FDI, Innovations and Technology in Rice Cultivation

Case of Savannah Seeds

Ashok Gulati | Reena Singh
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ABBREVIATIONS

ARDE	Agricultural Research, Development and Education
ARI	Agriculture Research Intensity
CGWB	Central Ground Water Board
CH	Chhattisgarh
CSR	Corporate Social Responsibility
DSR	Direct Seeded Rice
FAO	Food and Agriculture Organization
FCI	Food Corporation of India
FDI	Foreign Direct Investment
FGD	Farmer Group Discussion
FTE	Full-time-equivalent
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GM	Genetically Modified
GWP	Global Warming Potential
HCES	Household Consumption Expenditure
HR	Haryana
HRS	Household Responsibility System
HT	Herbicide Tolerant
HYVs	High-yielding Varieties
LUS	Land Use Statistics
mbgl	Metres below ground level
Mha	Million Hectares
MT	Metric Tonnes
MMT	Million Metric Tonnes
MP	Madhya Pradesh
MSP	Minimum Support Price
NFSM	National Food Security Mission
OPVs	Open-pollinated Varieties
PAU	Punjab Agricultural University
PPV&FR	Protection of Plant Varieties and Farmers' Rights
PTR	Puddled Transplanted Rice
R&D	Research & Development
RKVY	Rashtriya Krishi Vikas Yojana
SRI	System of Rice Intensification
Savannah	Savannah Seeds Private Limited
UK	Uttarakhand

FOREWORD – ICRIER

Indian agriculture is facing growing climate-related challenges, with rising temperatures, erratic monsoon patterns, extreme rainfall events and increasing water stress affecting crop productivity and the resilience of farming systems. Rice, which occupies a central place in India's food security framework and rural economy, is particularly exposed to these risks. This vulnerability is reflected in projections of a decline in India's rice production in 2026 from the record 154 million metric tonnes (MMT) achieved in the previous year, partly due to deficient monsoon rainfall. More importantly, assessments by the Indian Council of Agricultural Research (ICAR) under the National Innovations in Climate Resilient Agriculture (NICRA) project that, in the absence of adaptation measures, climate change could reduce rainfed rice yields by 20 per cent by 2050 and 47 per cent by 2080, while irrigated rice yields could decline by 3.5 per cent and 5 per cent, respectively. These projections underscore the urgency of building a more climate-resilient rice production system.

Alongside climate risks, conventional rice cultivation places considerable pressure on water resources and contributes to greenhouse gas emissions. Rice occupies 23.5 per cent of India's gross cropped area (MoAFW, 2026), accounts for around 40 per cent of irrigation water use (Sharma et al., 2018), and contributes 17.1 per cent of agricultural GHG emissions, primarily through methane released from flooded paddy fields (MoEFCC, 2023). These challenges underscore the need for innovations that sustain productivity while improving resource use efficiency, reducing environmental impacts and strengthening resilience to climate change. Against this backdrop, this report examines hybrid rice innovation in India, with particular attention to Savannah to explore the role of private sector investment, research and development, seed technology and associated agronomic practices in advancing rice production systems. The report also considers the potential of direct-seeded rice (DSR) to reduce dependence on standing water and puddling, while recognising that its performance depends on agroecological conditions, weed management, crop establishment practices and appropriate farmer guidance.

At ICRIER, we believe that evidence-based research and constructive engagement among policymakers, researchers, industry and farmers are essential to shaping the future of Indian agriculture. A key message emerging from this study is that agricultural technologies must be evaluated not only in terms of their technical performance, but also through their implications for farm profitability, resource use, risk and long-term sustainability. The enabling environment, including agricultural extension, market access, farmer awareness and supportive public policies, will be critical to translating technological advances into durable benefits at scale. I hope this report contributes to a more informed discussion on the role of agricultural innovation in strengthening rice productivity, improving resource efficiency and advancing climate-resilient and sustainable farming systems.

SHEKHAR AIYAR
Director & Chief Executive
Indian Council for Research on International Economic Relations (ICRIER)

FOREWORD – SAVANNAH

Seed is the foundation of agriculture. It determines crop productivity, quality, resilience and the efficient use of land, water and labour. As agriculture faces increasing complexity from climate change, resource scarcity, new pests and diseases, and evolving consumer expectations, continuous innovation in seed is essential. This requires a strong ecosystem in which government research institutions and foreign seed companies should coexist and complement each other, combining national priorities with global science, technology and investment.

Innovation in agriculture does not happen overnight. Developing a new seed product or trait requires years of research, multi-location trials, regulatory approvals and testing under farmers' field conditions. Not every research effort results in a successful commercial product. The process therefore requires patient capital, scientific perseverance and commercial patience. At the same time, successful technologies must create incremental value for farmers and other stakeholders so that companies can continue investing in the next generation of innovation. This focus on solving farmer problems and creating measurable value has been central to Savannah's journey in India.

Rice is fundamental to India's food security, rural economy and agricultural livelihoods. Yet rice cultivation faces growing pressures from water scarcity, rising labour costs, climate uncertainty and the need to produce more from limited natural resources. Addressing these challenges requires sustained investment in science, locally relevant innovation and technologies that can deliver tangible value to farmers.

Since establishing Savannah Seeds in India in 2010, we have remained focused on transforming rice agriculture through better genetics and sustainable production systems. We have built an integrated platform spanning research and development, core seed production, farmer-led commercial seed production, processing, quality assurance, distribution and technical support. Our objective has always been clear: to understand the needs of rice farmers and develop products and services that improve their productivity, profitability and resilience.

Our SmartRice® hybrids have been developed to deliver higher and more stable yields, improved resource use efficiency, lodging tolerance and better grain quality. A production-oriented survey by ICAR–Indian Institute of Rice Research reported SmartRice® yields of up to 10 metric tonnes per hectare for paddy under farmers' field conditions. This demonstrates what improved rice genetics can potentially contribute when supported by appropriate agronomic practices.

Our FullPage® Rice Cropping Solution addresses another major farmer challenge. Wild or weedy rice is a serious problem in parts of Central India, where it competes with the crop, reduces productivity and is difficult to control through conventional methods. FullPage® combines SmartRice® genetics, seed treatment, herbicide tolerance and effective weed management to make Direct-Seeded Rice more practical and profitable. It can help farmers protect yield while reducing manual weeding, water use and labour dependence. This reflects our belief that technology must deliver a win-win proposition for the farmer and the environment.

The significance of higher rice productivity extends beyond the rice crop itself. India can produce more rice from less land, creating headroom to diversify suitable acreage towards pulses and oilseeds. This can improve farm resilience and support an *Atmanirbhar Bharat* by reducing dependence on imported pulses and edible oils, in alignment with the Government of India's vision for crop diversification, agricultural sustainability and national self-reliance.

Savannah's contribution also extends across the broader rural economy. Our investments support scientific and technical employment, seed production farmers, processing operations, logistics partners, distributors and retailers. By producing seed in India and supplying both domestic and international markets, we are working towards a "Make in India, Make for the World" model and strengthening India's potential as a research and seed production hub.

There is often a perception that when a private agricultural company earns a profit, it does so at the expense of farmers. This overlooks the value created by successful agricultural innovation. A seed company may earn one rupee, but the technology it delivers potentially create several times that value through higher farmer income, lower cultivation costs, rural employment and business for Indian MSMEs and supply-chain partners. Profits also sustain the long-term R&D investment needed to develop the next generation of products and technologies. The real measure of a responsible agricultural enterprise is therefore not profit in isolation, but the wider value it creates and shares across the ecosystem. This study attempts to quantify that socio-economic multiplier through the experience of Savannah Seeds in India.

We commissioned this independent socio-economic impact assessment because impact must be measured objectively. The report examines how Savannah's operations have contributed to farmer productivity and income, climate-resilient rice cultivation, seed production livelihoods, employment, domestic value creation and technology transfer. It will also help us identify gaps and define where our future investments can create greater value.

Our journey of the past 15 years has reinforced one conviction: science-led innovation, when connected to real farmer needs, can transform agriculture. We remain committed to investing in research, bringing relevant technologies from the lab to the farm, and creating a positive and sustainable impact for farmers, stakeholders and the environment.

AJAI RANA
Chief Executive Officer and Managing Director
Savannah Seeds Private Limited

PREFACE

Agricultural innovation can play an important role in addressing the twin challenges of raising farm productivity and improving the sustainability of agricultural production. In India, rice cultivation provides a particularly relevant context for examining this relationship. While rice remains indispensable to national food security and farmers' livelihoods, conventional cultivation practices in several regions have contributed to growing pressure on groundwater resources and raised concerns about the environmental sustainability of rice-based cropping systems. The need to improve resource use efficiency while safeguarding farmers' incomes has consequently become an important priority.

This report examines the economic, environmental and social dimensions of hybrid rice innovations, focusing on Savannah Seeds Private Limited (Savannah) and its hybrid rice technologies, including the FullPage® system for direct-seeded rice (DSR). Chapter 1 examines rice's importance to India's food security and rural economy, alongside the challenges posed by yield gaps, resource-intensive cultivation and climate change. With India's paddy yield at 4.4 metric tonnes (MT) per hectare, compared with 7.5 MT per hectare in China and the global average of 4.5 MT per hectare, the chapter highlights the scope for increasing production through productivity gains rather than further expansion of the area under rice.

Chapter 2 examines the potential of hybrid rice technology to enhance productivity and farm profitability. Findings indicate that Savannah's SmartRice® (Sava 7501) recorded a reported yield potential of 7.3–10.3 MT per hectare in Haryana, based on ICAR-IIRR assessments conducted during 2023–2025. At these yield levels, estimated net returns could range from ₹1,16,732 to ₹1,87,802 per hectare, highlighting the potential economic benefits of improved hybrid rice technology.

Chapter 3 assesses DSR as an alternative to conventional puddled transplanted rice (PTR). The study finds that Savannah's FullPage® DSR system delivered comparable or higher yields than PTR across almost all study locations. It also highlights the system's potential environmental benefits, including water savings of up to 40 per cent and methane emission reductions of up to 90 per cent, as reported by CSKHPKV (2026). These findings point to opportunities for improving resource use efficiency while maintaining rice productivity.

Chapter 4 examines the seed production system that underpins hybrid rice development and adoption, with particular attention to its implications for farmers' incomes. Evidence from participating farmers indicates that hybrid seed production can offer higher returns than commercial grain cultivation. In Hanumangarh, Rajasthan, farmers engaged in hybrid seed production reportedly earned net profits of approximately ₹1,77,916–₹2,59,461 per hectare, compared with ₹1,33,437–₹1,42,827 per hectare from commercial grain cultivation. Similarly, in Telangana, net returns from hybrid seed production were approximately ₹1,59,324–₹2,39,633 per hectare, compared with ₹80,013–₹1,01,486 per hectare for commercial paddy cultivation, including bold- and fine-grain varieties. These findings highlight the potential of seed production to diversify farm income and improve profitability.

Chapter 5 takes a broader view of Savannah's hybrid rice ecosystem, examining the linkages

between research and development, seed production, distribution, cultivation and market access. According to assessments of datasets provided by Savannah, the adoption of its seed technologies has contributed approximately ₹255.40 billion in incremental farmer income, cumulative since 2013, including area covered during 2026 *kharif* season. This assessment underscores the potential contribution of private sector innovation across the rice value chain, while recognising that the estimated income gains are company-reported figures.

Chapter 6 sets out key policy recommendations for advancing a productivity-led and environmentally sustainable rice strategy. First, India should pursue the "−5, +10" vision of reducing rice area by 5 million hectares while increasing production by 10 million metric tonnes, supported by high-yielding, climate-resilient and region-specific hybrid varieties, particularly in water-stressed states such as Punjab and Haryana. Second, India should strengthen its position as a global seed production and export hub through robust seed quality systems, public–private partnerships, international collaboration and incentives for seed multiplication. Third, regulatory reforms, stronger intellectual property protection and performance-linked incentives should encourage greater private investment in research and development. Finally, DSR adoption should be supported through an integrated ecosystem combining financial incentives, including potential carbon-credit mechanisms, with targeted research, extension services, field demonstrations and farmer training. Addressing constraints related to weed management, crop establishment, suitable varieties and mechanisation, alongside location-specific evidence on costs, yields and profitability, will be essential to scaling DSR sustainably.

AUTHORS

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We extend our sincere thanks to the Savannah team for providing relevant information, technical inputs and operational perspectives that have contributed to strengthening this report. In particular, we are grateful to **Mr. Amit Maheshwari**, Product Manager – FullPage® & New Technology, who played a pivotal role in providing inputs and facilitating interactions with Savannah's team, organising stakeholder consultations and farmer meetings, and coordinating with the various participants. We also gratefully acknowledge the contributions of **Mr. Anil Garg**, Mr. Anuj Choudhary, **Mr. Mukesh Kumar** and **Mr. Vipin Kumar** (Business Managers); **Mr. Arun Soni** and **Mr. Sunny Sindhu** (Zonal Business Managers); **Mr. Manoj Kumar Singh** (Business Development Lead – Southeast Asia); **Mr. Manoj Mahuli** (Director – Sales); **Mr. Mrinmoy Choudhary** (Director – Marketing); **Mr. Praveen Kumar Kallihal** (Manager – Foundation Seeds); **Mr. Rajeev Kumar** (Seed Production Lead); **Mr. Sheshagiri Kasul** (Head of Rice Breeding); **Mr. Sunil Kumar Poonia** (Manager – Plant Operations); and **Dr. Venkatesh Hubli** (Director – R&T) for sharing their perspectives and providing valuable information across different aspects of Savannah's operations.

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The responsibility of facts, figures, analysis and views expressed in this report fully rests with the authors.

AUTHORS

EXECUTIVE SUMMARY

Ashok Gulati, Reena Singh and Bidisha Chanda

India is the world's largest rice producer, producing 154 million metric tonnes (MMT) on approximately 52.8 million hectares (Mha) in 2025-26 (UPAg, n.d.). This accounts for nearly 28 per cent of global rice production and 30 per cent of the global rice area (USDA, n.d.). Rice contributes 42 per cent of India's total foodgrain output and accounts for nearly 55 per cent of cereal consumption (HCES, 2022-23), making it the country's primary staple. Its economic significance is further reflected in its contribution of 8 per cent to India's agricultural gross value of output in the triennium ending (TE) 2023-24. India is also the world's leading rice exporter, exporting 21.5 MMT valued at approximately USD 12.5 billion in 2025-26 (PIB, 2026). This scale of production, however, carries significant resource and environmental costs. Rice occupies 23.5 per cent of India's gross cropped area (MoAFW, 2026) and accounts for around 40 per cent of irrigation water use (Sharma et al., 2018). Importantly, rice cultivation is distinct from most other crops because flooded paddy fields generate substantial methane (CH_4) emissions through anaerobic decomposition of organic matter and therefore is also responsible for 17.1 per cent of the country's agricultural greenhouse gas (GHG) emissions (MoEFCC, 2023). This makes rice a particularly important crop for climate mitigation and resource use efficiency.

Seeds are a critical determinant of agricultural productivity, farm incomes and food security, and an important enabler of the transition towards climate-resilient and resource-efficient agriculture. In rice, improved seed technologies can raise yield potential, strengthen resilience and improve resource use efficiency, reducing pressure on land and other natural resources. This is particularly important for India, where future increases in production will need to come increasingly from productivity gains rather than the expansion of area under rice. Despite its position as the world's largest rice producer, India's average paddy yield (4.4 MT per hectare) remains marginally lower than the world average (4.5 MT per hectare) and countries like China (7.5 MT per hectare) and Vietnam (5.8 MT per hectare). This productivity gap persists despite substantial public sector investment in agricultural research and knowledge infrastructure and is partly associated with the limited adoption of hybrid rice, which remains below 10 per cent in India. Wider adoption of high-yielding and climate-resilient hybrids, supported by appropriate agronomic practices and enabling policies, could help narrow the yield gap, enhance farm profitability and improve resource use efficiency. Thus, strengthening the rice seed ecosystem, including greater complementarities between public research and private sector innovation, has important implications for India's future rice and agricultural policy.

Against this backdrop, this study assesses the socioeconomic impact of Savannah Seeds Private Limited's (Savannah's) operations in India, with particular focus on rice farmers and the broader rice economy. It examines 15 years of private sector investment in rice seed innovation, from SmartRice® to the FullPage® Rice Cropping Solution, and evaluates its contribution to productivity, farm profitability, resource use efficiency and the transformation of rice cultivation. The study highlights the potential

role of private sector seed innovation, alongside public research and enabling policies, in accelerating productivity-led and more sustainable transformation of India's rice sector. The assessment draws on seven face-to-face and one on-line focus group discussions involving approximately 70-80 rice farmers across Punjab, Haryana, Rajasthan, Telangana, Madhya Pradesh, Chhattisgarh, and the *Terai* region of Uttarakhand, as well as a separate discussion with farmer organisers[1] in Telangana. The discussions explored farmers' experiences with Savannah's seed innovations, particularly SmartRice® and FullPage® Rice Cropping Solutions. The study also examined the performance of the seed production value chain and the broader socio-economic benefits generated across stakeholders. These findings were complemented by field visits to Savannah's seed production and processing facilities and interactions with other value chain participants.

This report evaluates the overall socioeconomic impact of Savannah's operations in India's rice seed sector, with a focus on its contribution to agricultural innovation, farm productivity, farmers' livelihoods and the broader agricultural economy. It examines Savannah's role in advancing hybrid rice technology, expanding access to improved seed varieties, strengthening seed distribution networks and building farmer awareness through training and extension activities. The report also assesses the implications of these innovations for farmers, including their adoption experiences, production outcomes, resource use efficiency and the potential for more sustainable rice cultivation. By bringing together evidence on technological development, business operations and farmer-level outcomes, the study provides a comprehensive assessment of Savannah's contribution to the evolution of India's rice seed sector and highlights the opportunities and challenges associated with scaling agricultural innovations in ways that generate economic and environmental benefits.

The report's findings highlight the important role of private sector investment in agricultural innovation in strengthening India's rice seed sector. The findings are particularly relevant for India, where rice production must respond simultaneously to growing food demand, climate change, and increasing pressure on land and water resources. By examining the linkages between private investment, technological innovation, and farmer-level outcomes, the report offers valuable insights for shaping policies that encourage greater private sector participation, strengthen the last-mile delivery of agricultural technologies, and promote climate- smart rice cultivation.

[1] Farmer organisers are individuals who facilitate the mobilisation, coordination, and participation of farmers in agricultural activities, collective initiatives and stakeholder consultations.

