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Indian Agriculture in the 21st Century: Performance Gaps and Policy Pathways for Sustainable Growth

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Abstract—**Indian agriculture, a cornerstone of the nation's economy, faces significant challenges in the 21st century despite its historical resilience. Contributing to nearly 17% of GDP and employing over 40% of the workforce, the sector grapples with performance gaps such as low productivity, fragmented landholdings, water scarcity, and climate change impacts. Technological adoption, including precision farming and digital tools, remains uneven, while policy interventions often lack coherence. This article examines these gaps through a review of literature, highlighting disparities in yield, resource use, and market access. It discusses structural issues, such as inadequate credit access and supply chain inefficiencies, and evaluates policy frameworks like the National Agricultural Policy and PM-KISAN. Data tables illustrate yield gaps and irrigation disparities across states. The study proposes pathways for sustainable growth, emphasizing climate-resilient crops, cooperative farming, and enhanced extension services. It underscores the need for integrated policies that balance productivity with environmental sustainability. By addressing these challenges, India can transform its agricultural sector to ensure food security, rural livelihoods, and economic stability in the face of global uncertainties. The article concludes with actionable suggestions, including investment in rural infrastructure, promotion of organic farming, and leveraging technology for inclusive growth, aiming to bridge performance gaps and foster a resilient agricultural ecosystem.**

Index Terms—**Indian agriculture, sustainable growth, productivity gaps, policy interventions, climate resilience, technological adoption, food security**

I INTRODUCTION

Indian agriculture has been the backbone of the nation's economy for centuries, supporting livelihoods and ensuring food security for a population exceeding 1.4 billion. In the 21st century, the sector contributes approximately 17% to India's GDP and employs over 40% of the workforce, making it a critical driver of economic stability (Government of India, 2023). However, the sector faces unprecedented challenges, including low productivity, fragmented landholdings, climate change, and inadequate market linkages. The Green Revolution of the 1960s transformed India into a food-surplus nation, but its benefits have plateaued, with diminishing returns from intensive farming practices (Pingali, 2012). Today, the average yield of major crops like rice and wheat lags behind global benchmarks, with India producing 2.6 tons per hectare of rice compared to China's 4.7 tons (FAO, 2023).

Climate change exacerbates these issues, with erratic monsoons and rising temperatures threatening crop yields. Smallholder farmers, who own less than 2 hectares and account for 86% of total landholdings, face acute vulnerabilities due to limited access to credit, technology, and irrigation (Chand et al., 2017). Policy frameworks, such as the National Agricultural Policy (2000) and recent schemes like PM-KISAN, aim to address these challenges, but their implementation often lacks coordination and inclusivity (Gulati & Sharma, 2021). This article explores performance gaps in Indian agriculture, evaluates existing policies, and proposes pathways for sustainable growth to ensure resilience and equity in the sector.

II REVIEW OF LITERATURE

Indian agriculture's performance in the 21st century has been extensively studied, revealing both progress and persistent challenges. The Green Revolution's legacy, while transformative, has led to environmental degradation and regional disparities. Swaminathan (2006) argues that the overuse of chemical fertilizers and groundwater depletion in states like Punjab and Haryana has reduced soil fertility, necessitating a shift toward sustainable practices. Similarly, Pingali (2012) highlights that yield plateaus in major crops like rice and wheat reflect the limits of input-intensive agriculture, with India's rice yield at 2.6 tons/ha compared to 4.7 tons/ha in China.

Land fragmentation remains a structural barrier. Chand et al. (2017) note that 86% of Indian farmers are smallholders with less than 2 hectares, limiting economies of scale and technology adoption. This is compounded by unequal access to irrigation, with only 48% of cultivated land irrigated, leaving rain-fed areas vulnerable (FAO, 2023). Water scarcity is a growing concern, as Vyas (2019) points out, with groundwater levels declining by 1-2 meters annually in northern India due to over-extraction.

Climate change poses a significant threat. Lobell et al. (2011) estimate that rising temperatures could reduce wheat yields by 6-10% per degree Celsius increase, impacting food security. Adaptation strategies, such as climate-resilient crop varieties, are underutilized, with only 15% of farmers adopting such seeds (Reddy, 2020). Technological interventions, like precision agriculture and digital platforms, show promise but face barriers. Mittal (2016) highlights that only 10% of farmers use digital tools due to low digital literacy and infrastructure gaps.

