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# From Bullocks to Drones

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How India's Agricultural Transformation Redefined the Ease of Doing Agriculture



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## INTRODUCTION

Agriculture has been the backbone of the Indian economy since time immemorial. For centuries, farmers cultivated land and bred livestock for survival, gradually shaping one of the world's largest agrarian systems. Over time, Indian agriculture evolved through a gradual and long-term transformation (Tekinerdogan, 2018). While early agriculture was constrained by environmental dependence and low productivity, today's farming reflects technological sophistication, institutional backing, and policy-driven support systems that have significantly improved the ease with which agricultural activities are performed.

The concept of "Ease of doing agriculture" captures the transformation from traditional to modern agriculture by focusing on reduction in constraints associated with production, efficiency, market, access to resources and information. Thus, this article showcases the journey of Indian agriculture across four phases, each representing a shift in farming pattern and progressive improvement in operational ease (Figure 1). The study involved data from previous researches, FAO reports and other policy documents, making it empirically grounded.

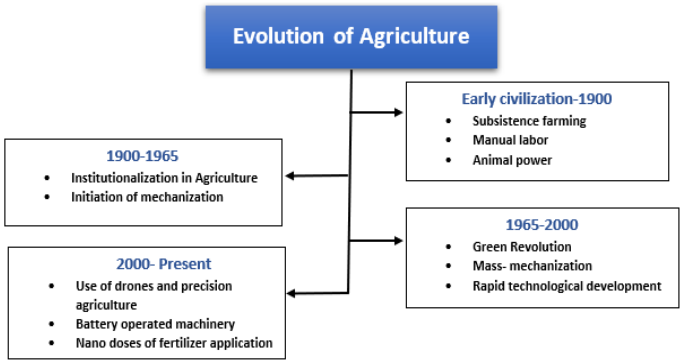


**Figure 1.** Phases of transformation in Indian agriculture

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**Agriculture 1.0: Survival, subsistence and struggle**

Agriculture 1.0 extending from early civilization to 1900 was dominated by traditional and subsistence farming. The origin of agriculture in India can be traced back to the Neolithic period around 7000-9000 BCE. Archaeological evidence traces Indian agriculture back to the Neolithic period around 7000–9000 BCE, when cultivation of wheat and barley and domestication of cattle, sheep, and goats marked the shift from hunting-gathering to settled farming (Possehl, 1999). Farming relied heavily on natural rainfall, manual labor, and animal power.

Colonial intervention after the mid-eighteenth century intensified agrarian distress. The land revenue and zamindari systems imposed rigid revenue obligations regardless of output, burdening cultivators heavily. With rent extraction prioritized over productivity, little investment was made in irrigation, land development, or technological improvement (Baden-Powell, 1892). Subsistence farming gradually shifted toward forced commercialization, increasing vulnerability to food shortages. Catastrophic famines such as the Great Famine of 1876–78 exposed severe weaknesses in agricultural governance and rural welfare systems (Dutt, 1960).

Thus, throughout this phase, agriculture remained labour-intensive, institutionally unsupported, and highly climate-dependent. The concept of "ease" was virtually absent.

**Agriculture 2.0: Science entered the field**

Between 1900 and 1965, Indian agriculture began transitioning toward scientific and institutional modernization. The establishment of the Indian Agricultural Research Institute in 1905 marked the beginning of organized agricultural research in crop breeding, soil science, and farm tool development (Randhawa, 1986).

Post-Independence the government prioritized in its first five-year plan, the irrigation development program through multipurpose river valley projects such as the Bhakra Nangal Dam. Community development programmes in 1952 and land reforms abolishing the zamindari system aimed to reduce structural constraints. However, technological penetration remained limited.

Between 1950 and 1965, fertilizer consumption averaged only 1.88 thousand tonnes per million hectares of gross cropped area (GOI, 2010). Tractorization was minimal, with only a few tractors operational in the early 1950s (Singh, 2005). While this phase built institutional foundations, it did not significantly ease day-to-day farming operations. This phase still paved the way for technological development in agriculture that led to ease of doing agriculture till today.

**Agriculture 3.0: The Green Revolution that changed everything**

The year 1965 marked a turning point with the onset of the Green Revolution, ushering in Agriculture 3.0. This era, lasting until 2000, saw rapid technological intensification and input expansion. The use of fertilizer increased dramatically (Figure 2). Total NPK consumption increased nine-fold i.e., from 2 million to 18 million tonnes between 1969-70 to 1999-2000 (Fertiliser Association of India, 2004).

Farm mechanization also accelerated with number of tractors used in agriculture sector increasing from approximately 242 per million hectares during 1960-61 to 10489 per million hectares of gross cropped area during 2000-01 (Figure 3). With the expansion of tractors in India particularly during 1970-80, tractor-mounted sprayers began to emerge in Indian field operations. These sprayers significantly enhanced operational efficiency, reducing labor intensity, ensuring uniform application, and lowering costs compared to manual labor (Nageshkumar, 2017; Dhawale et al., 2026).