Overall Socio-Economic Impact of Savannah



Source: Authors' creation from data provided by Savannah

R&D and Investments

The adoption and scaling of improved paddy technologies require sustained investments in research and development, technological innovation, germplasm development, field validation and extension services. Since its establishment in 2010, Savannah has invested US$50 million in R&D, while continuing to reinvest approximately 10-15 per cent of its annual revenue in R&D. It commercialised Thermo-Sensitive Genic Male Sterility (TGMS)[2] based hybrid rice technology in India. Further, these sustained investments have supported the development and commercialisation of Savannah's SmartRice® hybrids, introduced commercially in 2013, followed by the launch of FullPage® Rice Cropping Solutions in 2023. Savannah commissioned an R&D laboratory in India in 2025 to further strengthen its research capabilities and serve the wider Asia-Pacific (APAC) region. The company's R&D ecosystem is also supported by germplasm and technology linkages with research and breeding programmes in the United States, Brazil and China, enabling access to diverse genetic material, technologies and scientific expertise. Together, these investments demonstrate a long-term commitment to developing high-performing, resource efficient and locally adaptable rice technologies, while positioning India as an important R&D and innovation hub for the wider rice-growing region. The development and commercialisation of these technologies have been supported by a team of more than 30 Indian scientists, along with 15-20 parent seed production farmers engaged through formal agreements, creating a structured linkage between R&D, seed multiplication and farmer participation. Their development and evaluation have involved collaboration with 19 ICAR institutes and agricultural universities, which have participated in testing and field evaluation.

The expansion of R&D has been accompanied by investment in seed production infrastructure, strengthening the domestic seed production and technology ecosystem. A 4-acre (1.6 ha) parent seed facility has been acquired and redeveloped, with dedicated infrastructure for parent seed multiplication, seed processing, storage and quality control. These investments have also generated employment and local economic opportunities. The seed production facility has created more than 50 high-skill jobs during 2025-26, particularly in seed production, quality assurance, technical operations and facility management. In addition, approximately 50-80 farmers, primarily land lessors, are actively associated with the facility, providing land and participating in activities linked to seed production. This illustrates an integrated R&D and innovation ecosystem in India, spanning scientific research, international germplasm and technology linkages, institutional testing, commercial seed development, seed production infrastructure and farmer participation. The investments, thus, extend beyond the development of individual rice hybrids, contributing to the strengthening of India's agricultural research, seed production, technology transfer and skilled employment ecosystem.

[2] TGMS system in rice (also called the 2-line system) is a hybrid rice breeding sterility method in which one parent behaves as female (sterile for male part) above a given temperature (referred as Critical Temperature (CT) and fertile at below a given temperature.

Agriculture research intensity (ARI) - agricultural R&D expenditure as a share of agricultural GDP-declined from 0.75 per cent in 2008-09 to 0.43 per cent in 2020-21, well below the one per cent target recommended by the Government of India and the Food and Agriculture Organization (FAO). Against this backdrop, Savannah's average annual R&D expenditure of around 10-15 per cent of its revenue is significant.

Seed Production Farmer Outreach, Adoption and Income Impact

Savannah's field-level operations have expanded across a substantial geographic and farmer network. During 2025-26, its activities covered 47 districts and 698 villages across Rajasthan, Telangana and Himachal Pradesh (Palampur), encompassing more than 30,000 acres (12,000 ha) under SmartRice® hybrids, FullPage® Rice Cropping Solution (DSR), improved varieties and open-pollinated (OP) varieties**.** This indicates a significant field-level footprint and provides a broad platform for testing, demonstrating and scaling improved rice technologies across diverse agro-climatic conditions. The programme involved approximately 6,000 contract farmers across the three states during 2025-26. The contractual arrangement provides a structured mechanism for linking farmers with the company's seed production and technology ecosystem, while facilitating access to technical guidance and ensuring greater coordination of production activities. The geographical spread also creates opportunities for knowledge diffusion and peer-to-peer learning, potentially supporting wider adoption of improved rice technologies beyond the directly participating farmers. The scale of farmer engagement is supported by a substantial field extension network. In 2025-26, more than 270 field officers conducted over 25,000 field visits, providing farmers with agronomic guidance, monitoring crop performance and supporting technology adoption and seed production activities.

The income evidence from participating farmers also indicates the potential for improved profitability. In Hanumangarh, Rajasthan, farmers engaged in hybrid seed production reportedly achieved net profits of approximately ₹1,77,916-₹2,59,461 per hectare as compared to ₹1,33,437-₹1,42,827 per hectare from commercial grain cultivation. The difference represents an indicative additional earning potential of approximately ₹35,389-₹1,26,024 per hectare for farmers engaged in hybrid seed production, although the magnitude of the gain would depend on production costs, prices, agronomic practices and the specific contractual arrangement. Similarly, in Telangana, hybrid seed growers earned approximately ₹1,59,324-₹2,39,633 per hectare as compared to ₹80,013-₹1,01,486 per hectare for farmers cultivating commercial paddy, including bold and fine varieties.

The scale of operations: 47 districts, 698 villages, nearly 6,000 contract farmers and an extensive field extension network indicate that Savannah's activities extend beyond the introduction of improved seed technology to the creation of broader farmer engagement, technical support and income-generation ecosystem. The reported profitability differential further suggests that participation in seed production can provide farmers with a higher income opportunity relative to conventional commercial grain production.

Processing, Storage, Quality Control and Packaging

Savannah's seed processing, storage, quality control and packaging operations constitute an important downstream component of its agricultural value chain and generate economic activity beyond primary seed production. The company currently operates through seven processing units under the toller model, located in Sonepat, Raipur, two facilities in Siddipet and Karimnagar. The Sonepat facility is a greenfield project developed by Savannah in North India.

Processing facilities generate both skilled and semi-skilled employment. During 2025-26, more than 120 skilled toller staff and over 465 labourers were engaged across the processing network. Women account for approximately 55 per cent of the labour workforce, indicating the potential of seed processing activities to create employment opportunities for women in rural and semi-urban locations. Employment is generated across activities such as seed processing, grading, treatment, quality control, packaging, warehousing and facility operations.

The downstream supply chain also creates demand for a wider network of Indian MSMEs. More than 100 Indian MSMEs supply seed-treatment and packaging materials, with procurement estimated at over ₹500 million over four years. Such linkages demonstrate how the development of the seed industry can stimulate domestic manufacturing and service providers supplying specialised materials and inputs required for seed processing and packaging. The economic impact therefore extends beyond Savannah's own operations to a broader network of Indian enterprises. Logistics represents another important component of this downstream value chain. The movement of processed, packaged and finished seed across production, processing, storage and distribution locations has contributed an estimated ₹935 million to India's MSME logistics industry, associated with more than 20,000 truckloads of movement. This expenditure supports trucking and fleet operators as well as associated services such as loading, unloading, warehousing and freight handling.

Commercial Distribution and Farmer Outreach

Savannah's commercial distribution network represents the final link between seed development and farmer adoption, enabling improved rice technologies to reach a large and geographically dispersed farmer base. Since inception, Savannah has delivered across more than 21 million acres (8.5 Mha) cumulatively through its SmartRice® hybrids, FullPage® Rice Cropping Solution (DSR), improved varieties and OP varieties, with 2.8 million acres (1.13 Mha) covered in the last financial year (2025-26). The distribution network is further supported by more than 10,000 distributors and retailers, all of whom are reported to be MSMEs selling Savannah-packed seed. This creates an extensive last-mile distribution system and provides business opportunities for small and medium enterprises operating within the agricultural input market. Farmer awareness and capacity building constitute an important complementary component of commercial distribution. Savannah has conducted more than 11,000 training programmes, reaching approximately 420,000 farmers. These programmes provide an avenue for communicating appropriate

agronomic practices, technology use and crop-management recommendations, thereby supporting informed adoption and potentially improving the effectiveness of the seed technologies under field conditions.

According to assessments of datasets provided by Savannah, the adoption of its seed technologies has contributed to approximately ₹25,540 cr (₹255.4 billion) (Annexure i) in incremental farmer income since 2013, attributed to higher rice yields and income generated through seed production, including area covered under ***Kharif* 2026** season.

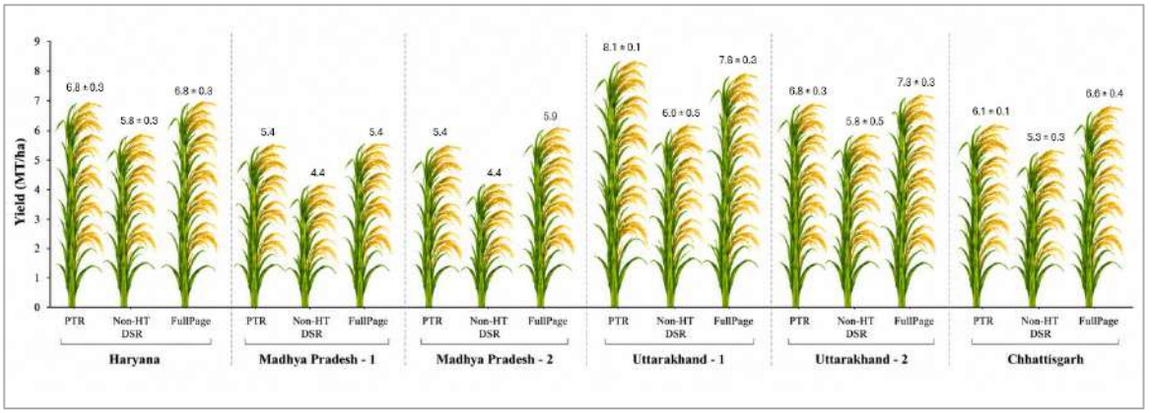
Hybrid Paddy Yield and Farmers' Income

Improved varieties and production technologies can contribute to higher paddy yields and improved farm-level profitability when supported by appropriate agronomic practices and timely access to inputs and technical guidance. The findings indicate that Savannah's SmartRice® (Sava 7501) has a reported yield potential of 7.3-10.3 MT per hectare in Haryana, based on ICAR-IIRR assessments conducted during 2023-2025. At these productivity levels, SmartRice® has the potential to generate estimated net returns of ₹1,16,732-₹1,87,802 per hectare. This compares favourably with the estimated net profitability from non-basmati paddy cultivation, which is on average approximately ₹73,556 per hectare (5.4 MT per hectare yield) in Haryana and ₹1,01,984 per hectare (6.6 MT per hectare yield) in Punjab, although actual performance varies with location, agronomic practices and growing conditions.

Environmental Sustainability along with Farmers Profitability

The study finds that Savannah's FullPage® Rice Cropping Solutions address two key constraints to DSR adoption: poor weed control and low crop establishment, through the integrated FullPage® Rice Cropping Solution, which combines SmartRice® genetics, Squad seed treatment, the FullPage® trait and ADAMA herbicides. The FullPage® DSR system delivered comparable or higher yields than puddled transplanted rice (PTR) across almost all locations as depicted in **Figure i**.

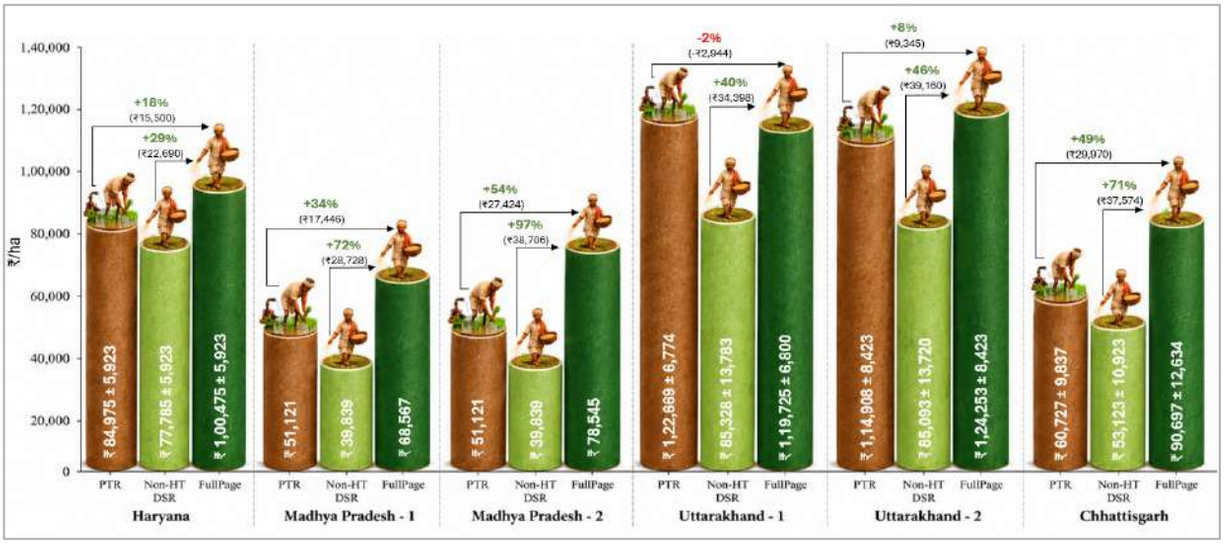
Figure i: Comparison of average yields from different paddy establishment methods



Source: Authors' compilation based on FGDs (mean values are represented); Note: 1 and 2 indicate FGD-1 and FGD-2; ± symbol indicate two possible values of yield

The FullPage® DSR system also demonstrates a strong profitability advantage over both PTR and non-herbicide tolerant (non-HT) DSR **(Figure ii)**, which is the combined benefit of lower cultivation costs and comparable or higher yields. In addition, farmers reported water savings upto 40 per cent, along with improvements in labour-use efficiency and overall profitability. Himachal Pradesh Agriculture University (2026) found that Sava-134 FullPage® DSR system reduced methane emissions by nearly 90 per cent.

Figure ii. Comparison of average net profits from different paddy establishment methods



Source: Authors' compilation based on FGDs (bars show average values and exclude government incentives provided to promote DSR) ; Note: 1 and 2 indicate FGD-1 and FGD; ± symbol indicate two possible values of net profits.

Key Recommendations

The study proposes four key recommendations:

- India should pursue a productivity-led rice strategy aligned with the "−5, +10" vision, reducing rice area by 5 Mha while increasing production by 10 MMT by scaling high-yielding, climate-resilient and region-specific hybrid rice, particularly in water-stressed states such as Punjab and Haryana.
- At the same time, India should position itself as a global seed production and export hub by strengthening seed quality systems, public-private partnerships, international collaborations and incentives for seed multiplication.
- Regulatory reforms, stronger intellectual property protection and performance-linked incentives should encourage greater private investment in R&D and innovation.
- DSR should be promoted through an integrated adoption ecosystem through financial incentives (including carbon credits), addressing key constraints such as weed management, crop establishment, availability of suitable varieties, mechanisation and farmer knowledge through targeted research, extension, demonstrations and location-specific evidence on costs, yields and profitability.

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CHAPTER 1 – INTRODUCTION: INDIA'S RICE SEED SECTOR, FDI AND PRIVATE INNOVATION

Ashok Gulati, Reena Singh and Bidisha Chanda

1.1 India's Global Position in Rice Production, Cultivated Area and Exports

Technologies and agrifood policies associated with the Green Revolution have transformed rice productivity and strengthened domestic food security in India since the 1970s. Beyond its importance for food security, rice is a major contributor to India's agricultural economy and international trade, accounting for approximately 8 per cent of agricultural gross value of output in the triennium ending (TE), 2023-24. India is also the world's leading rice exporter and an important contributor to global food security, with exports of 21.5 MMT of rice valued at USD 12.5 billion in 2025-26 (AIREA, 2026), equivalent to around 40 per cent of global rice exports. Yet India's dominance in rice production is driven primarily by the scale of cultivation rather than high productivity. With approximately 52.8 Mha under rice, India produces an estimated 154 MMT (USDA, **Table 1.1**). By comparison, China produces nearly the same volume, about 146 MMT, from only around 29 Mha, less than 60 per cent of India's rice area. China's paddy yield of 7.5 MT per hectare is approximately 73 per cent higher than India's 4.4 MT per hectare. While India outperforms several major rice-producing countries in yield, its productivity remains below that of China, Vietnam (5.8 MT per hectare), Bangladesh (4.8 MT per hectare), Indonesia (4.5 MT per hectare) and the global average (4.5 MT per hectare). The comparison highlights the considerable scope for increasing rice production through productivity gains rather than further expansion of area under rice. This is also critical as traditional rice cultivation methods have substantial environmental impacts, such as excessive water use, greenhouse gas emissions, soil erosion, and loss of biodiversity (Singh et al., 2024). In India, rice cultivation accounts for 23.5 per cent of the gross cropped area (MOAFW, 2026) and consumes around 40 per cent of irrigation water (Sharma et al., 2018). Rice cultivation is also responsible for 17.1 per cent of India's agricultural GHG emissions in the form of methane (MoEFCC, 2023).

Table 1.1: Top 10 countries - Area, Production, and Yield: 2025-26

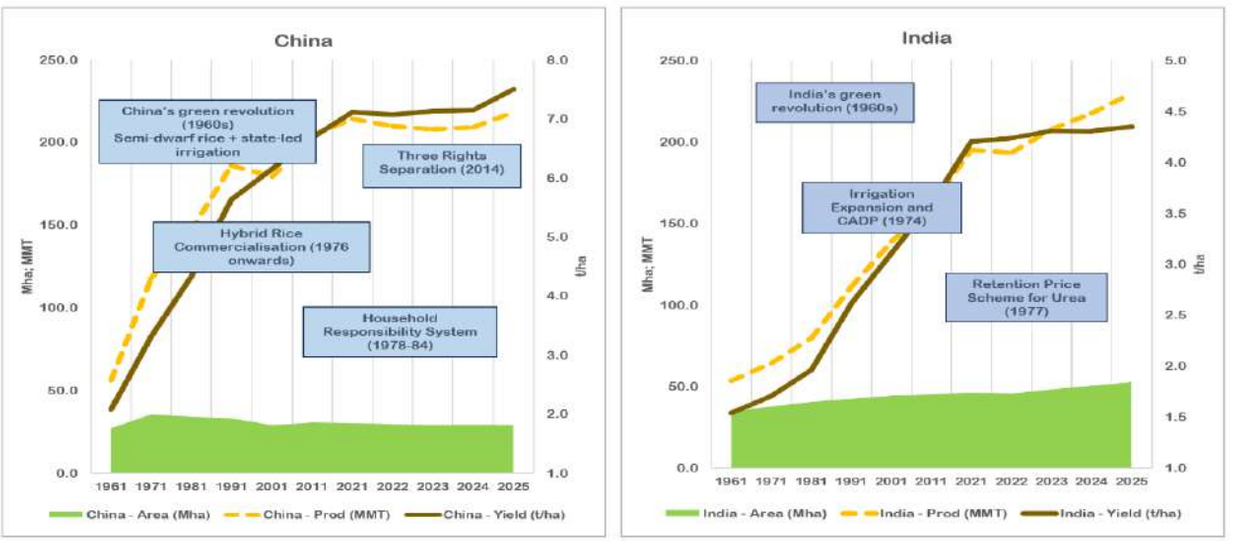
Country	*Area (Mha)*	*Rice Production (MMT)*	*Paddy Yield (MT/ha)*	*Yield Gap (%) with India*
India	52.8	154.02	4.4	-
China	29	146.33	7.5	73
Bangladesh	11.8	37.65	4.8	9

Country	*Area (Mha)*	*Rice Production (MMT)*	*Paddy Yield (MT/ha)*	*Yield Gap (%) with India*
Indonesia	11.3	33.8	4.5	3
Vietnam	6.8	26.2	5.8	32
Thailand	11	20.7	2.8	-35
Philippines	4.7	12.4	3.9	-10
Burma	6.8	12.0	2.6	-39
Pakistan	3.8	10.0	3.9	-10
Cambodia	3.8	8.1	3.2	-27
World	173.2	523.5	4.5	4

Source: USDA

Together, India and China account for approximately 47 per cent of the world's area under rice and 57 per cent of global rice production; hence, it is useful to examine the factors underlying their yield trajectories **(Figure 1.1).**

Figure 1.1: China and India: Area, Production and Yield



Source: USDA

As shown in **Figure 1.1**, China's growth in rice production has been predominantly yield driven. Its rice area peaked at 35.6 Mha in 1971 and subsequently declined by approximately 19 per cent to 29 Mha in 2025. Over the same period, however, rice production more than tripled, rising from 37.7 MMT to 146.3 MMT. This increase was underpinned by a 257 per cent rise in paddy yield from 2.1 MT per hectare in 1961 to 7.5 MT per hectare in 2025. China has thus succeeded in substantially increasing rice production while using a smaller cultivated area. China's sustained yield growth reflects the combined effects of institutional reforms, technological advances and continued investment in agricultural productivity. A major turning point was the introduction of the Household Responsibility System (HRS) between 1978 and 1984, which

linked farm output more directly to household income and strengthened incentives to raise production and productivity. The commercialisation of Yuan Longping's three-line hybrid rice system from 1976 provided an important technological impetus, with hybrid varieties generating yields approximately 20-30 per cent higher than conventional varieties (Qian et al., 2021). There was also a sharp increase in fertiliser use during this period, from 66.3 kg per hectare in 1976 to 159.4 kg per hectare in 1980 and 394 kg per hectare of arable land in 2023-24. Hybrid rice currently accounts for approximately 62-63 per cent of China's rice area and yields 15-31 per cent more than other cultivated rice varieties (Spielman et al., 2012; Gong et al., 2026). Agricultural incentives were further strengthened in 1979, when China began shifting from state-controlled grain prices towards a more market-oriented system, allowing farmers to sell surplus production at market prices (World Bank, 1992). These reforms were complemented by sustained public and private investment in irrigation, fertiliser, agricultural research, extension services and mechanisation. A further institutional shift occurred in 2014 with the Three Rights Separation reform, which distinguished collective ownership from household contract rights and transferable management rights (Gong et al., 2022). The reform enabled farmers to lease management rights to larger farms, co-operatives and agribusinesses while retaining their contractual rights. Greater consolidation of fragmented plots, in turn, facilitated mechanisation and the adoption of modern production technologies (Gong et al., 2022).

