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ECONOMIC AND ENVIRONMENTAL IMPACT OF INDIGENOUS AGRICULTURAL PRACTICES ON SUSTAINABLE AGRICULTURE IN INDIA

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ABSTRACT

The growing concerns of declining farm profitability, soil degradation, biodiversity loss, and excessive dependence on chemical inputs have intensified the search for sustainable agricultural alternatives in India. In this context, indigenous agricultural practices, particularly Zero Budget Natural Farming (ZBNF), have emerged as promising models that integrate traditional ecological knowledge with resource-efficient farming systems. This study investigates the economic and environmental impact of indigenous agricultural practices on sustainable agriculture in India using empirical secondary data from Andhra Pradesh and national-level institutional reports. The findings reveal that ZBNF significantly reduces input costs and chemical dependency, with the median input cost for rice cultivation declining from ₹14,700 per acre under conventional farming to ₹12,200 under natural farming. Urea application decreased sharply from 74.46 kg per acre to 0.59 kg, while fertiliser use in groundnut cultivation declined by up to 91%. Despite reduced external inputs, crop productivity remained stable, showing a marginal yield increase of 1.5%, and profitability improved substantially, with reported profit gains of 123.6%. Environmental assessment further indicates enhanced biodiversity, with 114 bird species recorded in ZBNF fields and considerable increases in functional bird guilds. At the national level, the expansion of organic and natural farming areas from 1.78 million hectares in 2019 to 2.66 million hectares in 2021–22 reflects growing adoption and policy support. The study

concludes that indigenous agricultural practices simultaneously promote economic resilience and ecological sustainability, offering a viable and scalable pathway toward sustainable agricultural development in India.

KEYWORDS: Indigenous Agricultural Practices, Zero Budget Natural Farming, Sustainable Agriculture, Biodiversity Enhancement, Economic Sustainability.

INTRODUCTION

Sustainable agriculture has emerged as a critical development priority in India in the context of climate change, environmental degradation, declining soil fertility, and agrarian distress. Despite significant technological advancements during the Green Revolution, Indian agriculture today faces multiple challenges, including excessive reliance on chemical inputs, groundwater depletion, biodiversity loss, and rising production costs. In this backdrop, **indigenous agricultural practices (IAPs)**—developed through centuries of farmers' experiential knowledge—are gaining renewed academic and policy attention as viable pathways toward sustainable agriculture.

Indigenous agricultural practices refer to location-specific, traditional farming systems that are ecologically balanced, resource-efficient, and socially embedded. These practices include mixed cropping, crop rotation, use of organic manures, botanical pesticides, seed preservation techniques, rainwater harvesting, agroforestry, and traditional soil management methods. Rooted in an intimate understanding of local agro-climatic conditions, IAPs emphasise harmony between nature and farming activities, thereby minimising ecological disruption while ensuring livelihood security.

From an **economic perspective**, indigenous practices contribute to sustainability by reducing input costs, enhancing income stability, and improving risk resilience among small and marginal farmers. The reliance on locally available resources such as farmyard manure, bio-inputs, and indigenous seeds lowers dependence on costly external inputs. Moreover, diversified cropping systems associated with traditional agriculture help spread income risk and provide multiple livelihood sources, thereby strengthening rural economic resilience. In an era marked by price volatility and climate uncertainty, these attributes assume particular significance for India's agrarian economy.

From an **environmental standpoint**, indigenous agricultural practices play a crucial role in conserving soil health, water resources, and biodiversity. Organic nutrient recycling improves soil structure and microbial activity, while traditional water management systems enhance

water-use efficiency and groundwater recharge. Furthermore, the conservation of indigenous seed varieties contributes to agrobiodiversity, which is essential for long-term food security and climate adaptability. Unlike conventional intensive farming, IAPs generate minimal environmental externalities, making them inherently aligned with the principles of sustainable development.

Despite their potential, indigenous practices have often been marginalised in mainstream agricultural policy and research, which has historically prioritised input-intensive and technology-driven approaches. However, recent global commitments such as the Sustainable Development Goals (SDGs) and India's emphasis on natural and climate-resilient farming have renewed interest in integrating indigenous knowledge systems into contemporary agricultural frameworks.

