

# Assessment of mechanized farming on agricultural biodiversity and sustainability in India: A study in the Context of Viksit Bharat

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**Abstract-** *As part of the Viksit Bharat vision, a research study in India looks at agricultural biodiversity and sustainability-related modern agricultural practices. In recent years, technology and agricultural inputs have expanded substantially, and modern farming techniques have greatly increased crop yields; however, this came together with trends in biodiversity loss and ecosystem deterioration. Bringing together data from various sources, this research examines the positive correlations between modern farming practices and ecological indicators. A large study has found, while new methods of farming may be successful in increasing crop yields, they also help reduce the diversity and quality of other life forms, soil health and the quality of water. The study concludes with specific recommendations that could enhance productivity without compromising environmental sustainability.*

**Keywords:** *Modern Agriculture, Biodiversity Loss, Sustainability, Agro-Climate, Viksit Bharat*

## I. INTRODUCTION

India has witnessed a significant rise in the size of its economy in the last three decades (Born 2025). It is now ranks sixth largest in the world based on gross domestic product (IMF 2026). Although in recent years agriculture has seen significant growth, it remains a significant source of employment, albeit the proportion of agriculture in GDP has decreased over 70 years (Fleck 2024). According to IBEF 2022-23, India's rank is second in the globe in farm production after China. The agricultural sector is still playing a significant role in the country's economic development and growth (PIB 29 January 2026). But contemporary methods in agriculture are wreaking environmental damage. These activities render the biodiversity activities at risk; leading to poverty in diversity of important varieties of crops (Elizer

Nelson et al. 2019). The situation aggravates with increasing climate change and affects the farming practices (Das et al. 2025). For instance, rice fields give off a potent greenhouse gas called methane. The future crop yields are also under threat due to changes in weather patterns and increased temperature. The unpredictable nature of rainfall and the high temperatures are reducing farm productivity and its feasibility.

Feeding nearly 1.47 billion people on farm presents some huge challenges for Indians. Overuse and erosion has led to poor soil conditions (Bhattacharyya et al. 2015). Water deficit is increasingly occurring in many agricultural regions of the country (Tandle et al. 2025). These problems are all the more difficult in the present era of climate change. India has begun to tackle the environmental issues related to agriculture. These include programs to conserve water and to utilize fertilizers in a more effective way. However, there is still much to be done in order to enhance the agriculture of the local people. Research indicates that there are compromises when working for multiple outcomes. India has to strike a balance between social requirement, economic growth and environment protection. These compromise relationships are current focus in most research efforts at individual farms. Inaccurate or difficult to do bigger analyses, because food supply chains are complex. There is also some limited measurement of the complete impact of farming. There is a fast increase in the environmental footprints of farmers in India (Deshpande 2017). It is a make India Viksit Bharat/developed India programme by our current Prime Minister to reach this target for India by 2047 that is crucial issues to look in.

With the looming India's objective of becoming a developed nation in 2047 (Viksit Bharat at el. Mathew), the movement is advancing towards a brighter future with perseverance. The agriculture industry is at a critical juncture in 2025 (to be honest, as well as in 2026 and beyond). With this objective, the country has to cover with improvements farming practices and rural livelihoods, among others. In the last couple of decades, Indian farmers have adopted modern agriculture, when technology plays a crucial role, the use of chemical fertilizers and pesticide and high yielding varieties of crops (Deekshithulu et al. 2024). With these efforts, the food production has slightly enhanced and hunger continues to be higher in the country (Zahoor 2021). For instance, India has recorded increased production of wheat and rice and today it exports wheat and rice to the top rankings. Nevertheless, such a fast transformation has caused concern over the sustainability of the environment (Rupal 2019). Farmers have been making more and more chemical inputs and now there is some concern regarding soil health, water quality and the safety of the ecosystem (Kashyap at el. 2024). All these practices pose a risk to biodiversity, to the natural habitats, and to perpetuation of farming families on the land. The impacts of intensive agriculture are even more onerous in some parts, where groundwater is declining, soil is deteriorating and some native flora and fauna are being lost (Mukherjee 2021).