By contrast, India's production growth has been driven by a combination of area expansion and substantial gains in productivity. India's rice area increased by 50.4 per cent from 34.7 Mha in 1961 to 52.8 Mha in 2025, while paddy yield increased by 193 per cent from 1.5 MT per hectare to 4.4 MT per hectare. India's transformation in rice productivity began with the Green Revolution in the 1960s, when the technological foundations of modern agriculture were established through the widespread adoption of high-yielding varieties (HYVs), which was accompanied by a more extensive system of public investment and policy support, particularly through irrigation, input subsidies, institutional credit, agricultural research and price support. Expansion of irrigation was central to this transformation. Large multipurpose irrigation projects, were complemented by rapid growth in private and public tube-well irrigation. Net irrigated area increased from approximately 25 Mha in 1960-61 to around 50 Mha by 1991-92 and reached 84.5 Mha in 2024-25, equivalent to about 60 per cent of the net sown area (MoAFW, 2026). Irrigation also became increasingly important for rice cultivation. The share of rice area under irrigation rose from 36.8 per cent in 1961 to approximately 70 per cent in 2024-25 (MoAFW, 2026). Greater access to assured water reduced production risks and enabled farmers to adopt HYVs, which generally required more reliable water and nutrient availability. The intensification of input use further supported productivity growth. Fertiliser consumption in Indian agriculture increased more than fivefold from 6.1.MMT in 1981-82 to 32.9 MMT in 2024-25, which is 151 kg per hectare of gross cropped area (MoAFW, 2025). However, India's rice sector has remained heavily dependent on high-yielding inbred varieties, alongside increasing but still relatively limited adoption of hybrid rice, which is 7-8 per cent of its rice area. India's production incentives were also strengthened through price and market support. The government introduced the Minimum Support Price (MSP) framework in 1965-66, alongside the establishment of the Food Corporation of India (FCI) in 1965 for procurement and management of foodgrains.

Vietnam provides a useful comparison. From the 1990s, the government promoted hybrid rice through public research, demonstrations, imported seed and financial support (Khac et al.,

2018; Khanh et al., 2021). Household- and field-level studies reported yield advantages of approximately 21-22 per cent over conventional varieties in particular settings. Hybrid seeds (rice, maize, vegetables, and cotton) were introduced between 1986 and 1995. The available estimates suggest that more than 10 per cent of rice area is under hybrids (Spielman et al., 2012). In addition, Đổi Mới reforms[3], improved irrigation, fertiliser use, multiple cropping, market liberalisation and the diffusion of improved inbred varieties also encouraged productivity growth (Nhan Dan, 2026).

The United States (US) provides a useful complementary case for illustrating the role of hybrid rice, although its rice sector is much smaller in scale and, therefore, not directly comparable to those of major rice-producing countries such as India and China. In 2025-26, the US produced approximately 6.5 MMT of rice on 1.1 Mha of land (USDA, n.d.). Hybrid rice varieties became commercially available in the US in the late 1990s, initially developed through partnerships between RiceTec and international breeding programmes (Andrews, 2001). By 2013, hybrid rice accounted for around 29 per cent of total US rice area and subsequently expanded to approximately 90 per cent of Southern rice acreage, particularly in Arkansas, Louisiana and Mississippi (Childs et al., 2020). However, the high yields achieved in the US reflect not only varietal technology but also the structural advantages of its rice production system, including large-scale, highly mechanised, precisely levelled and irrigated farms, supported by advanced agronomic management (Rizzo et al., 2022). Thus, while the US experience demonstrates the potential contribution of hybrid rice to yield improvement, its production model and scale differ substantially from those of major Asian rice-producing countries, limiting direct cross-country comparisons of yield performance.

The diverging experiences of China, Vietnam and the US have important implications for the future of India's rice sector. With limited scope for further expansion of cultivated land and increasing concerns over groundwater depletion, input use, soil degradation and environmental pressures, future production growth will need to rely increasingly on yield enhancement and resource use efficiency rather than area expansion.

Hybrid Seed Technology

Hybrid seeds are produced by crossing two genetically distinct parent cultivars through controlled pollination. To ensure desirable characteristics and genetic uniformity, the parent lines are typically inbred over several generations before being crossed to produce the hybrid. Since the parental cross has to be repeated each season to produce F1 hybrid seed, hybrid seed production involves relatively high costs. However, these costs can be offset by higher yields. According to the ICAR-AICRP programme, hybrids can achieve yield gains of at least 20 per cent compared to pure-bred varieties.

The widespread adoption of hybrid corn from the 1930s marked an important milestone in the development of hybrid seed technology, which subsequently expanded to crops such as pearl millet, sunflower and sorghum. Today, hybrid seeds dominate corn cultivation in the United States (99 per cent) and are widely used across several other crops, including sorghum, cotton, peanuts, soybean and vegetables.

[3] **Đổi Mới Reforms:** Đổi Mới ("renovation" or "renewal") refers to the economic reform programme initiated by Vietnam in 1986 to transition from a centrally planned economy towards a market-oriented economy.

Rice hybrids are also cultivated widely across Southeast and East Asia, particularly in China. Decades of research by Yuan Longping, widely regarded as the 'father of hybrid rice', played a pivotal role in expanding hybrid rice cultivation to more than 60-70 per cent of China's rice cultivation area and achieving yield gains of 20-30 per cent over conventional varieties. However, hybrid rice accounts for only about seven per cent of the India's rice area. India has shown early success with Sava 7501, delivering upto 10 MT per hectare as per ICAR-IIRR 2024.

India's hybrid maize yields have nearly tripled in six decades from 3.5 MT per hectare at first release (1964) to 9-10.5 MT per hectare in hybrids released during 2017-2022. Recent ICAR trials confirm this under real field conditions too: modern hybrids averaged 8.75 MT per hectare, with top performers hitting 12-13 MT per hectare. India could pull the same lever for rice, where yields still trail China and Vietnam. The land freed up by higher rice yields could go to the National Oilseed Mission, or National Pulses Mission, cutting edible oil and pulses imports. If 2.5 Mha of rice cultivation area is diverted to pulses (from 28.7 to 30.2 Mha), it could increase pulses production from 27.4 MMT to about 29.8 MMT, an increase of roughly 2.4 MMT (around 8.5 per cent). Allocating 2.5 Mha to oilseeds (from 30.9 to 33.4 Mha) would raise oilseeds output from 43.1 MMT to about 46.5 MMT, a gain of around 3.5 MMT (about 8.1 per cent). These estimates assume constant yields and no change in cropping intensity or input use.

1.2 Private Seed Sector

Historically, India's formal seed sector was largely led by public institutions, which laid the foundations of the modern seed industry by developing improved varieties and supporting their multiplication and distribution to farmers. Crop breeding research was primarily undertaken by institutions under the Indian Council of Agricultural Research (ICAR), including the Indian Agricultural Research Institute (IARI), and by state agricultural universities. Formal seed production and distribution were carried out mainly by the National Seeds Corporation, state seed corporations and a limited number of private firms. At the same time, farmer-saved seed of open-pollinated varieties, produced and exchanged by farmers, farmer organisations, and local seed enterprises, remained an important source of seed supply.

The policy environment began to shift in the 1980s. India permitted 100 per cent foreign direct investment (FDI) in the seed sector in 1986, followed by the New Policy on Seed Development in 1988, which expanded opportunities for private sector participation and facilitated the entry and growth of both domestic and multinational seed firms. From 2006, 100 per cent FDI was permitted through the automatic route, eliminating the requirement for prior government approval and further easing foreign investment in the sector (FSII, 2024). These policy changes contributed to the expansion and diversification of private seed enterprises and encouraged investment in crop breeding, varietal development, hybrid technology, and seed production, processing and distribution.

Private seed production expanded particularly rapidly in crops amenable to hybridisation, including cotton, pearl millet, sorghum, maize and several vegetables (Morris et al., 1998; Pray et al., 2001; Kolady et al., 2012). In crops such as rice and wheat, where hybrid seed adoption has historically been more limited, private sector seed

production expanded more gradually but steadily (Tripp and Pal, 2001; Matuschke et al., 2007; Spielman et al., 2013). The introduction of intellectual property rights protection for new plant varieties under the Protection of Plant Varieties and Farmers' Rights Act, 2001, provided an additional impetus to private investment in Crop breeding research. By 2020, the Indian seed industry was valued at approximately USD 3.6 billion, making India the world's fifth-largest seed market (TAAS-ISST, 2020).

The expansion of the private seed sector has also been accompanied by increasing participation of multinational and technology-oriented firms. By 2014, around 850 seed companies, predominantly engaged in seed production, were operating in India, although only about 50 had significant Crop breeding research capabilities (Schreinemachers et al., 2017). Private seed and agri-input firms, including Bayer, Corteva, Syngenta, BASF and Savannah, alongside technology-oriented domestic enterprises, participate in India's seed economy through diverse organisational and technological arrangements. These include wholly or majority-owned subsidiaries operating under the automatic FDI route, licensing and joint-technology agreements with domestic seed firms, and, more selectively, acquisitions or minority investments in established Indian breeding businesses (IMARC, 2025). These organisational models differ in the extent of technology transfer, access to germplasm and breeding capabilities, and the degree of integration between research and development, seed production and commercialisation.

The growing role of private sector R&D is particularly important given the high returns to agricultural research relative to several other forms of public investment. Gulati et al. (2018) estimated that every rupee invested in agricultural research, development and education (ARDE) generated a return of ₹11.20, compared with ₹0.88 from fertiliser subsidies, ₹0.79 from power subsidies, ₹0.97 from education and ₹1.10 from roads. More recent research by Indian Council of Agricultural Research-National Institute of Agricultural Economics and Policy Research (ICAR-NIAP) similarly estimated that every rupee invested in agricultural research generates a return of ₹13.85 (Kandpal et al., 2024). Despite these high returns, public investment in agricultural R&D remains relatively low. Agriculture research intensity (ARI) –agricultural R&D expenditure as a share of agricultural GDP – declined from 0.75 per cent in 2008-09 to 0.43 per cent in 2020-21, well below the 1 per cent target recommended by the Government of India and the Food and Agriculture Organization (FAO).

Against this backdrop, private sector investment assumes greater significance. Globally, private seed firms invest, on average, around 10-12 per cent of its revenue in R&D, whereas the corresponding share in India is estimated at approximately 3 per cent (FSII, 2022). While India's private sector R&D investment has expanded alongside the growth of the seed industry, the gap with global investment levels suggests considerable scope for strengthening private research capabilities, technology development and innovation in the Indian seed sector.

1.3 Foreign Direct Investments in Seed Sector

FDI contributes not only to economic growth but also to financial market development by providing foreign capital, technology, innovation and skills. In India, evidence from the 2021-2023 period indicates a positive relationship between FDI inflows and the performance of major stock market indices, including the Sensex and Nifty (FSII, 2024). Total FDI inflows in the country went up from USD 51 billion in 2021 to USD 57

billion in 2025 (**Table 1.2**). Of this value, agriculture services attract minimal FDI inflows, making up 0.4 per cent in 2021, but increasing to 1.5 per cent in 2025. Agriculture services attract FDI in certain sub-sectors: horticulture, floriculture, hybrid seeds and plantations, and other services. Hybrid seeds and plantations make up for the most of FDI in agriculture in certain years – 47 per cent in 2022, and 36 per cent in 2024, while it was only 6.1 per cent in 2023 and 1.6 per cent in 2025.

Table 1.2: FDI Inflows into agriculture in India

		Agriculture services		*Hybrid seeds & plantation*	
Year	Total FDI Inflow (in USD million)	Value (in USD million)	% of FDI	Value (in USD million)	% of Agriculture services
2021	51339	223	0.4	34.5	15.4
2022	52346	215	0.4	100.8	46.9
2023	41325	351	0.8	21.5	6.1
2024	53058	51	0.1	18.2	35.8
2025	57221	868	1.5	13.6	1.6

Source: DPIIT, various years

1.4 Seed Regulation Acts

The regulatory framework governing India's seed sector comprises multiple instruments that address variety notification, intellectual property protection, biosafety and market conduct. Two key measures are variety notification under the Seeds Act, 1966, and variety registration under the Protection of Plant Varieties and Farmers' Rights (PPV&FR) Act, 2001. These serve complementary regulatory functions. Variety notification is primarily intended to support the regulation of seed quality and commercial availability, whereas registration under the PPV&FR Act provides legal recognition and protection to plant varieties and establishes rights for breeders and farmers. At the same time, firms may market truthfully labelled varieties that have neither been notified under the Seeds Act nor registered under the PPV&FR Act, subject to applicable regulatory requirements.

The State also retains important regulatory levers over pricing, market conduct and the commercialisation of new technologies. In the case of GM crops, the regulatory framework requires biosafety assessment and approval through the Review Committee on Genetic Manipulation (RCGM) and the Genetic Engineering Appraisal Committee (GEAC) before environmental release and commercialisation, alongside compliance with applicable FDI regulations (PIB, 2022). To date, Bt cotton remains the only GM crop approved for commercial cultivation in India.

The government has also exercised direct control over seed prices through its powers under the essential commodities framework. A prominent example is the Cotton Seeds Price (Control) Order, 2015, which provided for regulation of the maximum retail price of Bt cotton seeds and the trait value payable on such seeds. Such

interventions demonstrate that, beyond quality and biosafety regulation, the State can influence the pricing and market conduct of seed producers.

The PPV&FR Act also provides a mechanism to address concerns regarding the availability and affordability of protected varieties. Section 47 empowers the PPV&FR Authority to grant a compulsory licence if, after three years from the date of registration, the seed of a registered variety has not been made available to the public at a reasonable price or where the reasonable requirements of the public have not been adequately met. The Act further provides for benefit sharing with communities that have contributed genetic material to a registered variety.

1.5 Study Objectives and Methodology

Against this backdrop, an impact assessment of Savannah Seeds Private Limited (Savannah) was undertaken to understand private sector innovation in the Indian seed industry. Established in October 2010, Savannah is a 100 per cent foreign-owned subsidiary of the Liechtenstein Group and RiceTec Inc. and operates across 15 states in India. Over the past decade, Savannah has commercially introduced 10 hybrid varieties, 20 improved varieties and 10 OP varieties across three core maturity concepts **(Annexure 1.1).** Savannah has also expanded its innovation portfolio beyond varietal development through the introduction of the FullPage® Rice Cropping Solution, designed for DSR, which integrates SmartRice® genetics, SQUAD™ seed treatment, the FullPage® IMI herbicide-tolerance trait, and ADAMA's Vezir herbicide. The solution includes rice hybrids such as Sava 134 and Sava 127, targeted to specific agro-ecological regions and mid-early maturity segments. The overall objective of the Savannah case study is to assess socio-economic and environmental impacts of Savannah's Indian operations, focusing on four core areas:

- Farmer Economics: Assessing the impact of Savannah's SmartRice® hybrids on increased yields, optimised cultivation costs and overall profitability per acre
- Climate Resilience: Evaluating Savannah's FullPage® technology's role in driving DSR and enhancing water-use efficiency and positive environmental impact along with improved profitability per acre for farmers
- Seed Production Value: Quantifying the direct socio-economic benefits generated through Savannah's seed production network for local farmers
- Supply Chain and Employment: Measuring the domestic footprint of Savannah across the value chain, including logistics, processing, and direct/indirect job creation.

This case study combines primary qualitative evidence collected through farmer and value-chain stakeholder interactions **(Annexure 1.2-1.3)** with secondary evidence from published literature and quantitative and operational data shared by Savannah.