Also, post-revolution irrigation expansion led to investment in canal system, tube wells and dams which supported year-round cultivation. Drip irrigation, introduced through ICAR research efforts in the 1970s, grew from 1,500 hectares in 1985 to approximately 71,000 hectares by 1992 (INCID, 1994). The method saved 39 to 55 percent water and increased crop productivity by 33 to 41 percent (Narayanamoorthy et al., 2024).

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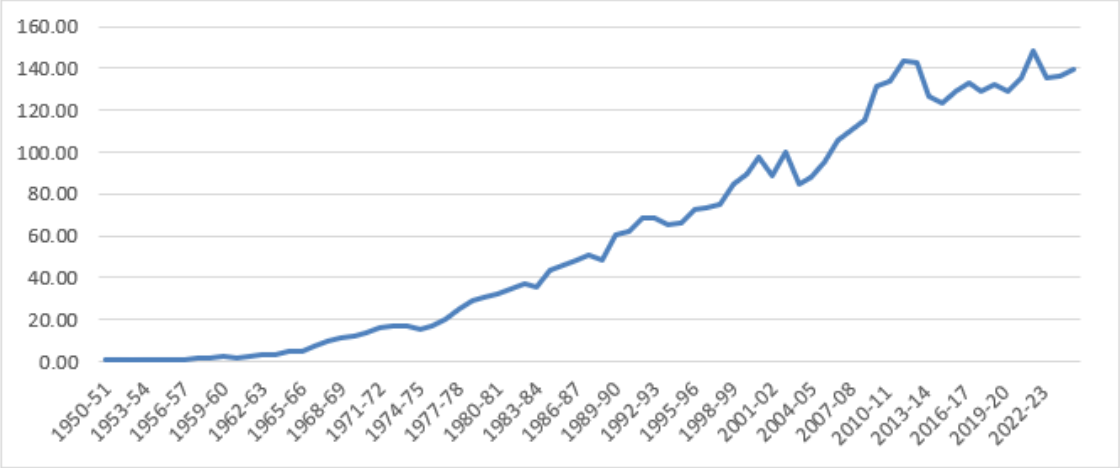


**Figure 2.** Fertilizer consumption per million hectares

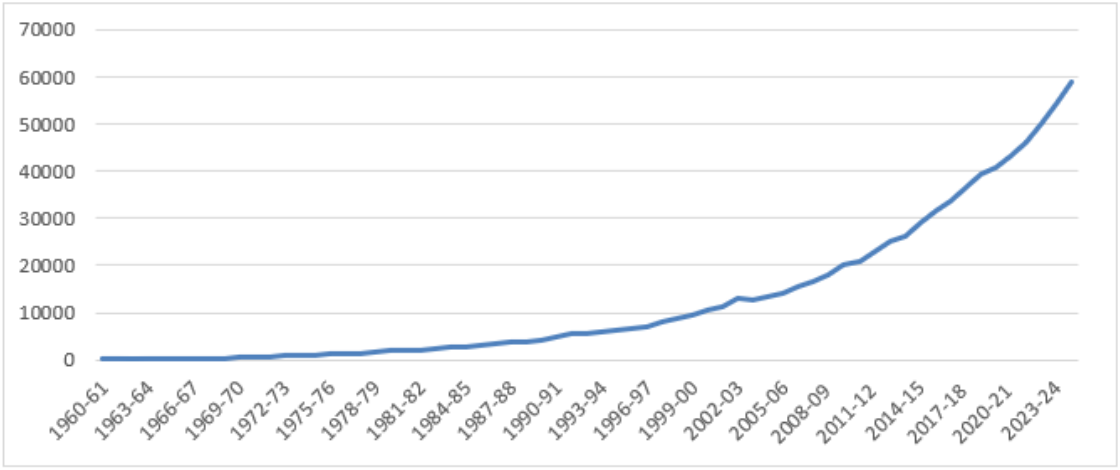


**Figure 3.** Number of tractors used in agriculture per million hectares

The phase Agriculture 3.0 represented a decisive shift from traditional farming to input-intensive, technology driven agriculture in India. The on-farm and off-farm interventions significantly improved the ease of doing agriculture by stabilizing input availability, enhancing productivity and reducing production risk. Thus, the transition in this phase laid the foundation for the digital and precision-oriented transformation in Agriculture 4.0 phase.

**Agriculture 4.0: The age of digitalization and precision farming**

Since 2000, Agriculture 4.0 has redefined farming through digital tools, precision techniques, financial inclusion, and smart infrastructure. A major off-farm infrastructure breakthrough occurred with the launch of scheme under Pradhan Mantri Gram Sadak Yojana (PMGSY) launched in 2000 which provided all-weather road connectivity to especially rural areas (Ministry of Rural Development, 2023). Improved roads enhanced access to markets, quality inputs, and reduced post-harvest losses.

