienting agriculture development policies from focusing on increasing crop productivity to increasing farmer income - by creating the right ecosystem for better off-take of the increasing agricultural surplus at a remunerative price.

II. Challenge of inefficiencies across the agri-supply chain

To be responsive to growing demand of high-quality agricultural produce, there is a need to take focused action to overcome certain key challenges that hinder efficiencies across each leg of the agri-supply chain. A snapshot of critical challenges that hinder efficiency and development in each leg of the supply chain are captured herewith.

Farm level

Small and fragmented land holdings

- Average size of farm holding has decreased to 1.08 ha. Majority of small & marginal farmers exhibit inefficiencies in production, adoption good agriculture practices, technology and access to market- leading to low yields.

Inadequate availability of good quality seed and plant propagation material

- Farmers typically use farm saved seeds. India's overall SRR is <15% against desirable 25% for self-pollinated crops, 35% for cross pollinated crops and 100% for hybrids. The use of certified quality seeds is also low. Rampant supply of spurious seeds.

Non-judicious use of fertilizers and agro-chemicals

- Suboptimal fertilizer use, improper N: P: K ratio leads to soil imbalances.
- Use of spurious pesticides and its overuse threatens food safety & causes environmental degradation.
- Dominance of generic molecules instead of new generation, hi-tech specialized molecules due to costs and IPR issues

Irrigation and water use efficiency

- Low water use efficiency and high wastage, with indiscriminate production of water intensive crops in unsuitable locations. Disproportionate use of groundwater aquifers in many parts of the country, spurred by subsidized electricity and skewed policies
- Inadequate surface irrigation facilities. Agricultural production impacted heavily due to vagaries of monsoon

Low levels of mechanization

- Mechanization penetration is approximately 40-45%. Farm operations such as plowing, sowing, threshing and harvesting are still majorly being done manually due to high cost of mechanisation.

Labour shortage

- Recent NSSO surveys and census data suggest a gradual withdrawal of labor and cultivators from agriculture. This has pushed up labor costs.

Adverse environmental impact and loss of biodiversity due to climate change

- Increasing temperatures, reduced rainfall, irregular weather patterns being experienced throughout the country and impacting yields.
- The pace of establishing early warning systems is slow, further compounding climate related loss in production.

Low investment in agricultural research and development

- India spends around 0.3% of its agriculture GDP on research and development[36], compared to countries, such as Brazil and South Africa, which spend 1.8% and 3.06% respectively.
- Lack of techno-commercially oriented skilled manpower focused on R&D. Private sector R&D curtailed by ineffective IP regime; public R&D suffers from low focus on commercially viable solutions and resource constraints.

Post-harvest Infrastructure deficit

- Low access to primary processing and storage infrastructure at farm level – accentuated by low scale production and high storage costs curtailing economic viability
- High cost of agro-logistics due to fragmentation and high dependence on road transport. Logistics cost estimated at 14% for India, higher than Japan's 11% and the US' 9-10%[37].
- High cost of cold storage due to low scale, poor access to affordable power.
- Road connectivity yet to be fully developed to reach the last farm-mile.

[36] *Economic Survey 2018-19, Government of India*
[37] *A New Vision for India Agriculture, FICCI*

Lack of access to markets

- Inadequate access to reliable and timely market information for the farmers, absence of supply & demand forecasting.
- e-NAM is not utilized to its maximum potential, given the infrastructure for quality testing, grading and certification is yet to come up.

Low levels of processing

- Value addition at the farm level is minimal. Food production in India is further characterized by high wastage and low levels of processing. Processing levels in India are ~10% compared to more than 20% levels in the US[38].
- Volatile raw material quality and cost, high power costs, seasonal capacity utilization and lack of product diversification renders investment in processing economically unviable.

III. Sustainability and climate related challenges

Growing demand for food and the growing aspiration of farmers to generate higher income from their farms through increased productivity has led to unsustainable use of limited natural resources – such as water, as well as pollution and degradation of soil and water resources due to excess and unscrupulous use of chemical fertilizers and pesticides.

Compounding this challenge, is the vulnerability of agriculture to climate change. Weather-related events such as floods and draughts and natural hazards like hailstorm, cyclone, high speed winds, heat waves & frosts. These events are becoming frequent and intense and almost regular in some regions of the country. In addition, the seasonal and spatial variability of rainfall in India makes 68% of area under cultivation prone to drought in varying degrees[39].

According to Economic Survey, 2018, India faces annual loss of US$ 9-10 billion due to the adverse effects of climate change - with Small and marginal farmers being the most affected segment due to adverse effects of climate change.

Addressing all these three critical challenge areas – demand supply mismatch, inefficiencies across agri-supply chain as well as sustainability and climate related challenges – is crucial for sustainable growth and development of agricultural sector.

[38] *Industry Sources, YES Bank analysis*
[39] *Ministry of Climate and Water Resource. 35% of the area which receives rainfall between 750 mm and 1,125 mm is considered as drought prone while 33% of the area receiving less than 750 mm is chronically drought prone*

2

Smart and sustainable agriculture – Need & opportunities



The cereal-based Green Revolution brought about significant progress in Indian agricultural production. While this was driven by increased use of fertilizers, water, agrochemicals, machinery, and pesticides– the equation of these inputs to productivity remains non-linear. With intensification of inputs use, decreasing per capita arable land and a cereals-dominated agricultural production, India has been witnessing depletion and degradation of its natural resources which is further aggravated by the adverse impact of climate change. The current agricultural practices present a formidable challenge to agricultural sustainability. For instance, of the total GHG emissions from Indian agriculture, 54.6% was from enteric fermentation (livestock), followed by 19.1% from agricultural fertilizers, 17.5% from rice cultivation, 6.7% from poor manure management and 2.2% from burning crop residue[40]. For sustainable growth of Indian agriculture, it has become vital to promote and develop sustainable agricultural production systems which enable food security for all, in an ecologically sound, economically viable, and socially responsible manner.

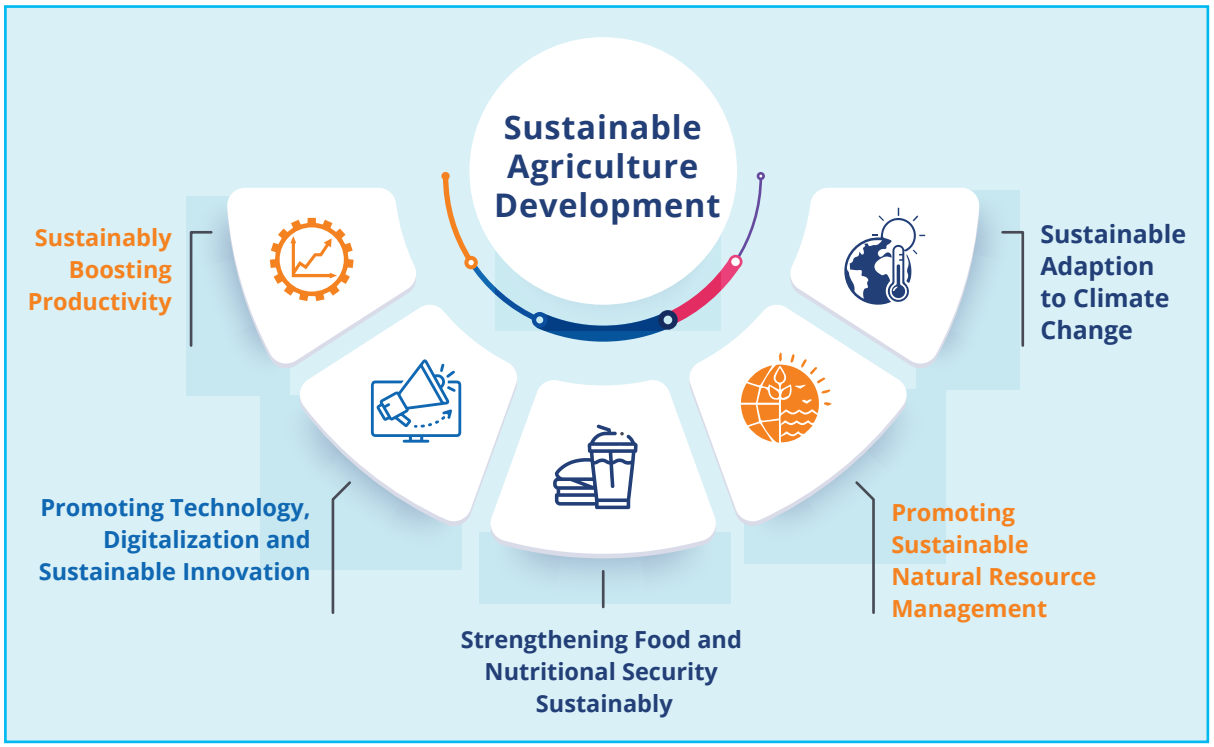
2.1 Envisioning sustainable agriculture imperatives