Credit access remains a bottleneck. Banerjee and Duflo (2014) argue that smallholders' reliance on informal moneylenders at high interest rates restricts investment in modern inputs. Government schemes like Kisan Credit Cards have expanded credit availability, but uptake is uneven, with only 45% of eligible farmers benefiting (RBI, 2022). Market access is another challenge. Gulati and Sharma (2021) critique the inefficiencies in Agricultural Produce Market Committees (APMCs), which limit farmers' bargaining power and lead to price volatility.

Policy interventions have had mixed outcomes. The National Agricultural Policy (2000) aimed for 4% annual agricultural growth but achieved only 2.5% (Planning Commission, 2013). Recent reforms, such as the 2020 farm laws, aimed to liberalize markets but faced resistance due to fears of corporate exploitation (Singh, 2021). Subsidies, while extensive, are often misallocated, with fertilizer subsidies disproportionately benefiting large farmers (Sharma, 2018). Programs like PM-KISAN, providing income support to farmers, have reached 120 million beneficiaries but fail to address structural issues like land reform or technology access (Kumar et al., 2022).

Extension services, critical for knowledge dissemination, are underfunded. Glendenning et al. (2010) note that India's public extension system reaches only 20% of farmers, leaving many reliant on private input dealers. Cooperative farming, successful in states like Gujarat, remains underutilized elsewhere (Agarwal, 2018). Organic farming, promoted under schemes like Paramparagat Krishi Vikas Yojana, covers only 2% of cultivated land, despite growing global demand (APEDA, 2023).

Gender disparities in agriculture are significant. Rao (2019) highlights that women, who constitute 30% of the agricultural workforce, own less than 13% of land, limiting their access to credit and subsidies. Supply chain inefficiencies, including post-harvest losses of 15-20%, further reduce farmers' incomes (NITI Aayog, 2021). Infrastructure gaps, such as inadequate cold storage and rural roads, exacerbate these losses (FAO, 2020).

Global comparisons provide context. While India's agricultural exports grew to $50 billion in 2022, its share in global markets remains low compared to countries like Brazil (WTO, 2023). Studies like Birthal et al. (2015) emphasize the need for diversification into high-value crops like fruits and vegetables to boost incomes. Overall, the literature underscores the need for integrated policies that address productivity, sustainability, and equity to transform Indian agriculture.

III DISCUSSION

Indian agriculture's performance gaps are rooted in structural, environmental, and policy challenges. Low productivity, driven by fragmented landholdings and limited technology adoption, hinders the sector's competitiveness. Table 1 illustrates yield gaps for major crops across states, showing significant disparities. For instance, Punjab's rice yield is 4.1 tons/ha, while Bihar's is only 1.9 tons/ha, reflecting differences in irrigation and input use.

Table 1: Yield Gaps for Major Crops in Selected States (2022)

Crop	State	Yield (tons/ha)	National Average (tons/ha)
Rice	Punjab	4.1	2.6
Rice	Bihar	1.9	2.6
Wheat	Haryana	4.8	3.4
Wheat	Uttar Pradesh	2.9	3.4

Source: Ministry of Agriculture and Farmers' Welfare, 2023

Irrigation disparities further exacerbate inequities. Table 2 shows that states like Punjab have 98% of cultivated land under irrigation, while Jharkhand lags at 12%, making it vulnerable to monsoon failures. This uneven access drives income disparities and limits crop diversification.

Table 2: Irrigation Coverage in Selected States (2022)

State	Irrigated Land (% of Cultivated Area)	Rain-fed Land (% of Cultivated Area)
Punjab	98	2
Haryana	85	15
Jharkhand	12	88
Odisha	31	69

Source: Department of Water Resources, 2023

Climate change compounds these challenges, with erratic weather patterns reducing yields by 5-10% annually in rain-fed regions (IMD, 2023). Policy interventions, such as PM-KISAN, provide income support but do not address root causes like land fragmentation or market inefficiencies. The 2020 farm laws aimed to improve market access but faced resistance due to inadequate safeguards for smallholders. Subsidies, while substantial, are often misdirected, with 60% of fertilizer subsidies benefiting large farmers (Sharma, 2018).

