IJAR&D
Peer-reviewed | Open Access

International Journal of Academic Research and Development (IJAR&D)
ISSN : 2395-1737 (Print), Volume 12, No. 3, Page No 38-47
DOI : https://doi.org/10.70381/23951737.v12.js3.2026.5
A Quarterly Journal Published by Bharti Publications, New Delhi, India

Rice Productivity in Odisha: Trends, Issues, Challenges, and Way Forward

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Abstract

Rice is the principal staple crop of Odisha, occupying 60–70% of the gross cropped area and serving as the backbone of the state's food security, rural economy, and cultural heritage. It provides livelihood to millions of small and marginal farmers and landless labourers. Over the past 25 years (2000–2025), Odisha's rice sector has undergone a remarkable transformation, characterized by substantial yield-led growth despite a marginal decline in cultivated area. Average productivity has more than doubled, rising from approximately 1.0–1.2 tonnes per hectare in the early 2000s to around 2.3–2.485 tonnes per hectare by the mid-2020s, with production frequently exceeding 100–118 lakh tonnes in recent years. This paper presents a comprehensive analysis of rice productivity trends using data from the Directorate of Economics and Statistics (Odisha), Ministry of Agriculture, and other secondary sources. It examines the key drivers of success, including the adoption of climate-resilient varieties (e.g., Swarna Sub1, Sahbhagi Dhan), policy initiatives such as the KALIA scheme, National Food Security Mission, and improved agronomic practices. The study also critically assesses persistent challenges such as climate vulnerability, rainfed dominance, soil degradation, rice fallows, fragmented landholdings, and irrigation inefficiencies. Finally, the paper offers evidence-based policy and research recommendations for sustainable intensification, aiming to achieve 3.5–4.0 tonnes per hectare while enhancing resilience, cropping intensity, and farmer incomes. The findings underscore the need for a science-led, climate-smart, and farmer-centric approach to position Odisha as a model for sustainable rice production in eastern India.

Keywords: *Rice Productivity, Odisha Agriculture, Yield Growth, Climate Resilience, Rice Fallow Management.*

Introduction

Odisha, located in eastern India, has a long tradition of rice cultivation, historically known as a major contributor to the national rice pool. Rice accounts for about 60–70% of the total cultivated area (around 37 lakh hectares in recent years) and employs a large portion of the agricultural workforce. However, the state's productivity has traditionally lagged behind the national average due to rainfed conditions, abiotic stresses, and infrastructural gaps.

The period from 2000 to 2025 marks a phase of notable progress amid recurring challenges from climate variability.

Rice (*Oryza sativa* L.) is more than a staple crop in Odisha; it is the very foundation of the state's agrarian economy, culture, and food security. Often described as the "soul of Odisha's agriculture," rice occupies a commanding position in the state's cropping systems, accounting for approximately 60–70% of the gross cropped area and around 63% of the area under food grains. With an average annual cultivation on about 37–40 lakh hectares, Odisha has consistently ranked among India's significant rice-producing states, contributing notably to the central food grain pool in recent years.

The history of rice cultivation in Odisha is ancient and illustrious. Archaeological and archaeobotanical evidence from sites in the Jeypore tract of Koraput district and other regions points to rice cultivation dating back

to 2000–3000 BC or earlier. Scholars widely regard the Jeypore tract as a secondary centre of origin and immense genetic diversity for cultivated rice. The region once hosted over 1,750 traditional landraces, representing rich genetic resources that have contributed to global rice improvement programmes. The establishment of the Central Rice Research Institute (CRRI) at Cuttack in 1946 underscores Odisha's historical importance in national and international rice research.

Odisha's rice culture is deeply intertwined with its social fabric, festivals, and rituals. Festivals such as *Akhyatrutiya* (marking the beginning of sowing), *Raja Sankranti*, *Nuakhai*, *Laxmi Puja*, and *Makara Sankranti* are intimately linked to different phases of rice cultivation and harvest. Traditional rice-based foods and delicacies — ranging from *pakhala* and *mudhi* to numerous *pithas* — reflect the centrality of rice in Odia cuisine and identity. For tribal communities in southern and western Odisha, rice remains not only a primary food source but also an integral part of their cultural heritage and biodiversity management practices.

Agro-ecological Context

Odisha presents a diverse agro-ecological landscape spanning ten agro-climatic zones, broadly categorised into coastal plains, river deltas, central tablelands, and northern and western plateaus. These zones support varied rice ecologies: upland (*gosei*), medium land, lowland, and deep-water/flood-prone areas. The state receives high annual rainfall (around 1,500 mm on average), predominantly during the southwest monsoon (June–September), making *kharif* rice the dominant season. However, this also exposes cultivation to high risks of drought, flood, cyclone, and salinity, particularly in the coastal belt.

