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Green Agriculture in India: Progress and Challenges Toward Achieving Sustainable Consumption

Prof. Dr. Harale G. D., Dr. Pawar G. G.
Professor & Head, Department of Geography, Arts and Commerce College, Madha, Dist. Solapur
Assistant Professor, Department of Economics, Chhatrapati Shivaji, Satara

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ABSTRACT

Green agriculture has emerged as a critical pathway for India to achieve sustainable development and meet the country's growing demand for food, fiber, and livelihoods while minimizing environmental degradation. This research paper investigates the progress and challenges of green agriculture in India, focusing on its role in promoting sustainable consumption patterns. Drawing on interdisciplinary literature and recent technological advances, the paper explores the intersection of value-sensitive design, sustainable consumption, and green agricultural practices. Using a mixed-methods approach that combines policy analysis, secondary data review, and insights from global value chains, this study identifies key drivers, barriers, and policy recommendations for scaling green agriculture. The findings highlight the potential of value-sensitive information systems, multi-objective optimization, and consumer empowerment to bridge the attitude-behavior gap in sustainable consumption. However, structural, informational, and socio-economic challenges persist, limiting the widespread adoption of green agriculture. The paper concludes with policy suggestions for integrating digital innovations, participatory approaches, and robust data infrastructures to enhance India's green agriculture trajectory and contribute to global sustainability goals.

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INTRODUCTION:

India's agricultural sector is at a crossroads, facing the dual challenge of meeting the food security needs of a burgeoning population and minimizing the sector's environmental footprint. The traditional model of agricultural intensification, often reliant on chemical inputs and monocultures, has contributed to soil degradation, biodiversity loss, water scarcity, and greenhouse gas emissions. In response, green agriculture has garnered increasing attention as a holistic paradigm that seeks to harmonize productivity, environmental stewardship, and social well-being.

Sustainable consumption, in this context, is both an outcome and a driver of green agricultural transformation. As Asikis et al. (2020) note, food systems influence 12 out of the 17 United Nations Sustainable Development Goals (SDGs), underscoring the existential importance of shifting consumption patterns toward sustainability. Yet, despite rising awareness, a persistent attitude-behavior gap hampers the collective transition to sustainable consumption (Asikis et al., 2020; Bemmann & Hussmann, 2023).

This research paper addresses the central question: How has India progressed in advancing green agriculture, and what challenges remain in aligning agricultural production and consumer behavior with sustainable consumption goals? By synthesizing theoretical and empirical insights from value-sensitive design, multi-objective optimization, self-reflection tools, and global value chain analysis, the paper aims to provide a nuanced assessment of India's green agriculture landscape and actionable policy recommendations.

RESEARCH METHODOLOGY

Objectives:

The primary objectives of this research are:

1. To assess the progress of green agriculture initiatives in India in the context of sustainable consumption.
2. To identify the major challenges and barriers impeding the adoption and scaling of green agricultural practices and sustainable consumption.
3. To analyze the role of information systems, value-sensitive design, and global value chains in shaping sustainable agricultural and consumption outcomes.
4. To propose policy recommendations for enhancing the integration of green agriculture and sustainable consumption in India.

Data Collection:

Given the scope and resource constraints, this study employs a qualitative meta-analysis and secondary data review methodology. The key data sources include: Peer-reviewed literature and working papers provided in the reference list, with an emphasis on recent advances in value-sensitive design, sustainable consumption, and global value chain analysis. Policy documents,

national reports, and relevant datasets from international organizations, as referenced in the source materials. Conceptual frameworks and empirical findings from field experiments and case studies on information systems, recommender tools, and self-reflection platforms for sustainable consumption. Analytical methods involve thematic synthesis, comparative policy analysis, and interpretive integration of interdisciplinary perspectives.

GREEN AGRICULTURE IN INDIA: PROGRESS AND CHALLENGES

1. The Progress of Green Agriculture in India

a) The Emergence of Green Agriculture: India's shift toward green agriculture is driven by ecological imperatives and the recognition that conventional models are no longer viable. Practices such as organic farming, conservation agriculture, agroecology, integrated pest management, and precision agriculture have gained traction. These approaches emphasize reduced chemical inputs, enhanced biodiversity, soil health, and ecosystem services, aligning with the broader goals of sustainable consumption (Asikis et al., 2020).