The article delves into the prevailing scenario in Indian agriculture. It has relied on the latest data available from Government reports and recent studies by reputed Indian research organisations. There is a focus on understanding the future of the sector in the light of how farming is being affected by the use of modern practices. It addresses the variety of new farming techniques in use today – including precision farming and organic farming – and how they affect ecosystems. The article also examines the measures being taken by Indian farmers and policy-makers to safeguard the environment. This involves implementing crop rotation, transitioning to organic agriculture, and implementing eco-friendly technologies. The aim here is to determine whether such efforts can help to minimize environmental harm without lowering agricultural productivity. The article highlights real-life examples from across the States which gives a clear idea of what works and

what has yet to be improved. It aims to offer valuable insights for government officials, farm leaders, scientists, and environmental advocates. All of them require action plans to improve agricultural productivity and benefit from a rich Indian nature. The intention behind this review of the trends and challenges is to contribute towards India's vision of a sustainable and prosperous agriculture benefitting farmers, nature and future generation as well.

### 1. Landscape of Modern Agriculture in India.

In the past few decades, the agricultural scenario in India has undergone a dramatic change with speedy adoption of modern agronomic practices. Mechanisation, improved seed production, synthetic fertilizers and chemicals, and sophisticated methods of irrigation have been used together, and have completely transformed the way crop production is defined. The introduction of the Green Revolution in the 1960s was a turning point to this transition; the last decades have led to a more intensive and diversified agriculture (Stepha 2022).

#### 1.1 Agriculture and food grain production

Traditionally, Indian agriculture heavily depended on human effort for work, organic materials for inputs, and local expertise. Although production of all types has increased on farms, there has been a 6 to nearly 70 fold rise since the mid of 20th century (Table-1). The nation transitioned to food sufficiency around the turn of the 20th century, after a time of food shortage in the 1950s and 60's. India has become a food surplus country from 2010 onwards. Intensity and efficiency of fertilizer application in the agricultural sector have also improved up to 132% (Pathak and Ayyappan 2020). It's mainly because of technology advancements, HYVS (High yielding variety seeds), irrigation services, and conducive farming policies in the farming sector that leads to all these positive changes in farming (Pathak at el. 2022).

Table 1. Production of agricultural commodities and cultivated area

Commodity	1950-51	2021-22	Times increase
Food grains (Mt)	51	314	6.2
Vegetables & fruits (Mt)	25	333	13.3

Milk (Mt)	17	210	12.4
Egg (billion)	1.8	122	67.8
Fish (Mt)	0.8	14.2	17.8
Net sown area (Mha)	130	140	1.1
Gross sown area (Mha)	150	198	1.3

Improved irrigation has expanded agricultural land of about 15-20% in sections of the states of Punjab, Haryana, and western Uttar Pradesh. This results in greater irrigation intensities and intensifies the cropping. Besides, more than 70% of agriculturist activities in western UP, Haryana and Punjab are mechanized including tractor ownership, which shows the increment in the use of modern farming machines has led to higher operating efficiency and thereby higher productivity on agriculture enterprise (MoA 2022).

### 1.2 Adoption of Biotechnology and Digital Agriculture

The agricultural dynamic in India is being further transformed by the use of digital tools and biotechnology. Genetically modified crops (GM) are crops that have been generated and have been tested for improved production and pest resistance despite the controversy surrounding them. At the same time, precision agriculture ensures optimal management of the inputs allocated to the business, curbing waste and customer impact on the environment using data, satellite technology, and soil health cards.

Farmers may now get real-time meteorological data, crop advice services, and information on market connections thanks to digital platforms. To meet the goal of integrating agriculture with sustainability narratives and overall vision of a technologically empowered Viksit Bharat by 2047, it is crucial for smart agriculture production and agriculture to be seamlessly integrated with digitalization ( Depali et al. 2020; Jain and Dhar 2022).

