Regenerative Agriculture in India: A Pathway towards Sustainable and Resilient Farming

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ABSTRACT

Indian agriculture faces mounting challenges arising from soil degradation, increasing input dependency, and heightened exposure to climate variability, which collectively threaten long-term farm sustainability (Food and Agriculture Organization of the United Nations, 2017; Rockström *et al*., 2009). This review examines regenerative agriculture as a systems-oriented farming approach that focuses on restoring soil biological functions, enhancing soil organic carbon, and improving agro-ecosystem resilience (Lal, 2020; Montgomery, 2017). Drawing upon national and international literature, the paper discusses the relevance of regenerative practices for India's small and marginal farming systems, outlines major practices adopted across diverse agro-ecological regions, and identifies key institutional and economic barriers to adoption. The analysis indicates that regenerative agriculture holds substantial potential to support sustainable productivity, climate resilience, and long-term livelihood security in Indian agriculture (Gosnell *et al*., 2019; FAO, 2021).

INTRODUCTION

Agriculture in India has been central to national food availability and rural livelihoods, supported largely by input-intensive production systems involving chemical fertilizers, pesticides, assured irrigation, and improved crop varieties

(Evenson & Gollin, 2003; Pingali, 2012). While these interventions substantially increased output and ensured food security, their prolonged and widespread use has exerted considerable pressure on natural resources (Tilman *et al*., 2002; Pretty, 2008). Declining soil quality, depletion of groundwater reserves, erosion of biological diversity, and heightened sensitivity of farming systems to climatic variability are now evident across many regions of the country (FAO, 2017; Lobell *et al*., 2011; Rockström *et al*., 2009).

What is Regenerative Agriculture?

Regenerative agriculture refers to a systems-based approach to farming that prioritizes the recovery and strengthening of soil functions, ecological interactions, and on-farm stability (Rhodes, 2017; LaCanne & Lundgren, 2018). Rather than focusing solely on maximizing output through external inputs, it seeks to enhance soil organic carbon, stimulate beneficial biological processes, and support self-regulating nutrient dynamics within the agro-ecosystem (Lal, 2020; Montgomery, 2017).

This approach integrates principles from agroecology and conservation-oriented land management, while also drawing upon time-tested indigenous and traditional farming practices (Altieri, 2018; Pretty, 2008). By aligning crop production with natural processes, regenerative agriculture aims to create resilient farming systems capable of sustaining productivity over the long term, while simultaneously improving environmental integrity and climate adaptability (Gosnell *et al*., 2019; FAO, 2021).

Why Regenerative Agriculture is Important for India

The relevance of regenerative agriculture in India is closely linked to the predominance of small and marginal landholdings, which account for the majority of the country's farming systems (Agricultural Census, 2015–16). In these systems, rising input costs, declining factor productivity, and increasing environmental stress have significantly reduced profit margins and heightened production risks (Pingali, 2012; Narayanamoorthy, 2013). Continuous degradation of soil resources, declining soil organic carbon, and inefficient use of water further constrain agricultural productivity, particularly in rainfed and resource-poor regions that are highly vulnerable to climate variability (Lal, 2015; Rockström *et al*., 2009).

Regenerative farming practices address these challenges by rebuilding soil fertility, improving soil structure and moisture retention, and enhancing the adaptive capacity of crops to climatic stress (Montgomery, 2017; Lal, 2020). By reducing dependence on purchased chemical inputs and promoting biologically driven nutrient cycling, regenerative agriculture contributes to lower cost of cultivation and greater resilience of farm enterprises (Pretty *et al*., 2018). Moreover, the stabilization of yields under uncertain weather conditions supports income stability, risk reduction, and long-term livelihood security for farming households, making regenerative agriculture particularly relevant for sustainable agricultural development in India (Gosnell *et al*., 2019; FAO, 2021).

Major Regenerative Practices in India

A range of farming approaches currently practiced in different parts of the country reflect the core principles of regenerative agriculture. These include natural farming models such as Zero Budget Natural Farming (ZBNF), input-minimizing organic and biodynamic systems, and conservation-oriented practices that emphasize minimal soil disturbance, diversified crop rotations, and retention of crop residues (Palekar, 2016;

Kassam *et al*., 2019). In addition, agroforestry-based land-use systems and integrated watershed management strategies play a significant role in restoring soil health, enhancing carbon sequestration, and improving water-use efficiency (Nair, 2011; Wani *et al*., 2009).