A long-term vision and strategy need to be framed for achieving sustainability throughout the agricultural value chain. This strategy could be based on three core pillars: promoting holistic ecology, developing efficient markets, and devising policy incentives that enable both farmers

[40]*India – Third Biennial Update Report to the United Nations Framework Convention on Climate Change, 2021. Ministry of Environment, Forest and Climate Change, Government of India*

as well as the industry to facilitate the first two pillars. This strategy need to be in alignment with Doubling Farmer's Income Committee's five pillars: Increasing productivity as a route to higher production; reduced cost of production; optimal monetization of the produce; Sustainable production technology; and risk negotiation all along the agricultural value chain. In line with this vision, 5 core themes have been identified for sustainable agriculture development as depicted in exhibit 13.

Exhibit 13: Five Core Themes for Sustainable Agriculture Development



Source: Yes Bank analysis

A. Sustainably boosting productivity

Improving productivity of the agricultural system is the most pressing expectation from Indian agriculture as it is vital for ensuring food sufficiency as well as to boost farmer income. Increasing the productivity of cereal and legumes will release land and allow for sustainable development of high-value agricultural produce. Increasing farm productivity is critically dependent on efficiently using farm inputs. Developing drought resistant, temperature tolerant and disease resistant varieties suitable for specific micro level climate in India while enhancing productivity and developing best practices in crop cultivation based on scientific methods - such as fertilizers application based on soil testing and optimizing water use with micro-irrigation systems are important measures to increase productivity.

Given the small holder nature of Indian farmers, it is important to develop cohesive institutional systems for dissemination of knowledge of best scientific practices, enabling adoption of new technologies in agricultural mechanization and finally aggregating produce. Organizing farmers into collectives and formation of agricultural clusters could be the most critical pathway to achieve success.

There is an urgent need to reform land laws and free up the lease market so as to facilitate tenant farmers access inputs, subsidies and credit. Promoting contract farming could facilitate private sector's entry into multi-season contracts thereby boosting farmer income. These measures will help in encouraging land consolidation, long term investments and to achieve viable size of holdings for leveraging technology to increase productivity.

A significant but often overlooked component of enhancing agricultural production is investment in agricultural research, education and skill development to improve extension systems. Increasing investment in agriculture research, both in the public and private sector by way of increasing incentives to participate in the agri research, education and extension systems, will be critical for the long term development of the agriculture sector.

B. Promoting sustainable natural resource management

Resource conservation and sustainable management of natural resources is critical for enhancing productivity. Natural Resource Management consists of interventions related to in-situ moisture conservation; water harvesting and recycling for supplemental irrigation; water saving irrigation methods including promoting conservation or zero tillage; location specific inter-cropping systems with high sustainable yield index; green manuring for soil health and fertility improvement; laser levelling; straw management through baler cum-knotter; vermi-composting, and alternate energy sources among others.

Cultivation of additional cover crops in fallow period could be promoted on mission mode, especially the utilization of fallow lands in hilly and north eastern states to produce cereals & oilseeds. Natural farming practices are reported to induce better soil health, crop health, resilience and biodiversity. Innovative farming practices such as hydroponics, aeroponics, aquaponics and poly-house farming systems must be assessed for their socio-economic viability.

C. Strengthening food and nutritional security sustainably

India has come a long way from being a grain deficient country to now being the leading producer of cereals, horticultural crops and a net exporter of agricultural produce. India's production of food grain has increased fivefold since the Green Revolution. However, fast growing population, changing dietary habits, imbalanced nutrition and agricultural vulnerability to climate & natural disasters make food security a top priority for the country. Food security is thus a multi-dimensional concept, requiring producing adequate quantities of high-quality produce and ensuring equal access to food for all. Equally, a strong agricultural marketing system becomes a critical leg of a smooth functioning agricultural supply chain.

Diversification of agriculture in favor of non-cereals and high-value crops, livestock, forestry and fishery is a necessity to augment food security with nutritional security and boost farm income. Higher farm incomes would automatically enable better access to nutritional food. Equally, reforming both the Public Distribution System & private agricultural marketing system, upgrading agri marketing infrastructure across mandis and strengthening market linkages are important tasks to achieve food security. Effort needs to be put in to assess involvement of private sector in public procurement programs to introduce efficiency and reduce the government's burden.

D. Sustainable adaption to climate change

The impact of climate change on agriculture cannot be understated and it will have serious implications for food security. It is important to take a holistic, systems view of the risks and impacts of climate change when designing climate-smart agriculture strategies for sustainable food systems. Substantial investments in adaptation of new practices and technology will be required to maintain current yields and boost food quality to meet increasing demands. The role of private sector and local community institutions will be critical in mitigating the impact of climate change. Farmers and extension workers need to be trained and incentivized to use climate smart technology.

Potential adaptation strategies to deal with the impact of climate change include developing cultivars tolerant to heat and salinity stresses and resistant to flood and drought, modifying crop management practices, improving water management, adopting new farm techniques such as resource conserving technologies (RCTs), crop diversification & biodiversity preservation, improving pest management, better weather forecasts and crop insurance and enhancing the indigenous technical knowledge of farmer. Creation and strengthening of FPOs will be critical for building resilience in the farming ecosystem and for better delivery of climate mitigating measures.

E. Promoting Technology, Digitalization and Sustainable Innovation

Geo-tagging of farms, digitization of agri-value chains, big data analytics, Internet of Things and artificial intelligence in agriculture are the next frontiers of knowledge to drive agriculture into a new growth trajectory. A swift implementation of digital agri-stack will play a catalytic role in moving towards Direct Benefit Transfer and efficient implementation of Government welfare schemes. Digitization of not only farmers information but also of their crops, land holdings and farm dimensions will help in building a smart agriculture supply chain which is efficient, market driven as well as traceable.



Advance data analytics and network mapping to monitor produce flow and identify gaps is necessary for collating information on risks in the supply chain. This will also be valuable while devising suitable strategies to curb post-production losses. Even as farmers and farming moved from subsistence to market-driven, the information systems are yet to be evolved from only restricting to extension services.

There is a need to incentivize agtech companies, mainly start-ups, as well as companies and farmers adopting technology such as for crop diagnostics and precision farming need. These solutions improve farm economics by ensuring sustainable input use, curbing losses and improving farm productivity.

The government needs to consider incorporating enhanced use of ICT and Smart Digital solutions for real time extension. Farmer advisory and data driven crop monitoring / precision farming will lead to optimization of the use of agricultural inputs and will enable delivery to farmers based on farm and crop diagnostics. Quality assaying of agricultural commodities and tech enabled aggregation & distribution of farm produce are some of the other key areas of digital intervention that need to be suitably incentivized.