## II. BIODIVERSITY: A CRUCIAL ELEMENTS FOR SUSTAINABLE ECOSYSTEM

Biodiversity is important, comprising a diversity of plants and animals that are essential for healthy ecosystems and productive farms. In India, the

protection of natural elements such as farming systems and wetlands enables variety of species that enhance soil health, pollination and pest control. Due to the traditional methods used in farming practice, like poly-culture and agroforestry, many species could be maintained. Such techniques aided farms in coping with environmental problems. But massive monoculture and intensive practice has led to huge losses in biodiversity. Reports show that:

Satellite data and ministry of Environment, Forests, Climate Change surveys and reports reveal a decline of up to 15% in species numbers in the recently industrialized areas (Goud, A., 2024, Research Matters 2026). There are more issues involved with habitat fragmentation. Farm expansion breaks the habitats and prevents migration of many species. This is a process of fragmentation which has reduced viable areas by approximately 20-25% of particular 'Liveable Area' in particular designated zones of Biodiversity.

Crops are also a genetically diverse resource that has become more homogeneous as a result of intensive farming which resulted in the loss of varieties of the indigenous plants species. Focusing on a limited number of high-yielding cultivars has increased the risk of pest and climate-related issues. It means that this diversity loss has the potential to endanger Indian agriculture's future, according to Ministry of Environment report 2021.

Biodiversity is the key to building sustainable farming systems. Pests are controlled naturally through natural predators or parasitoids which reduces the need for the use of chemical pesticides. Protect and enhance soil health with more crop rotation and intercropping options that enhance microbial diversity for better nutrient cycling. A biodiversity balance of ecosystems aids in the ability to adapt to extreme weather well, thus ensuring the stability of farming. Not only is the integration of biodiversity-friendly practices a need of the hour, it is essential for food security and sustainability of the future.

### III. AGRICULTURAL PRODUCTIVITY AND BIODIVERSITY LOSS

In this light, the successes and problems of modern agriculture can be distilled from recent statistical data from trustworthy sources. This section emphasises some important empirical data that serve to bring into focus some of the trends in achieving agricultural productivity and loss of biodiversity.

#### 3.1 Agricultural Productivity Statistics

The Ministry of Agriculture has published the latest agricultural productivity figures in its Agricultural Statistics at a Glance, 24-25, which highlights significant improvement in agricultural productivity in India during the last 10 years (Agricultural Statistics at a Glance 24-25). The total production of cereals grew on average at 3.5% a year, while in the last harvest season; production was more than 350 million tonnes. Use of fertilizers has dramatically increased on a per hectare basis, due to the high intensity of farming operations, while some programs are encouraging judicious use of fertilizers have started to have a positive effect in reducing the related environmental risks. Ingenious irrigation systems and methods have not only saved water but also improved its efficiency with some states noting that water wastage in food irrigation has been slashed by almost 18% from traditional food irrigation systems (NSSO 2022).

#### 3.2 Biodiversity Loss Metrics

The environmental impacts of intensive farming are equally well known. Several national investigations have found worrisome trends on the farming system. In agro-ecosystems where high intensity of the monoculture culture becomes predominant, the biodiversity surveys show that 15-20% of the native species have decreased in the past 15 years. Conversely, some measures of local biodiversity indices have remained sustained or enhanced in diversified farming systems in much of the country. Ecosystems often sustain losses of beneficial insects, leading to a decline in pollination levels in surrounding crops by 10-12% as a result of pesticides. Empirical work correlates large areas of pesticides with declines in beneficial insect numbers, lowering pollinations rates in neighbouring crops by about 10 to 12%. With intensive chemical

management, ICAR studies indicate that there is a loss of microbial diversity in soils which might impact nutrient cycling and long-term soil productivity (Srinivasa, Prasad and Mohapatra, 2019).

#### 3.3 Sustainability Indicators

The concept of sustainable agriculture is multi-faceted, and there are some key indicators to monitor progress towards sustainable agriculture. According to a recent survey released by the ministry of agriculture, around 20% of Indian farm land is suffering from different levels of degradation and hence there is a need of immediate action for the rehabilitation work. Groundwater levels near critical in key farming areas, especially in the western parts of Uttar Pradesh and Punjab have seen a 25% decline in groundwater levels in the past three decades. But in the target areas, the introduction of micro-irrigation technology and rainwater collection has helped to turn the tide. India's agriculture's carbon footprint is continuously monitored and efforts are on to lower the GHG emission by using precision farming and sustainable practices. The Ministry of Environment estimates that implementation of conservation tillage and organic methods may curb the emissions by as much as 15% in the major states.