In this context, analysing the **economic and environmental impact of indigenous agricultural practices on sustainable agriculture in India** becomes highly relevant. A systematic assessment not only contributes to academic discourse but also provides empirical insights for policymakers, development practitioners, and stakeholders seeking inclusive, environmentally sustainable, and economically viable agricultural solutions for India's future.

Review of Literature

1. *Berger, I., et al. (2025)* This multi-site empirical study rigorously examines the biodiversity and economic impacts of India's large-scale Zero Budget Natural Farming (ZBNF) programme, particularly in Andhra Pradesh. The study demonstrates that natural/ZBNF practices significantly improved bird biodiversity and more than doubled farmers' economic gains due to reduced input costs, while average crop yields did not decline. The findings provide strong empirical evidence supporting policy-level adoption of natural farming.

2. Bharucha, Z. P., Mitjans, S. B., & Pretty, J. (2020) This paper analyzes ZBNF in Andhra Pradesh as a large-scale agricultural "redesign" initiative. It highlights systemic, institutional, and social challenges associated with scaling up ZBNF while emphasizing its advantages in reducing costs and promoting the use of local inputs. However, the authors caution that large-scale expansion requires continuous monitoring and rigorous scientific evaluation.

3. Dorin, B. (2021) This evaluative article discusses the theory, practice, and challenges of agroecology in India. It emphasizes the socio-political diffusion of traditional and local agricultural practices and their governance context. The study argues that beyond technical

solutions, local institutional transformation is essential for the effective implementation of agroecological systems.

4. Patel, S. K., Sharma, A., & Singh, G. S. (2020) This integrative review presents traditional Indian agricultural practices, such as mixed cropping and organic manuring, from the perspectives of environmental sustainability and food security. The article provides both theoretical insights and field-based evidence highlighting the ecological and biological benefits of traditional farming systems.

5. Vernooy, R. (2020) This study provides empirical evidence and policy-oriented recommendations on Community Seed Banks (CSBs) as mechanisms for seed conservation, local accessibility, and farmer control over genetic resources. It demonstrates that CSBs contribute not only to conservation but also to food security and resilience enhancement, while acknowledging challenges related to operational sustainability.

6. Joshi, B. K. (2021)Focusing on indigenous and tribal seed conservation and selection practices, this study highlights the importance of traditional seed systems in maintaining local diversity and biological resilience. The paper presents experimental protocols, conservation workflows, and grassroots-level data, making it particularly valuable for informing local seed-based policy interventions.

7. Duddigan, S., et al. (2023) Based on field trials conducted in southeastern India, this study shows that natural/ZBNF practices do not result in yield reductions compared to conventional chemical systems under many relevant conditions and significantly improve soil quality. The research provides biophysical explanations for these outcomes and offers scientific validation for natural farming approaches.

8. Tione, G., Westengen, O. T., Holden, S. T., et al. (2025) This empirical study published in *Food Policy* provides international evidence demonstrating that Community Seed Banks (CSBs) have positively impacted household food security in contexts where they were effectively implemented. The findings strengthen the policy argument for supporting CSBs in countries such as India.

9. Adikini, S., et al. (2025) This recent regional survey analyzing conservation practices and farmer-managed seed systems shows that traditional seed protection behaviors remain widespread in several parts of India and are closely linked to diverse soil and agroecological conditions. The study supports the case for policy transformation and increased investment in community-based seed systems.

10. Prathapachandran, N. (2023) This case study from Wayanad, Kerala, documents the economic and environmental benefits of traditional farming practices within indigenous tribal

communities. It highlights the role of organic food production and community-based resource management systems. The policy implication suggests that with institutional support and improved market connectivity, traditional agricultural systems can become both commercially viable and sustainable.

Research Gap 1

Existing studies on indigenous agricultural practices in India largely examine **economic and environmental impacts separately**, with very limited research offering an **integrated assessment of both dimensions** in the context of sustainable agriculture. There is a notable lack of **micro-level, region-specific empirical evidence** on the economic and environmental outcomes of indigenous agricultural practices across India's diverse agro-ecological and socio-economic settings.