2.2 Addressing the impact of climate change on Indian Agriculture

Indian agriculture is particularly vulnerable to climate change, given its growing population density, small and fragmented farm holdings, a predominantly rain-fed agricultural system, Himalayan glacier-fed, river-based irrigation in the north and east and a significantly large livestock population. The overwhelming loss of biodiversity, ground water deficit, pollution of ground water and increase in atmospheric greenhouse gases are serious threats to sustainability. Climate change and its erratic manifestations will have their greatest impact in the most vulnerable areas[41].

According to International Panel on Climate Change report, the predicted temperature rise for India is in the range of 0.88–3.16°C by 2050 and 1.56–5.44°C by the year 2080. Studies showed significant negative impacts of climate change, predicting yield reduction by 4.5% to 9.0%, depending on the magnitude and distribution of warming.[42] An IARI study suggests that for every one-degree change in temperature, wheat production loss will average at 4-5 Mn MT. Depending on the modeling technique, it has been estimated that the rice yields can be impacted by up to 40% while for wheat it can decrease by 52%[43].

Overall, climate change adversely impacts both kharif and rabi crop yields across agro climatic zones in the country. Fall harvested kharif crops are most affected by rainfall variance, while winter planted rabi crops face challenges with rise of minimum temperatures. Rice and wheat will be the most impacted crops, therefore jeopardizing the country's food security. However, shorter duration, water stress tolerant crops like coarse grains, rapeseed & mustard and pulses may perform better than the other higher yielding input intensive crops under varying climate change conditions. An overview of the impact of climate change on Indian agriculture is provided in Exhibit 14[44].

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[41] *Sustainable Agriculture - ISA article - DM Hegde & SNS Babu July 30 2016.pdf (icar.gov.in)*

[42] *Intergovernmental Panel on Climate Change Report (IPCC), 4th Assessment report*

[43] *Climate Change and Indian Agriculture: Impact, Adaptation and Vulnerability – Salient Achievements from ICAR Network Project, 2012, Eds. S. Naresh Kumar, Anil Kumar Singh, P.K. Aggarwal, V.U.M. Rao and B. Venkateswarlu. IARI Publication*

[44] *Climate Change and Agriculture in India, Gupta and Pathak. Department of Science & Technology, Ministry of Science & Technology Government of India*

Exhibit 14: Impact of Climate Change on Indian Agriculture

Crops

- Increased frequency and intensity of extreme weather events such as heat waves, droughts, floods and cyclones will affect production levels and increase uncertainty threatening agricultural biodiversity
- Reduction in yield in the rainfed areas due to increased crop water demand and changes in rainfall pattern
- Declined quality of fruits, vegetables, tea, coffee, aromatic, and medicinal plants
- Heat stress due to higher temperature at critical stage of the crop growth

Soil and Water

- Reduced quantity and quality of organic matter content, which is already quite low in Indian soil
- Under elevated CO2 concentration, crop residues have higher C:N ratio, which may reduce their rate of decomposition and nutrient supply.
- Change in rainfall volume and frequency and wind intensity may alter the severity, frequency and extent of soil erosion
- Rise in sea level may lead to salt-water ingression in the coastal lands turning them less suitable for conventional agriculture
- Declining water availability as result of changing rainfall patterns, alteration in stream flow and increase in crop water demand
- Deterioration of water quality due to sea water intrusion, transport of salts from the deeper soil layers as a result of over exploitation of aquifers and faulty irrigation practices

Pests

- Emergence of new diseases/pest problems and increased risk of invasion by migrant diseases and pests. Changes in population growth rates of pathogens and insect-pests.
- Reduced efficacy of different components of disease and insect-pest management.
- Changes in pathogen/insect-pest × host × environment interactions, and loss of resistance in cultivars containing temperature-sensitive genes.

Mitigating the impact of climate change

Concerted efforts are required to in-build environmental sustainability and climate adaptation strategies in all government policies as well as in private sector's future business strategy to reduce

vulnerability and increase resilience of Indian agriculture. Such sustainable mitigation strategies may include the following:

Identifying and developing climate resilient varieties

- Breeding for improved crop varieties /hybrids to mitigate the impacts of high temperature, droughts, floods, insect-pests and disease infestation.
- Identification of crops and varieties (or hybrids) with high water use efficiency, adapted to temperature extremes and high concentration of CO2.
- Breeding new cultivars with enhanced adaptation to high temperatures, CO2 and other GHGs as well as cultivars that yield well with lower water and nutrient inputs. Genetic resources and breeding methods combining conventional and molecular tools, including transgenic approach, are needed to develop such cultivars.

Efficiency in operations of farming systems

- Adjustment of planting dates to minimize the effect of high temperature induced spikelet sterility can be used to reduce yield instability so that the flowering period does not coincide with the hottest period.
- Changing the cropping calendar to take advantage of the wet period and to avoid extreme weather events (e.g., typhoons and storms) during the growing season.
- Development of viable, efficient farming systems through diversification which can withstand climate change situations such as tree-crop-livestock, fisheries, poultry components. Agroforestry systems buffer farmers against climate variability and reduce atmospheric loads of GHGs.
- Promoting Integrated pest management with more emphasis on biological control and changes in cultural practices; pest forecasting using recent tools such as simulation modelling,
- Promoting Zero tillage which has a direct mitigation effect as it converts the GHGs like CO2 in to O2 in the atmosphere and carbon enriches soil organic matter. Keeping the rice fields moist rather than flooded or continuously saturated, thereby minimizing anaerobic conditions, and improving root growth and diversity of aerobic soil organisms, helps in mitigation of climate change.

Efficient water management

- In-Situ moisture conservation, rainwater harvesting and recycling, efficient use of irrigation water and use of poor-quality water are key strategies of adaptation to climate change in India. Integrated watershed management approach could be the most appropriate technology for rainwater harvesting, storage and reuse of harvested water to minimize the loss of crop production during drought and flood years.

Other

- Introduction of new credit instruments with a focus on vulnerable areas, addressing extreme weather events, and weather insurance need to be developed as major vehicle to transfer risk.
- Promoting digitalization and innovative technologies at the farm level for preservation and conservation of resources. This could include drone mapping, ICT tools for weather & disease monitoring among others.

Exhibit 15: Case Study: Promoting Happy Seeder Technology in Rice-Wheat Cropping

Recommended Action: Sowing of short duration rice varieties like PR-126 with DSR machine, followed by sowing of wheat with Happy Seeder machine developed by ICAR must be universalized in Punjab and Haryana.

Demonstration: KVKs demonstration in Bathinda & Faridkot, Punjab and successful adoption by farmers in over 100 acres of land. The KVKs provided Happy Seder machine along with other inputs like wheat seed (HD 3086/PBW-725), Raxil 6 FS (Tebuconazole), Tilt (propaconazole) and Topik (weedicide) to conduct demonstrations

Technology: Happy seeder / zero tillage sowing of wheat in the standing paddy residues, which provides an alternative to the residue burning.