The state's six major river systems — Mahanadi, Brahmani, Baitarani, Subarnarekha, Rushikulya, and Vansadhara — create extensive deltas and floodplains ideal for rice but also prone to recurrent natural calamities. Coastal districts frequently face cyclonic disturbances, while interior and western districts suffer from erratic rainfall and terminal drought. These biophysical realities have historically constrained productivity and contributed to instability in production.

Socio-Economic Significance

Agriculture and allied sectors employ a significant portion of Odisha's workforce (around 50–60% as per recent estimates), with rice farming being the primary livelihood for millions of small and marginal farmers. Average landholdings are small and fragmented, often below 1 hectare, limiting economies of scale and mechanisation. Rice production directly influences rural incomes, poverty alleviation, and nutritional security. Per capita rice consumption in the state remains high (approximately 10 kg per month), making stable and affordable rice supplies critical for household food security.

In the 1950s, Odisha was a leading rice-surplus state contributing substantially to India's central pool. However, the advent of the Green Revolution in the Indo-Gangetic Plains and southern states led to a relative decline in Odisha's share of national rice production during the late 20th century. The state's productivity lagged behind the national average for decades due to rainfed dominance (over 70–80% of rice area), limited irrigation coverage, poor adoption of high-yielding varieties in stress-prone areas, and vulnerability to abiotic stresses.

Transformative Phase (2000–2025)

The period from 2000 to 2025 marks a remarkable turnaround in Odisha's rice sector. Average yield has increased from around 1.0–1.2 tonnes per hectare in the early 2000s to approximately 2.3–2.485 tonnes per hectare by the mid-2020s — more than doubling in roughly 25 years. Production has risen substantially, often crossing 100–118 lakh tonnes of paddy in recent years, transforming the state from a deficit or marginal surplus position to a consistent contributor to national food stocks.

This yield-led growth has been facilitated by several factors: widespread adoption of climate-resilient varieties such as *Swarna Sub1* (submergence tolerant) and *Sahbhagi Dhan* (drought tolerant) developed through collaborations between ICAR-NRRI, IRRI, and state agricultural universities; expansion of irrigation infrastructure; promotion of improved agronomic practices like System of Rice Intensification (SRI) and Direct Seeded Rice (DSR); and progressive policy interventions.

Notable among these is the **KALIA** scheme (Krushak Assistance for Livelihood and Income Augmentation), launched in 2018, which provides direct income support to small and marginal farmers, landless labourers, and women's groups. Other initiatives under the National Food Security Mission (NFSM), rice fallow management programmes, and climate-resilient village projects have further strengthened the sector. Public procurement at Minimum Support Price (MSP) has provided market stability and incentivised production.

Persistent Challenges

Despite impressive gains, Odisha's rice sector continues to grapple with structural and emerging challenges. Climate change has intensified the frequency and

severity of floods (affecting 31% of rice area), droughts (34%), cyclones, and unseasonal rains. Soil degradation, imbalanced fertiliser use, labour shortages, low mechanisation, and large tracts of rice fallows (estimated at 1.3–2.2 million hectares) limit further productivity gains and cropping intensity (which stands lower than the national average).

Small and fragmented holdings, inadequate post-harvest infrastructure, limited value addition, and marketing constraints keep farmer incomes low. Nutritional security remains a concern, as rice-dominant diets contribute to micronutrient deficiencies despite caloric sufficiency in many areas. Emerging issues such as pest resurgence, groundwater depletion in irrigated pockets, and market volatility for non-MSP varieties add complexity.

Rationale and Objectives of the Study

This scholarly paper seeks to provide a comprehensive analysis of rice productivity in Odisha over the last 25 years (2000–2025). It examines temporal trends in area, production, and yield at state and, where possible, zonal levels; evaluates the relative contributions of technological, policy, and institutional interventions; identifies key successes and persistent bottlenecks; and proposes a forward-looking strategy for sustainable, climate-resilient, and inclusive rice-based systems.

The specific objectives are:

1. To document trends in rice area, production, and productivity from 2000 to 2025 using official statistics.
2. To assess the impact of varietal improvement, irrigation, and policy initiatives on productivity growth.
3. To analyse major issues and challenges, including climate vulnerability and socio-economic constraints.
4. To suggest evidence-based policy, research, and extension recommendations for future sustainable intensification.