Objectives

1.To study the **economic benefits** of indigenous and natural agricultural practices for farmers.

2.To examine the **environmental benefits** of indigenous and natural agricultural practices.

3.To analyze the **combined economic and environmental impact** of indigenous and natural agricultural practices on sustainable agriculture.

4.To understand the **role of indigenous and natural agricultural practices** in supporting sustainable farming in India.

Research Methodology

Research Design

The study adopts a **descriptive and analytical research design**. This design is appropriate for examining both the **economic and environmental impacts** of indigenous and natural agricultural practices and for analyzing their **combined role in promoting sustainable agriculture in India**.

Nature of the Study

The research is **empirical and quantitative in nature**, relying primarily on **secondary numerical data** obtained from published surveys, peer-reviewed research articles, and institutional reports related to indigenous and natural farming practices in India.

Sources of Data

The study is based on secondary data collected from reliable and authentic sources. Economic and environmental data were obtained from peer-reviewed journal articles such as *Nature*

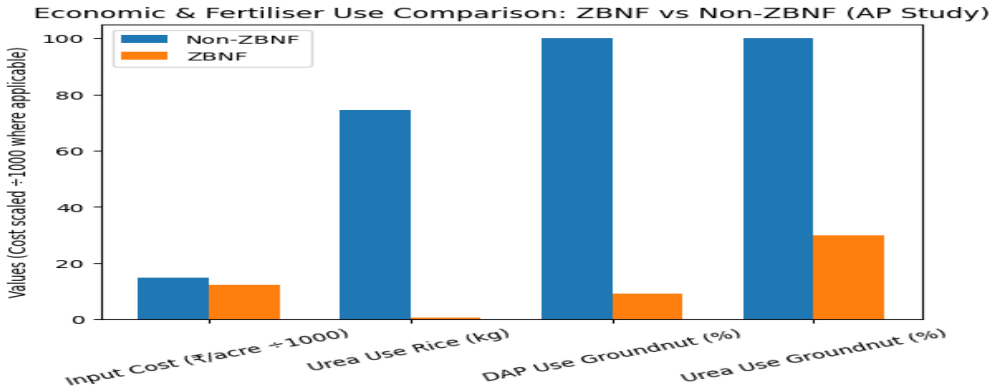
Ecology & Evolution and *Agronomy for Sustainable Development*, which provide empirical evidence on yield performance, biodiversity, and soil quality under natural farming systems. Input cost and fertiliser reduction data were sourced from reports published by the Council on Energy, Environment and Water (CEEW), based on farmer surveys conducted in Andhra Pradesh. National-level statistics on area under organic and natural farming were collected from official reports of NITI Aayog, ICAR-NAARM, APEDA, and the Ministry of Agriculture & Farmers' Welfare.

Data Collection and Analysis

Table 1: Input Cost & Fertiliser Use – Andhra Pradesh. (ZBNF Study)

Indicator	Non-ZBNF Farmers	ZBNF Farmers
Median Input Cost – Rice (₹/acre)	₹14,700	₹12,200
Urea Use – Rice (kg/acre)	74.46 kg	0.59 kg
DAP Use – Groundnut	Baseline	91% lower
Urea Use – Groundnut	Baseline	70% lower

Council on Energy, Environment and Water (CEEW). (2020). *Can Zero Budget Natural Farming save input costs and fertiliser subsidies? Evidence from Andhra Pradesh*. New Delhi: CEEW. https://www.ceew.in/publications/can-zero-budget-natural-farming-save-input-costs-and-fertiliser-subsidies-evidence



The graph shows that Zero Budget Natural Farming (ZBNF) significantly reduces both production costs and chemical fertiliser use compared to conventional farming in Andhra Pradesh. The median input cost for rice cultivation declined from ₹14,700 per acre under conventional farming to ₹12,200 under ZBNF, indicating improved cost efficiency.A substantial reduction in synthetic fertiliser use is also observed. Urea application in rice decreased from 74.46 kg per acre to only 0.59 kg under ZBNF. Similarly, DAP use in