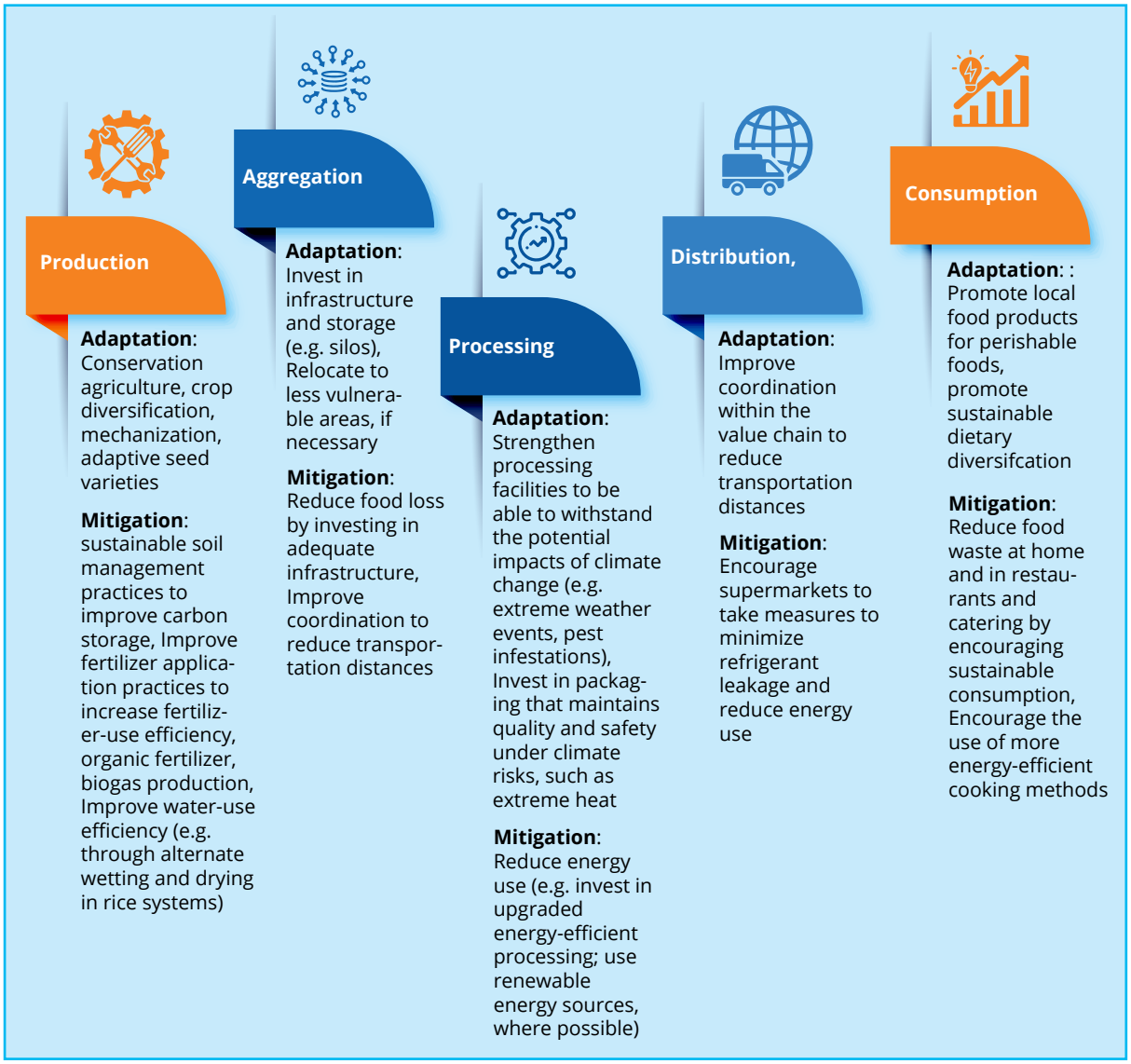
Benefits

- The paddy straw isn't burned but remains in the soil and promotes the beneficial micro organisms which increase the soil fertility and organic carbon.
- This technique saves labor and diesel and wheat crop is sown in the moisture which is already present in the soil which saves one irrigation (rauni) and time of 7-10 days. Irrigation water saved, as first irrigation applied after 55 days of sowing.
- The technology ensures no emergence of weeds, hence saving labour costs.
- Only 5-6 liter diesel is required for sowing wheat crop in one acre with happy seeder, as opposed to 25 litres with traditional methods.
- The potential increase in yield is to the tune of 0.4 to 1.5 q/acre.

Source: Department of Science and Technology, GoI

In addition to variable climate risks, agricultural commodities have different carbon footprints across the supply chain. Since the impacts of climate change pose threats to all stages of agricultural value chain, each level presents opportunities to adapt and become more resilient. The private sector also plays a critical role given its presence across key legs of the post-harvest supply chain. Exhibit 16 provides a snapshot of potential activities for private agribusiness companies and the government to adapt to and mitigate climate change.

Exhibit 16: Climate Impact Adaptation & Mitigation Strategies



Source: https://www.fao.org/climate-smart-agriculture-sourcebook/production-resources/module-b10-value-chains/chapter-b10-5/en/

2.3 Initiatives taken by the Government to promote sustainable agriculture

The Government of India (GoI) along with state governments has taken numerous proactive steps to combat climate change and to promote sustainable agriculture. The government launched National Mission for Sustainable Agriculture (NMSA) in 2014-15 which derives its mandate from Sustainable Agriculture Mission, one of the eight missions outlined under National Action Plan on Climate Change (NAPCC) adopted by Government of India. NMSA focuses on the key dimensions encompassing Indian agriculture including improved crop seeds, livestock and fish cultures, water use efficiency, pest management, improved farm practices, nutrient management, agricultural insurance, credit support, markets, access to Information and livelihood diversification. Within NMSA, Rainfed Area Development is a component focusing on Integrated Farming System (IFS) which promotes supplementary farm based livelihood support activities apart from crops/ cropping system (animal husbandry, forestry etc.) to provide greater resilience & sustenance to

farmer in the wake of extreme climatic events. To promote agro-forestry as a farming system, National Agro-forestry Policy has been formulated by Government of India.

Similarly, the Mission Organic Value Chain Development for North Eastern Region (MOVCD-NER) promotes holistic, organic farming, which aims at development of end to end organic value chains, thereby conserving biodiversity in the North East Region of India.

The Department of Agriculture Cooperation & Farmers' Welfare is also implementing 'Per Drop More Crop' component of Pradhan Mantri Krishi Sinchayee Yojana (PMKSY- PDMC). The PMKSY-PDMC focuses on enhancing water use efficiency at farm level through Micro Irrigation technologies viz. Drip and Sprinkler irrigation systems. During the last five years (2015-16 to 2019-20), an area of 4.7 million hectare has been covered under Micro Irrigation through PMKSY-PDMC.