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CHAPTER 2 – HYBRID RICE IN INDIA: POTENTIAL FOR RAISING PRODUCTIVITY

Ashok Gulati, Reena Singh and Bidisha Chanda

2.1 Hybrid Rice in India

Hybrid rice is a proven technological pathway for enhancing rice production and productivity. Sustained research and development efforts over the past three decades have resulted in the release and notification of 162 rice hybrids for commercial cultivation in India. Of these, 44 hybrids have been developed by the public sector and 118 by the private sector, reflecting the growing role of private sector research and innovation in hybrid rice development. In 2024, hybrid rice was cultivated on approximately 3.5 Mha, with more than 80 per cent of the total hybrid rice area concentrated in Uttar Pradesh, Jharkhand, Chhattisgarh, Madhya Pradesh, Odisha and Haryana (IHRT, 2024). Studies from different parts of India show that hybrid rice can give higher yields than normal rice varieties, but how much higher depends on where it is grown and how well it is managed. In irrigated areas of states like Chhattisgarh, Odisha, Tamil Nadu and Uttar Pradesh, hybrid rice often gives about 5.5-7.5 MT per hectare, while common inbred varieties give around 4-5.5 MT per hectare, meaning hybrids can produce roughly 15-30 per cent more grain (ICAR, 2021; Gill et al., 2021). Sava 7501 has been reported to deliver between 7.3 and 10.3 MT per hectare as per ICAR-IIRR 2023-25. Experimental evaluations have demonstrated that some hybrid rice combinations can achieve yield advantages of 15-20 per cent over high-yielding check varieties under favourable growing conditions (FAO, n.d.). But this advantage is not the same everywhere. In rainfed or drought-prone areas and where farmers use less fertiliser and water, the difference between hybrids and normal varieties becomes smaller, and sometimes hybrids give less stable yields because they are more sensitive to water stress and poor soil conditions (Born et al., 2022; Kumar & Palanisamy, 2013). Research in eastern India also shows that families using hybrid rice can have better food security, but only if they have reliable irrigation, enough fertiliser and good advice on how to grow the crop (Qaim & Zilberman, 2012; Singh et al., 2020). Many studies also point out that farmers often do not get the full yield benefit of hybrids because of late planting, poor weed control and wrong or imbalanced use of fertilisers (Yadav et al., 2018; Arora et al., 2022). So, while hybrid paddy clearly has the potential to give higher yields, the actual gain that farmers see in their fields varies a lot and depends on better irrigation, timely operations and proper crop management.

Despite the availability of hybrid rice varieties with demonstrated yield advantages, India's adoption of hybrid rice remains low (Roy et al., 2021). Hybrid seed is significantly more expensive than conventional inbred seed, as was confirmed during our farmer group discussions (FGDs), and smallholder farmers often face liquidity constraints and limited access to credit, which reduce their willingness to invest in higher-cost inputs (Qaim & Zilberman, 2012). The seed system for hybrids is also less developed than that for inbred varieties, with limited availability of certified hybrid seed, leading to reliance on informal seed sources of uncertain quality (Singh et al., 2020). Observation from the field suggested that hybrid paddy seeds were not available in

quantities demanded by farmers, which influences their decision to cultivate them next season. Hybrid rice varieties often exhibit greater yield variability across environments, and farmers in risk-prone, rainfed regions often prioritise yield stability over potential yield gains (Born et al., 2022), given market prices fluctuations. Grain quality concerns further constrain adoption, as some hybrid varieties have been perceived to have inferior cooking and eating quality compared with preferred local inbred varieties, reducing market demand and farmer incentives (Gill et al., 2021). Extension services and information about hybrid rice management remain weak in many states, limiting farmers' awareness of appropriate agronomic practices for realising hybrid yield potential (Arora et al., 2022). Finally, public procurement and support price policies have historically favoured established inbred varieties, creating a policy environment that does not strongly incentivise a shift towards hybrids (Yadav et al., 2018). These factors explain why India's rice productivity growth has relied more on area expansion and incremental improvements in inbred varieties than on large-scale hybrid adoption (Kumar & Palanisamy, 2013).

The national average yield stands at just 4.4 MT per hectare, falling well short of China's 7.5 MT per hectare. Even India's top-performing states, such as Andhra Pradesh (6.0 MT per hectare), Punjab (5.7 MT per hectare), and Haryana (5.3 MT per hectare), lag behind China's benchmark. States in eastern India, such as West Bengal (4.5 MT per hectare) and Bihar (3.9 MT per hectare), possess naturally favourable agro-ecological conditions and abundant water resources for rice cultivation, yet their yields remain far below potential. Conversely, northern states like Punjab and Haryana dedicate an intensive 60-70 per cent of their gross cropped area to wheat-paddy monocropping despite facing severe groundwater depletion. Given this reliance on the north for national food security, elevating yields in rainfed regions of paddy is critical to maximising output per hectare, while simultaneously tapping into the unfulfilled potential of ecologically suited eastern states.

2.2 Savannah's SmartRice® Hybrids

2.2.1 Yield

The FGD conducted in the Barnala cluster of Punjab in July 2026 indicates that SmartRice® hybrids can deliver high yields under farmers' field conditions. Among the 10 farmers in the FGD, those predominantly cultivating Sava 7501 reported an average yield of 9.0 MT per hectare, which is also broadly consistent with Savannah's estimated yield of 9.5-10 MT per hectare (**Table 2.1**).

Independent evidence from ICAR-IIRR (2023, 2024 & 2025) provides further support for the yield potential of these hybrids. Data from 80 Haryana farmers across Kaithal, Kurukshetra, Karnal, Jind, Yamunanagar, Ambala and Panipat reported yields of 7.3-10.3 MT per hectare for Sava 7501 and 6-10 MT per hectare for Sava 7301. The comparison of yield from these hybrids with state-level average yields in Punjab and Haryana provides an additional perspective on the performance of SmartRice® hybrids. According to 2024-25 regional and district-level data, the average paddy yield in Punjab and Haryana is 5.7 MT per hectare and 5.3 MT per hectare respectively. However, these regional and state averages cover both basmati and non-basmati paddy; therefore, for comparison we used non-basmati yields. The comparison indicates that the yield observed among Sava 7501 farmers who participated in the FGD was substantially above the prevailing average productivity in both states.

Table 2.1: Hybrid seed yield vs Conventional variety yields of Paddy

Survey / Seed / Location	*Paddy Yield (MT / ha)*	*Source*
Barnala Cluster, Punjab (10 farmers)	9 (primarily 7501)	Punjab Survey, July 2026
Savannah Estimate (7501)	9.5 – 10	Ajai Rana, Indian Express (Nov 2024)
Savannah Estimate (7301)	8.5	Ajai Rana, Indian Express (Nov 2024)
Sava 7501 (80 Haryana farmers)	7.3 – 10.3	ICAR-IIRR, 2023, 2024 & 2025
Sava 7301 (80 Haryana farmers)	6 – 10	ICAR-IIRR, 2023, 2024 & 2025
Punjab Average Yield	5.7	UPAg 2025-26
Punjab Basmati Yield*	4.7	APEDA, 2023; UPAg
Punjab non-Basmati Yield*	6.6	APEDA, 2023; UPAg
Haryana Average Yield	5.3	UPAg, 2025-26
Haryana Basmati Yield*	4.7	APEDA, 2023; UPAg
Haryana non-Basmati Yield*	5.4	APEDA, 2023; UPAg

*Source: Author's Compilation. Note: *numbers are from 2023-24*

2.2.2 Cost of cultivation and profitability

Based on the farmer level estimates, the cost of cultivating SmartRice® (Sava 7501) was ₹56,205 per hectare (**Table 2.2; Detailed break-up in Annexure 2.1**), which was approximately ₹1,835 per hectare, or 3.4 per cent more, as compared to the conventional variety. Despite the higher seed cost of hybrid, the profitability of SmartRice® compares favourably with the average non-basmati paddy yields in Punjab and Haryana considered in the analysis. At an assumed yield of 7.3-10.3 MT per hectare (ICAR-IIRR 2023-2025 field trial estimates), and at the prevailing MSP of ₹2,369 per quintal, Sava 7501 generates gross revenue of ₹1,72,937- ₹2,44,007 per hectare. After deducting the cultivation cost, the resulting net profit is estimated to be ₹1,16,732 - ₹1,87,802 per hectare.

The comparison with the non-basmati state average in Punjab and Haryana benchmark provides a useful context. At an MSP of ₹2,369 per quintal, gross revenue from the conventional variety amounts to ₹1,56,354 per hectare for Punjab and ₹1,27,926 per hectare for Haryana. This translates into a net return of ₹1,01,984 per hectare for Punjab and ₹73,556 per hectare for Haryana. On this basis, the net returns estimated for SmartRice® are higher than the state average. However, this difference should be interpreted with caution, as the yield depends upon many factors such farmer's practices, fertiliser, climate, disease and pest occurrence etc.

Table 2.2: Net profitability of SmartRice® vs conventional variety in Punjab and Haryana

₹/ha	Sava 7501	Haryana non-Basmati	Punjab non-Basmati
Cost of Cultivation	56,205	54,370	54,370
Paddy Yield (MT/ha)	7.3 - 10.3	5.4	6.6
Gross Revenue @ 2369/qtl.	1,72,937 - 2,44,007	1,27,926	1,56,354
Net profit	1,16,732 - 1,87,802	73,556	1,01,984

Source: CACP Kharif report 2025-26; ICAR-IIRR 2023-2025

2.2.3 Milling Quality

Under normal milling conditions, rice typically records a milling recovery of around 67-70 per cent, while Food Corporation of India (FCI) norms stipulate that broken rice should not exceed 25 per cent. The available milling and grain quality data **(Table 2.3)** indicate that Sava 7501 performs competitively with established rice varieties such as PR 126, although the reported values vary across testing environments, milling facilities and years. The Punjab Agricultural University (PAU, 2023) reported a milled rice recovery of 72.7 per cent and head rice recovery of 63.5 per cent for Sava 7501, compared with 70.0 per cent and 61.4 per cent, respectively for PR 126. The reported amylose content of Sava 7501 (17.3 per cent) is also broadly comparable with PR 126 (17.9 per cent). The International Rice Research Institute (IRRI, 2025) results further substantiated the evidence of the milling performance of Sava hybrids.

Data obtained from commercial rice mills during 2026 show somewhat greater variation in milled rice recovery for Sava 7501, ranging from 70.2 to 72.3 per cent across the reported mills. This variation is not unexpected because milling recovery is influenced not only by varietal characteristics but also by grain moisture at milling, harvesting and drying practices, milling machinery, milling settings, grain quality and operator practices. Therefore, mill-level observations should be interpreted as field evidence of commercial milling performance rather than as controlled varietal trials. The available mill-level observations also provide useful evidence on the proportion of broken rice. Sava 7501 recorded 10.8-20.3 per cent broken rice (**Table 2.3**).

Table 2.3: Milling Recovery and Grain Quality of Savannah's Hybrids from Institutional and Commercial Sources

Variety	Milled Rice Recovery (%)	Head Rice Recovery (%)	Broken Rice (%)	Amylose (%)	Source[4]
Sava 7501	72.7	63.5	NR	17.3-19.68	PAU 2022, 2023
PR 126	70.0	61.4	NR	15.93-17.9	PAU 2022, 2023
Sava 7501	73.5	66.3	NR	NR	IRRI 2025

[4] Data submitted to Savannah

Variety	*Milled Rice Recovery (%)*	*Head Rice Recovery (%)*	*Broken Rice (%)*	*Amylose (%)*	*Source*
Sava 7301	74.3	66.4	NR	NR	IRRI 2025
PR 126	71.6	60.0	NR	NR	IRRI 2025
Sava 7501	72.3	NR	19.9	NR	Hari Om Rice Mills 2026
Sava 7501	71.2	NR	18.6	NR	Maa Bala Sundaru Rice Mills 2026
Sava 7501	71.8	NR	20.3	NR	Ram Kishore Rice Mills 2026
Sava 7501	70.5	61.4	12.7 (and 3 chalky rice)	NR	Arora Rice Mills 2023
Sava 7501	71.5	60.1	10.8 (and 3 chalky rice)	NR	Shi Radhy Krishna Rice Mills 2023
Sava 7501	70.2	59.8	11.3 (and 2.4 chalky rice)	NR	Shri Shyam Industries, n.d.
Sava 7501	70.5	NR	16.5	NR	Shiv Shankar Rice Mill 2026

Note: *NR = Not Reported. Milling recovery and head rice recovery are reported from institutional and mill-level sources and may not be directly comparable because milling outcomes are affected by grain moisture, drying conditions, milling equipment, processing parameters and other operational factors. Broken rice observations from individual rice mills are indicative and should not be interpreted as controlled varietal comparisons. Where chalky rice is reported separately, it is retained as reported by the source and is not included in the broken-rice per centage.*

2.3 Conclusion

In the Barnala cluster of Punjab, the farmers reported an average yield of 9 MT per hectare, with the sample predominantly cultivating Sava 7501. However, the results should be interpreted as evidence of yield potential and competitive performance rather than a definitive yield advantage given the small Punjab survey sample, differences in agro-climatic conditions and the use of different sources and benchmarks. The consistency between the Barnala farmer survey, Savannah's estimates and independent ICAR-IIRR observations nevertheless provides a reasonable basis for concluding that SmartRice® hybrids offer competitive to high yield performance relative to commonly cultivated rice varieties.

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CHAPTER 3 – DIRECT SEEDED RICE: UNLOCKING ITS POTENTIAL FOR CLIMATE SMART AGRICULTURE

Ashok Gulati, Reena Singh and Bidisha Chanda

3.1 Conventional rice cultivation is water-intensive and GHG-intensive

Conventionally, rice is established by transplanting seedlings from nursery into puddled soil following intensive wet tillage, with fields often kept continuously flooded for 30-40 days after transplanting. While puddling facilitates initial crop establishment, suppresses weeds and reduces percolation losses, the combination of puddling, transplanting and prolonged flooding is highly labour- and resource-intensive. Rice is among the most water-intensive crops cultivated in India, typically requiring 20-25 irrigations per season, compared with only 4-5 for many other crops, and is widely regarded as an inefficient user of water (ICAR-NRRI, 2021). According to the Kharif Price Policy Report 2013-14, producing just 1 kg of rice requires about 5,400 litres of water in Punjab, while the all-India average is 4000 litres (CACP, 2013). Punjab and Haryana, which boast of being key contributors to India's rice production has the highest average farm-applied irrigation water requirement, at around 208 cm and 135 cm, respectively (Singh et al., 2026) while the All-India average is 94 cm (Sharma et al. 2018). In these states, approximately 0.22 kg of rice are produced per cubic metre of irrigation water applied, indicating inefficient water use. This inefficiency has led to severe groundwater depletion as rice occupies 38 per cent and 23 per cent of the gross cropped area in Punjab and Haryana respectively (MoAFW, 2026). As a result, the share of over-exploited groundwater blocks has increased to approximately 72.6 per cent in Punjab and 63.6 per cent in Haryana (CGWB, 2025). As groundwater levels fall, tube wells are required to reach increasingly deeper aquifers. Between 2000 and 2022, groundwater levels declined by approximately 11.94 metres below ground level (mbgl) in Haryana, the steepest decline among Indian states, and by 10.89 mbgl in Punjab (Singh et al., 2024).

Rice is also among the most GHG-intensive plant-based carbohydrate crops, particularly when cultivated under continuous flooding. Anaerobic decomposition of organic material in flooded rice fields produces methane (CH_4), which escapes to the atmosphere by diffusive transport through the rice plants during the growing season (Takai, 1970). CH_4 is 27.2 times more powerful than carbon-dioxide (CO_2) for causing temperature rise on a 100-year time scale. Having a shorter life span of 12 years, it is 80.8 times more impactful than CO_2 on a 20-year time-scale (IPCC, 2021). The second source of GHG emission from rice cultivation is nitrous oxide (N_2O), which is 273 times more impactful than CO_2, on both the 100-year and 20-year time-scales. N_2O result from anthropogenic nitrogen (N) inputs through (i) direct pathways (i.e. directly from the soils through synthetic fertilisers and organic manures), and (ii) indirect pathways through volatilization of ammonia (NH_3) and nitrogen oxide (NO_x) and the subsequent re-deposition of these gases and their products to

soils. Leaching and run off of N, mainly as nitrate (NO_3) is another indirect pathway for N_2O emission. Field operations i.e. ploughing, cultivation, sowing, irrigation (20-25 irrigations, predominantly through ground-water pumping), application of inputs like fertilisers and pesticides, and harvesting require diesel and electricity, leading to CO_2 emissions – which is the third source of emissions from rice cultivation. In India, rice residue burning is a major concern, particularly in Punjab, Haryana, and western Uttar Pradesh producing CO, CH_4, N_2O, NOx, NMHCs, SO_2 and many other gases. This not only poses a health hazard and leads to loss of nutrients, but is also the fourth source of non-CO_2 GHG emissions.

Continuous flooding can generate 3,500-3,700 kg CO_2 equivalent (CO_2eq) per hectare, compared with 900-1,050 kg CO_2eq per hectare under intermittent flooding. This is approximately 7-11.6 times higher than wheat (340-450 kg CO_2eq per hectare) and maize (320-365 kg CO_2eq per hectare), 12-15 times higher than millets (230-250 kg CO_2eq per hectare) and oilseeds (220-275 kg CO_2eq per hectare), 15-20 times higher than pulses (180-240 kg CO_2eq per hectare), and 6-8 times higher than vegetables (440-475 kg CO_2eq per hectare) (Pathak et al., 2014). Although its emissions remain substantially lower than those associated with animal-based foods, the GHG intensity of rice is particularly significant given its scale of cultivation in India. In India, rice cultivation emitted an average 3,100 kg CO_2eq per hectare in 2022-23 (Singh and Gulati, 2025). Emissions are particularly high in Punjab and Haryana, where intensive fertiliser use, widespread residue burning and high electricity consumption for groundwater extraction contribute to emissions of around 5 tonnes CO_2eq per hectare.

There is substantial scientific evidence that rising GHG concentrations have increased global surface temperatures by approximately 1.1°C above pre-industrial levels (1850–1900) over the past century. Global warming is projected to exceed 1.5°C above pre-industrial levels within the next two decades under all emission scenarios (IPCC, 2022). Climate change has added a new dimension of uncertainty to India's rice production. Some of these adverse effects are high temperature-induced sterility in rice, increased pests and diseases in Punjab and Haryana, and the additional problem of rain during maturity of rice in Uttar Pradesh and Western Bihar (Wassmann et al., 2009). Using modelling tools (IPCC, 2022), the production yield of rice is projected to decline in India by 2.3 per cent (by 2030) and 8.62 per cent (by 2050) with the current global warming trends. Therefore, in addition to adaptation measures, accelerated mitigation strategies are needed for rice cultivation to ensure its sustainability.

3.2 Direct Seeded Rice (DSR): Adoption constraints and status

In order to meet sustainable farming objectives, deploying innovative technology that allows for reduced water usage, reduced GHG emissions and increased crop yield for rice production is crucial. DSR is one such option, where rice seeds are sown directly into the main field rather than transplanting seedlings from a nursery. Thus, DSR avoids repeated puddling, preventing soil degradation and plow-pan formation. Similarly, DSR facilitates the timely establishment of paddy as well as of succeeding crops, as the crop matures 10-15 days earlier as compared to puddled transplanting. Furthermore, DSR requires lesser tillage operations and thus, saves energy, labour, and fuel.

A majority of research studies shows that DSR reduces paddy water use, while the total volume of saved water varies greatly with soil type and the DSR method. DSR can be done either by sowing pre-germinated seeds into puddled soil (wet direct seeding) or into a well-prepared non-

puddled seedbed (dry direct seeding). In dry direct-seeded rice (D-DSR), dry seeds are sown directly into the main field without prior germination. This method is commonly used in rainfed uplands, medium lowlands, lowlands and deepwater ecologies during the wet season and can save up to 30 per cent water as compared to conventional transplanted rice (ICAR-NRRI, 2024). Punjab Agriculture University (PAU) has recommended *Tar-wattar* DSR where pre-sowing irrigation is applied and primed seed is sown in a *Tar-wattar* condition. A major difference from conventional D-DSR is delay in applying first irrigation, which is applied at three weeks after sowing (21 days). As per the package of practices by PAU, DSR provides 10-20 per cent saving on irrigation water and 10-12 per cent higher groundwater recharge as compared to PTR (PAU, 2025).