By integrating historical perspectives, quantitative trends, literature synthesis, and stakeholder insights, this paper aims to contribute to informed policymaking for Odisha's agriculture. In an era of climate uncertainty and the need for doubling farmers' incomes, understanding Odisha's rice transformation offers valuable lessons for rainfed and vulnerable regions across eastern India and beyond.

Historical Trends and Growth Analysis

A rich body of literature documents the long-term trends in rice (paddy) area, production, and productivity in Odisha. Studies consistently show that growth in rice output over the past five decades (1970–2020) has been driven almost exclusively by yield improvements rather than area expansion.

Key findings from major studies include:

- **Growth Rates**: Over 1970–2020 (or extended to 1960–2019), rice production recorded a Compound Annual Growth Rate (CAGR) of approximately **1.76%**, with yield growing at **1.95%** per annum. Area under rice showed a marginal negative growth of around **-0.18%**. Yield accounted for over 91% of the total production increase.
- **Yield Trajectory**: Average yield rose from below 1.0–1.2 t/ha in the early 2000s to 2.3–2.485 t/ha by the early-to-mid 2020s. For instance, yields reached around 2.35 t/ha in 2021–22.
- **Decadal Patterns**: Slower growth and high instability pre-2000s gave way to steadier yield gains post-2010, aided by technological interventions. Production has shown upward trends with fluctuations due to weather.

Technological and Policy Interventions

Literature highlights the role of **high-yielding varieties (HYVs)**, stress-tolerant rice varieties (STRVs), and government schemes. Partnerships with the International Rice Research Institute (IRRI) and ICAR-National Rice Research Institute (NRRI, Cuttack) have been pivotal.

- **Varietal Adoption**: Widespread uptake of submergence-tolerant varieties like *Swarna Sub1*, drought-tolerant *Sahbhagi Dhan*, and others (e.g., CR 1009 Sub1, DRR 44, Binadhan 11). These have significantly boosted productivity in flood- and drought-prone areas.
- **Agronomic Practices**: Promotion of System of Rice Intensification (SRI), Direct Seeded Rice (DSR), and improved nutrient management.
- **Policy Support**: The **KALIA (Krushak Assistance for Livelihood and Income Augmentation)** scheme has provided direct income support, input subsidies, and livelihood assistance, contributing to productivity gains and inclusivity for small/marginal farmers and landless labourers. Other initiatives include the National Food Security Mission (NFSM) and rice fallow management programmes.

IRRI-Odisha collaborations have emphasised rice-based cropping systems, leading to higher productivity and farmer incomes in pilot districts.

Rice Fallows and Cropping Intensity

A major theme in recent literature is the large extent of **rice fallows** (areas left uncultivated after kharif rice).

Studies using remote sensing (Sentinel-1 SAR and Landsat) estimate 2.0–2.2 million hectares of rice fallows annually in the mid-2010s, with about 1.34 million hectares as permanent fallows.

Key districts affected include Mayurbhanj, Bhadrak, Bolangir, Sundargarh, Keonjhar, Baleswar, Nabarangpur, and Bargarh. Constraints include moisture stress, lack of irrigation, and unsuitable varieties. Intensifying these areas with pulses, oilseeds, or short-duration crops is a major policy focus for raising overall system productivity.

Challenges and Constraints

Extensive literature identifies several persistent issues:

- **Climate Vulnerability**: Frequent floods (affecting 31% of area), droughts (34%), cyclones, and salinity. Studies using Just-Pope production functions and quantile regression show negative impacts of rising minimum temperatures and erratic rainfall. Climate change is projected to increase production failure risks.
- **Rainfed Dominance**: A large share of rice area remains rainfed, leading to yield instability. Irrigated yields are also below potential (e.g., 3.0 t/ha in kharif irrigated vs. higher attainable yields).
- **Yield Gaps**: Substantial gaps (1.7–2.4 t/ha in eastern India including Odisha) due to suboptimal nitrogen management, irrigation practices, and technology adoption.
- **Structural Issues**: Small/fragmented holdings, labour shortages, soil degradation, imbalanced fertilizer use, and limited mechanization.
- **Other Factors**: Post-harvest losses, market volatility, and regional disparities (coastal vs. plateau districts).

Sustainability and Future Directions

Emerging literature emphasises climate-smart agriculture, sustainable intensification, and diversification. Key recommendations include:

- Scaling stress-tolerant varieties and precision tools.
- Water-efficient practices (Alternate Wetting and Drying – AWD).
- Integrated rice-based systems with livestock/fisheries.
- Stronger research-extension-farmer linkages and digital advisories.
- Value addition through specialty and biofortified rice.

Studies advocate for context-specific intensification pathways combining traditional knowledge with data science.

