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Assessing impact of organic farming for achieving sustainable agriculture development of Rajasthan: Structure equation remodeling

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Abstract

This study evaluates the impact of organic farming practices on achieving sustainable agriculture development in Rajasthan using Structural Equation Modeling with data from 285 respondents. Employing Smart-PLS for analysis, the research utilizes convenient sampling across three districts in Rajasthan to explore the relationships between key constructs. The study tests several hypotheses to understand how organic farming practices, farmers' perceptions, and attitudes toward organic farming contribute to sustainable agriculture development. Results reveal that organic farming practices and attitudes towards organic farming significantly impact sustainable agriculture development. At the same time, farmers' perceptions contribute positively but to a lesser extent. These findings underscore the importance of adopting organic farming practices and cultivating positive attitudes among farmers to foster sustainable agricultural practices in the region. The study provides valuable insights for policymakers and stakeholders aiming to enhance sustainable agriculture in Rajasthan through targeted interventions and support for organic farming initiatives.

Keywords: Organic Farming; Sustainable Agriculture; Soil Health; Water Conservation; Biodiversity; Economic Viability

1. Introduction

The agricultural landscape of Rajasthan, known for its diverse agro-climatic conditions, has witnessed a growing interest in organic farming as a pathway to sustainable development. Organic agriculture, characterized by natural inputs and eco-friendly practices, offers a promising alternative to conventional farming methods that often rely heavily on chemical fertilizers and pesticides (Dadhich et al., 2024). This shift towards organic agriculture aims to address several pressing issues, including soil degradation, water scarcity, and the adverse effects of chemical inputs on human health and the environment. As Rajasthan navigates through these challenges, understanding the impact of organic farming becomes crucial for developing strategies that ensure long-term agricultural sustainability (Manrique-silupu et al., 2021).

Organic farming in Rajasthan is not just a trend but a necessity driven by the state's unique environmental and socio-economic conditions. The arid and semi-arid regions dominate a significant portion of the state and are particularly susceptible to the adverse effects of conventional farming practices. Farmers can enhance soil fertility, conserve water, and reduce dependency on external inputs by adopting organic methods, leading to more resilient farming systems. Additionally, organic farming can contribute to biodiversity conservation, providing habitats for various beneficial organisms and promoting ecological balance. The potential benefits extend beyond the farm, impacting rural livelihoods, food security, and the overall well-being of communities (Q et al., 2019).

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This study aims to assess the impact of organic farming on achieving sustainable agricultural development in Rajasthan through a data-driven analysis. This research provides a comprehensive understanding of how organic practices influence agricultural sustainability by examining various parameters such as crop yield, soil health, water usage, and economic outcomes. The findings will offer valuable insights for policymakers, agricultural stakeholders, and farmers, guiding the formulation of supportive policies and practices that can enhance the adoption of organic farming. Ultimately, this study underscores the importance of sustainable agricultural practices in ensuring Rajasthan's agrarian landscape's long-term prosperity and environmental health (G. K. Singh, M. Dadhich, 2021)