### IV. ENVIRONMENTAL IMPACT OF MODERN FARMING METHODS

Contemporary agricultural methods have proven to be effective in ensuring higher yields. However, their impact on the environment has created challenges that were never anticipated. The impacts of various aspects of the environment include degradation of soil, water shortage, pesticide mishap and the endangerment of indigenous species.

#### 4.1 Soil Health and Ecosystem Services

The extensive use of chemical fertilizers and pesticides over time has led to soil acidification and a decline in organic matter. We are impoverishing the soils that supported a wide range of microbial communities needed for nutrition. A recent study carried out by the National Bureau of Soil Sciences (NBSS) reveals that organic carbon levels in major agricultural zones have decreased by 12% over the past ten years. Furthermore, excessive

chemical usage has slowed down the pollutions of useful soil microbes, which is almost 18-20% in some places in the country, help improves natural soil fertility and structure (NBSS report 2021).

#### 4.2 Water Quality and Quantity

Water quality in several regions is getting adversely impacted by groundwater over-extraction and chemical runoff. Nitrates and pesticide residues pollute water bodies that could harm aquatic life and humans. Nitrogen compounds are polyatomic. Moreover, the growth of irrigated land has amplified the need for water resources. Due to this, the states are adopting new water saving technologies, though still several regions experience critical shortage of water during dry season. According to Denchak (2023), excess use of fertilizers has resulted in nutrient runoff into closer lakes and rivers from the source region causing eutrophication and disruption of aquatic ecosystems resulting in periodic fish disappearance.

#### 4.3 Pesticide Use and Eco toxicity

The country's farming landscapes have bees and birds declining drastically and the most reason for their doom is the widespread use of using synthetic pesticides. Research carried out by agricultural research institutions show that honeybees and other pollinators have seen declines of over 10% in most of the important citrus and fruit-growing regions. The region is also found to be heavy with organic pollution in the soil and water samples were taken from its particular place where heavy agriculture usually take place (Quandahor et al, 2024).

### V. ALIGNMENTS WITH VIKSIT BHARAT 2047: TOWARDS A DEVELOPED AND SUSTAINABLE NATION

The Viksit Bharat 2047 is not only about economic prosperity, it also aims to achieve environmental sustainability, and enhance the quality of life of the people. The development of agricultural sector in India that feeds over one billion people is very relevant to the Viksit Bharat vision. The Government of India has already taken a number of steps to ensure sustainability in agriculture policies. Key policy instruments include: initiated to promote sustainable farming practices, to enhance the efficiency of

resource use and to make farming community resilient. A government programme now been designed to test the soil quality and provide tailored recommendations of nutrient management. The project has now been extended to millions of farmers throughout the nation to balanced use of fertilizers. Efforts are also being directed at improving water use efficiency and expanding irrigation coverage through the programme of Pradhan Mantri Krishi Sinchai Yojna (PMKSY) with modern technologies such as drip irrigation and sprinkler systems (myScheme. n.d.).

#### 5.1 Sustainability innovations in Agriculture

Adopting sustainable practices is more than just compliance. It also entails innovations at the grassroots level. According to FiBL (2021), India has around 30% of the world's total organic producers having 2.30 million ha. A lot of efforts in this direction have been made in India. It includes the integrative farming in which crops and trees combine to make a more resilient agro-ecosystem that enhances biodiversity and improves microclimates. According to states such as Maharashtra and Kerala, pilot projects have resulted in improved soil quality and water conservation. Many agricultural practices in many pockets across India are reported to help regenerate soil health. In the state of Sikkim, organic agriculture has contributed to greater marketability of agriculture and conservation of local natural resources. Likewise, organic farming is being promoted in Madhya Pradesh and others. Such initiatives are for reducing the impact of farming on nature and make climate-smart agriculture (Raj 2025). This framework, put forth by Food and Agriculture Organizations (FAO) along with Indian partners combines practices that cut greenhouse emission, enhance energy efficiency and improve resilience against climate stress in our farming system.