Field-level experiences and pilot programmes implemented in states such as Andhra Pradesh, Odisha, and Maharashtra, along with several agro-ecologically diverse regions of North-Eastern India, have reported positive outcomes in terms of soil quality improvement, reduced input dependency, and enhanced system sustainability (FAO, 2018; Reddy *et al*., 2020; ICAR, 2021). These initiatives demonstrate the potential of regenerative practices to improve farm resilience and ecological stability under diverse Indian farming conditions.

Challenges in Adoption

Although regenerative agriculture offers significant ecological and economic advantages, its wider adoption remains constrained by several interrelated factors. Limited access to reliable information, weak extension services, and inadequate technical guidance restrict farmer awareness and understanding of regenerative principles, particularly among small and marginal farmers (Feder, Just & Zilberman, 1985; Pretty *et al*., 2018). Moreover, the absence of standardized and widely accepted indicators for measuring soil health regeneration, ecosystem services, and long-term productivity makes it difficult to assess regenerative outcomes in clear and quantifiable terms (Giller *et al*., 2021).

During the transition phase, farmers may also face perceived or actual production risks arising from yield variability and delayed benefits, which can discourage early adoption (Knowler & Bradshaw, 2007). In addition, insufficient market recognition and price premiums for sustainably produced commodities, along with the continued institutional emphasis on chemical input–based subsidy and procurement systems, reduce economic incentives for change (Pingali, 2012; FAO, 2021). Overcoming these structural, institutional, and policy-related barriers through targeted extension support, incentive realignment, and evidence-based evaluation frameworks is essential for scaling up regenerative agriculture across India's diverse farming systems.

Future Prospects

The long-term expansion of regenerative agriculture in India will depend on the development of location-specific knowledge, effective extension mechanisms, and an enabling policy environment that aligns sustainability goals with farmer welfare (FAO, 2021; ICAR, 2022). Research tailored to India's diverse agro-climatic regions—covering rainfed, irrigated, tribal, and hill ecosystems—combined with timely field-level advisory services, can significantly enhance farmer confidence and reduce perceived risks during the transition towards regenerative production systems (Lal, 2020; Pretty *et al*., 2018).

The increasing use of digital platforms for information dissemination, decision-support tools, and real-time advisory services offers new opportunities to overcome traditional extension constraints (Aker, 2011). Collective action through Farmer Producer Organizations (FPOs) can facilitate input access, knowledge sharing, and market linkage for regenerative produce, thereby improving economic viability for small and marginal farmers (Trebbin, 2014). Furthermore, emerging opportunities linked to ecosystem service valuation—including soil carbon sequestration, climate-smart agriculture incentives, and carbon-related initiatives—have the potential to provide additional income streams and

strengthen adoption incentives (Smith *et al*., 2020; Lal, 2021).

Sustained capacity-building efforts, participatory learning approaches, and farmer-centric innovations will be critical in ensuring the successful integration of regenerative practices into mainstream Indian agriculture, contributing simultaneously to food security, environmental resilience, and long-term rural livelihoods (Gosnell *et al*., 2019; FAO, 2021).

CONCLUSION

Regenerative agriculture presents a viable framework for strengthening the ecological foundation of Indian farming systems while maintaining their economic relevance. By promoting the restoration of soil functions, enhancing soil organic carbon, and improving overall resource-use efficiency, this approach supports both environmental stability and farm-level viability in the long run (Lal, 2020; Montgomery, 2017). Its emphasis on biologically driven processes and system resilience makes it particularly suited to the diverse and resource-constrained conditions of Indian agriculture (Pretty *et al*., 2018).

When reinforced through scientific validation, coherent policy initiatives, and coordinated institutional efforts, regenerative agriculture has the potential to contribute meaningfully to the long-term sustainability of agricultural production and enhanced livelihood security in rural areas (Gosnell *et al*., 2019; FAO, 2021). Integrating regenerative principles into mainstream research, extension, and development programmes can thus play a critical role in achieving environmentally sound, economically viable, and socially inclusive agricultural growth in India.

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