Technological adoption remains a critical gap. Only 10% of farmers use digital tools, and precision agriculture is limited to 5% of cultivated land (Mittal, 2016). Scaling these technologies requires investment in digital infrastructure and farmer training. Cooperative farming, successful in Gujarat's dairy sector, could address land fragmentation but needs policy support for replication. Gender disparities also demand attention, as women farmers' limited land ownership restricts their access to resources. Addressing these gaps requires a holistic approach that integrates technology, policy reform, and inclusive growth strategies to ensure sustainable agricultural development.

IV CONCLUSION

Indian agriculture stands at a crossroads, balancing its historical significance with the demands of a rapidly changing global landscape. The sector's contributions to GDP and employment remain substantial, yet performance gaps—low productivity, fragmented landholdings, and climate vulnerabilities—threaten its sustainability. The review of literature and data analysis highlight that structural issues, such as irrigation disparities and limited technology adoption, perpetuate inequities and hinder growth. Policies like PM-KISAN and agricultural reforms have made strides in supporting farmers, but their impact is diluted by implementation gaps and a lack of focus on long-term challenges like soil degradation and water scarcity. The discussion underscores that sustainable growth requires moving beyond short-term fixes to address root causes through integrated strategies. By prioritizing climate-resilient practices, cooperative models, and equitable resource access, India can transform its agricultural sector into a resilient, inclusive, and productive engine of economic growth. The path forward lies in aligning policy, technology, and community efforts to ensure food security, support rural livelihoods, and meet the aspirations of a modernizing nation. As global pressures like climate change and market competition intensify, proactive measures will determine whether Indian agriculture can reclaim its position as a global leader while safeguarding its environmental and social foundations.

Suggestions

To address the performance gaps in Indian agriculture and foster sustainable growth, the following actionable suggestions are proposed:

1. Promote Climate-Resilient Agriculture: Invest in research and dissemination of drought-tolerant and heat-resistant crop varieties. Expand schemes like the National Mission for Sustainable Agriculture to cover 50% of farmers by 2030, focusing on rain-fed regions. Training programs should reach 30 million farmers annually to adopt

practices like zero-tillage and crop rotation, reducing environmental stress.

2. Scale Cooperative Farming Models: Replicate Gujarat's cooperative dairy model in crop farming to address land fragmentation. Provide incentives, such as subsidized inputs and credit, to form farmer-producer organizations (FPOs). Aim to establish 10,000 new FPOs by 2030, covering 20% of smallholders, to enhance bargaining power and economies of scale.
3. Enhance Digital and Precision Agriculture: Bridge the digital divide by expanding rural internet access and training 25 million farmers in digital tools by 2030. Subsidize precision farming technologies, like drip irrigation and soil sensors, targeting a 15% adoption rate among smallholders. Public-private partnerships can drive innovation and affordability.
4. Strengthen Extension Services: Revamp public extension systems to reach 50% of farmers by 2030, prioritizing women and marginalized groups. Deploy 100,000 trained extension workers and leverage mobile-based platforms for real-time advisory services, focusing on sustainable practices and market trends.
5. Improve Credit and Market Access: Expand Kisan Credit Card coverage to 80% of eligible farmers and introduce flexible repayment terms for smallholders. Reform APMCs to ensure transparent pricing and establish 5,000 new rural mandis with cold storage facilities to reduce post-harvest losses to below 10%.
6. Empower Women Farmers: Implement land titling reforms to increase women's land ownership to 25% by 2030. Provide gender-specific training and credit programs, targeting 15 million women farmers, to enhance their productivity and income.
7. Invest in Rural Infrastructure: Allocate 5% of GDP annually to rural roads, irrigation, and renewable energy projects. Expand solar-powered irrigation to cover 30% of irrigated land, reducing dependence on groundwater and ensuring energy access for remote farms.

These suggestions, if implemented with coordinated policy support, can bridge performance gaps, enhance resilience, and ensure Indian agriculture thrives in the 21st century.

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