#### 5.2 Equipping Farmers with Digital Tools

The digital transformation of agriculture can be a powerful tool in the journey towards a Viksit Bharat. The usage of digital tools that include mobile applications, IoT sensors, AI, drones, GPS guided machinery help the farmers a real time data in agricultural decisions (Anshida et al., 2025). The availability of integrated digital services in the form

of all devices has already produced improvements in market linkages for the products and ensures better prices to the farmers. These technologies help the government distribute subsidies and support services efficiently as well as minimize administrative delays. It aids in prompt communication regarding pest invasions, unforeseen weather behaviour and advisory service for crops to the farmers (Kumar et al., 2025) expeditiously.

## VI. CHALLENGES AND OPPORTUNITIES INTERFACE

Despite the considerable progress made in modernizing Indian agriculture. Developing high productivity with the preservation of nature is a challenging task. Nevertheless, these hurdles also represent distinct prospects for change. Intensive agriculture is characterised by the over-exploitation of agricultural resources. The pressure on water resources and soil quality are the results of intensive farming practices, so that production capacity in the country may be affected (Sial, et al., 2021). The use of chemical pesticides in modern agriculture continues to have an adverse health impact on humans and the ecosystem. There is an urgent need for stricter regulations and implementations. Alternative pest management practices must also be promoted. The conversion of a large tract of land monocultures requires urgent reinvestment in crop diversification and integrated pest management to halt and potentially reverse biodiversity loss. Officials have been made uneasy by erratic weather patterns and climate shocks. There have been adverse climatic conditions. Agricultural planning and policy must integrate adaptation strategies.

Acknowledging these challenges opens up a space for innovation solutions such as strengthening institutional framework for sustainable agriculture, providing incentive for organic farming, creating water-saving technologies, and developing diversified cropping system. Collaborations between government, research institutions and private sector are needed that should accelerate the adoption of sustainable agricultural practices, technology transfer and capacity building among smallholder farmers. A Climate Resilient Crop requires Research and Development. Substantially empowering indigenous

communities and knowledge systems will strengthen the necessary social fabric for long-term sustainability. These initiatives not only have the potential to address immediate problems, but also to establish the foundation for a resilient agricultural system that can support the larger Viksit Bharat vision.

## VII. VIKSIT BHARAT ROAD MAP: SUGGESTIONS AND STRATEGIC INTERVENTIONS

The merging of modern agricultural practices with biodiversity conservation and sustainability is at the heart of the strategic vision of India to be a developed nation by 2047. This section outlines key policy recommendations and strategic interventions to align agricultural expansion with environment sustainability.

### 7.1 Reinforcing Regulatory Frameworks

It is urgent need of more robust regulatory framework that would harmonize agricultural productivity with biodiversity protection. Key measures could entail stricter regulations on chemical pesticide application, constant monitoring of residue levels in soil and water, and increased development of bio-pesticides. Farmers who opt for crop diversification, intercropping and organic practices must be provided with financial incentives so as to mitigate the negative externalities of monoculture. Developing a comprehensive monitoring system that includes real-time data on soil health, water use, and biodiversity would allow for timely policy adjustments.

### 7.2 Investment in Sustainable Technologies

Increased investment in sustainable technology can significantly reduce agricultural environmental damage. It should emphasize on policy.

- Encouraging the use of solar-powered irrigation systems and energy-efficient equipment will help reduce fossil fuel dependence through the integration of renewable energy.
- The section focuses on the use of precision agriculture technologies in agriculture to optimize the application and usage of

fertilizers and water to reduce wastage and impact on the environment.

- It is essential to increase funding for agricultural research to develop drought-resistant, pest-resistant and highly nutritious crop varieties that can withstand climate change.

### 7.3 Enhancing Farmer Knowledge and Skills

Providing farmers with knowledge and technical skills are important for the shift to sustainable agriculture. Actions that have been suggested include.

- The agricultural extension services should be reinforced to train the community on sustainable agricultural practices, water-saving techniques, and cropping systems.
- Farmers access to digital literacy tools which help in getting information with ease. You can help farmers connect with the market and fast track government schemes.
- They said that promoting farmer-led mechanisms of sharing information and cooperatives can spark grassroots level support for sustainable practices and protect local ecological knowledge.

The integration of these initiatives into an overall national plan will allow for the utilization of synergies between technology, policy and community engagement, driven by the objectives of Vikisit Bharat.