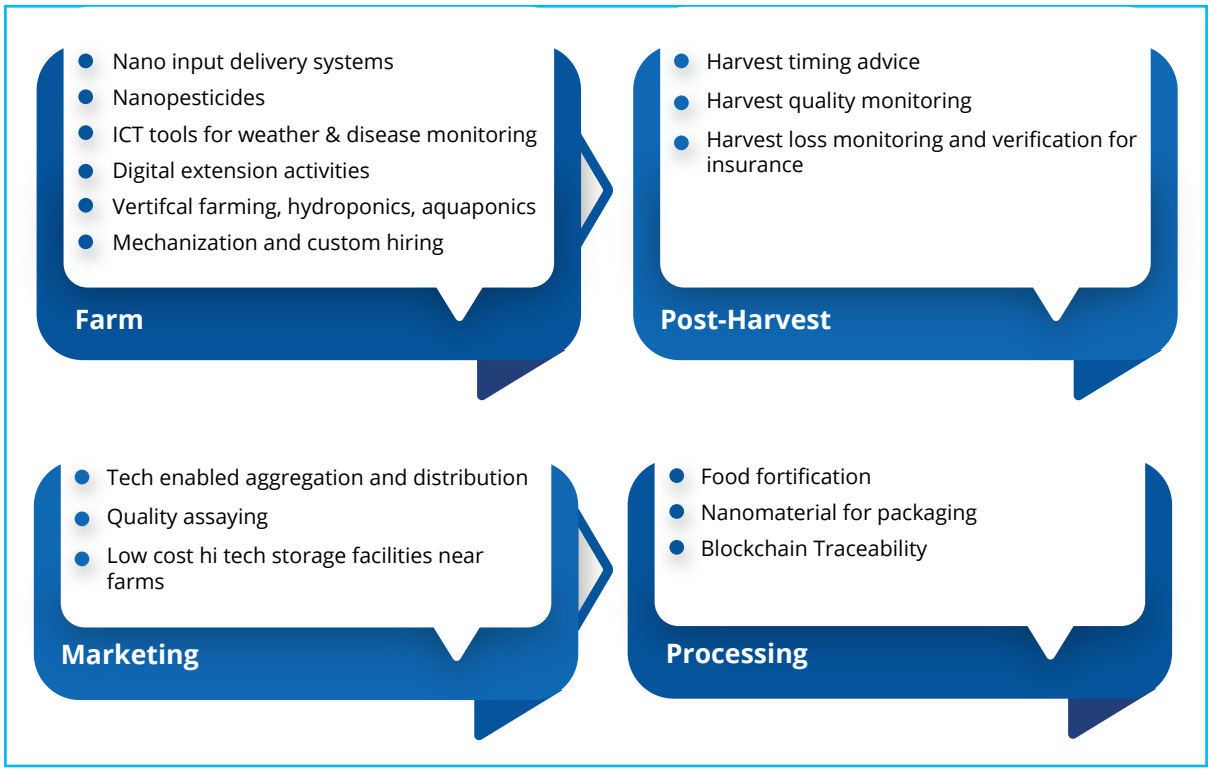
ICAR under the Ministry of Agriculture and Farmers' Welfare launched a flagship network project 'National Innovations in Climate Resilient Agriculture' (NICRA) during 2011 to develop climate resilient technologies through short term and long term research, and also to demonstrate the existing technologies on farmers' fields for enhancing the resilience across vulnerable areas of the country. ICAR has also prepared District Level Contingency Plan and a district level climate vulnerability atlas for undertaking location specific adaptation activities both by public, private and non-governmental sector . ICAR has developed several in situ and ex situ water conservation technologies and improved dryland agriculture technologies, which are being upscaled through the Integrated Watershed Management Program (IWMP) and Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGA).

2.4 Role of smart and digital agriculture

Efforts to promote sustainable agriculture and to combat the impact of climate change will necessitate the use of innovative technology and digitalization. Digitalizing agriculture involves leveraging digital technology to ensure greater productivity, rationalize input resource use to bring predictability and minimize farming shocks. This also positively benefits consumers as digitalization offers potential traceability and information on origin and lifecycle of the product and its quality. Digitalisation is being enabled using drones to map the boundaries of fields and monitor plant health, ground sensors to measure soil moisture and humidity, digital apps to provide farmers with localized weather forecasts and market price information and extension services. A range of technologies are being leveraged - such as remote sensing, machine learning, IoT and artificial intelligence to provide holistic end-to-end value chain digitization.

'Climate-smart agriculture' increasingly leverages digital technologies in the agricultural domain. Digitalisation enables prediction of extreme climatic events in advance to minimize crop loss. Farmers with awareness of weather events can respond by planting more appropriate crops or varieties and in adopting suitable crop management options. Major innovations in response to climate variability will take the form of improved information through monitoring, forecasting and better micro-climate modeling. This weather based agro-information can be made available to farmers through audio-visual media and mobile telephony. Information and communication technologies could also greatly help researchers and administrators for development of micro level contingency plans to combat climate change. Some of the key smart & digital technologies across the value chain are mentioned in Exhibit 17.

Exhibit 17: Some of the key smart technologies across the value chain



Source: Industry sources, Yes Bank analysis

Indian agritech start-ups are leading the way to innovate smart agriculture solutions for solving multi-dimensional problems prevalent in Indian agriculture. The key emerging innovation themes in Indian agriculture are mentioned below:

- **Farmer advisory and data driven crop monitoring for facilitating precision farming and agri lending**
- **Environment-controlled agriculture** using techniques such as vertical farming, hydroponics and aquaponics
- **Optimising the use of agricultural inputs and enabling delivery to farmers** based on farm and crop diagnostics
- **Reducing labour cost through mechanization** on pay-per-use model and innovative mechanical tools
- **Building near-farm storage, warehouse and processing units** with access to post-harvest finance and market linkage through digital and physical modes
- **Quality assaying of agricultural commodities** through image processing and digitization of transactional data, price discovery and traceability
- **Demand driven and technology enabled aggregation and distribution of farm produce** from point of collection to consumption

Exhibit 18: Case study: Government of India's Swamitva scheme using drones for mapping rural assets

SVAMITVA, a Central Sector Scheme of Ministry of Panchayati Raj is being implemented with the collaborative efforts of the Ministry of Panchayati Raj, State Revenue Department, State Panchayati Raj Department and Survey of India. Digital maps of every single rural property are being created with the help of drones for clear demarcation of boundaries. This will allow farmers to use their formal property records in order to access formal and cheaper financing from banks and financial institutions. A Central Sector Scheme of Ministry of Panchayati Raj was nation-wide launched by the Hon'ble Prime Minister on National Panchayati Raj Day, 24th April 2021 after successful completion of pilot phase of scheme (2020-2021) in 9 states.

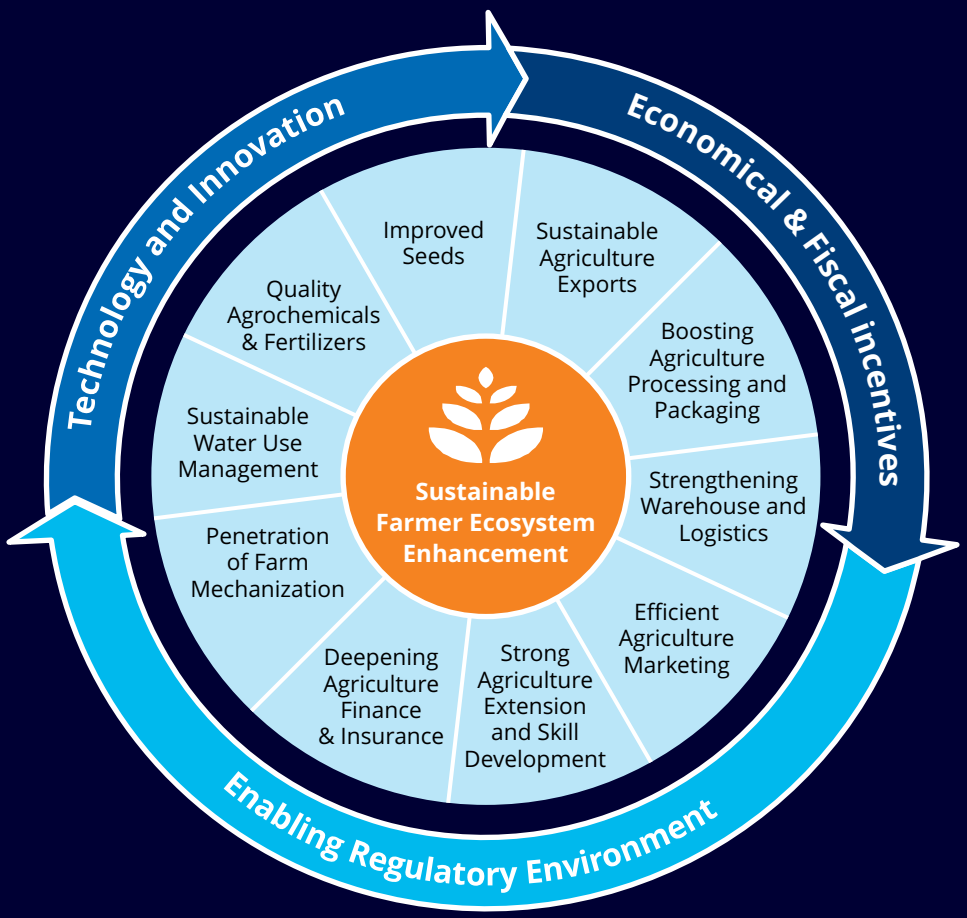
Source: https://svamitva.nic.in/



3

Towards smart & sustainable agriculture – Key recommendations

Sustainable farming requires access to right inputs at the right time, efficient farm production techniques and an efficient supply chain to deliver quality produce at reasonable price to the end consumers. Access to quality inputs, finance & insurance, along with improvement of logistics and marketing infrastructure assumes greater significance to provide farmers adopting sustainable farming measures, a sustainable income and a sustained market. This chapter posits recommendations across critical legs of the supply chain as well overarching policy recommendations for building an enabling environment for sustainable and inclusive agricultural growth.