In addition to water saving, DSR reduces methane (CH_4) emissions by 18-20 per cent A study by Pathak et al. (2013) showed that the total Global Warming Potential (GWP) of PTR rice in various districts of Punjab ranged from 2.0 to 4.6 t CO_2 eq. per hectare and in the DSR, from 1.3 to 2.9 t CO_2 eq. per hectare and, if the entire area under PTR is converted to DSR, the GWP will be reduced by 33 per cent of the current levels.

3.3 Savannah's FullPage® Rice Cropping Solution

Weed infestation is one of the major constraints to the large-scale adoption of DSR, as uncontrolled weeds can cause substantial yield losses. Apart from other weeds, the spread of weedy rice became significant mainly after a shift from rice cultivation from transplanting to direct seeding due to shortage of water and labour scarcity. Since weedy rice belongs to the same species as cultivated rice, it is difficult to distinguish during the vegetative stage. It is highly competitive, with faster growth, greater tillering and biomass production, efficient nitrogen use, easy seed shattering, greater tolerance to adverse conditions and prolonged seed dormancy. It is also resistant to selective herbicides used in rice cultivation. For farmers, weedy rice is a difficult-to-control weed that raises production costs, reduces yields and grain quality, and, therefore poses a serious threat to rice production and farmers' livelihoods in major rice-growing regions worldwide, including India (Saha et al. 2013). In India, weed management relies largely on manual weeding and backpack spraying, both of which are labour-intensive, time-consuming and increasingly uneconomical amid rising labour costs and shortages, particularly during peak agricultural seasons (Chaudhary et al., 2023). Chemical herbicides provide a more efficient alternative; however, India has yet to adopt herbicide-tolerant (HT) rice technology, which enables the use of broad-spectrum herbicides for more effective and potentially mechanised weed control. At the same time, policymakers and other stakeholders remain concerned about the risks associated with indiscriminate herbicide use, including environmental impacts, the evolution of herbicide-resistant weeds and potential health risks particularly if HT cultivars are introduced and used intensively (Parven et al., 2025).

Globally, HT crop cultivars have emerged as an important technological innovation to address the growing challenge of weed management (Lamichhane et al., 2017). These cultivars, developed through genetic engineering or conventional breeding, are designed to withstand specific broad-spectrum herbicides, allowing farmers to control a wide range of weeds while minimising damage to the crop. HT technology can simplify weed management, reduce labour requirements, improve the efficacy and timeliness of weed control, enhance yield stability and facilitate reduced-tillage practices, with potential benefits for soil health and carbon sequestration (Green, 2012). HT crops tolerant to herbicides such as glyphosate and glufosinate-ammonium

have been widely adopted globally and have significantly influenced weed-management practices in several major agricultural economies (Ofosu et al., 2023).

Against this backdrop, Savannah's FullPage® Rice Cropping Solution combines SmartRice® hybrid genetics and hybrid rice seeds, SQUAD™ seed treatment, the proprietary FullPage® HT trait, and compatible herbicide in partnership with ADAMA (Savannah). According to Savannah, FullPage® hybrids exhibit improved tolerance to imidazolinone (IMI) herbicides, which minimises the risk of crop injury under stressful growing conditions and in situations involving herbicide overlap, while also contributing to improved yield performance. As per Savannah, the system supports uniform germination and early crop establishment, provides protection against early season pests and diseases, and enables effective control of difficult weeds while maintaining crop safety. Currently, Savannah offers Sava 134 FullPage®, and Sava 127 FullPage® in India.

3.3.1 Comparison of FullPage® Rice Cropping Solution with conventional PTR and other DSR

Table 3.1 illustrates the range of cultivation cost, yield, gross revenue and net profitability reported during the farmer group discussions (FGDs) on FullPage®

Table 3.1: Yield, average cost of cultivation, average gross revenue and net profits in studied states

States	*Establishment Method*	*Cost of Cultivation (CoC) (₹/ha)*	*Increase/ Decrease in CoC Over PTR and Non-HT DSR (Per cent)*	*Gross Revenue (₹/ha)*	*Increase/Decrease in gross revenue Over PTR and Non-HT DSR (Ratio)*	*Paddy Yield Range (MT/ha)*	*Net Profit Range (₹/ha)*
HR	**PTR**	74,933	--	1,59,908	--	6.5 - 7.0	79,052 – 90,897
	Non-HT DSR	58,433	PTR: **-22%**	1,36,218	PTR: **0.9**	5.5 - 6.0	71,862 – 83,707
	FullPage®	59,433	PTR: **-21%**; DSR: **2%**	1,59,908	PTR: **1**; DSR: **1.2**	6.5 - 7.0	94,552 – 1,06,397
MP-1	**PTR**	77,663	--	1,28,784	--	5.4	51,121
	Non-HT DSR	65,530	PTR: **-16%**	1,05,368	PTR: **0.8**	4.4	39,839
	FullPage®	60,217	PTR: **-22%**; DSR: **-8%**	1,28,784	PTR: **1**; DSR: **1.2**	5.4	68,567

States	Establishment Method	Cost of Cultivation (CoC) (₹/ha)	Increase/ Decrease in CoC Over PTR and Non-HT DSR (Per cent)	Gross Revenue (₹/ha)	Increase/Decrease in gross revenue Over PTR and Non-HT DSR (Ratio)	Yield Range (MT/ha)	Net Profit Range (₹/ha)
MP-2	**PTR**	77,663	--	1,28,784	--	5.4	51,121
	Non-HT DSR	65,530	PTR: **-16%**	1,05,368	PTR: **0.8**	4.4	39,839
	FullPage®	61,947	PTR: **-20%**; DSR: **-5%**	1,40,491	PTR: **1.1**; DSR: **1.3**	5.9	78,545
UK-1	**PTR**	69,813	--	1,92,482	--	8.0 - 8.3	1,15,895 – 1,29,443
	Non-HT DSR	56,813	PTR: **-19%**	1,42,140	PTR: **0.7**	5.5 - 6.5	71,545 – 99,110
	FullPage®	63,875	PTR: **-9%**; DSR: **12%**	1,83,598	PTR: **1**; DSR: **1.3**	7.5 - 8.0	1,12,925 – 1,26,525
UK-2	**PTR**	40,625	--	1,59,908	--	6.5 - 7.0	1,06,485 – 1,23,330
	Non-HT DSR	46,500	PTR: **14%**	1,36,218	PTR: **0.9**	5.3 - 6.3	71,373 – 98,813
	FullPage®	43,125	PTR: **6%**; DSR: **-7%**	1,71,753	PTR: **1.1**; DSR: **1.3**	7.0 - 7.5	1,15,830 – 1,32,675
CH	**PTR**	84,375	--	1,45,102	--	6.0 - 6.3	50,890 – 70,563
	Non-HT DSR	71,250	PTR: **-16%**	1,24,373	PTR: **0.9**	5.0 - 5.5	42,200 – 64,045
	FullPage®	66,250	PTR: **-21%**; DSR: **-7%**	1,56,947	PTR: **1.1**; DSR: **1.3**	6.3 - 7.0	78,063 – 1,03,330

Source: Based on 15 farmers from Shahabad, Haryana, 11 farmers in Jabalpur, MP, 11 farmers in Rudrapur, UK, and 5 farmers from Chhattisgarh

Note: HR: Haryana; MP-1: Madhya Pradesh's FGD-1; MP-2: Madhya Pradesh's FGD-2; UK-1: Uttarakhand FGD-1; UK-2: Uttarakhand FGD-2; CH: Chhattisgarh

As seen in **Table 3.1,** the FullPage® DSR system has been reported to have a lower total cost of cultivation compared to conventional PTR. The higher cost burden under PTR is driven primarily by substantial expenditure on nursery operations, land preparation and puddling, and transplanting labour. In contrast, the FullPage® DSR system eliminates the need for nursery preparation, puddling, and transplanting labour, replacing these labour-intensive operations with mechanised sowing and integrated HT seeds with compatible herbicides. A detailed state-wise break-up of the cost of cultivation is provided in **Annexures 3.1-3.6**.

The cost advantages of the FullPage® DSR system are particularly significant in the context of yield performance. Farmers reported that yields under non-HT DSR were generally lower than those under PTR. In contrast, yields under FullPage® DSR were reported to be either comparable to or higher than PTR in all the FGDs, with the exception of the first FGD in Uttarakhand. In Haryana, farmers reported yield of (6.5-7 MT per hectare) under both FullPage® DSR as well as PTR. The yield gains in Madhya Pradesh were comparable under FullPage® DSR (5.4 MT per hectare) to PTR (5.4 MT per hectare) in the first FGD to 9 per cent higher under FullPage® DSR (5.9 MT per hectare) over PTR (5.4 MT per hectare) in the second FGD. Chhattisgarh also recorded a substantial yield advantage, with farmers reporting 4-12 per cent higher yields (6.3-7.0 MT per hectare) under FullPage® DSR compared with PTR (6.0-6.3 MT per hectare). In Uttarakhand, yields reported in the first FGD were 3-6 per cent lower under FullPage® DSR (7.5-8.0 MT per hectare) than under PTR (8.0-8.3 MT per hectare), whereas in the second FGD reported a 7-8 per cent increase under FullPage® DSR (7.0-7.5 MT per hectare) over PTR (6.5-7.0 MT per hectare). Overall, the findings suggest that the yield advantage of FullPage® DSR was particularly pronounced in Madhya Pradesh while in the other states yields, were either comparable to or moderately higher than those under PTR.

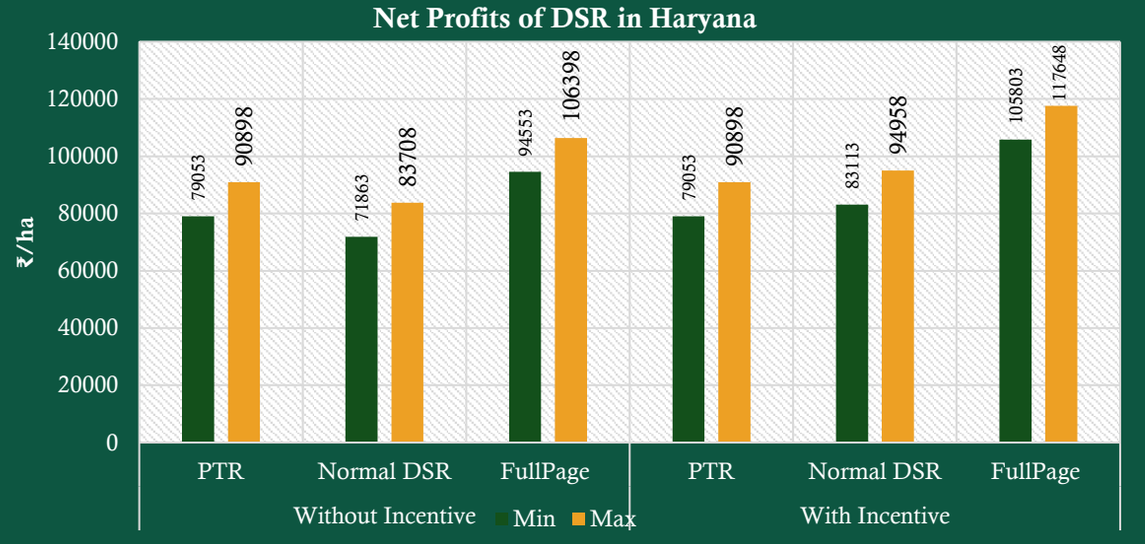
Across the states studied, the highest net profit under FullPage® DSR was reported during the second FGD in Uttarakhand, ranging from ₹1,15,830 - ₹1,32,675 per hectare, which reflects the combined effect of lower cultivation costs and the substantial yield advantage reported by farmers under FullPage® DSR. In comparison, PTR has the net profitability of ₹1,06,485 - ₹1,23,330 per hectare. In Haryana, without DSR incentives, FullPage® DSR net profits are between ₹94,553 - ₹1,06,398 per hectare, which are higher than PTR profitability of ₹79,052 - ₹90,897 per hectare. Adding additional DSR incentives of ₹11,250 per hectare provided by the Government of Haryana under the "Incentivising DSR scheme", net profits of FullPage® DSR go further up between ₹1,05,803 and ₹1,17,648 per hectare in Haryana.

The findings from first FGD in Uttarakhand present a somewhat different picture. Although the net profits under FullPage® DSR (₹1,12,925-₹1,26,525 per hectare) was slightly lower (2 per cent) than that under PTR ₹1,15,895 - ₹1,29,443 per hectare), farmers demonstrated a strong inclination towards DSR because of the greater use of mechanisation in rice establishment, including strip seed drills. The availability and growing use of such machinery have created an enabling environment for DSR adoption and reduced farmers' dependence on labour-intensive transplanting operations. Farmers also highlighted acute labour shortages as a major factor driving their interest in DSR. In addition to addressing labour constraints, they recognised the environmental benefits associated with DSR, particularly its potential to reduce water use and avoid the resource-intensive puddling and transplanting operations associated with PTR.

Overall, the profitability performance of non-HT DSR was less favourable. This suggests that,

despite the potential cost savings associated with non-HT DSR, lower yields and/or other operational costs may offset these savings, limiting its overall profitability relative to PTR. FullPage® DSR, in contrast, consistently delivered higher net earnings than PTR across the other study locations, although the magnitude of the advantage varies with the state.

Haryana's 'Incentivising Direct Seeded Rice scheme' provides farmers with ₹4,500 per acre for cultivating paddy through DSR rather than PTR. It compensates farmers for the transition risk and potential management constraints associated with shifting from PTR to DSR. The profitability estimates show that the incentive is large enough to alter the relative economics of DSR, including normal non-HT DSR. Without the incentive, normal DSR returns range from ₹71,863 to ₹83,708 per hectare, compared with ₹79,053 to ₹90,898 per hectare for PTR; normal DSR, therefore, is less profitable than PTR across both the minimum and maximum estimates. With the ₹4,500 per acre payment, normal DSR returns increase to ₹83,113 to ₹94,958 per hectare, exceeding PTR by ₹4,060 per hectare. FullPage® DSR is already more profitable than PTR without support, at ₹94,553 - ₹106,398 per hectare, and the incentive raises these returns further to ₹105,803 - ₹117,648 per hectare. Thus, the scheme makes non-HT DSR financially competitive with and marginally more profitable than PTR while improving returns to FullPage® DSR.



Wild (Weedy) Rice Control

During FGDs at Madhya Pradesh and Chhattisgarh, farmers highlighted that FullPage® DSR system has enabled them to tackle the issue of wild rice (locally called *Kargaa* or *Saada-Laamba*).

Water Saving

Regarding water savings, the number of irrigations required under DSR is significantly lower than under PTR due to the complete elimination of puddling. In Haryana's Shahabad cluster, farmers reported needing 25-30

irrigations in PTR compared to only 15-20 irrigations in DSR. In Jabalpur, MP, where a typical crop cycle spans 10 distinct irrigation events, farmers noted that the FullPage® DSR system consumes 2 to 3 times less irrigation overall compared to conventional flooded transplanting, which binds fields to a mandatory 60 days of continuous water management. Overall, water saving up to 40 per cent was reported by farmers and Savannah's experimental field trials. This water efficiency carries a substantial economic impact: a single complete irrigation event requires eight hours of continuous pumping at a diesel cost of ₹400-500 per hour, translating to ₹7,907 - 9,884 per hectare per event. Similarly, in Rudrapur, Uttarakhand, farmers reported requiring 3-4 fewer irrigations under DSR compared to PTR.

Green-House Gas Emissions Saving

Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya (CSKHPKV), commonly referred to as Himachal Pradesh Agriculture University, has revealed that a specific Sava 134 FullPage® DSR hybrid rice variety reduces methane emissions by nearly 90 per cent compared with conventional transplanted rice systems and recorded the highest water productivity (PIB, 2026).

Improvement of soil properties

Soil physical properties play a critical role in regulating soil-water dynamics, root growth and crop water use efficiency. In the study conducted by CSKHPKV, Sava 134 FullPage® was observed to improve soil physical properties compared with puddled transplanted rice (PTR), reducing soil bulk density by 4 per cent and increasing water-holding capacity by 10 per cent (CSKHPKV, 2026). CSKHPKU also recorded higher microbial biomass and dehydrogenase activity, reflecting biological activity.

Challenges for large scale adoption of FullPage® DSR

Three key sets of challenges emerged from the FGDs. First, the suitability of FullPage® rice varieties is constrained by local agro-ecological conditions. Currently, Savannah offers medium-duration varieties under the FullPage® Rice Cropping Solution: Sava 127 (115-120 days) and Sava 134 (120-125 days). Their relatively shorter maturity periods enable early harvesting, thereby facilitating timely establishment of the subsequent rabi wheat crop and reducing the duration of groundwater pumping. However, this feature limits their suitability in low-lying, flood-prone areas such as Chhattisgarh, where fields naturally retain rainwater for extended periods. Farmers in these areas conventionally cultivate long-duration rice varieties (150-180 days) that are better adapted to prolonged standing-water conditions. Consequently, the medium-duration FullPage® varieties may not be well suited to such waterlogged ecosystems.

A second consideration is the compatibility of FullPage® with existing cropping systems. The system may be well suited to the predominant rice–wheat rotation in many rice-growing regions, where IMI does not have any residual impact on next crop. However, as a precautionary measure, Savannah's agronomic guidelines recommend avoiding potato and mustard as rabi crops following FullPage® DSR cultivation.

Third, successful adoption depends on access to appropriate machinery and precision in sowing. The FGDs, particularly in Rudrapur, Uttarakhand, highlighted the importance of accurate seed placement under the FullPage® system. Farmers using specialised seed drills are required to maintain a sowing depth of approximately 0.5-1 inch, as placement within this range helps position the seed in a soil-moisture zone conducive to germination. Sowing

either too deep or too shallow can adversely affect germination and, consequently, crop establishment and yields. Where specialised rice sowing equipment is unavailable, farmers often adapt conventional wheat sowing machines for rice establishment. While such adaptations can facilitate adoption, variations in equipment and sowing precision may affect the consistency of crop establishment.

3.4 Conclusion

The FGD findings suggest that the economic rationale for adopting FullPage® DSR differs across states. In Haryana and Madhya Pradesh, FullPage® DSR achieved comparable or higher yields and gross revenues than PTR at lower cultivation costs, resulting in higher net profits. Uttarakhand's adoption momentum is driven strongly by mechanisation, labour scarcity and environmental considerations. In Madhya Pradesh and Chhattisgarh, FullPage® DSR system helps to tackle the issue of wild rice. These differences underscore the importance of tailoring strategies for scaling FullPage® DSR to state-specific production conditions and farmer priorities.