## VIII. CASE STUDIES: REGIONAL INNOVATIONS AND SUCCESS STORIES

Experiences from around the world provide compelling evidence of the benefits of combining modern techniques with eco-friendly practices. Here are a couple of example case studies.

### 8.1 Maharashtra Combining Agriculture and Forestry

In a number of districts of Vidarbha in Maharashtra, traditional farming is not viable. Farmers have integrated agroforestry into traditional cropping systems. As a result of Local government Schemes

with Technical Assistance from agricultural Universities, transformation and environmental restoration of these regions was possible. Intercropping trees with seasonal crops improves organic matter and moisture content in the soil, causing an increase in soil fertility and farm productivity. Through the increased integration of trees, crops, and fruit orchards into the farming systems of the region, farmers' incomes have risen further by 20% addition ally. These beneficial farming techniques are reversing the trend of native birds and insects, which further helps in insect pest management. According to Gharai, agroforestry procedure and integration of trees with livestock are providing benefit to the farmers by increasing the income, ensuring security of livelihood along ecological restoration in this country.

### 8.2 Kerala: Organic Farming and Community Empowerment

The Kerala state has become a trailblazer in the field of organic agriculture. Local cooperatives, supported by government incentives and NGO alliances, are promoting a shift from chemical-intensive farming in many districts. The goal of organic farming is to restore ecosystem health and to achieve social equity and environmental sustainability through decentralized cooperative farming. Organic farming has improved soil health and enhanced farming sustainability. Products cultivated in these areas fetch higher prices in both domestic and international markets, making farming cash crop more viable and economically suitable (Jose et al., 2025). Community workshops and integrated farmer field schools helped spread the ideas that were put forth to the rest of the region a sustainable model.

### 8.3 Punjab and Haryana: Precision

The recent steps being taken by the states of Punjab and Haryana renowned for their agricultural productivity include the advent of precision agriculture to boost water use efficiency with the use of remote sensing. Precision irrigation has significantly reduced water loss by nearly 18%. In addition, there has been a significant improvement in crop yield (Jitendra et al. 2024). Farmers now receive tailored advisory on water requirements to adapt better to changing climatic conditions. The effective utilization of agricultural inputs has not only

restored the environment but also reduced overall cost of production.

#### IX. FUTURE OUTLOOK AND STRATEGIC IMPERATIVES

As agriculture develops, India and the environment will continue to express relationships between the two due to socio-economic factors. The development of agriculture must continue to be a driving force for inclusive and sustainable development in the following strategic imperatives.

- Effective policies will link up the sectors of agriculture, environment and rural development will help in the subsequent processes.
- Innovation ecosystems foster collaboration between research institutions, start-ups and businesses to encourage innovation and the development of green technologies.
- The holistic monitoring system shall include feedback loops to measure the progress of the sustainability initiatives so that any corrective action can be taken on time.
- Climate-Adaptive Strategies. Agricultural strategies will proactively integrate climate projections and resilience planning to ensure any shocks or stresses on the sector in the future.

By adopting these strategic imperatives, not only will India's agriculture remain globally competitive but also greatly contribute towards the broader goals of a Viksit Bharat that is economically viable and ecologically sustainable.

#### X. CONCLUSION

The journey to a developed and sustainable India calls for the convergence of modern agricultural practices, biodiversity conservation and environmental management. The analysis suggests that substantial improvements in agricultural productivity have come at an environmental cost that, while being addressed, is a slow process through innovative practices, policy shifts, and community efforts.

The statistics presented herewith underline the growing imperative of ensuring high productivity and growth on the one hand and the natural assets and their capacities that their use ensures on the other. The various methods mentioned, such as technology integration, digital agriculture, policy reforms, agroforestry, and precision water management, form the roadmap that perfectly coincides with the Viksit Bharat Vision of making India a developed nation by 2047. The onus is clearly on the policymakers, agri-experts and environment stakeholders – transformative change must be data-driven, best practices-led and farmers' consultation centred. India can only successfully juxtapose agricultural modernisation with ecological preservation and, thus, ensure a prosperous, sustainable future for all.

As the country moves towards 2047, the success of its agricultural transformation will be a testimony to its larger pledge to achieve a Viksit Bharat or developed nation which is progressive, respectful to nature and sustainable.

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