3.1 Specific recommendations for each leg of the value chain

Seeds

To enable access to quality seeds for all farmers and to achieve average seed replacement rate of 25% for self-pollinated crops, 35% for cross pollinated crops and 100% for hybrids in the medium term

- **Institute an Integrated National Sustainable Seed Development Program**: Program contours could include identification and development of climate-resilient crop varieties with high sustainability index, promoting modern technology like gene editing after public consultations and constituting a matching grant fund to attract private sector contribution.
- **Empower state government universities and private sector to lead climate policy implementation** Entrust SAUs to devise dynamic, responsive micro-level climate adaptation seed strategies, in conjunction with KVKs and crop research institutes. Time bound actionables linked to fund release could drive efficient implementation.
- **Devise, monitor and target time-bound, district level plans to boost seed and varietal adoption rates in an integrated manner**. Enhanced varietal replacement rate coupled with seed replacement rate could lead to improved access to quality seeds of high yielding hybrids and varieties resulting in increased productivity and returns.
- **Encourage seed companies to adopt seed treatment solutions** to manage biotic stress like pest and diseases and abiotic stress like water stress, vigour as an integrated offer to the farmers. This will help to reduce dependency on weather for application, limited exposure of chemicals to the environment and minimal water need for application. Equipment manufactures to be incentivized for manufacturing seed treatment machines in the country to boost their availability at affordable cost enabling farmers to adapt this application method.
- **Frame and enforce a predictable Intellectual Property Rights (IPR) regime & The Plant Variety Protection Act (PVP&FRA) landscape** to assure and incentivize private companies to further invest in research and development of more resilient and efficient seed varieties. Measures could include offering tax breaks on R&D.
- **Fast track regulatory regime for seed approvals, single window clearance mechanism for export /import of seed & planting material.** Swift passage of draft Seeds Bill by resolving the concerns of farmers as well as industry and ensuring overall Ease of Doing Business is critical to promote investment in seeds sector.
- **Launch model, unified seed licensing and seed testing program guidelines and support adoption by states**. Upgradation of seed testing facilities accredited by the International Seed Testing Association (ISTA) and technical skill development is critical. There is a need to strengthen enforcement mechanism to control fake/spurious seeds.
- **Prioritize production of export-oriented seed varieties and promotion of PPP-IAD models for seed production** may be evaluated along with blockchain based community seed farming. Allowing bulk hybrid seed imports for export purposes as well as import of export-oriented seed germplasm will be important and could lead to developing India as a seed hub for Asia and Africa.

Agro Chemicals and Fertilizers

To reduce crop losses by promoting judicious use of agrochemicals and achieving higher fertilizer usage efficiency

Agro Chemicals

- **Strengthen conservation compliance at state level - states could submit time bound implementation plans to increase soil carbon levels, INM and IPM measures**. Prepare district level nutrient maps to promote district-and-crop-specific customized fertilizers.
- **Incentivize adoption of green products** such as Bio-Pesticides by placing them at par with bio and organic fertilizers. Sustainable tools such as pheromone traps need to be heavily promoted.
- **Fast track regulatory regime for approving new agro chemical molecules**: Clause 9(3) of the Insecticide Act could be used to provide provisional approvals for new molecules and emergency one-time approval for molecules in the regulatory pipeline for more than two years.
- **Passage of Pesticide Management Bill** needs to be done considering the industry inputs on PRD, penalty clause and registration timelines. Enforcement mechanism to control spurious or fake agrochemicals need to be strengthened.
- **Promote improved spraying technology by incorporating into government and private extension programs**: assess Spraying as a Service model via custom hiring centres and KVKs.
- **Incentivize pesticide companies adopting carbon efficient manufacturing processes & sustainable packaging** - Devise sustainable brand labels/logos and explore tax breaks to promote paper-based packaging and other technologies that minimize residues. Government may devise a mechanism for establishing reverse supply chain for reused bottles
- **Overhaul quality control system & compliance**: Introduce KYC system to track and monitor manufacturing facilities and better equip NABL accredited laboratories for quality checks including strict enforcement of compliances.

Fertilizers

- **Incentivize fertilizer companies for incorporating customized, controlled-release and stabilized fertilizers in their portfolio** - that reduce nitrogen emissions, by lowering taxes, brand recognition and facilitating procurement of subsidized fertilizers for making customized fertilizers. Provide targeted subsidies for liquid fertilizers to promote fertigation.
- **Incentivize adoption of green products** such as micronutrient fertilizers and their mixtures by placing them at par with bio and organic fertilizers.

Sustainable Water Use Management

To conserve water resources & bring additional 2 million hectares under micro-irrigation per year

- **Frame a cohesive, integrated national agricultural water policy**. There is a strong need for convergence of existing water schemes (PMKSY-PDMC, ABHY, PM-KUSUM) to bring synergy and resource efficiency. States need to be nudged to adapt/adopt the model Groundwater Bill (2017).
- **Devise differential micro-irrigation incentives and provide DBT based investment subsidies for micro-irrigation and solar pumps.** Higher subsidies are needed for farmers in water stressed areas. Direct benefit transfers into farmers accounts could be considered instead of routing subsidies through companies.
- **Ensure irrigation schemes are made functional all year round**. Funds are disbursed during specific seasons making planning and implementation difficult.
- **Centre may consider compensating water stressed states who adopt ecological practices**. States like Punjab & Haryana which are highly water stressed will need to dedicate large financial and administrative resources to launch sustainability programs on mission mode, which would require support from the central government.
- **Prioritize funds for climate adaptation measures** for integrated watershed management approach, in-situ moisture conservation, rainwater harvesting and recycling, efficient use of irrigation water and use of poor-quality water.
- **Dedicate funds for promoting crop specific water saving cultivation methods & location specific inter-cropping systems with high sustainable yield index**. Constitute crop-level programs along with state governments, and SAUs to implement water conserving methods.
- **Constitute integrated scheme for energy efficient, micro irrigation** - Government to identify areas with high scope for solar power and devise special scheme for combining solar pumps based micro irrigation systems.

Farm Mechanization

Support conservation agriculture and boost Total Factor Productivity by facilitating farmers with access to appropriate machineries through custom hiring centers and rental mechanization models, achieving 4 kw/ha by 2030

- **Dedicate greater funds to establish custom hiring centers (CHC) linked to KVKs and promote rental pay-as-you-go mechanization**. Aspire for one CHC per Gram Panchayat or per Primary Agricultural Credit Society (PACS) comprising a cluster of small villages for at least all low duty machinery.
- **Replace CAPEX subsidies on farm equipment and pay farmers with DBT** on actual rental mechanization costs per hectare basis. Instead of giving subsidies to the farmers

on tractors and implements, the amount could be used to reimburse the actual cost per hectare of equipment rental through direct benefit transfer (DBT).

