

Population Growth and Sustainable Agriculture

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Article Info	ABSTRACT
<p>Article History: Received: 26th Sep 2025 Accepted: 10th Oct 2025 Published: 25th Oct 2025</p> <p>Keywords: Population Growth, Sustainable Agriculture, Land Fragmentation, Food Security</p>	<p>India, with its burgeoning population exceeding 1.4 billion as of 2025, faces unprecedented challenges in balancing demographic expansion with the imperatives of sustainable agriculture. This research paper explores the intricate relationship between population growth and agricultural sustainability in India, drawing from historical trends, current data, and future projections. Occupying just 2.4% of the world's land area, India supports over 17% of the global population, making agriculture not only a economic pillar but a critical determinant of food security and environmental health. The study analyses how rapid population growth has led to fragmented land holdings, resource depletion, and intensified pressure on arable land and water resources, exacerbating issues like soil degradation and groundwater scarcity.</p> <p>Utilizing secondary data from agricultural censuses, government reports, and recent web-sourced studies (2020-2025), the paper employs descriptive statistics and trend analysis to decompose impacts. Key findings reveal that average land holding sizes have dwindled from 1.41 hectares in 1995-96 to approximately 1.25 hectares by 2025, with over 62% of holdings being marginal (<1 ha), hindering mechanized and sustainable farming practices. Population pressures have driven a shift towards intensive agriculture, but innovations like precision farming, AI-driven advisories, and climate-resilient crops offer pathways to sustainability.</p> <p>The paper recommends policy interventions including digitalization under Agriculture 4.0, promotion of agroforestry, and enhanced family planning to align population dynamics with ecological limits. By integrating sustainable development goals (SDGs), India can transform demographic challenges into opportunities for resilient agriculture, ensuring food security for future generations. This analysis underscores the urgency of holistic strategies to mitigate overpopulation's adverse effects on agricultural ecosystems.</p>

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Introduction

India's demographic landscape has changed dramatically since independence in 1947. The population grew from 361 million to over 1.46 billion by 2025. This rapid growth fuels economic activity but threatens sustainable agriculture, which is essential for the economy and livelihoods for nearly 60% of the population. Agriculture contributes 17-18% of India's GDP in 2025. However, it struggles to maintain productivity due to rising demands for food, water, and land. The relationship between population growth and agricultural stability is a geographic challenge, as uneven distribution, particularly in densely populated northern states like Uttar Pradesh and Bihar, increases competition for resources.

Historically, the population growth rate peaked at 2.15% annually from 1971 to 1981 but slowed to 1.64% between 2001 and 2011, and is expected to drop to 0.87% for the period from 2021 to 2031. Even with this slowdown, the addition of nearly 17 million people each year places great pressure on arable land. This land accounts for 52% of India's total area but underpins an agricultural economy based around small villages where 72.2% of the population lived according to the 2001 census. This figure is projected to decrease slightly to around 65% by 2025 due to urbanization. Sangwan et al. (2018) state that India has more arable land than any country except the United States. However, population pressures have led to smaller landholdings, diminished average sizes, and hindered sustainable practices such as crop rotation and soil conservation.

Sustainable agriculture, as defined by the UN, involves practices that satisfy current food needs without compromising future generations' ability to meet theirs. This approach includes resource-efficient techniques, biodiversity preservation, and resilience to climate challenges. Yet, population growth worsens issues such as the over-extraction of groundwater, with 37% of aquifers at risk by 2100, soil erosion affecting 147 million hectares, and a potential water crisis, where 40% of the population may face shortages. The Green Revolution of the 1960s increased yields fourfold from 1961 to 2020, temporarily outpacing population growth. However, its reliance on chemicals led to environmental damage, highlighting the importance of a "Second Green Revolution" centered on sustainability.

The goal of this paper is to examine the various ways population growth impacts Indian agriculture, with a focus on sustainability. This analysis builds on the 2018 study by Sangwan et al., which broke down agricultural changes into mean, inequality, and population effects using data from 1995-96 and 2000-01. It also incorporates recent

information (2020-2025) through web searches on trends and innovations. The methodology includes secondary data analysis from agricultural censuses, UN reports, and online sources, using averages, percentages, and trend forecasts. The study will cover population trends, landholding impacts, sustainable practices, challenges, and recommendations, aiming to guide policy for the alignment with Sustainable Development Goals, particularly Goals 2 (Zero Hunger) and 15 (Life on Land).

Geographically, India's varied agro-climatic zones from the fertile Indo-Gangetic plains to the arid Thar desert create vulnerabilities. Northern states with high population densities, such as Bihar (1,106 persons/sq km), experience severe land fragmentation, while southern states like Kerala (with 95.2% of holdings being marginal) focus on sustainable alternatives. As India is set to surpass China as the world's most populous nation in 2025, with predictions reaching 1.53 billion by 2030, the need for sustainable agriculture is urgent. This growth adding a population equivalent to Australia each year continues cycles of poverty, affecting 380 million rural poor reported in 2018, likely more now, who depend on shrinking farm sizes.