Also, the financial breakthrough that enabled the ease of doing agriculture occurred with the launch of KCC (Kisan Credit card) in 1998 and scaled in the 2000s, provided farmers with short-term formal credit for agricultural inputs (NABARD, 1998). The Leaf Colour Chart (LCC) for rice cultivation developed in the early 2000s, in collaboration of International Rice Research Institute with agricultural research system of several Asian countries, enabled farmers to assess nitrogen deficiency based on leaf color variation. This diagnostic tool optimized the fertilizer doses, reduced over-application and improved nutrient-use efficiency (Singh *et al.*, 2005).

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The evolution of agricultural mechanization has significantly eased farming activities for Indian farmers. To promote mechanization, the Government of India introduced various schemes (Figure 4) aimed at improving productivity, sustainability, and accessibility. Institutions such as the Central Institute of Agricultural Engineering have further supported this transition by developing small-scale machinery suitable for smallholders, including seed planters, seed-cum-fertilizer drills, multi-crop threshers, and zero-till drills. The institute also introduced an automatic irrigation system for rice using sensors and microcontrollers to monitor ponding water levels (CIAE, 2018). In addition, battery-operated sprayers, which gained prominence after 2010, have reduced labor burden and improved the efficiency of fertilizer and pesticide application (Zilpilwar *et al.*, 2021).

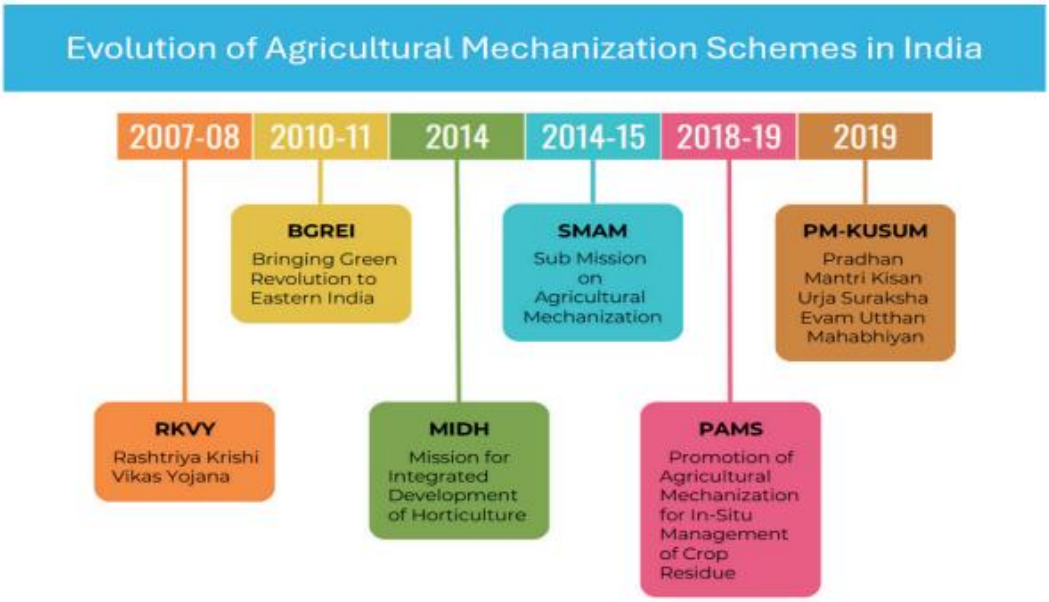


**Figure 4.** Agricultural mechanization schemes in India (Source: Khandai *et al.*, 2024)

Rising food demand required smarter nutrient management. Traditional fertilizers increased cultivation costs (IFFCO, 2023), leading to the adoption of nanotechnology (Kumar et al., 2021). In 2023, IFFCO introduced nano-DAP liquid fertilizer to enhance farmer income and nutrient efficiency (IFFCO, 2023).

Drones have emerged as transformative tools in precision agriculture (Singh and Singh, 2025). Thus, in 2022, the Government of India formally approved usage of drone in agriculture for pesticide and nutrient application (PIB, 2022). The usage of drones enables farmers to increase crop yields, help reduce labor cost and risk associated with pesticides application (Dutta and Goswami, 2020). Additionally, drones are equipped with censors enabling crop health monitoring throughout the season, allowing farmers to assess the nutrient deficiencies or any pest attack (Singh and Singh, 2025).

Thus, the focus shifted from "more inputs" to "smarter inputs" in this phase, redefining ease of doing agriculture in terms of efficiency, cost optimization, risk mitigation, and environmental sustainability.

**The long arc of transformation**

From subsistence farming dependent on rainfall and animal power to precision agriculture guided by sensors and drones, India's agricultural journey reflected cumulative advancement in technology, infrastructure, policy, and institutions. Agriculture 1.0 was marked by vulnerability. Agriculture 2.0 built structural foundations. Agriculture 3.0 delivered productivity and

mechanization. Agriculture 4.0 integrates digital intelligence, sustainability, and financial inclusion. The ease of doing agriculture in India has not emerged overnight. It is the result of layered reforms and innovations across centuries; steadily transforming farming into a more efficient, resilient, and technology-driven enterprise.

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