- **Facilitate faster testing** of farm tractors, equipment & implements, limiting testing to safety, emission. Agricultural tractors and equipment should be tested for safety and regulatory compliance only. There is a need to rationalize the current multiple testing requirements by different ministries.
- **Provide coverage of equipment rental under Kisan Credit Card Scheme** to encourage farm mechanization. Instead of ownership (or concurrently) KCC scheme should promote rental models of mechanization.
- **Encourage farmer to farmer rental scheme** so that tractors available in country can be utilized and are made available to small and marginal farmers by way of effective DBT mechanism.
- **State governments should formulate a taskforce to promote adoption of farm machinery**, direct seeding technology and crop diversification as labor scarcity is most likely to impact the sowing of Kharif crops such as paddy.

Agri Finance and Insurance



To ensure access to agricultural credit for all and 60% area coverage over the medium term under insurance through digitalization and technology deployment

Agri Finance

- **Enforce proper implementation of agri stack to develop system wide, micro level understanding of risks for agri lending**. Data points can be fed into a credit risk assessment algorithm, which can accurately assess farmers and their produce to provide them easy finance options and ease payouts of insurance settlements, loan recoveries.
- **Evaluate the option of nudging financing institutions to apply a comprehensive lifetime assessment of GHG emissions to funding priorities**: Devise a scheme tying easier lending norms to agri companies high on sustainable procurement and promoting sustainable agriculture which can be quantified and monitored transparently.
- **Promote use of innovative blended finance instruments to mobilize public, private and philanthropic investments towards sustainable agriculture**. Developing a formal blended finance scheme which ensures public investment in sustainable agriculture will play a key role in unlocking long-term developmental finance for high risk projects which would otherwise go unfinanced through traditional routes.

Agri Insurance

- **Devise weather-based insurance by dedicating funds for installation of 20,000+ block level automated weather stations and rainfall data loggers on a priority basis**. This will be critical to devise new credit instruments focusing on vulnerable areas, addressing extreme weather events.

- **Optimize crop cutting experiments through adoption of ICT** – Mainstream the usage of drones, ICT and satellite imagery to conduct high quality crop cutting experiments monitored by State Agricultural Universities and independent agri experts for transparency. It is estimated that about 8,000 crop cutting experiments are required to be conducted in each district every year (inclusive of both Kharif and Rabi crops). Adoption of technology will help in smart sampling and cost reduction.
- **Inclusion of non-loanee farmers and ensuring swift claim settlement under PM Fasal Bima Yojna**. Incentivizing Banks to increase Non loanee coverage and allowing Non Loanee farmers to be covered by any insurance company.

Agri Extension & Skill Development



To enable skilling by linking farmers to agricultural technology and information through ICT

- **Promote further decentralization and autonomy to reorient ATMA/KVKs towards action-oriented extension programs** – this includes promoting synergy between Agriculture Technology Management Agency (ATMA) and Krishi Vigyan Kendras (KVKs)
- **Promote Public Private Partnership in KVKs**: KVKs need to incubate private sector initiatives in extension delivery. It is important to ensure market led extension activities focusing on value addition opportunities that will curb post-harvest losses.
- **Conduct district level skill mapping**: ICAR and SAUs need to map the demand for and supply of skills in agriculture at the district level, and coordinate with skill development missions to impart the required skills to farmers and agricultural labour.
- **Formation of Governing Council for strengthening agri academia and skill development in country**: This needs to have representation from Agri scientists, Industry, IT professionals, State Agriculture universities and other relevant stakeholders.

Agri Marketing



To enable transparent and smooth marketing with AI backed e-NAM and stronger role for FPOs in marketing & public procurement

- **Rationalize public procurement of cereals and incorporate pulses & millets** to ensure sustainability of PDS and public agricultural infrastructure
- **Easing collateral margin policies to boost market depth in commodity derivatives market** and encourage private sector participation.
- **Provide FPOs bigger role in public procurement** and marketing by giving them APMC licenses and MSME status

- **Assess direct marketing models and government-backed initiatives for their scalability** such as "rythu bazars" in Andhra Pradesh, "apni mandi" in Punjab need to be studied
- **Devise and implement on mission mode a national-wide, AI based market intelligence system**
- **Ensure all e-NAM mandis are linked with WDRA accredited warehouses/cold storages**
- **All e-NAM mandis need to allow any bulk buyer with proper KYC without having a trading license** as well to have efficient price discovery in favour of farmers.
- **e-NAM needs to be fully integrated with Artificial Intelligence** and Internet of Things (IoT) to provide real-time information as well as analytics to different stakeholders.
- **Utilize AIF funds for modernization of mandis; to create government facilities for testing, storage and primary processing at APMCs**. This will promote negotiable warehousing receipts ecosystem and encourage formal financial institutions to develop customized financing products.

Agricultural Storage and Logistics

To create modern and scientific storage across Indian villages to empower farmers and reduce farm losses

- **Provide tax holidays and facilitate access to land** – so as to encourage private sector to build village level storage infrastructure, including mechanical or solar dryers critical for post-harvest crop drying. Consider inclusion of farm level storage creation under the purview of MNREGA scheme.
- **Declare warehouses as mandis and provide infrastructure status to warehouses**, packhouses and cold storages. Relocate critical agri infrastructure to less climate vulnerable areas.
- **Include Refurbishment of existing warehouses for scientific storages** in the Agri infrastructure fund (AIF) scheme and ensure warehousing projects approved follow the WDRA (Warehousing Development and Regularity Authority) norms.
- **Encourage private sector to provide quality testing and certifying services**
- **Provide tax incentives to companies investing in or adopting sustainable reefer systems** for transportation, storage and quality protection.

Agri Processing & Packaging

To double the volume of agri produce undergoing processing and value addition over the medium term

- **Provide CAPEX incentive for innovative sustainable packaging companies** (R&D/ manufacturing)
- **Provide income tax holiday to food processing companies utilizing carbon efficient manufacturing technology and climate friendly packaging**
- **Evaluate the option of incentivizing the development of an action strategy with quantifiable targets to promote and procure sustainable produce** – specially for large food processing companies
- **Qualify as CSR** direct farm extension programs on sustainable resource management run by companies

Sustainable Agri Exports

To double India's agri exports in the medium term

- **Frame a 5-10-year sustainable agri export strategy** which promotes climate friendly practices, traceability and sustainable farmer income enhancement
- **Drive Productivity enhancement and create economies of scale** through export-oriented cluster development, export oriented farmer collectives and export oriented contract/contact farming
- **Nurture an amenable policy and regulatory environment which promotes investment in export oriented post-harvest infrastructure** including in processing and value addition.
- Enabling strong **public-private partnerships** in the agri export ecosystem to **promote international demand led research and development**
- **Promote export-oriented farm level extension to meet international market demands**
- **Modernize handling at ports to match international benchmarks**
- **Promote private sector investment in developing scientific and integrated bulk storage** and transportation infrastructure focused on exports
- **Investing heavily on country level and product level export branding & marketing**
- **Ensuring swift resolution of trade barriers and trade agreements**

Promoting Technology, Digitalization and Sustainable Innovation

- **Facilitate swift implementation of Digital Agri-stack** in conjunction with private sector
- **Create Centre for Excellence for data science application in agriculture to address information asymmetry**. Advance data analytics and network mapping to monitor produce flow and identify gaps is necessary for collating information on risks in the supply chain.
- **Provide tax breaks and remove GST on Agtech companies, companies adopting precision farming solutions and tech enabled aggregation & distribution of farm produce**
- **Promote enhanced use of ICT, Drones and Smart Digital solutions** for real time extension by both government and private sector