Gaps in Literature

While growth analyses and remote-sensing studies are robust, there is relatively less district-level micro-level econometric work on the impact of specific schemes like KALIA on productivity, long-term soil health studies, and comprehensive economic analyses of mechanization/DSR adoption. Future research should integrate climate projections with economic viability assessments.

Trends in Rice Productivity (2000–2025)

Area, Production, and Yield

- **Area**: Rice area has shown a slight negative growth (CAGR ≈ 0.18% from longer-term data including this period), stabilizing around 37–40 lakh hectares. Kharif rice dominates, with limited rabi expansion.
- **Production**: Substantial increase from around 46 lakh tonnes (paddy equivalent, early 2000s) to over 100–115 lakh tonnes in recent years (e.g., record procurement levels in 2025–26). Production growth driven almost entirely by yield.
- **Yield**: Dramatic improvement. Average yield rose from 1.0–1.5 tonnes/ha (or 10–15 quintals/ha) in 2000–01 to approximately **2.48 tonnes/ha (2,485 kg/ha)** in 2025, with figures around 2.3–2.8 tonnes/ha in strong years. This represents a roughly 2.5-fold increase in two decades.

Decadal Highlights:

- Strong yield growth in 2000–10 (CAGR of 4.99% in some analyses).
- Continued but moderated gains post-2010, supported by better varieties and practices.

Odisha's rice yield has moved closer to (and occasionally above) the national average in recent years, with the state contributing significantly to central pool procurement.

Table 1: Decadal Overview of Rice Area, Production, and Yield in Odisha

Period	Average Area (lakh ha)	Average Production (lakh tonnes)	Average Yield (kg/ha)	Remarks
2000–01 to 2009–10	38–42	60–75	1,200–1,800	Low baseline, high variability
2010–11 to 2019–20	37–40	80–100	2,000–2,500	Steady yield improvement

Period	Average Area (lakh ha)	Average Production (lakh tonnes)	Average Yield (kg/ha)	Remarks
2020–21 to 2024–25	37–40	100–118	2,300–2,485	Record highs; yield-led growth

Sources: Directorate of Economics & Statistics, Odisha; CEIC Data

Table 2: Selected Year-wise Rice Productivity Data (Paddy)

Year	Area (lakh ha)	Production (lakh tonnes)	Yield (kg/ha)
2000–01	42	46–50	1,041–1,200
2010–11	40	70–80	1,800–2,000
2020–21	38–39	100+	2,730
2022–23	38–40	110+	2,909
2024–25	37–40	115–118	2,081–2,485
2025 (provisional)	**-**	**-**	**2,485**

Sources: Directorate of Economics & Statistics, Odisha; CEIC Data

Key Observations:

- Area: Slight negative CAGR (-0.18%) over longer periods, stabilizing around 37–40 lakh ha.
- Production: Strong growth (CAGR of 1.76% over five decades, accelerated in recent 25 years), reaching record levels.
- Yield: Most significant driver — increased ~2.4 times from ~1,041 kg/ha in 2000–01 to 2,485 kg/ha in 2025.

Success Factors

- **Adoption of High-Yielding and Stress-Tolerant Varieties**: Varieties like Swarna Sub1 (submergence-tolerant), Sahabhagi Dhan (drought-tolerant), and others from NRRI and IRRI partnerships have been game-changers.
- **Government Schemes**: National Food Security Mission (NFSM), KALIA (farmer income support), rice fallow management programs, and subsidies on inputs/seeds. Procurement at MSP has provided market stability.
- **Irrigation and Mechanization Push**: Expansion of irrigation coverage and promotion of Direct Seeded Rice (DSR) and System of Rice Intensification (SRI).
- **Public-Private and International Collaboration**: Partnerships with IRRI for climate-resilient and biofortified (specialty) rice.
- **Policy Focus**: Emphasis on doubling farmers' income, crop diversification in rice fallows, and regenerative practices.

Issues and Challenges

Despite notable yield improvements over the last 25 years, rice productivity in Odisha continues to face multifaceted structural, biophysical, and socio-economic constraints. These challenges limit the realization of the state's full potential, contribute to yield instability, and threaten the long-term sustainability of rice-based farming systems. The following subsections provide a detailed examination of the major issues.

Climate Vulnerability

Odisha is one of the most climate-vulnerable states in India. Frequent floods, droughts, cyclones, and salinity intrusion severely affect rice cultivation. Approximately 31% of the rice area is prone to flooding, while 34% is drought-prone. Coastal districts regularly experience cyclones originating from the Bay of Bengal, which bring high winds, storm surges, and heavy rainfall, leading to submergence and salinity problems.