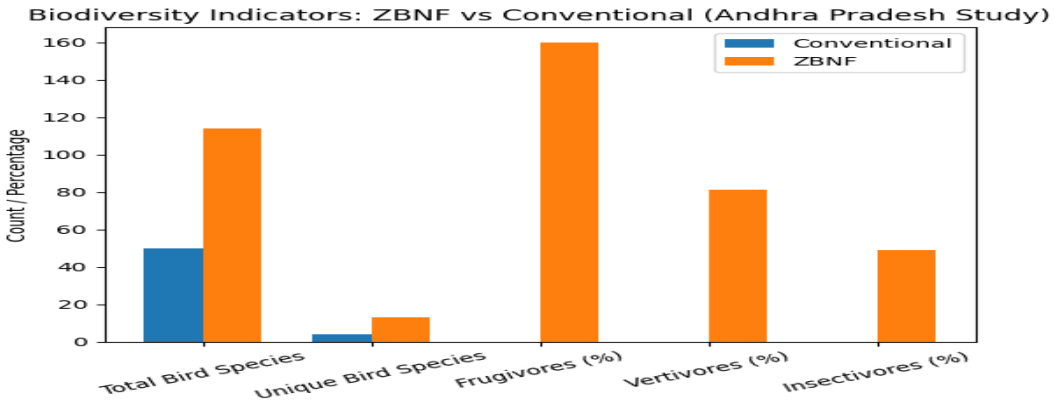
groundnut cultivation declined by 91%, and urea use by 70%.These findings suggest that indigenous natural farming practices not only reduce farmers' financial burden but also minimize environmental pressure through lower chemical input use. Thus, ZBNF demonstrates strong potential to support economically viable and environmentally sustainable agriculture in India.

Table 2: Biodiversity Impact under ZBNF. (Andhra Pradesh)

Environmental Indicator	Conventional	ZBNF
Total Bird Species Recorded	Lower	114 species
Unique Bird Species	4	13
Increase in Frugivores	—	+160%
Increase in Vertivores	—	+81%
Increase in Insectivores	—	+49%

Berger, I., et al. (2025). *India's agroecology programme, "Zero Budget Natural Farming", delivers biodiversity and economic benefits without lowering yields*. Nature Ecology & Evolution.

https://doi.org/10.1038/s41559-025-02849-7



The graph clearly illustrates that Zero Budget Natural Farming (ZBNF) significantly enhances biodiversity compared to conventional farming systems. ZBNF fields recorded 114 total bird species, which is substantially higher than conventional fields. Similarly, the number of unique bird species was 13 under ZBNF compared to only 4 under conventional farming. Guild-level analysis further highlights ecological improvement. Frugivorous birds increased by 160%, vertivores by 81%, and insectivores by 49% in ZBNF fields relative to conventional plots. These increases indicate improved habitat quality, greater ecological balance, and enhanced ecosystem functioning under indigenous natural farming practices.

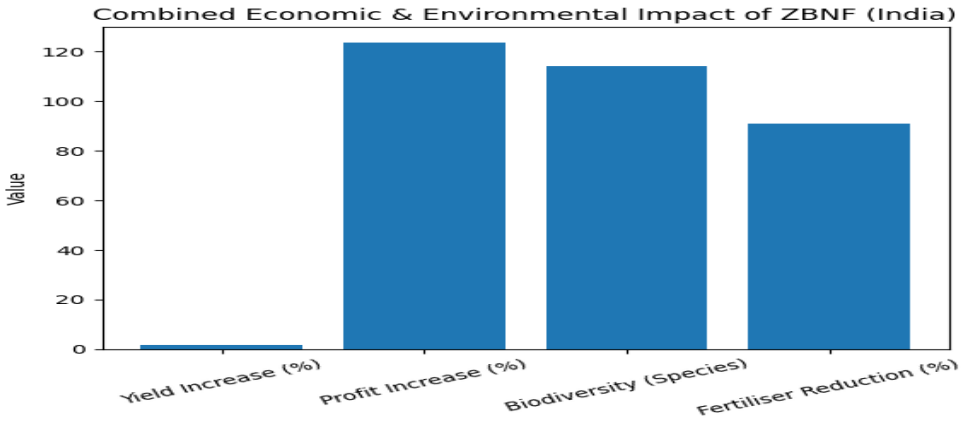
Overall, the evidence suggests that ZBNF contributes positively to environmental sustainability by promoting biodiversity conservation within agricultural landscapes.