3.2 Policy recommendations for building an enabling environment for sustainable growth

1. **Devise Policy framework to promote efficiency and resilience in Cropping System**
    a. **Incentivize states to promote climate friendly cropping and to adopt diversified efficient farming systems** which withstand climate change situations such as tree-crop-livestock, fisheries, poultry, coarse cereals, legume crops; utilization of fallow lands in regions with higher adaptability to climate change; promote hybridization, rootstock technology research & adoption
    b. **Validate and promote innovative holistic farming practices by offering direct farmer subsidies in stressed regions** - such as hydroponics, aeroponics, aquaponics and poly-house farming systems
    c. **Dedicate greater funds for productivity enhancement programs critical for diversification and food security** - increasing productivity of cereal and legumes will release land and allow for sustainable development of high-value agricultural produce.
    d. **Institutionalize and test an adaptive and responsive system to review, revise cropping calendar** - Adjustment of planting dates to minimize the effect of high temperature. Changing the cropping calendar to take advantage of the wet period and to avoid extreme weather events
    e. **Modify tax and credit policies to encourage integrated farming & diversification** (crops, livestock, agroforestry) by farmers & sustainability adoption by agribusiness companies
2. **Promoting consolidated cultivation**
    a. **Promote drone mapping of lands and digitalization of land records**
    b. **Promote contract farming & facilitate land leasing act** - Encourage states to adopt Model Agriculture Land Leasing Act, 2016.
    c. **Frame state level plans for utilization of marginal, waste and fallow land** – for eg. Utilize fallow lands in hilly regions and North Eastern states to produce cereals and oilseeds to reduce burden on highly stressed states.

3. **Institute strong center-state cooperative mechanism** which jointly disincentivizes overuse of natural resources and rewards farmers producing (and companies procuring) through sustainable practices that also mitigate the impact of climate change. Centre must support states to develop climate tolerant regional/district level production clusters.

4. **Increase research funds** for the development of publicly available seeds adapted to regional climate regimes and to climate-friendly, low-input, ecological farming systems.

5. **Modify government and state agricultural universities' research policies to emphasize the development of sustainable alternatives**. Research spending, currently at 0.3%, needs to be increased to at least 1% of agricultural GDP.

6. **Continue investing in strengthening FPOs** – which are critical for building resilience in the farming ecosystem and ensuring better delivery of climate mitigating measures. FPOs may be given bigger role in public procurement and marketing by giving them APMC licenses and MSME status.

7. Extensively promote soil conservation and soil health development programs at state level. - concerted policy efforts are needed for soil generation in high stress regions by promoting conservation tillage, crop residue management technology such as Happy Seeder in wheat-rice systems, DSR machines in Haryana/Punjab; promoting INM & soil health cards; improving testing facilities and use of biochar to increase carbon storage could be considered.

8. **Incentivize DISCOMS for feeder separation**. Agriculture connections and electricity supply feeders should be separated from domestic rural electricity supply to optimize power usage and generate savings by minimizing power losses.

9. **Develop a crop residue management policy in each state**, clearly defining various competitive uses; adopt appropriate legislation on monitoring of on-farm crop residue handling through incentives and technology support.

10. **Restructure government price support programmes** to disincentivize non-judicious use of agri inputs, cereals production in resource scare regions and reward smart agricultural practices.

11. **Assess involvement of private sector in public procurement programs** - include private traders operating in markets to complement the minimum support price regime through a system of incentives and commission payments.

12. **Integrate food safety laws in all agri sustainability policies and increase consumer awareness** –Emphasize food safety & traceability compliance in future farm and food related consumer affair policies and awareness campaigns. Evaluate trade-offs between food safety, food security and environment sustainability. Aligning food safety laws to pesticide regulatory framework and strengthen extension activities for ensuring judicious pesticide use.



4 Abbreviations

Agri	Agriculture
AI	Artificial Intelligence
AIBP	Accelerated Irrigation Benefit Programme
AIDIS	All-India Debt and Investment survey
AIF	Agriculture Infrastructure Fund
AMIF	Agri-Marketing Infrastructure Fund
APLM	Agriculture Produce and Livestock Marketing
APMC	Agriculture Produce Marketing Committee
ASI	Annual Survey of Industries
ATMA	Agriculture Technology Management Agency
Bn	Billion
BREI	Bringing Green Revolution in Eastern India
CAGR	Cumulative Average Growth Rate
CAPEX	Capital Expenditure
CDP	Cluster Development Programme
CHCs	Custom Hiring Centers
Co2	Carbon Dioxide
CSR	Corporate Social Responsibility
DAC&FW	Department of Agriculture and Farmers Welfare
DAP	Di Ammonia Phosphate
DBT	Direct Benefit Transfer
DISCOMS	Distribution companies
DSR	Direct Seeded Rice

e-NAM	Electronic National Agriculture Market
EU	European Union
F&V	Fruits and Vegetables
FAAS	Farming as a Service
FCI	Food Corporation of India
FDI	Foreign Direct Investment
FPO	Farmer Producer Organization
FSS	Farm Saved Seed
GCA	Gross Cropped Area
GDP	Gross Domestic Product
GHG	Green House Gas
GIA	Gross Irrigated Area
GoI	Government of India
GrAMs	Gramin Agricultural Markets
GST	Goods and Service Tax
GVA	Gross Value Added
Ha	Hectare
IARI	Indian Agriculture Research Institute
ICAR	Indian Council of Agricultural Research
ICT	Information and Communication Technology
INM	Integrated Nutrient Management
INR	Indian Rupee
IoT	Internet of Things
IPCC	International Panel on Climate Change
IPM	Integrated Pest Management

IPR	Intellectual Property Rights
ISTA	International Seed Testing Association
IT	Information Technology
KCC	Kisan Credit Card
KUSUM	Kisan Urja Suraksha evam Utthaan Mahabhiyan
KVKs	Krishi Vigyan Kendras
KYC	Know Your Customer
MIDH	Mission for Integrated Development of Horticulture
ML	Machine Learning
Mn	Million
MNCs	Mutli National Corporation
MNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
MoA&FW	Ministry of Agriculture and Farmers Welfare
MoFPI	Ministry of Food Processing Industries
MoP	Murate of Potash
MoSPI	Ministry of Statistics and Program Implementation
MOVCD-NER	Mission Organic Value Chain Development for North East Region
MSME	Micro Small and Medium Enterprise
MT	Metric Tonnes
NABARD	National Bank for Agriculture and Rural Development
NABL	National Accreditation Board for Testing and Calibration Laboratories
NAPCC	National Action Plan on Climate Change
NFSM	National Food Security Mission

NHB	National Horticulture Board
NHM	National Horticulture Mission
NICRA	National Innovations in Climate Resilient Agriculture'
NITI	National Institution for Transforming India
NMSA	National Mission for Sustainable Agriculture
NPK	Nitrogen, Phosphorus, Potassium
NSO	National Statistics Office
O2	Oxygen
ODOP	One District One Product
PACS	Primary Agriculture Cooperative Society
PDMC	Per Drop More Crop
PDS	Public Distribution System
PIB	Press Information Bureau
PKVY	Paramparagat Krishi Vikas Yojana
PM AASHA	Pradhan Mantri Annadata Aay SanraksHan Abhiyan
PMFBY	Pradhan Mantri Fasal Bima Yojana
PMFME	Pradhan Mantri Formalisation of Micro Enterprise Scheme
PMKISAN	Pradhan Mantri Kisan Samman Nidhi
PMKSY	Pradhan Mantri Krishi Sinchayee Yojana
PRD	Product Requirement Document
PVP	Plant Variety Protection
R&D	Research and Development
RBI	Reserve Bank of India
RCT	Resource Conserving Technology

RKVY	Rashtriya Krishi Vikas Yojana
SAMPADA	Scheme for Agro-Marine Processing and Development of Agro-Processing Clusters
SAU	State Agriculture Universities
SDG	Sustainable Development Goal
SMAM	Sub Mission on Agricultural Mechanization

SMS	Straw Management System
SRR	Seed Replacement Rate
Tn	Trillion
US	United States
USD	United State Dollar
WDRA	Warehouse Development and Regulatory Authority

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