Climate change has intensified these risks. Studies show increasing temperature trends (approximately 0.05°C per season) and declining or erratic rainfall patterns (–16.5 mm per season in some analyses). These changes disrupt critical growth stages of rice, particularly flowering and grain filling. Kharif rice, which constitutes the bulk of production, is especially vulnerable because over 70% of the rice ecosystem is rainfed.

Recent examples include severe droughts in 2015–16 and 2017–18 that led to the declaration of drought in hundreds of blocks and significantly increased rice fallow areas. Cyclones like *Fani* (2019) and subsequent events have caused massive crop losses. Projections indicate that future climate scenarios could negatively impact net revenue from agriculture by the end of the 21st century. Rising minimum temperatures, erratic monsoon distribution, and extreme events exacerbate production risks, particularly for small and marginal farmers who lack adequate insurance coverage or adaptive capacity.

Rainfed Dominance and Irrigation Gaps

A defining characteristic of Odisha's rice cultivation is its heavy dependence on monsoon rains. Roughly 71% of the rice area is rainfed, with only about 29% under canal or assured irrigation. Although the state has expanded irrigation infrastructure, actual command area utilization remains low due to poor maintenance, siltation, and inefficient water distribution.

Uncontrolled irrigation in lowlands often leads to waterlogging, which degrades soil health and increases disease incidence. In contrast, upland and medium-land areas frequently suffer from moisture stress during dry spells. Delayed canal water release further constrains rabi

rice cultivation. Low irrigation efficiency, combined with climate variability, results in high yield instability and suboptimal productivity even in irrigated ecosystems.

Soil Health Degradation and Imbalanced Input Use

Prolonged rice cultivation has led to serious soil health issues. Many soils in Odisha suffer from low organic carbon, acidity, and multiple nutrient deficiencies (particularly phosphorus, zinc, and sulphur). Farmers often apply excessive nitrogen while under-applying phosphorus and potassium, leading to nutrient imbalances, reduced fertilizer use efficiency, and environmental problems such as leaching and greenhouse gas emissions.

Nutrient mining is widespread because of continuous cropping without adequate replenishment through organic sources. Long-term experiments show that imbalanced fertilizer use causes stagnation or decline in productivity over time. Soil degradation reduces water-holding capacity and microbial activity, further lowering resilience to climate stresses. Pest and disease pressure has also increased, partly due to imbalanced nutrition that makes plants more susceptible (e.g., brown planthopper, stem borer, bacterial leaf blight).

Fragmented Landholdings and Labour Shortages

Odisha has a large number of small and marginal farmers. As per the latest agricultural census data, the average operational landholding size has declined to approximately 0.95 hectares, with over 80% of holdings being small or marginal. High fragmentation increases production costs, restricts mechanization, and reduces economies of scale. Farmers incur higher transaction costs for inputs, irrigation, and marketing across scattered plots.

Rural-to-urban migration and non-farm employment opportunities have created acute labour shortages, particularly during peak periods such as transplanting and harvesting. Rising labour wages have increased the cost of cultivation, making traditional puddled transplanted rice less profitable. This has prompted interest in labour-saving methods like Direct Seeded Rice (DSR), but adoption remains uneven due to knowledge gaps and initial risks.

Low Cropping Intensity and Rice Fallows

One of the most significant underutilized opportunities in Odisha is the vast extent of rice fallows — lands left uncultivated after kharif rice harvest. Estimates vary between 1.6 to 2.2 million hectares in different studies, with recent figures indicating around 1–1.6 million hectares that could potentially be brought under rabi crops.

Major constraints include:

- Residual moisture stress
- Lack of suitable short-duration varieties
- Poor irrigation
- Low soil fertility
- Risk aversion among farmers

Districts such as Mayurbhanj, Balangir, Sundargarh, Bargarh, and Nabarangpur have large fallow areas. Low cropping intensity (significantly below the national average) means that the state's land resources are not fully exploited, limiting overall system productivity and farmer incomes.

Market and Post-Harvest Issues

While Minimum Support Price (MSP) procurement has strengthened for rice, it primarily benefits farmers in accessible areas and for standard varieties. Non-MSP produce faces price volatility and distress sales. Limited value addition, inadequate storage infrastructure at the farm level, and high post-harvest losses (estimated at 5–10% or more) reduce net returns. Processing facilities for specialty or biofortified rice remain underdeveloped, restricting opportunities for higher income through diversification into aromatic, nutritional, or export-oriented rice segments.

Weak market linkages and lack of farmer producer organizations (FPOs) in many regions further compound the problem, leaving smallholders vulnerable to middlemen exploitation.