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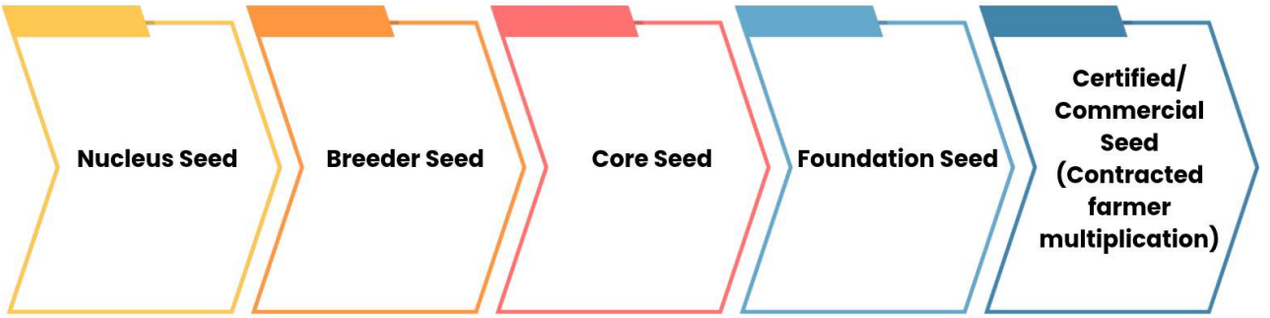
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CHAPTER 4 – IMPACT OF SAVANNAH ON SEED PRODUCTION FARMERS AND RURAL LIVELIHOODS

Suvangi Rath and Ashok Gulati

Seed production is the process by which proprietary parental lines are multiplied, under contract, into certified hybrid and varietal seed that is sold to commercial paddy growers elsewhere in the country. It is distinct from, and sits upstream of, ordinary grain cultivation. Proprietary parental material is first developed at Savannah's Research & Development (R&D) stations by developing parenting material under two-line and three-line hybrid breeding systems, and is then advanced through a tightly controlled seed-multiplication hierarchy – from a few grams of nucleus seed, through breeder and core seed, to several metric tonnes of foundation seed – before it ever reaches a contracted farmer's field (**Figure 4.1**). It is this final, farmer-facing stage of the chain – the multiplication of foundation lines into certified commercial seed — with which this chapter is concerned.

Figure 4.1: Savannah's seed-line multiplication chain



Source: Field visit, Savannah R&D facility, Hyderabad (8 July 2026); Comprehensive Field Notes

4.1 The Seed Production Network

Savannah 's seed portfolio splits into two broad classes: hybrid seed, sold under the FullPage® and SmartRice® brands, and open-pollinated/varietal (OPV) seed. Roughly 30,000 acres (12,000 hectare) are under seed multiplication across Savannah's two principal clusters, Hanumangarh and Telangana. The Hyderabad R&D centre develops the proprietary germplasm and elite lines that feed both clusters. It is worthwhile to note that Rajasthan's Hanumangarh unit is a strategic greenfield project that was started in the year 2013 with a zero base. The Telangana operation, by contrast, is a seed hub built up over four decades, first by

public sector breeding institutions and subsequently by private and multinational seed companies, including Bayer, Corteva, Syngenta and BASF alongside a wide field of domestic seed companies (Gadwal, 2003; Pray et al., 2001). An estimated 96 per cent of seed growers in Telangana already operate under some form of contract (Sheelam et al., 2025); hence, Savannah entered this belt as one more player within an already mature institutional ecosystem.

4.2 The Contract Farming Model

Savannah operates what the literature terms a centralised contract farming model, in which a single firm coordinates a large body of dispersed out-growers through standardised agreements and intensive supervision. This is precisely the institutional form found to dominate the Telangana hybrid rice seed industry, where an estimated 96 per cent of seed growers operate under contract, with written agreements proving more effective than verbal ones because their terms are better defined (Sheelam et al., 2025). Savannah's structure aligns closely with this pattern, and its operational features can be understood under the following five contractual functions:

Procurement arrangements: A group of trained farmer organisers mediate the recruitment, build awareness in their communities and enrol growers into structured seed blocks in Karimnagar. Farmers are given the foundation seed directly by Savannah field staff and the cost is later deducted from the procurement settlement. A nominal supply-adjustment fee is reconciled at buyback. The company then brings back the entire F1 (hybrid) or varietal produce, closing a vertically co-ordinated loop from parent line to processed seed.

Price assurance: Hybrid seed is procured at a pre-agreed price. However, line-specific rates exist in Rajasthan depending on the seed line and its yield. Assured pricing is repeatedly identified in the literature as the single most valued feature of seed contracts, because it removes the price volatility that characterises open-market grain (Swain, 2011; Sheelam et al., 2025).

Quality standards: Because even minor genetic or physical impurity in a parental line can lead to rejection of an entire production plot (Nirmala & Viraktamath, 2008), quality control is essential. Growers undertake intensive roguing of off-types, and the produce passes a three-tier quality architecture at the plant: in-process checks during active processing, post-packaging verification, and comprehensive physiological testing of moisture, germination and vigour. Strict internal gates yield a rejection rate of under one per cent, and stored lots are re-audited quarterly.

Duration of contracts: Savannah has a seasonal contract term with its farmers but most of them have been associated with the company since 2019-2020 (as reported in Karimnagar). The company secures its land base on multi-year terms – Hyderabad's R&D hub has taken a 20-year lease and longer five-year land leases are being negotiated in the multiplication tracts.

Risk-sharing mechanisms: Savannah 's contract transfers substantial production and price risk from farmer to firm. A guaranteed minimum floor settlement applies in Rajasthan for eventualities like extreme weather, pest outbreaks or crop failure, resolved within 21 days of harvest. In Telangana, an assured minimum price per hectare per season is offered to hybrid growers, who also receive a pre-harvest cash advance in cases of severe smallholder credit constraint (not extended in Rajasthan). A cross-regional transport allowance also helps growers mitigate logistics costs. Indian contract farming more generally faces constraints such as delayed payment, lack of credit and quality-compliance disputes (Swain, 2011), and these instruments

help Savannah's farmers (FGD) overcome such problems.

4.3 Human Capital Development

The seed enterprise functions as a rural skills and extension system as much as a procurement operation. Farmer training is delivered through a cadre of 57 specialised organisers for the hybrid and varietal programmes, who receive technical training and, in turn, disseminate agronomic knowledge and recruit new growers, earning service charges of ₹3,950–4,940 per hectare for hybrid blocks and ₹3,710 per hectare for OPV.

Skill enhancement is reinforced by an unusually dense supervisory hierarchy. Field staff conduct two to three mandatory plot visits every week; one field supervisor is deployed for every 40-200 hectares; one Production Development Assistants to handle 100-200 hectares; and each Production Executives oversee 400-800 hectares, reporting to Regional Managers. A dedicated on-call helpline supplements five to six structured advisory visits per season. Through this structure, growers become specifically competent in pollination synchronisation, purity maintenance and roguing discipline.

Beyond this seed production organiser network, Savannah maintains a company-wide rural extension and training footprint that underpins these farmer-facing activities **(Table 4.1)**. As of 2025-26 this comprised 270 field officers delivering training and advisory support, a cumulative 417,000 farmer participants trained through 11,575 training programmes since inception, 1,534 active demonstration plots, and close to 10,000 crop and harvest shows that have together reached approximately 300,000 farmers. About 7,500 women participated in training across the northern and central belt in FY2025-26 alone. These figures span Savannah 's full operating footprint rather than the Hanumangarh and Telangana clusters alone, but they give scale to the extension effort that supports the organiser- and supervisor-led training described above.

Table 4.1: Savannah 's rural extension and human-capital footprint (company-wide)

Indicator	*Value*
Field officers delivering extension (FY2025–26)	270
Training programmes conducted (since inception)	11,575
Cumulative farmer participants trained	417,000
Demonstration plots (FY2025–26)	1,534
Crop & harvest shows (FY2025–26)	≈10,000
Farmers reached through crop & harvest shows (FY2025–26)	≈300,000
Female farmer participants trained (Jharkhand & Chhattisgarh–North, FY2025–26)	7,500

Source: Savannah seed production network and capital-development data

Technology dissemination occurs through formal advisory and demonstration effects – nearby farmers who observe the secure returns from Savannah's lease and production model actively convert their cotton fields to hybrid seed production. The enterprise also supports tangible asset creation. Better and more stable incomes have enabled farmers to invest in higher education (a successful farmer had funded his son's relocation to Delhi for civil services (IAS) coaching). Savannah's corporate social responsibility (CSR) programme has likewise upgraded rural social infrastructure in the Hanumangarh tract, most visibly through the adoption and upgrading of a local government primary school (**Box 4.1**). The combination of skills, education financing and community infrastructure represents a broadening of the rural asset base beyond farm income alone.

Box 4.1: Savannah's CSR in Action: School Infrastructure Development, Hanumangarh

As part of its wider CSR programme, Savannah, working through its own production team, identified a government primary school serving the children of poor farmers and labourers in the surrounding seed production tract in a Hanumangarh village (recorded internally as Village 35STG) for infrastructure support. Summer temperatures in the village range from 45-47°C (113-118°F).

Baseline conditions (before Phase 1): Children seated on the floor for lack of furniture; frequent power cuts a day; no cold-drinking-water facility; and no digital learning infrastructure.

Phase 1 (completed, 2025-26):

- Physical infrastructure – repair and whitewashing of classroom and boundary walls to improve safety.
- Digital access – a computer lab with three computers and a printer.
- Basic amenities – desks, benches and classroom furniture; solar panels and solar-powered lighting; RO drinking-water coolers.

Phase 2 (identified for follow-on investment): air coolers for classrooms; chairs and tables for teachers, who currently stand throughout the teaching day; flooring repair; tiling of dust-prone areas, given the village's frequent evening dust storms.



Source: CSR & Other Social Initiatives (Savannah, 2026)

4.4 Economics of Seed Production

The economics of Savannah's seed production vary sharply between the hybrid and OPV segments, and this gap explains observed farmer preferences. The comprehensive cost of cultivation is approximately ₹98,842-1,11,197 per hectare for hybrid seed and ₹61,776-74,132 per hectare for OPV in Telangana (**Table 4.2, Annexure 4.1**). Many farmers prefer OPV despite the higher gross and net returns available from hybrids, as OPV is cheaper, less risky and does not demand separate male and female parental lines. They exercise a rational risk-return trade-off rather than an income-maximising one.

A second, FGD-based dataset (**Table 4.2**), compiled specifically to compare seed production against the commercial grain alternative available to the same farmers, corroborates this picture at both locations. In Hanumangarh, Savannah hybrid seed returned a net profit of roughly ₹1,77,916-2,59,461 per hectare against ₹1,33,437-1,42,827 per hectare for commercial basmati paddy, underlining that seed production's advantage lies in price per kilogram rather than in physical yield. In Karimnagar, the comparison is more granular: OPV/varietal seed already improves modestly on the equivalent commercial paddy variety (for example, ₹1,08,899 net for bold-variety OPV against ₹1,01,486 for bold-variety commercial paddy), while Savannah hybrid seed, at ₹1,59,324-2,39,633 net per hectare offers a substantially larger premium over both.

Table 4.2: Seed economics comparison table

	Gross revenue (₹/ha)	*Cost of Cultivation (₹/ha)*	*Net profit (₹/ha)*
Hanumangarh, Rajasthan			
Commercial basmati paddy	₹1,87,800–1,97,190	₹54,363	₹1,33,437–1,42,827
Savannah hybrid seed	₹2,64,403–3,45,948	₹86,487	₹1,77,916–2,59,461
Karimnagar, Telangana			
Commercial paddy — bold variety	₹1,75,618	₹74,132	₹1,01,486
Commercial paddy — fine variety	₹1,41,789	₹61,776	₹80,013
OPV/varietal seed — bold variety	₹1,83,031	₹74,132	₹1,08,899
OPV/varietal seed — fine variety	₹1,61,557	₹66,718	₹94,839
Savannah hybrid seed	₹2,70,521–3,38,475	₹98,842–1,11,197	₹1,59,324–2,39,633

Source: Focus Group Discussions in Rajasthan and Telangana

4.5 Conclusion

Evidence shows that Savannah's seed production network has reshaped rural livelihoods across two very different geographies through a common contractual architecture. In Telangana, Savannah's investment entered an already-established seed hub built up over decades by public and private breeding institutions. In Hanumangarh, by contrast, the company

pioneered an entirely new seed geography from a zero base in 2013 in a tract with no prior seed industry presence. In both places, assured pricing, floor settlements and organiser-mediated technical support have lifted farmer incomes well above the returns available from commercial grain, while reshaping agronomic practice, building human capital through initiatives such as the Hanumangarh school upgrade, and extending Savannah's footprint into rural social infrastructure.

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CHAPTER 5 – BROADER ECONOMIC IMPACT OF SAVANNAH'S RICE OPERATIONS IN INDIA

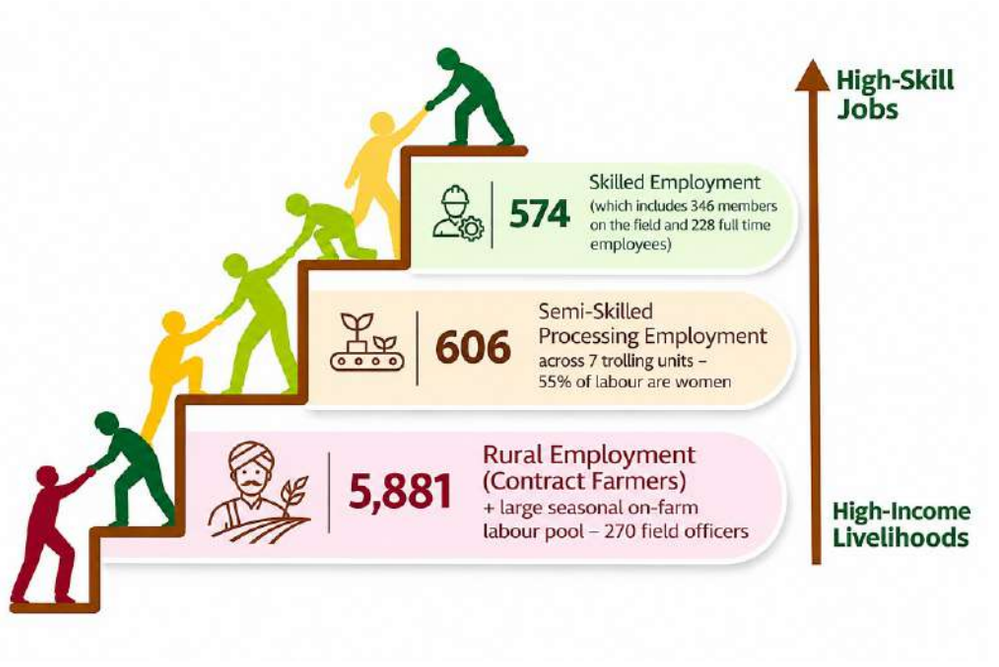
Suvangi Rath and Ashok Gulati

Savannah's rice seed value chain runs through six linked stages: (1) R&D and breeder-seed development, where new hybrids and parental lines are bred and screened, (2) core seed production, in which breeder seed is multiplied under controlled conditions, (3) seed production proper, where a wider base of contract farmers multiplies foundation seed into certified or commercial seed, (4) procurement and transportation of the harvested raw seed from production centres to processing units, (5) processing, storage, quality checking and packaging of that raw seed into finished, certified product, and (6) commercial distribution of the packed seed to dealers, retailers and, ultimately, farmers. This chapter describes the impact of Savannah's rice operations in India.

5.1 Employment Generation

Savannah's employment structure is spread across three broad categories: a direct skilled workforce of 574 people (including 228 full-time scientific and commercial functions and 346 people on ground); a semi-skilled processing workforce (606 people employed annually including labourers; and a much larger rural base of contracted farmers (5,881 per year) and seasonal labour **(Figure 5.1, details in Annexure 5.1).**

Figure 5.1: Savannah's three-tier overall employment footprint



Source: Savannah operational data (Annexures 5.1–5.2). Tier width is illustrative of relative headcount, not to scale.

5.2 Industrial Linkages

Savannah's operations generate demand for a network of supporting industries–processing, packaging, logistics and, increasingly, farm mechanisation–through which investment in seed multiplies into wider industrial activity. Seed processing, summarised in **Annexure 5.2**, is the clearest example: rather than owning all processing capacity itself, Savannah routes processing through seven Indian toller partners, extending domestic micro, small and medium enterprise (MSME) processing capacity that must meet its quality requirements. This model is well illustrated by Alliance Agritech at Sonipat, the lead northern partner, which alone supports 105 jobs and embeds investment in processing infrastructure (Hirschman 1958). **Box 5.1** illustrates the case study of farm mechanisation for DSR in Rudrapur.

Box 5.1: Case Study on Mechanising Direct-Seeded Rice in Rudrapur

The Rudrapur cluster in Udham Singh Nagar district, Uttarakhand, offers a field level illustration of how farm mechanisation is driving adoption of DSR. ICRIER's field visit to Rudrapur on August 6-7, 2026, which included two farmer group discussions (FGDs) and an interaction with G.B. Pant University of Agriculture & Technology (GBPUAT), examined the on-ground economics of this mechanisation push.

- Deployment scale: Farmers reported deployment of 117 zero-till/DSR seed drills (of the generic 'Lucky' seed-drill type, ₹135,000-150,000 per unit) across the Rudrapur area without government subsidy.
- Custom-hiring returns: In the Lenken AgroVision cluster, machine-owner operators charged farmers ₹3,210-3,710 per hectare for drill-sowing, netting ₹1,235-1,485 per hectare in service margin, and covering 101-121 ha (250-300 ac) per machine per season across roughly a 60 km radius – evidence of a commercially viable, privately financed hiring model rather than a subsidy-dependent one.
- Labour-time savings: Sowing 12.1 ha (30 ac) by drill took about 2 days, against roughly 10 days for manual transplanting under PTR – a substantial reduction in peak-season labour demand and drudgery.
- Agronomic precision required: Sowing depth must be held at 0.5 inch for reliable germination, and herbicide spray timing (first spray at ~12 days, second at 22-25 days after sowing) is critical to outcomes – signalling a real, non-trivial extension/training requirement alongside the machinery.

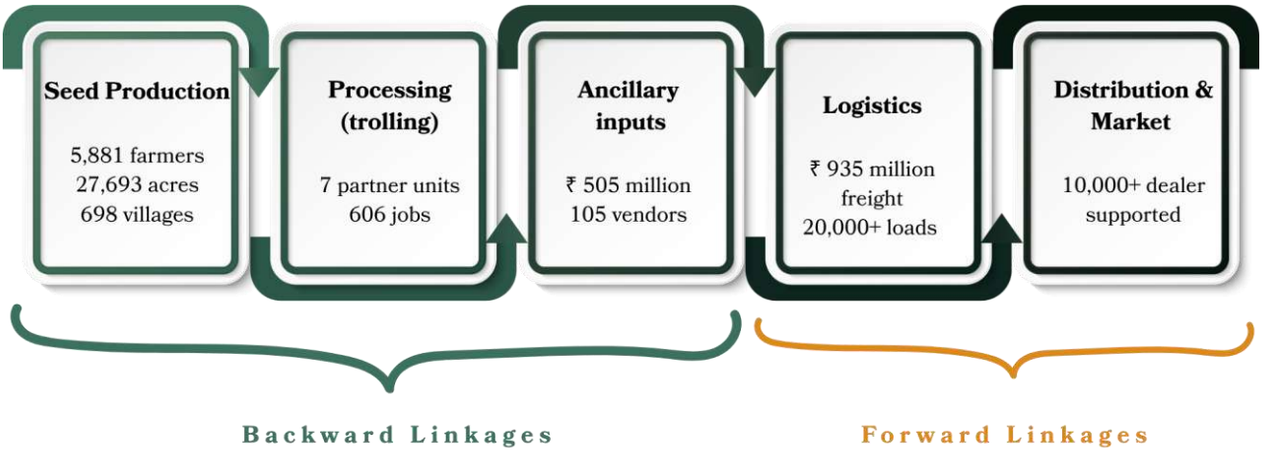
In the surveyed cluster, adoption stood at ~30 per cent under mechanised FullPage® and ~50 per cent under general DSR (farmer reported estimates), implying roughly four-fifths of the sample had already moved away from PTR. Assuming one DSR machine can service 200 acres per season, transitioning 50 per cent of India's 52 Mha paddy area to DSR would require approximately 321,000 machines nationwide, which has the potential to create employment opportunities.