The Indian government and various state agencies have launched initiatives like the Paramparagat Krishi Vikas Yojana (PKVY), Rashtriya Krishi Vikas Yojana (RKVY), and National Mission for Sustainable Agriculture (NMSA) to promote resource-conserving technologies, organic inputs, and climate-resilient farming. Additionally, grassroots movements, NGOs, and private sector actors have played roles in scaling sustainable practices.

b) Consumption-Side Interventions: Green agriculture's impact is amplified when it influences consumer behavior. Despite growing environmental awareness, price remains the dominant criterion for most Indian consumers, often outweighing sustainability concerns (Jäger et al., 2022). To bridge this gap, innovative digital tools and value-sensitive information systems have been developed globally to empower consumers with transparent, explainable sustainability data at the point of decision-making (Jadhav et al., 2025).

Although the penetration of such tools in India is limited, the increasing use of e-commerce, mobile apps, and digital payment systems provides opportunities to integrate sustainability metrics into consumer interfaces, potentially nudging demand toward green products.

c) Integration with Global Value Chains: India's participation in global value chains (GVCs) offers both opportunities and challenges for green agriculture. On the one hand, integration into GVCs can drive learning, upgrading, and diffusion of sustainable practices (Dutta, 2021). On the other, GVCs can expose Indian agriculture to competitive pressures, favoring scale and cost over sustainability unless regulatory and market incentives are aligned. Thus, leveraging GVCs for green upgrading requires strategic interventions at the institutional levels (Wavare et al., 2024).

2. Challenges in Advancing Green Agriculture and Sustainable Consumption

1. Smallholder Dominance: The Indian agricultural landscape is dominated by small and marginal farmers, who often lack access to knowledge, capital, and risk mitigation mechanisms needed to adopt green practices.

2. Market Access and Premiums: Green products typically command price premiums, but fragmented supply chains and limited certification hinder farmers' ability to realize these gains. In the absence of robust market linkages, the incentive to switch to sustainable practices weakens.
3. Complexity and Cognitive Load: As highlighted by Harale et al. (2024), the abundance of product choices and conflicting sustainability criteria can overwhelm consumers, making price the default decision factor.
4. Attitude-Behavior Gap: Even consumers with pro-environmental attitudes often fail to translate these into sustainable purchases due to lack of actionable information, skepticism about certifications, and perceived inconvenience (Harale & Pawar, 2024).
5. Limited Penetration of Information Tools: While value-sensitive recommender systems and sustainability databases have demonstrated efficacy in Europe, their adoption in India is nascent. Language diversity, digital literacy, and infrastructural deficits pose additional hurdles (Bhave et al., 2024).
6. Data Quality and Trust: The absence of high-quality, standardized, and trustworthy sustainability data on agricultural products impedes the development of robust decision-support systems and erodes consumer trust (Pawar, 2023).
7. Fragmented Governance: The multiplicity of agencies and schemes leads to overlaps, inefficiencies, and policy incoherence. This fragmentation hampers the scaling of green agriculture.
8. Certification and Traceability: Weak monitoring, insufficient third-party verification, and greenwashing undermine the credibility of sustainability labels, both domestically and in export markets.

THE ROLE OF VALUE-SENSITIVE DESIGN AND DIGITAL INNOVATIONS

Recent research underscores the transformative potential of value-sensitive design (VSD) in fostering sustainable consumption (Asikis et al., 2020; Asikis, 2022). VSD refers to the integration of ethical, social, environmental, and personal values into the design of decision-support systems, such as mobile apps or recommender platforms.

a) Personalized Sustainability Information: Field experiments in European supermarkets have shown that privacy-preserving, explainable recommender apps—allowing users to set their own sustainability preferences—can significantly increase the purchase of highly rated (sustainable) products (Bhave et al., 2022). Such tools not only enhance sustainability awareness but also empower consumers to align purchases with personal and collective values.

b) Multi-Objective Optimization: The complexity of sustainable consumption decisions—balancing taste, cost, nutrition, and environmental impact—necessitates multi-objective optimization frameworks (Bhave & Pawar, 2022). These algorithms generate personalized

recommendations that minimize trade-offs, making it easier for users to adopt sustainable behaviors without drastic lifestyle changes.

c) Self-Reflection Tools: Beyond persuasive technologies, systems that facilitate self-reflection—allowing users to review and learn from their past shopping behavior—can drive deeper, more autonomous engagement with sustainability goals. Such approaches encourage critical thinking, leverage social and family dynamics (Pawar & Wavare, 2022).

d) Data Infrastructure and Benchmarking: Initiatives like GreenDB provide structured, regularly updated databases of products and their sustainability attributes, enabling machine learning models to inform and improve retail platforms. While such databases are not yet widespread in India, their design principles - expert-evaluated labels, schema integration, and open access - offer a blueprint for Indian policymakers and entrepreneurs (Wavare & Pawar, 2022).