Table 3: Integrated Impact – Andhra Pradesh. (Multi-field Study)

Indicator	ZBNF Outcome
Yield Difference vs Conventional	+1.5% (No yield penalty)
Profit Increase	+123.6% higher
Biodiversity Gain	114 species observed
Fertiliser Reduction	83–99% lower

Berger, I., et al. (2025). *Nature Ecology & Evolution*.

https://doi.org/10.1038/s41559-025-02849-7



The graph presents the integrated economic and environmental performance of Zero Budget Natural Farming (ZBNF) in India. The results indicate that ZBNF achieved a 1.5% yield increase compared to conventional farming, demonstrating that productivity is maintained without any yield penalty. More significantly, farmers experienced a 123.6% increase in profit, primarily due to substantial reductions in input costs. From an environmental perspective, ZBNF fields recorded 114 bird species, indicating enhanced biodiversity within agricultural landscapes. Additionally, fertiliser use was reduced by approximately 83–99%, reflecting a major decline in synthetic chemical dependency. Overall, the graph confirms that ZBNF simultaneously improves farm profitability while promoting ecological sustainability, thereby supporting the broader goal of sustainable agriculture in India.

Table 4: Scale of Organic/Natural Farming in India.

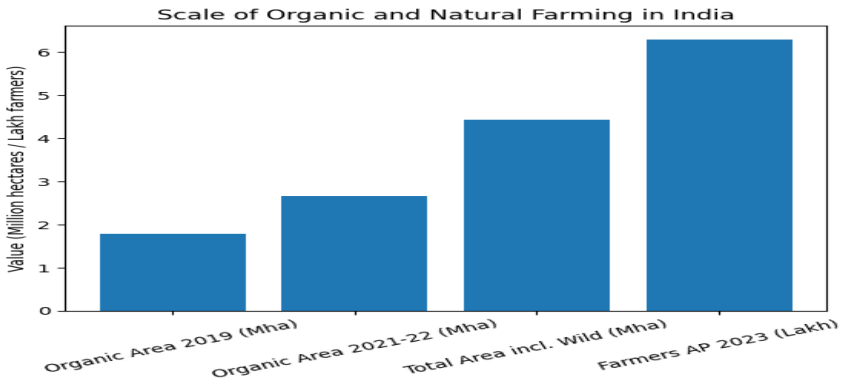
Indicator	Value (India)
Area under Organic Farming (2019)	1.78 million hectares
Area under Organic Cultivation (2021–22)	2.66 million hectares

Total Area including Wild Harvest	4.43 million hectares
Farmers involved in Natural Farming (AP, 2023)	~6.3 lakh farmers

NITI Aayog & ICAR-NAARM. (2021). *Natural Farming in India: Policy and Implementation Framework*. Government of India.

https://www.niti.gov.in/sites/default/files/2021-03/NaturalFarmingProjectReport-ICAR-NAARM.pdf

APEDA. (2022). *National Programme for Organic Production Statistics*. Government of India.



The graph illustrates the expanding scale of organic and natural farming in India. The cultivated area under organic farming increased from 1.78 million hectares in 2019 to 2.66 million hectares in 2021–22, indicating steady growth in sustainable agricultural practices. When including wild harvest areas, the total organic area reaches 4.43 million hectares, reflecting the broader ecological footprint of organic systems in India. Additionally, approximately 6.3 lakh farmers were involved in natural farming initiatives in Andhra Pradesh in 2023, demonstrating significant farmer-level adoption. These figures highlight the growing institutional and grassroots support for indigenous and natural agricultural practices in India, reinforcing their role in promoting sustainable farming systems at both regional and national levels.