Overpopulation does not just refer to numbers but also to the ratio of resources available. In a closed system, India illustrates unsustainability, as it can provide food and water for fewer people than it has. Post-independence family planning policies initiated in 1952 lost momentum after the 1970s emergency, leading to unchecked population growth. Presently, literacy and gender awareness are increasing slowly, while unemployment and poverty are rising more quickly. The paper argues that without combining population control with agricultural innovation, India may face food shortages by mid-century, as global trends suggest that we will need two to three planets to meet resource demands by 2050.

Literature Review

The connection between population growth and sustainable agriculture in India has been widely studied, moving from early post-independence concerns to current digital and climate-focused discussions. Sangwan et al. (2018) offer a geographical perspective, noting that the population has tripled since 1947, which has impoverished many rural communities where 72.2% of residents were engaged in agriculture in 2001. Their analysis shows exponential growth from 36.23 crore in 1951 to 181.95 crore in 2011, fragmenting landholdings and decreasing average sizes from 1.41 ha to 1.33 ha, which is not conducive to mechanization. They stress the role of overpopulation in resource depletion and advocate for family planning and agro-processing.

More recent studies (2020-2025) build on this foundation by incorporating Sustainable Development Goals (SDGs) and technology. A 2025 ResearchGate article by Kumar examines India's growing population, forecasting 1.47 billion by 2031 and linking this growth to aquifer depletion (with 37% at risk) and land subsidence affecting 19% of the population. It calls for sustainable agriculture through renewable integration and education. A report by Farmonaut in 2025 highlights that 60% of the population depends on agriculture, with innovations such as precision farming (35% adoption) and AI advisories (62% mobile usage) helping to relieve pressures through water-saving technologies and organic farming.

The IJFMR analysis from 2025 emphasizes the significance of Agriculture 4.0, with AI and drones potentially increasing output by 60% (as noted by WWF India) to meet global demand, projected to reach nine billion by 2050, through NMSA initiatives focused on nutrient management. Singh and Singh (2020), referenced in a 2024 Junikhyat review, highlight the importance of organic and precision farming amidst population growth, noting declines in soil health due to monoculture practices. A ScienceDirect study from 2025 on SDG research in India reports rising productivity from 2015 to 2023, focusing on themes like resilient crops and policies supporting vulnerable farmers.

Kachru (n.d.), referenced by Sangwan et al., discusses challenges in agro-processing, such as low capacity and high energy costs. Satihal et al. (2007) quantify the population's effect on land use in Karnataka, showing that subdivision halves land sizes every 20-30 years, leading to 12% shortfalls in cereal production. New studies like the RRJ paper from 2025 detail sustainable approaches and government programs (e.g., PMKSY for irrigation) aimed at promoting diversification. A 2025 policy analysis by Springer critiques productivity-driven policies and calls for better support for vulnerable populations. There are still gaps in integrating demographic data with technology adoption, which this paper seeks to address.

Population Growth Trends in India

India's population trajectory reflects a typical demographic transition, moving from high birth and death rates to stabilizing fertility rates. As of 2025, India has 1.463 billion people, surpassing China, with projections of 1.53 billion by 2030 and stabilization around 1.7 billion by 2060. The decadal growth rate has declined from 21.34% (1991-2001) to 17.70% (2001-2011) and further to around 12% (2011-2021), based on Census data. However, there are still regional disparities. Northern states like Bihar, with a growth rate above 2%, contrast with southern Kerala, where the growth rate is below

1%. Access to education and healthcare drives these differences.

Urbanization is accelerating. The rural population dropped from 72.2% in 2001 to about 65% in 2025, increasing pressure on peri-urban agriculture. Fertility rates fell from 5.9 in the 1950s to 2.0 in 2025, which is below the replacement level of 2.1, but a youthful population (50% under 25) still ensures momentum. UN projections suggest that globally, the population will grow by 83 million each year, with India contributing approximately 17 million, the equivalent of adding Australia's population annually.

This growth, which has tripled since 1947, has socio-economic implications. The Human Development Report of 2016 ranked India 131st, with an HDI of 0.624. This figure has improved slightly by 2025, but poverty still affects 21% of the population (around 300 million), many of whom are rural farmers. Overpopulation metrics, specifically the population-to-resources ratio, illustrate unsustainability, as the available food can support only nine out of ten people in closed systems, according to Sangwan et al. Causes for this include medical advances that lower mortality rates (from 25 per 1000 in 1951 to 7 per 1000 in 2025), as well as immigration, though births still predominantly drive growth.

Family planning initiatives began in 1952 and peaked in the 1980s but lost momentum after the emergency, neglecting slogans like "Hum Do Hamare Do." Recent efforts by NGOs in Karnataka have seen some success in reducing fertility rates through sterilization and education. However, preferences for male children in rural areas persist, driving families to have more than four children related to agricultural labour needs.