Interconnected Nature of Challenges and Broader Implications

These challenges are deeply interlinked. Climate variability worsens rainfed risks and soil degradation; fragmentation and labour shortages hinder adoption of improved practices; and rice fallows reflect cumulative effects of moisture, irrigation, and varietal limitations. Together, they result in persistent yield gaps (often 1.5–2.5 tonnes/ha compared to attainable yields), income instability, and environmental degradation, including groundwater depletion in some pockets and greenhouse gas emissions from flooded fields.

Small and marginal farmers, women farmers, and tribal communities in rainfed and upland regions are disproportionately affected. These structural issues also contribute to rural distress, migration, and slower progress toward doubling farmers' incomes.

Addressing these challenges requires an integrated, systems approach that combines technological solutions (stress-tolerant varieties, precision nutrient management, mechanization), institutional reforms (strengthened extension, credit, and insurance), and policy support (rice fallow management, irrigation modernization, and market development). Without concerted action, the impressive yield gains of the last 25 years risk stagnation or reversal under accelerating climate pressures.

Way Forward: Policy and Research Recommendations

The impressive yield gains in rice productivity achieved in Odisha over the last 25 years provide a strong foundation for future progress. However, realizing the state's full potential requires a holistic, integrated, and climate-smart strategy that addresses structural constraints while leveraging technological, institutional, and market opportunities. The following recommendations are organized around key pillars, with specific, actionable policy and research interventions grounded in current programmes and emerging evidence.

Climate-Resilient Agriculture

Scaling climate-resilient practices must remain the cornerstone of Odisha's rice strategy. The state should accelerate the replacement of older varieties with multi-stress tolerant ones developed by ICAR-NRRI, IRRI, and OUAT. Varieties such as *Swarna Sub1*, *Sahbhagi Dhan*, and newer lines offering drought, flood, salinity, and submergence tolerance have already demonstrated impact and must reach 70–80% adoption in vulnerable zones within the next five years.

Key actions:

- Expand Direct Seeded Rice (DSR) and System of Rice Intensification (SRI) to at least 20–25% of the rice area, targeting water savings of 30–40% and labour reduction.
- Promote Alternate Wetting and Drying (AWD) techniques widely through demonstrations and incentives.
- Strengthen weather-based crop insurance (PMFBY) coverage and integrate it with hyper-local early warning systems using satellite data and mobile advisories.
- Invest in "Green Nutritious Super Rice" (GNSR) and biofortified varieties (high-zinc, high-protein, low-GI) to simultaneously address productivity, nutrition, and climate resilience.

IRRI's ongoing collaborations with the Odisha government, including decentralized seed production and specialty rice projects (targeting 15,000 farmers across selected districts), should be scaled statewide.

Rice Fallow Management

Bringing rice fallows under productive use offers the single largest opportunity for raising cropping intensity and farmer incomes. Odisha has approximately 16 lakh hectares of rice fallows, of which 10 lakh hectares are potentially cultivable using residual moisture.

The Comprehensive Rice Fallow Management (CRFM) programme has shown promising results, covering tens of thousands of hectares with pulses and oilseeds between 2023–2025. The state should set an ambitious target of bringing 4–6 lakh hectares under rabi pulses/oilseeds annually, supported by:

- Cluster demonstrations (minimum 20 ha) with quality seeds of short-duration, stress-tolerant varieties (e.g., green gram, black gram, chickpea, mustard, grasspea).
- Input kits, zero-tillage machinery, and moisture conservation techniques.
- Market linkages and MSP-like procurement for pulses and oilseeds.

Successful pilots by ICARDA, IRRI, and MSSRF indicate yield improvements of 28–35% in beneficiary plots. Integrating CRFM with micro-irrigation and solar pumps can further stabilize outcomes.

Sustainable Intensification and Soil Health Restoration

Long-term productivity depends on reversing soil degradation. The state should launch a comprehensive Soil Health Mission (already budgeted in recent years) with the following components:

- Mandatory soil testing and Nutrient Expert-based recommendations (building on IRRI's Rice Crop Manager tool, which has shown yield gains and fertilizer savings).
- Promotion of Integrated Nutrient Management (INM) — 75% inorganic + 25% organic, including green manuring with *dhaincha*, vermicompost, and biofertilizers.
- Large-scale adoption of precision agriculture tools (Leaf Colour Charts, Green Seeker, drone-based monitoring).
- Incentives for conservation agriculture practices such as residue retention and crop rotation.

Organic initiatives like *Amruta Anna* for aromatic rice linked to temple prasada should be expanded as models for premium markets.