A larger group of suppliers operates around the processing base: between FY2023-24 and FY2026-27, Savannah procured jute and BOPP (biaxially oriented polypropylene) bags, seed-treatment chemicals and printed labels through 105 vendor engagements worth ₹505 million **(Annexure 5.2).** Through this procurement, the seed business is interconnected with four ancillary industries: agrochemical formulation, commercial printing, the traditional jute trade and polymer packaging.

Seed movement contributes to a continuous logistics linkage at both ends of the value chain. About 20,000 truck movements and about ₹935 million in freight expenditure were generated from transportation of raw seed from production centres to processing units and the subsequent moving of finished seeds **(Annexure 5.3).** The forward linkage into distribution and retail is visible mainly through labour and volume indicators, including the dedicated customer-services and distribution function (**Figure 5.2**).

Figure 5.2: The seed value chain and its industrial linkages



*Source: Savannah operational data (**Annexure 5.1-5.3**). Backward linkages run from seed production through processing to input supply; forward linkages carry finished seed to market.*

5.3 Innovation and Investment

Alongside employment and industrial linkages, a full account of Savannah's broader economic contribution should also examine its investment in innovation and its role in strengthening India's wider seed ecosystem. Three dimensions are relevant here. First, R&D expenditure: the scale of Savannah's annual investment in breeding, biotechnology and product development relative to turnover, benchmarked against the 10 to 12 per cent of revenue that research-active private seed companies typically invest (Gadwal, 2003). Second, technology partnerships: Savannah's formal collaborations with public research institutions, such as the ICAR institutes and agricultural universities involved in trait testing, and with its parent entities, the Liechtenstein Group and RiceTec Inc., through which proprietary technologies including SmartRice® and FullPage® are introduced into the Indian market. Third, Savannah's contribution to strengthening India's seed ecosystem more broadly, for example through germplasm access, testing infrastructure for biotic stress traits, and capacity-building for public researchers and farmers that extends beyond Savannah's own commercial operations.

5.4 Conclusion

Taken together, these results indicate that Savannah supports 574 skilled employment (which includes 346 members on the field and 228 full time employees) and 606 processing jobs across its value chain, while also generating substantial seasonal employment across a rural production network comprising nearly 5,900 contracted farmers. Its activities are linked to an ancillary supply chain worth over ₹500 million and a logistics footprint of about ₹935 million. Female participation is also relatively high across several parts of this employment network. These linkages show how foreign direct investment in the seed sector can translate into wider rural and industrial activity.

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CHAPTER 6 – CONCLUSIONS AND WAY FORWARD

Ashok Gulati and Reena Singh

Rice remains central to India's food security, rural livelihoods, and agricultural economy. Over the past five decades, a combination of supportive policies, including public procurement, minimum support prices (MSP), and input subsidies, has underpinned the remarkable expansion of the rice sector. These interventions have contributed to higher production, reduced food insecurity, supported farm incomes, and transformed India from a net importer into one of the world's leading rice producers and exporters. The policy framework, therefore, has played a critical role in ensuring production stability and national food security.

The transformation of India's rice sector has also been accompanied by significant advances in seed research, breeding and innovation. Public sector agricultural research institutions laid the foundations for varietal development and technology generation, while the private seed sector has increasingly emerged as an important contributor to R&D, breeding, varietal innovation, and the development and dissemination of improved hybrids and varieties. Greater private sector participation has strengthened competition, accelerated innovation and expanded farmers' access to improved genetic material. The Indian seed industry consequently has become one of the most dynamic and innovation-driven segments of the agricultural inputs sector.

Further strengthening productivity through genetic improvement is particularly important because India's average paddy yield remains relatively low by international standards. With average productivity of around 4.4 MT per hectare, India's average paddy productivity is slightly below the global average of approximately 4.5 MT per hectare, and substantially lower than China's average of around 7.5 MT per hectare. This productivity gap highlights the considerable scope for raising rice output through improved genetics, better agronomic practices and more efficient production systems, rather than relying primarily on expansion or continued cultivation of rice in ecologically stressed areas.

In this context, high yielding varieties and hybrids will be critical to India's future rice strategy. Higher yielding genetics can enable India to increase or sustain aggregate rice production from a smaller and more efficiently cultivated area, thereby creating greater flexibility to reduce rice cultivation in regions where groundwater and other natural resources are under severe stress. In particular, high yielding hybrid rice, where agronomically and economically suitable, can make an important contribution to closing the productivity gap and meeting future production requirements. However, productivity gains should not be pursued at the expense of resource sustainability. The next generation of varieties and hybrids must increasingly combine high yield with traits such as water use efficiency, climate resilience, shorter duration, resistance to pests and diseases, grain quality, and suitability for resource-efficient production systems.

Within this transition, DSR offers an important pathway towards more resource efficient rice

production. Evidence from different states indicates that, when supported by suitable varieties, appropriate mechanisation, effective weed management and improved agronomic practices, DSR can achieve yields comparable to well-managed transplanted rice systems. Its potential benefits include reduced water and labour requirements, lower energy and production costs, lower GHG emissions, improved residue management, and timely establishment of succeeding crops such as wheat. The availability of high-yielding varieties and hybrids specifically suited to direct seeding and weed management will be an important enabler of wider adoption.

Recommendations

1. Promote High Yielding Hybrid Rice to Achieve the "−5, +10" Rice Strategy

India's future rice strategy should focus on the "−5, +10" vision–reducing the area under rice cultivation by 5 Mha while increasing national rice production by 10 MMT. Achieving this objective will require a shift from area expansion to sustained productivity growth. In this context, hybrid rice represents one of the most promising technological interventions. Under comparable production conditions, hybrid rice typically delivers higher yields than conventional varieties, yet it currently accounts for only 7-8 per cent of the area under rice in the country (IHRT, 2024). Expanding the adoption of hybrid rice, therefore, is critical to maintaining food security while enabling crop diversification, particularly in ecologically stressed states such as Punjab and Haryana, where a gradual reduction in rice cultivation is essential to address groundwater depletion, soil degradation, GHG emissions and environmental externalities. Higher-yielding hybrids can offset production losses arising from reduced rice acreage and facilitate the transition towards more sustainable and remunerative cropping systems. To reduce the area under rice by 5 Mha, while increasing production by 10 MMT, average paddy yield should be a minimum of 5.12 MT per hectare. ICAR-IIRR reported the yield of Sava 7501 to be 7.3 – 10.3 MT per hectare. A comprehensive policy framework should prioritise the development, evaluation, and large-scale dissemination of high-yielding, climate-resilient and region-specific hybrid rice varieties. This should be supported by strengthening hybrid seed production and quality assurance systems, creating an enabling regulatory environment for innovation, incentivising private sector investment in hybrid breeding and seed production, fostering public-private partnerships for research and commercialisation, and expanding extension services to improve farmer awareness, demonstration, and adoption. Particular emphasis should also be placed on developing hybrids with superior grain quality, stress tolerance and market acceptability to enhance farmer confidence and consumer demand.

2. Position India as a Global Seed Production and Export Hub

India possesses several inherent advantages that can enable it to emerge as a global leader in seed production and exports. These include (i) diverse agro-climatic conditions that facilitate the breeding, testing, and multiplication of a wide range of crop varieties across different environments, (ii) a large pool of skilled scientific and technical manpower, (iii) A well-developed seed industry supported by strong public and private sector capabilities in seed research, multiplication, processing, certification, and distribution, (iv) favourable tropical and subtropical climates that allow year-round seed production, rapid multiplication cycles, and the production of high-quality seeds for both domestic and international markets and (v) competitive production costs and a large agricultural base.

The profitability of seed production is higher than commercial cultivation for many crops e.g. Savannah's hybrid seed growers earned ₹159,324-239,633 per hectare in Telangana, compared to around ₹80,013-₹101,486 per hectare earned by commercial paddy (bold/fine) farmers; the corresponding figures in Hanumangarh in Rajasthan was ₹177,916-259,461 per hectare for hybrid seed growers, compared to ₹133,437-142,827 per hectare for commercial basmati farmers. Forging international partnerships for breeding, testing and seed multiplication would enhance FDI and export earnings, attract greater private investment in seed R&D, and position India as a reliable supplier of quality seeds to Asia, Africa and other emerging agricultural markets.

3. Regulatory reforms/Incentives for private R&D

In 2020, the Indian seed industry was valued at USD 3.6 billion (TAAS-ISST 2020) and has emerged as the fifth largest seed market across the globe. Private seed sector companies adopt innovation and uniqueness to capture or protect market shares and make substantial investment in R&D at their end. Globally, the average spends by private sector seed companies on research and development (R&D) ranged between 10 and 12 per cent of revenue, whereas in India it amounted to approximately 3 per cent (FSII 2022). In order to increase private players' research investments performance linked incentives (PLI) can be considered to develop world class plant varieties with natural resource conservation and climate resilience. Additionally, strong processes for Intellectual Property development and protection needs to be defined to encourage private players towards investment for innovations.

4. Direct Seeded Rice for Sustainable Rice Cultivation

DSR offers significant potential to reduce resource use and improve the sustainability of rice cultivation. Evidence suggests that dry seeding can reduce water use by 10-30 per cent compared to conventional transplanted rice (NRRI, 2024; PAU, 2025), while DSR can reduce methane emissions by 18-20 per cent (Pathak et al., 2013). Recognising these benefits, both Punjab and Haryana have introduced dedicated financial incentives to promote DSR. Punjab provides ₹1,500 per acre, while Haryana provides ₹4,500 per acre. However, despite these incentives, DSR accounts for only around 4-5 per cent of total rice acreage in each state, indicating that financial incentives alone have not been sufficient to achieve widespread adoption. Policy support, therefore, should move beyond input subsidies towards an integrated DSR adoption ecosystem. The principal constraints identified by farmers are poor weed management and inadequate crop establishment, compounded by limited availability of DSR-suitable varieties, inadequate access to precision machinery, and knowledge gaps, particularly regarding irrigation and water management. Policy interventions should focus on (i) strengthening DSR research and varietal development and suitability to local agro-climatic conditions, (ii) promoting integrated and sustainable weed management, (iii) developing institutional mechanisms for mechanisation to provide timely and affordable access to precision seeders, laser land levellers and other complementary equipment, (iv) strengthening farmer training and field demonstrations to provide practical training on land preparation, seed treatment, sowing, irrigation scheduling, weed management and nutrient application, (v) building an evidence-based business case for farmers, where clear, location-specific estimates of the costs and benefits of DSR should be generated and communicated to farmers and (vi) developing mechanisms to provide carbon credits to farmers adopting DSR.

ANNEXURES

Annexure i: Farmer Incremental Income Approach

The cumulative acreage covered by Savannah's hybrids, improved varieties and OP varieties from 2013 through the Kharif 2026 season was considered.

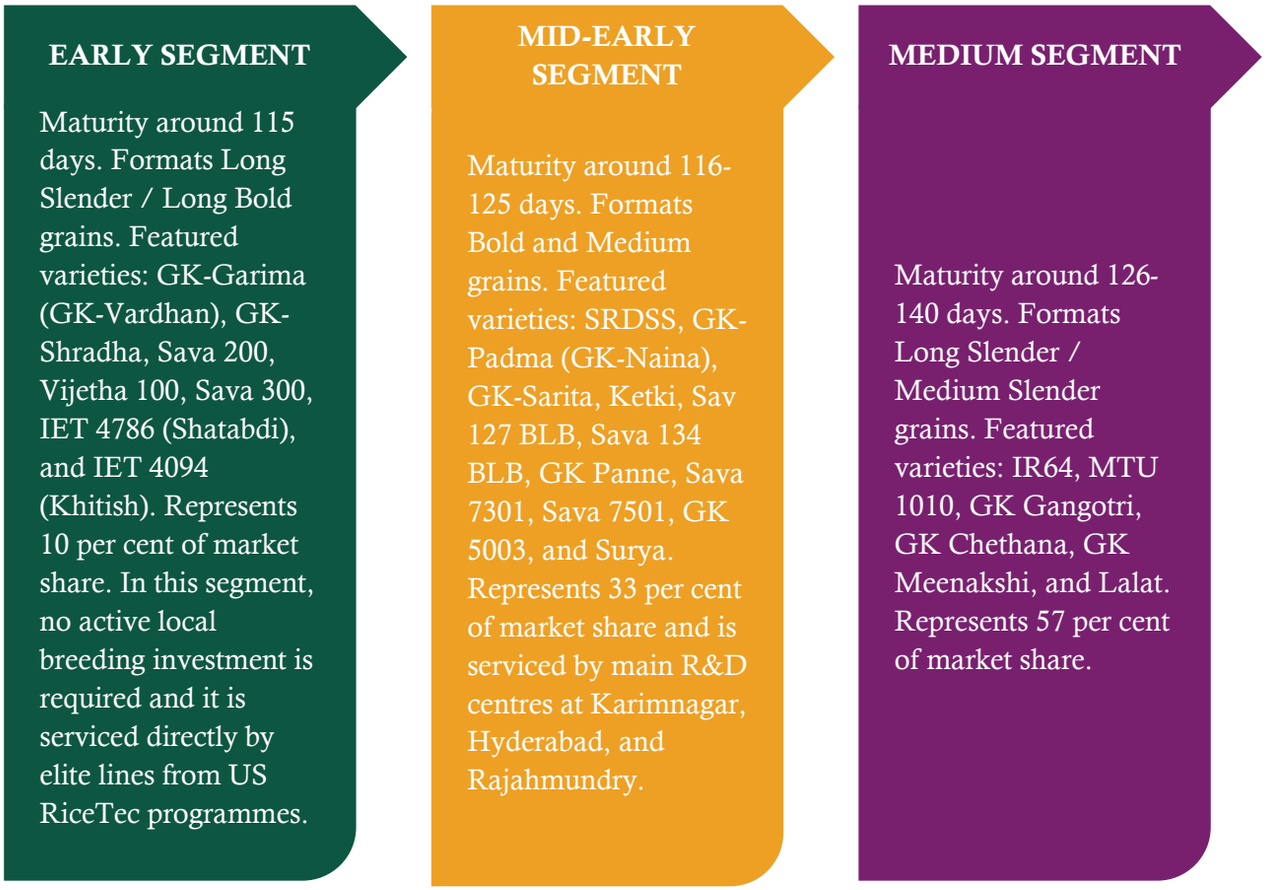
FAOSTAT data was considered for average paddy yield of India from 2013 till 2025 and yield data of 2025 was considered for 2026.

For Savannah products yield, the following was considered:

SKU	*Yield (MT/ha)**	*Source*
Sava 127 FullPage®	7.0	Savannah data
Sava 134 FullPage®	7.0	Savannah data
Marshal Plus	6.3	RPCAU, Bihar
Marshal-135(GK5017)	5.8	RPCAU, Bihar
Sava 124	7.5	JNKV
Sava 127	7.5	JNKV
Sava 134	7.8	JNKV
Sava 200	8.0	JNKV
SH 4613	7.0	Savannah data
Sava 7301	9.5	ICAR IIRR Survey
Shreshta Gold	6.8	Savannah data
Sava 7501	10.0	ICAR IIRR Survey
Improved varieties	10 per cent more than India yield	
OP Varieties	5 per cent more than India yield	

**** ranges from 4 to 13 years datasets***

Annexure 1.1: Savannah's Varieties in three maturity segments



Savannah's four varieties—Sava 134, Sava 127, Sava 7301 and Sava 7501—have been notified, while the Protection of Plant Varieties and Farmers' Rights (PPV&FR) registration applications have been filed for SRD 55, Sava 7501 and Sava 7301, with registrations obtained for GK5003 and GK5028.

Annexure 1.2: Methodology Followed

i. Primary qualitative research: Focus Group Discussions

Primary qualitative information was collected through seven focus group discussions (FGDs) involving approximately 70-80 rice farmers across Punjab, Haryana, Rajasthan, Madhya Pradesh and the *Terai* region of Uttarakhand/western Uttar Pradesh, supplemented by a separate interaction with farmer organisers in Telangana. The discussions were conducted between June and August 2026. The geographical coverage was deliberately designed to capture differences in rice production systems, agro-climatic conditions, seed-use practices, and the nature of Savannah's engagement with farmers and other value chain actors.

FGDs were selected as an appropriate qualitative research method because they facilitate interaction among participants with shared experiences and allow researchers to explore perceptions, experiences, constraints and behavioural responses that may not be captured through structured surveys alone. The literature recognises FGDs as particularly useful for exploratory and process-oriented research, including understanding farmers' experiences, perceptions and explanations for observed outcomes. Group interaction can also generate insights that may not emerge from individual interviews, as participants respond to, validate, challenge or elaborate upon one another's experiences (Bitsch, 2005; Krueger and Casey, 2014). FAO similarly identifies focus group discussions as a useful participatory method for obtaining detailed information on specific rural and agricultural issues and for cross-checking information obtained through other research methods.

The discussions followed a semi-structured discussion guide, rather than a rigid questionnaire. This allowed the research team to maintain consistency across locations while permitting participants to elaborate on issues that emerged during the discussions. The discussions covered farmers' experience with conventional and improved rice production practices, seed selection and adoption, perceived changes in productivity and input use, labour requirements, water and energy use, production costs, quality considerations, market access, and the perceived benefits and constraints associated with Savannah's seed technologies. Depending on the location and the specific innovation under consideration, discussions also focused on DSR, hybrid rice, open-pollinated varieties (OPVs) and seed production.

The composition of the groups was guided by the specific research question being examined at each location. Participants were selected based on their direct experience with the relevant technology or activity in Savannah. Thus, the FGDs were not intended to constitute a statistically representative sample of all rice farmers in the respective states. Rather, they were designed to obtain in-depth, experience-based evidence from farmers directly engaged with the technologies and production systems under study. Consequently, findings from the FGDs are interpreted as qualitative evidence of farmers' experiences and perceptions and are not extrapolated to the wider farming population without supporting quantitative evidence.