RESULTS AND FINDINGS

The analysis of secondary data from Andhra Pradesh and national-level reports indicates that indigenous and natural agricultural practices, particularly Zero Budget Natural Farming (ZBNF), generate significant economic and environmental benefits. From an economic perspective, the median input cost for rice cultivation declined from ₹14,700 per acre under

conventional farming to ₹12,200 under ZBNF. A substantial reduction in synthetic fertiliser use was observed, with urea application in rice decreasing from 74.46 kg per acre to only 0.59 kg. Similarly, DAP use in groundnut cultivation declined by 91%, while urea use was reduced by 70%. Despite this drastic reduction in chemical inputs, crop productivity was not negatively affected; rather, yields showed a marginal increase of 1.5% compared to conventional systems. More importantly, profit levels were reported to be 123.6% higher under ZBNF fields, indicating improved economic viability due to lower input costs and stable yields.

From an environmental standpoint, biodiversity indicators show remarkable improvements under indigenous natural farming systems. ZBNF fields recorded 114 bird species, significantly higher than conventional farms. The number of unique bird species increased from 4 under conventional farming to 13 under ZBNF. Additionally, guild-level biodiversity improvements were recorded, with frugivorous birds increasing by 160%, vertivores by 81%, and insectivores by 49%. These findings suggest improved ecological balance, better habitat quality, and enhanced ecosystem functioning. Furthermore, fertiliser use reductions ranging from 83% to 99% indicate a substantial decrease in chemical load on soil and water systems, contributing to environmental sustainability.

The combined analysis demonstrates that indigenous agricultural practices do not involve a trade-off between economic and environmental outcomes. Instead, they simultaneously improve profitability and ecological health, thereby strengthening the foundation of sustainable agriculture. At the national level, the area under organic and natural farming expanded from 1.78 million hectares in 2019 to 2.66 million hectares in 2021–22, with total organic area including wild harvest reaching 4.43 million hectares. Additionally, approximately 6.3 lakh farmers were engaged in natural farming initiatives in Andhra Pradesh alone by 2023, reflecting growing adoption and institutional support.

Overall, the findings confirm that indigenous and natural agricultural practices contribute significantly to economic resilience, biodiversity conservation, resource efficiency, and the broader goal of sustainable agriculture in India.

CONCLUSION

The present study concludes that indigenous and natural agricultural practices, particularly Zero Budget Natural Farming (ZBNF), play a significant role in advancing sustainable agriculture in India. The empirical evidence demonstrates that these practices substantially reduce input costs and chemical fertiliser dependency while maintaining or slightly

improving crop yields. The observed increase in profitability, primarily driven by reduced production expenditure, indicates that indigenous farming systems enhance farmers' economic resilience without compromising productivity.

From an environmental perspective, the study confirms that indigenous agricultural practices contribute positively to biodiversity conservation and ecological balance. The significant increase in bird species richness and functional guild diversity under ZBNF highlights the capacity of natural farming systems to restore and sustain agro-ecosystems. The drastic reduction in synthetic fertiliser use further minimizes soil and water contamination risks, thereby strengthening environmental sustainability.

Importantly, the integrated analysis reveals that economic gains and environmental improvements occur simultaneously under indigenous farming systems. This challenges the conventional assumption that ecological sustainability comes at the cost of reduced productivity or profitability. Instead, indigenous agricultural practices offer a balanced and viable pathway toward achieving long-term agricultural sustainability.

At the national level, the expanding area under organic and natural farming, along with increasing farmer participation, reflects growing policy recognition and institutional support. Therefore, indigenous agricultural practices represent not only a traditional knowledge system but also a strategic solution for addressing contemporary challenges such as input dependency, environmental degradation, and rural income instability.

In conclusion, indigenous and natural agricultural practices hold strong potential to contribute to economically viable, environmentally sound, and socially sustainable agricultural development in India. Their systematic promotion and scientific integration into mainstream agricultural policy can significantly strengthen the future of sustainable farming in the country.

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