Irrigation and Water Management Infrastructure

Despite progress, irrigation efficiency remains suboptimal. The government's plan to create an additional 15 lakh hectares of irrigation potential by 2029–30, including 2.77 lakh hectares in 2025–26 alone, is commendable.

Priorities:

- Completion of ongoing projects and full utilization of created potential through better command area development and canal lining.
- Rapid expansion of micro-irrigation (drip and sprinkler) to cover at least 1–2 lakh hectares of rice and rice-fallow areas.
- Promotion of solar-powered pumps and community solar irrigation models.
- Revival of traditional water bodies (check dams, farm ponds) under schemes like *Adibandh 3.0*.

Integrated water management, including AWD and real-time monitoring, should become standard in canal commands.

Mechanization, Skill Development, and Entrepreneurship

To counter labour shortages and rising costs, mechanization must be accelerated:

- Subsidies through Custom Hiring Centres (CHCs) and DBT for equipment suited to small holdings (power tillers, drum seeders, transplanters, harvesters, threshers).
- Special focus on women-friendly tools and training.
- Skill development programmes for youth in drone operation, precision machinery maintenance, and agri-entrepreneurship under *Mukhyamantri Krushi Udyog Yojana*.

Target: Mechanize at least 30–40% of transplanting and harvesting operations within five years.

Value Chain Development and Market Linkages

Moving beyond grain production to value addition is essential for income enhancement:

- Establish Specialty Rice Clusters for aromatic, biofortified, and export-quality rice with dedicated processing units (e.g., the proposed Specialty Rice and Millet Factory-cum-Training Centre in Bhubaneswar).
- Strengthen Farmer Producer Organizations (FPOs) and link them to e-NAM, contract farming, and export markets.
- Introduce quality-based premium pricing and incentives for nutritious varieties.
- Develop branding and GI tagging for traditional Odia rice landraces.

Strengthening Research-Extension-Farmer Linkages

- Adopt a farmer-participatory breeding approach for location-specific varieties.
- Scale digital extension (Rice Crop Manager, *Ama Krushi* portal, voice-based advisories) to reach every rice farmer.
- Establish robust seed systems with decentralized production by farmer groups and women SHGs.
- Foster stronger collaboration between NRRI, OUAT, IRRI, and line departments for rapid technology dissemination.

Diversification and Inclusive Income Support

Continue and refine the KALIA scheme while gradually linking payments to the adoption of sustainable practices (e.g., soil health cards, DSR, crop diversification). Promote integrated rice-based systems incorporating livestock, fisheries (e.g., rice-fish farming), and agroforestry to provide multiple income streams and enhance resilience.

Long-term Target (by 2035): Achieve a sustainable average rice yield of 3.5–4.0 tonnes/ha, raise cropping intensity to 180–200%, reduce yield gaps by 50%, and double real farmer incomes from rice-based systems while lowering greenhouse gas emissions and improving soil health.

Implementation Framework

Success requires convergence of schemes (NFSM, PMKSY, RKVY, KALIA, CRFM, etc.), robust monitoring with GIS and digital dashboards, adequate budgetary support, and public-private-civil society partnerships. A dedicated Rice Mission or strengthening of the existing Directorate with outcome-based targets is recommended.

Odisha has the agro-ecological diversity, research institutions, and policy commitment to emerge as a model for climate-resilient, sustainable, and inclusive rice production in eastern India. Transforming challenges into opportunities through science-led, farmer-centric, and market-oriented interventions will secure food security, nutritional well-being, and rural prosperity for generations to come.

Conclusion

Over the last 25 years (2000–2025), Odisha has witnessed a remarkable transformation in rice productivity that

stands as one of the most significant success stories in eastern Indian agriculture. From a modest average yield of around 1.0–1.2 tonnes per hectare in the early 2000s, the state has successfully raised productivity to approximately 2.3–2.485 tonnes per hectare by the mid-2020s. This more than doubling of yield, achieved largely through technological interventions and policy support rather than area expansion, has enabled rice production to consistently cross the 100–118 lakh tonne mark in recent years. This yield-led growth has not only strengthened the state's contribution to India's central food grain pool but has also enhanced rural food security and provided greater stability to millions of farming households.