The Savannah field teams facilitated access to farmers and assisted the ICRIER research team in organising the discussions and field interactions. The discussions were led by the ICRIER team to ensure that the research questions remained aligned with the objectives of the study. Notes and participant responses were documented systematically and were interpreted alongside the broader evidence rather than treated as statistically representative responses.

ii. Focus Group Discussion schedule

The FGDs were done under three major themes:

a) Assessing the impact of Savannah's SmartRice® and hybrids on increased yields, optimised cultivation costs, environmental impact and overall profitability per acre. During FGDs, Sava 7501 was covered, encompassing 11 farmers with 87 hectares under rice cultivation area.
b) Assessing the impact of Savannah's FullPage® technology's for DSR on increased yields, optimised cultivation costs, environmental impact and overall profitability per acre. During FGDs, Sava 127 FullPage® and Sava 134 FullPage® was covered, under the FGD with 42 farmers cultivating 154 hectares.
c) Assessing the impact of Savannah's seed production network for local farmers. During FGDs, 15 number of seed production farmers cultivating 72 hactares of seed production area.

The responses were organised around key dimensions relevant to the study: (i) productivity and yield, (ii) production costs and farm profitability, (iii) labour requirements, (iv) water, energy and other input use, (v) environmental implications, (vi) technology adoption and farmer preferences, (vii) constraints to adoption and (viii) broader value-chain and social effects. Recurring themes, contrasting experiences and location-specific observations were identified and used to inform the interpretation of the quantitative results. The location-wise coverage and principal purpose of the FGDs are presented in **Table 1.2.1.**

Table 1.2.1: Schedule and Purpose of Focus Group Discussions

Location	*Number of representative farmers and the districts covered*	*Total area cultivated by representative farmers (in hectares)*	*Savannah's variety (OP/hybrid) in cultivation*	*Purpose*
Shahbad, Haryana	10 (6 from Ambala, 2 from Kurukshetra, and 2 from Yamnunanagar)	32	Sava 127 FullPage®, Sava 134 FullPage®	FullPage® DSR
Barnala, Punjab	11 farmers from Barnala	87	Sava 7501	SmartRice® Hybrids
Hanumangarh, Rajasthan	10	262		Hybrid Seed Production
Jabalpur, Madhya Pradesh	21 farmers (12 from Seoni, 5 from Damoh, and 4 from Jabalpur) in two FGDs	72	Sava 134 FullPage®	FullPage® DSR
Hyderabad, Telangana	5 farmer organisers	17.2		Seed Production for Savannah s' OP and hybrid varieties
Rudrapur, Uttarakhand	11 (3 from Pilibhit, 3 from US Nagar and 5 from Rampur)	50	Sava 127 FullPage®, Sava 134 FullPage®	FullPage® DSR

iii. Field visits and value-chain stakeholder interactions

The FGDs were complemented by field visits to Savannah 's seed production, processing and research facilities and interactions with other value-chain participants. These interactions were undertaken to understand the innovation process beyond the farm level and to examine how seed processing, quality management, procurement, and distribution are organised and contributing to socio-economic development in the country. The principal field visits and stakeholder interactions are summarised below (**Table 1.2.2**).

Table 1.2.2: Field Visits and Value-Chain Stakeholder Interactions

Location	*Value Chain Players*	*Purpose*
Sonipat, Haryana	Alliance Agritech (Toller)	A third-party contractor who stores, processes, and packages seeds on behalf of Savannah.
Barnala, Punjab	Milling Unit	Milling standards for paddy
Hanumangarh, Rajasthan	Procurement and processing unit	FOCO (Farmer-Owned, Company-Operated) model
Hanumangarh, Rajasthan	State government primary school	Corporate Social Responsibility (CSR) initiative of Savannah
Rudrapur, Uttarakhand	Farmers owing and renting seed drills	Mechanisation ecosystem for DSR
Karimnagar, Telangana	Savannah's Core Seed Production Facility spanning an area of 4 acre	Multiplication of hybrids (8-line programme)
Hyderabad, Telangana	Savannah's R&D facility	Rice germplasm collection, breeding enhancement, trait hybrid releases, infrastructure for testing against biotic stresses, breeding nurseries and plant growth chambers.

iv. Secondary literature

The primary fieldwork was complemented by a review of published academic literature, government data sources and reports, industry studies and other relevant secondary sources. The literature review was used to establish the broader context for the analysis and, where appropriate, to benchmark the findings emerging from the fieldwork. In particular, published evidence was reviewed on rice production systems, conventional PTR, DSR, hybrid rice, seed technology, input use, farm economics, labour requirements, water use, environmental impacts and agricultural innovation.

The use of secondary literature is particularly important because the objective of the study is not simply to document farmers' perceptions but to assess the wider economic, environmental and social implications of seed and production innovations. Published studies provide an independent evidence base against which observations from the field can be assessed. At the same time, the study recognises that estimates reported in the literature may vary according to agro-climatic conditions, farm size, production practices, technology packages and the period of analysis. Accordingly, literature-based estimates are used with appropriate contextualisation rather than treated as universally applicable values.

v. Savannah – provided quantitative and operational data

In addition to the primary fieldwork and secondary literature, Savannah shared quantitative, operational and other relevant data with the ICRIER research team, which constitute an important source of the numerical information presented in this report. These data include, as applicable, information relating to varieties and hybrids developed and introduced by Savannah, seed production, farmer engagement, cultivated area, technology adoption, production and processing activities, and other operational parameters relevant to assessing the performance and impacts of the innovations examined in the study.

The Savannah provided data were used to derive or substantiate several of the quantitative estimates and calculations presented in the report. Where the analysis relies on Savannah provided data, this is explicitly acknowledged in the relevant sections and tables. The data were examined and, where possible, cross-checked against information obtained through farmer discussions, field observations and published literature.

vi. Data triangulation and analytical approach

The study follows a triangulation-based approach to improve the robustness and credibility of the findings. Information obtained from one source was compared, where feasible, with evidence from other sources. This distinction is important for interpreting the results. The FGDs provide qualitative, experience-based evidence, published literature provides an external benchmark and contextual evidence, and Savannah provided data provide the underlying quantitative and operational information for several of the estimates presented in the study. The findings, therefore, emerge from triangulation across these complementary sources rather than from any single source. Triangulation is particularly relevant in the present study because the technologies examined are implemented under diverse agro-climatic and production conditions. Outcomes may therefore differ across locations and farmers. Rather than assuming a uniform effect, the analysis identifies areas of convergence as well as differences in farmers' experiences and reported outcomes.

vii. Interpretation and limitations

The methodology is designed to provide a case-based assessment of private sector innovation and its implications, rather than a statistically representative impact evaluation of Savannah's technologies across the Indian rice sector. The purposive nature of the farmer selection and the relatively small number of FGDs mean that the qualitative findings should not be interpreted as representative of all rice farmers in the states or regions covered.

Similarly, where quantitative estimates are based on Savannah -provided data, they should be interpreted in the context of the underlying data source, definitions and coverage. The report therefore distinguishes, wherever relevant, between farmer-reported evidence, Savannah -provided data, published/secondary evidence and estimates derived by the research team. This transparent attribution of evidence helps avoid conflating perceptions, observed outcomes and externally reported estimates.

Annexure 1.3: Glimpses of Focused Group Discussions



Annexure 2.1: Cost of cultivation of SmartRice®

Component (₹/ha)	*Sava 7501*
Nursery & Seed	10,000
Land Preparation (Leased Land)	12,500
Land Preparation (Own Land)	6,250
Fertiliser	10,705
Fungicides	7,500
Transplanting Labour	10,500
Harvesting	3,750
Transportation	1,250
Cost of cultivation (Leased Land)	56,205
Cost of cultivation (Own Land)	49,955

Annexure 3.1: Haryana PTR versus DSR cost of cultivation

Cost / Return Head (₹/ha)	***PTR***	***Non-HT DSR***	***FullPage®***
Field Preparation	18,750	12,500	12,500
Nursery Preparation	6,000	0	0
Crop Sowing	12,500	0	0
Herbicide and Weedicide	5,000	11,250	4,250
Insecticide	15,000	15,000	15,000
Fertiliser	11,370	11,370	11,370
Irrigation	312.5	312.5	312.5
Harvesting	6,000	6,000	6,000
Seeds	0	2,000	10,000
Cost of Cultivation	74,933	58,433	59,433
Yield (MT/ha)	6.5 - 7.0	5.5 - 6.0	6.5 - 7.0
Gross Revenue @ MSP of 2369/qtl	1,53,985 - 1,65,830	1,30,295 - 1,42,140	1,53,985 - 1,65,830
Net Profit	79,052 - 90,897	71,862 - 83,707	94,552 - 1,06,397

Annexure 3.2: Madhya Pradesh FGD-1 PTR versus DSR cost of cultivation breakdown

Cost / Return Head (₹/ha)	*PTR*	*Non-HT DSR*	*FullPage®*
Field Preparation	13,591	8,896	8,896
Nursery Preparation	10,872	0	0
Crop Sowing	15,000	1,236	1,236
Herbicide and Weedicide	8,500	19,768	4,942
Insecticide	6,500	6,500	6,500
Fertiliser	18,200	18,200	18,200
Harvesting	5,000	5,000	5,000
Seeds	0	5,930	15,444
Cost of Cultivation	77,663	65,530	60,217
Yield (MT/ha)	5.4	4.4	5.4
Gross Revenue @ MSP of 2369/qtl	1,28,784	1,05,368	1,28,784
Net Profit	51,121	39,839	68,567

Annexure 3.3: Madhya Pradesh FGD-2 PTR versus DSR cost of cultivation breakdown

Cost / Return Head (₹/ha)	*PTR*	*Non-HT DSR*	*FullPage®*
Field Preparation	13,591	8,896	8,896
Nursery Preparation	10,872	0	0
Crop Sowing	15,000	1,236	2,965
Herbicide and Weedicide	8,500	19,768	4,942
Insecticide	6,500	6,500	6,500
Fertiliser	18,200	18,200	18,200
Harvesting	5,000	5,000	5,000
Seeds	0	5,930	15,444
Cost of Cultivation	77,663	65,530	61,947
Yield (MT/ha)	5.4	4.4	5.9
Gross Revenue @ MSP of 2369/qtl	1,28,784	1,05,368	1,40,491
Net Profit	51,121	39,839	78,545

Annexure 3.4: Uttarakhand FGD-1 PTR versus DSR cost of cultivation breakdown

Cost / Return Head (₹/ha)	*PTR*	*Non-HT DSR*	*FullPage®*
Field Preparation	6,250 – 7,500	5,000	5,000
Nursery Preparation	3,750	0	0
Crop Sowing	15,000	3,750	3,750
Herbicide and Weedicide	1,750 – 3,000	3,125 – 4,500	4,500
Insecticide	1,250 – 1,375	7,500	7,500
Fertiliser	15,500	15,500	15,500
Irrigation	12,500 – 15,000	10,000	10,000
Harvesting	3,750 – 5,000	3,750 – 5,000	3,750 – 5,000
Seeds	6,250 – 7,500	6,250 – 7,500	6,250 – 7,500
Cost of Cultivation	66,000 – 73,625	54,875 – 58,750	63,000 – 64,750
Yield (MT/ha)	8.0 – 8.3	5.5 – 6.5	7.5 – 8.0
Gross Revenue @ MSP of 2369/qtl	1,89,520 – 1,95,443	1,30,295 – 1,53,985	1,77,675 – 1,89,520
Net Profit	1,15,895 – 1,29,443	71,545 – 99,110	1,12,925 – 1,26,525

Annexure 3.5: Uttarakhand FGD-2 PTR versus DSR cost of cultivation breakdown

Cost / Return Head (₹/ha)	*PTR*	*Non-HT DSR*	*FullPage®*
Field Preparation	8,750	5,000	5,000
Nursery Preparation	2,500 – 3,750	0	0
Herbicide and Weedicide	1,750	11,250	3,750
Insecticide	5,000 – 6,250	5,000 – 6,250	5,000 – 6,250
Fertiliser	18,750 – 20,000	18,750 – 20,000	18,750 – 20,000
Harvesting	3,750 – 5,000	3,750 – 5,000	3,750 – 5,000
Seeds	2,000	5,500	8,750 – 10,000
Cost of Cultivation	38,750 – 42,500	45,000 – 48,000	41,250 – 45,000
Yield (MT/ha)	6.5 – 7.0	5.3 – 6.3	7.0 – 7.5
Gross Revenue @ MSP of 2369/qtl	1,53,985 – 1,65,830	1,24,373 – 1,48,063	1,65,830 – 1,77,675
Net Profit	1,06,485 – 1,23,330	71,373 – 98,813	1,15,830 – 1,32,675

Annexure 3.6: Chhattisgarh PTR versus DSR cost of cultivation breakdown

Cost / Return Head (₹/ha)	*PTR*	*Non-HT DSR*	*FullPage®*
Field Preparation	11,250	7,500	7,500
Nursery Preparation	5,000 – 6,250	0	0
Crop Sowing	15,000 – 20,000	1,250	1,250
Herbicide and Weedicide	7,500 – 8,750	16,250 – 20,000	5,000 – 6,250
Insecticide	17,500 – 20,000	12,500 – 15,000	12,500 – 15,000
Fertiliser	10,000 – 12,500	10,000 – 12,500	10,000 – 12,500
Harvesting	11,250 – 12,500	11,250 – 12,500	11,250 – 12,500
Seeds	0	7,500	15,000
Cost of Cultivation	77,500 – 91,250	66,250 – 76,250	62,500 – 70,000
Yield (MT/ha)	6.0 – 6.3	5.0 – 5.5	6.3 – 7.0
Gross Revenue @ MSP of 2369/qtl	1,42,140 – 1,48,063	1,18,450 – 1,30,295	1,48,063 – 1,65,830
Net Profit	50,890 – 70,563	42,200 – 64,045	78,063 – 1,03,330

Annexure 4.1: Comparative cost of cultivation, OPV vs hybrid seed production at Telangana

Operation / input (₹/ha)	*OPV / varietal*	*Hybrid*
Nursery development	2,470–3,710	2,470–3,710
Land preparation	19,800–24,700	~19,800
Fertiliser	14,700–22,100	14,700–27,100
Transplanting	14,800	19,800
Manual weeding	3,710	3,710
Roguing	2,500–3,700	12,400–14,800
Pollination assistance	Nil (self-pollinating)	12,400–14,800
Harvesting	~4,900	~12,400 (M+F lines)
Post-harvest processing	~4,450	~490 (raw sorting)
Irrigation management	1,240–2,470	1,240–2,470
Total	68,600–84,600	99,410–1,19,080

Source: Field FGDs; (The total may not match because of rounding off)

Annexure 4.2: Comparison of Cultivation Cost Expenditure for Savannah 's Hybrid and Commercial Grain at Hanumangarh

Cultivation Expense Component (₹/ha)	*Savannah Hybrid Seeds*	*Conventional Grain*
Nursery Preparation	3,710	2,470
Land Preparation	6,180	6,180
Transplanting	18,530	9,390
Fertilisers & Plant Nutrition	14,830	11,730
Crop Protection	25,100	22,140
Specialized Crop Operations	5,930	0
Harvesting	11,120	6,670
Total	86,460	58,580

Source: Field FGDs; (The total may not match because of rounding off)

Annexure 5.1 Employment

Direct Skilled workforce

In FY2025-26, the direct skilled workforce stood at 228 full-time-equivalent (FTE) positions. Of these, 33 are in research and technology, carrying out breeding, trait development and biotech testing that build the kind of local private sector R&D capacity Spielman et al. (2013) identify as necessary for FDI in the seed sector to translate into domestic capability; 45 are in the production function, responsible for seed-multiplication planning and quality oversight, 118 are in sales, marketing and customer services, managing Savannah's commercial relationships with dealers and farmers for its hybrid and FullPage® technologies; and the remaining 32 are in Seed Production Research and enabling functions such as finance, IT, HR, legal and general administration. A wider functional head-count that also includes field-facing extension and agronomy roles reached 346 in FY2025-26, reflecting the scale of on-ground commercial and technical support built around Savannah's product portfolio.

Table 5.1: Direct (skilled) Full-Time-Equivalent (FTE) workforce by function, FY2023-24 to FY2025-26

Function	*FY2023-24*	*FY2024-25*	*FY2025-26*
Sales, Marketing & Customer Services	105	110	118
Seed Production Research (SPR)	1	2	2
Production function	34	41	45
Research & Technology function	25	30	33
Enabling functions (Finance, IT, HR, Admin, Legal, CEO/MD)	19	28	30
Grand total (FTE)	184	211	228

Source: Savannah FTE data (as on 31 March). A broader functional head-count including field-facing roles rose from 208 to 346 over the same period; the two series differ in scope and are not directly additive.

Semi-skilled workforce

In the processing stage, many of the operations are manual and engage a large semi-skilled workforce. Savannah relies on a toller (outsourced) processing model, with seven partner units situated across the northern, central and southern zones of India (Field insights). A total of 606 jobs are supported by these units, comprising 20 supervisory staff of Savannah, 121 toller technical and administrative employees, and 465 processing labourers (**Table 5.2**). The composition of this labour force is varied: about one-fifth are skilled and two-fifths each are semi-skilled and unskilled. Around 55 per cent of the labour force in the processing units and 15 per cent of toller technical staff are women. This is consistent with existing literature showing that hybrid seed operations can generate employment opportunities for rural women in particular (ICAR–IIRR, 2021).

Table 5.2. Employment at seed processing (tolling) units, by partner and location

Processing partner	*Location / zone*	*Savannah staff*	*Toller staff*	*Labour*	*Total*
Alliance Agritech (AAT)	Sonipat / North	5	25	75	105
Jam-R	Raipur / Central	4	24	80	108
VR AgriTech	Siddipet / South	4	35	200	239
VR AgriTech	Karimnagar / South	4	20	60	84
Kakumanu	Siddipet / South	3	17	50	70
Total	7 units	20	121	465	606

Source: Savannah toller details. Labour skill split: skilled ≈ 20 per cent, semi-skilled ≈ 40 per cent, unskilled ≈ 40 per cent. Female participation: 55 per cent of processing labour and 15 per cent of toller technical staff.

Annexure 5.2. Partner and ancillary-industry linkage: packaging and input procurement, FY2023-24 to FY2026-27

Financial year	*Vendor engagements*	*Procurement (₹ million)*
FY2023-24	33	99
FY2024-25	28	166
FY2025-26	27	202
*FY2026-27**	17	39
Total	105	505

*Source: Savannah packaging economic contribution data. Categories: seed-treatment chemicals, labels, jute bags and BOPP bags. "Vendor engagements" counts category-by-year procurement lines, not unique firms. *FY2026-27 is a part-year figure. (The total may not match because of rounding off)*

Annexure 5.3. Logistics footprint: inbound raw seed and outbound packed seed

Segment	*Cumulative FY*	*Freight (₹ Million)*	*Truck-loads*
Packed Seed	FY 21-27	650	9,497
Raw Seed	FY 21-26	290	10,132

*Source: Savannah logistics data. Raw and packed series are reported over different reference periods in the source (calendar years and financial years respectively); *FY2026-27 outbound is a part-year figure. Volumes, therefore, are indicative of scale rather than strictly contemporaneous.*

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