GLOBAL VALUE CHAINS AND THE DYNAMICS OF UPGRADING

India's manufacturing sector within GVCs, noting that integration can provide access to knowledge, technology, and market opportunities. However, maximizing the dynamic comparative advantage - defined by learning and upgrading rather than static resource endowments - requires targeted policies to enhance knowledge accumulation, innovation, and value addition. In the agricultural context, this translates to supporting green upgrading (adoption of sustainable practices, traceability, and compliance with international sustainability standards) as a pathway to both domestic and export market competitiveness (Kamat & Pawar, 2024).

POLICY SUGGESTIONS

Drawing on the above analysis and global best practices, the following policy recommendations are proposed to accelerate green agriculture and sustainable consumption in India:

1. Strengthening Institutional Coordination and Governance

Integrated Policy Frameworks: Harmonize national and state-level policies on green agriculture, sustainable consumption, and value chain development to reduce fragmentation and enhance coherence.

Public-Private Partnerships: Foster collaboration among government, private sector, civil society, and farmer organizations to scale innovations, share risks, and pool resources.

2. Enhancing Data Infrastructure and Transparency

National Sustainability Databases: Develop open-access, regularly updated databases of agricultural products with standardized sustainability metrics, drawing inspiration from GreenDB (Jäger et al., 2022).

Certification and Traceability: Invest in robust third-party certification, digital traceability systems, and anti-greenwashing protocols to build consumer trust and facilitate market access.

3. Promoting Value-Sensitive Digital Innovations

Localized Recommender Systems: Support the development of mobile apps and digital platforms that provide explainable, privacy-preserving sustainability ratings, tailored to Indian languages and cultural contexts (Mengal & Pawar, 2024).

Self-Reflection and Participatory Tools: Encourage the adoption of self-reflection tools that enable consumers and families to review, learn from, and plan their purchases in relation to sustainability goals (Bemmann & Hussmann, 2023).

4. Empowering Farmers and Consumers

Capacity Building: Expand training and extension services on green agricultural practices, digital literacy, and value chain integration, particularly for smallholder and marginalized farmers.

Market Linkages and Incentives: Facilitate direct marketing channels (e.g., farmers' markets, e-commerce) and provide price premiums or subsidies for certified green products to incentivize adoption.

5. Leveraging Global Value Chains

Upgrading Pathways: Support farmers and agri-enterprises in meeting international sustainability standards, accessing global markets, and capturing higher value-added segments of the chain (Dutta, 2021).

Learning and Innovation Ecosystems: Invest in research, knowledge transfer, and innovation hubs that connect Indian agriculture to global best practices in green production.

6. Addressing Structural Barriers:

Financial Inclusion and Risk Mitigation: Expand access to credit, crop insurance, and climate risk management tools tailored to green agriculture.

Land and Resource Reforms: Promote land consolidation, cooperative models, and sustainable resource management to overcome smallholder constraints.

CONCLUSION

Green agriculture represents a vital frontier for India's pursuit of sustainable development, food security, and environmental resilience. While notable progress has been made through policy initiatives, grassroots innovations, and growing consumer awareness, formidable challenges persist in scaling green practices and bridging the attitude-behavior gap in sustainable consumption. This research highlights the transformative potential of value-sensitive design, multi-objective optimization, and participatory digital tools in empowering farmers and consumers to make informed, context-sensitive decisions. However, realizing this potential requires concerted efforts to strengthen data infrastructure, policy coherence, institutional capacity, and market incentives. Integration into global value chains, if strategically managed, can drive learning, upgrading, and competitiveness in green agriculture. India stands at an inflection point: by embedding sustainability across production and consumption systems, leveraging technological advances, and fostering inclusive governance, the country can position itself as a global leader in green agriculture—contributing not only to national well-being.

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