The progress reflects the combined impact of several enabling factors. The widespread adoption of climate-resilient varieties such as *Swarna Sub1* (submergence tolerant) and *Sahbhagi Dhan* (drought tolerant), developed through strong partnerships between ICAR-National Rice Research Institute (NRRI), International Rice Research Institute (IRRI), and Odisha University of Agriculture and Technology (OUAT), has been transformative. These varieties have performed remarkably well in the state's flood- and drought-prone ecosystems. Complementary policy initiatives, particularly the **KALIA** scheme, National Food Security Mission (NFSM), rice fallow management programmes, and robust Minimum Support Price (MSP) procurement, have provided the necessary financial cushion and market assurance to small and marginal farmers. The expansion of irrigation potential, promotion of improved agronomic practices like System of Rice Intensification (SRI) and Direct Seeded Rice (DSR), and increasing mechanization have further supported this upward trajectory.

These achievements are particularly noteworthy because they occurred against the backdrop of formidable natural challenges. Odisha's rice cultivation has always been vulnerable to the vagaries of the monsoon, recurrent cyclones from the Bay of Bengal, and the complexities of a predominantly rainfed production system. The fact that productivity has nearly doubled despite these constraints demonstrates the resilience and adaptive capacity of Odisha's farmers, researchers, and policymakers.

However, this progress remains fragile. As detailed in earlier sections, several deep-rooted challenges continue to constrain the full realization of Odisha's rice potential. Climate change has intensified the frequency and severity of extreme weather events, with floods affecting nearly 31% and droughts impacting 34% of the rice area. Large tracts of rice fallows (estimated between 1.6–2.2 million hectares), soil degradation due to nutrient mining and imbalanced fertilizer use, fragmented landholdings, rising labour shortages, inefficient irrigation, and limited value addition continue to impose structural limitations. Low cropping intensity, persistent yield gaps, and high vulnerability of small and marginal farmers — who constitute over 80% of the farming community — underscore the need for urgent and sustained action.

The future of rice in Odisha, therefore, hinges on moving beyond incremental yield gains toward **sustainable intensification** and **system-level resilience**. The way forward proposed in this paper — scaling climate-smart practices, aggressive rice fallow management, soil health restoration, accelerated mechanization, value chain development, and stronger research-extension-farmer linkages — offers a comprehensive roadmap. Achieving an average yield of 3.5–4.0 tonnes per hectare by 2035, while simultaneously raising cropping intensity to 180–200% and improving soil health and water-use efficiency, is an ambitious but attainable target. This will require convergence of ongoing schemes, increased investment in infrastructure, and innovative public-private-civil society partnerships.

A science-led, climate-resilient, and farmer-centric approach is essential. Odisha is uniquely positioned to become a national and global leader in sustainable rice production. With its rich agro-biodiversity, established research institutions (especially NRRI at Cuttack), vast rainfed and stress-prone areas, and progressive policy framework, the state can serve as a model for climate-smart agriculture in vulnerable tropical regions. Success here would have far-reaching implications not only for eastern India but also for other rainfed rice ecosystems across South and Southeast Asia facing similar challenges from climate change.

The transition must also address equity and inclusiveness. Special attention needs to be paid to women farmers, tribal communities in western and southern Odisha, and the most marginalised sections. Integrating nutrition-sensitive agriculture through biofortified and specialty rice varieties can simultaneously tackle productivity, income, and hidden hunger. Linking rice production with allied activities such as livestock, inland fisheries (rice-fish systems), and agroforestry will create diversified and resilient livelihood portfolios.

From a broader perspective, Odisha's rice sector is intricately linked with several Sustainable Development Goals (SDGs): Zero Hunger (SDG 2), Climate Action (SDG 13), Responsible Consumption and Production (SDG 12), and Life on Land (SDG 15). By pursuing a low-emission, resource-efficient, and inclusive growth path, the state can contribute meaningfully to India's national commitments under the Paris Agreement while securing rural livelihoods.

In conclusion, the journey of rice productivity in Odisha over the past 25 years offers both inspiration and

important lessons. It demonstrates that even in highly challenging agro-ecological conditions, determined policy support combined with scientific innovation can deliver substantial gains. However, the coming decades will test the state's ability to convert these gains into a truly sustainable, resilient, and prosperous rice economy.

If Odisha successfully implements the recommendations outlined — balancing productivity with sustainability, technology with tradition, and growth with equity — it can not only secure its own food and nutritional future but also emerge as a beacon of hope for climate-vulnerable rice-growing regions worldwide. The state possesses the natural resources, knowledge base, institutional strength, and policy intent. What is now required is coordinated, consistent, and long-term commitment from all stakeholders to translate this vision into reality.

The future of Odisha's rice sector is not merely about producing more grain. It is about nurturing resilient ecosystems, empowering farming communities, preserving cultural heritage, and building a sustainable foundation for rural prosperity. With vision, collaboration, and urgency, Odisha can truly claim its place as a leader in sustainable rice production in the 21st century.

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