Table 1: India's Population Growth (Selected Years)

Year	Population (Crore)	Growth Rate (%)
1901	27.13	-
1951	36.23	1.96
2001	102.70	1.95
2011	121.09	1.64
2025	146.39	1.20 (proj.)
2030	153.00	0.87 (proj.)

Source: Adapted from Sangwan et al. (2018) and UN Projections (2025).

Globally, the population reached 8 billion in 2022 and is projected to hit 9.8 billion by 2050. India's growing share increases the demand for agriculture, with grain needs growing 2.5% each year, outpacing land growth of only 1%. Climate change, exacerbated

by population density, poses significant threats. CO2 emissions in 2022 reached 2.8 gigatons, and air pollution is responsible for 7 million deaths annually. Sustainable solutions depend on education, as female literacy is projected to reach 77% in 2025, alongside improved urban planning.

This trend demands proactive measures for agricultural resilience.

Impact on Agriculture and Land Holdings

Population growth significantly affects agriculture through land fragmentation, resource overuse, and declining productivity, which threatens sustainability. Sangwan et al. (2018) show that land holdings increased from 115.58 million in 1995-96 to 119.23 million in 2000-01. Marginal holdings, which are less than 1 hectare, rose by 6%, averaging 1.33 hectares nationally and projected to drop to 1.25 hectares by 2025. Over 86% of farmers are small or marginal, with 62% farming less than 1 hectare (average of 0.40 hectares) according to 2025 estimates. This is largely due to inheritance subdivision, which halves land holdings every 20 to 30 years in villages like Khabra Kalan.

There are state variations: 95.2% of farmers in Kerala are marginal, while only 12.3% are in Punjab; these figures reflect population density and land redistribution. Uttar Pradesh accounts for 18% (2.17 crore) of the total 11.99 crore holdings, and Bihar has 9.7%. This fragmentation restricts mechanization and promotes labour-intensive, low-yield farming. Small farms see shortfalls of 12% in cereals and 42% in pulses.

Water stress is worsening; India uses 80% of its groundwater for irrigation, leading to the depletion of 37% of aquifers and risking water scarcity for 40% of the population. Soil degradation affects 120 million hectares due to overuse. Agriculture's share of GDP has fallen from 42% in the 1950s to 18% in 2025, yet it still employs 60% of the workforce. In 2018, 380 million people lived below the poverty line, and that number is likely over 300 million now.

Agro-processing is falling behind due to low usage, outdated techniques, and fluctuations in raw material supply. As the population grows, urbanization draws villagers away, resulting in labour shortages and urban sprawl invading farmland.

Recent data from the 2025 Farmonaut report indicates a 35% adoption of precision farming, which helps address some issues, but fragmented holdings continue to limit large-scale implementation. The IJFMR report (2025) connects population growth to food insecurity, highlighting how climate change is making droughts and floods worse.

Table 2: Distribution of Operational Holdings (2000-01 vs. Projected 2025)

Category	2000-01 (Million)	%	2025 Proj. (Million)	%
Marginal (<1 ha)	75.41	62.3	85.00	65.0
Small (1-2 ha)	22.69	19.0	25.00	19.1
Semi-Medium (2-4 ha)	21.83	18.3	20.00	15.3
Total	119.23	100	130.50	100

Source: Agricultural Census (Sangwan et al., 2018) extrapolated with 2025 trends.

Sustainability suffers: monoculture erodes fertility, but diversification potential exists.

Sustainable Agriculture Practices

Sustainable agriculture in India counters population pressures through eco-friendly innovations. Core practices include organic farming (covering 2.78 million ha in 2025, up 20% from 2020), precision agriculture (drones/AI for 35% adoption), and integrated pest/nutrient management. Climate-resilient varieties (e.g., drought-tolerant rice) yield 20-30% more under stress.

Government schemes like NMSA (2010) promote water efficiency (drip irrigation on 12 million ha), agroforestry (carbon sequestration on 25 million ha), and soil health cards (200 million issued). Digital tools: 62% farmers use apps for advisories, blockchain for traceability.

RRJ (2025) highlights PMKSY and PKVY for organic promotion, aligning with SDGs. Emerging tech: IoT irrigation saves 30% water; AI predicts yields, reducing waste.

Challenges: Small holdings limit adoption (only 12% in 2020 to 35% in 2025), but cooperatives aid scaling. ScienceDirect (2024) notes tech enhances productivity 4.6% yearly.

Challenges and Recommendations

Challenges: Resource depletion, inequality (northern vs. southern states), policy gaps. Recommendations: Strengthen family planning (target 2-child norm), invest in R&D (double agri-budget), promote cooperatives for processing. Decentralized power, cold chains in catchments. Digital literacy for 86% small farmers. National plan for private/coop management, incentives for modernization.

Conclusion

Population growth imperils India's agriculture, but sustainable practices offer hope. Integrating demographics with innovation ensures resilience.

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