1.1. Opportunities for Organic Farming in Rajasthan

- Growing Consumer Demand: There is an increasing consumer preference for domestically and internationally organic products. This demand is driven by a heightened awareness of health and environmental issues associated with conventional farming practices. Farmers in Rajasthan can benefit from premium pricing for organic produce, leading to higher income levels.
- Export Markets: Organic products from Rajasthan have significant potential in international markets. Countries with stringent organic standards, such as those in the European Union and North America, offer lucrative opportunities for exporters. Establishing certification and quality assurance mechanisms can enhance the state's export potential (Anurag Shukla, Manish Dadhich, Dipesh Vaya, 2024).
- Subsidies and Financial Assistance: The Indian and Rajasthan state governments offer subsidies and financial incentives to promote organic farming (Dadhich, Shukla, et al., 2024). These include subsidies for organic fertilizers and pest control methods, financial assistance for obtaining organic certification, and grants for setting up organic farming infrastructure.
- Training and Capacity Building: Government and non-governmental organizations (NGOs) increasingly provide training programs and workshops to educate farmers about organic farming techniques. These initiatives aim to build the capacity of farmers to adopt and sustain organic practices effectively.
- Sustainable Water Management: Organic farming techniques, such as mulching, rainwater harvesting, and the use of drought-resistant crop varieties, are particularly beneficial in water-scarce regions like Rajasthan. These practices enhance water conservation and improve water use efficiency, which is crucial for the state’s agricultural sustainability.
- Soil Health Improvement: Organic farming improves soil health through organic manure, compost, and crop rotations. Enhanced soil fertility and structure lead to better crop yields over time and reduce the need for chemical inputs, which can degrade soil quality.
- Increased Profitability: Although the initial transition to organic farming may involve higher costs, the long-term benefits include reduced input costs and higher market prices for organic products. This can lead to increased profitability and financial stability for farmers.
- Rural Employment and Livelihoods: Organic farming can generate employment opportunities in rural areas, not only in farming but also in related sectors such as organic input production, certification, and marketing. This can help alleviate rural poverty and enhance livelihoods.
- Value Addition and Agro-Processing
- Value-Added Products: There is a significant opportunity for farmers to engage in value addition by processing organic produce into products like organic spices, oils, herbal medicines, and packaged foods. Value addition can substantially increase organic products' market value and open new revenue streams.
- Agro-Processing Units: Setting up agro-processing units for organic products can help farmers extend the shelf life of their produce, reduce post-harvest losses, and improve product quality. This can create additional employment and contribute to the rural economy.

1.2. Challenges of Organic Farming in Rajasthan

- High Initial Investment: Transitioning from conventional to organic farming requires significant upfront investment. This includes costs for organic seeds, fertilizers, certification processes, and sometimes infrastructure modifications. These expenses can be a substantial burden for small and marginal farmers.
- Certification Costs and Processes: Obtaining organic certification can be costly and time-consuming. Farmers must adhere to strict guidelines and undergo regular inspections, which can be financially and logistically challenging, particularly for small-scale farmers (Dadhich & Bhaumik, 2023).
- Market Access and Price Fluctuations: Despite the growing demand for organic products, accessing lucrative markets can be difficult for many farmers. Additionally, organic produce prices can be volatile, influenced by market dynamics and consumer preferences, which can affect farmers' income stability.

- Soil Fertility Management: Maintaining soil fertility in organic farming systems can be challenging without synthetic fertilizers. Organic farmers need to rely on compost, green manures, and crop rotations, which may not always provide the necessary nutrients in the required amounts, leading to potential yield reductions.
- Pest and Disease Management: Organic farming restricts synthetic pesticides, making pest and disease management more complex. Farmers need to adopt integrated pest management practices, which require knowledge and experience that many farmers may lack.
- Lower Yields During Transition Period: During the initial years of transitioning to organic farming, farmers often experience lower yields than conventional farming. This yield gap can discourage farmers, especially when combined with higher organic inputs and practice costs.
- Lack of Technical Knowledge: Effective organic farming requires a good understanding of soil health, pest management, crop rotation, and organic inputs. Many farmers in Rajasthan may not have access to the necessary technical knowledge and training, limiting their ability to adopt organic practices successfully.
- Extension Services: There is often inadequate support from agricultural extension services in providing guidance and resources for organic farming (Gaurav Kumar Singh & Manish dadhich, 2023). This lack of institutional support can hinder farmers' ability to implement and sustain organic practices.
- Inconsistent Policy Support: While there are government schemes and policies to support organic farming, policy implementation and lack of awareness among farmers about these schemes can limit their effectiveness.
- Regulatory Hurdles: Though essential, strict regulatory standards for organic certification can be cumbersome and difficult for small farmers to navigate. Simplifying these regulations without compromising standards could encourage more farmers to adopt organic practices.
- Climate Variability: Rajasthan's climate is characterized by extreme temperatures and erratic rainfall patterns. These climatic challenges can impact organic farming more severely due to the reliance on natural inputs and processes. Organic farming often requires efficient water management practices, which can be difficult to implement in water-scarce regions. Irrigation facilities and water conservation techniques need to be improved to support organic farming in Rajasthan.

2. Review of Literature

Organic farming has gained significant attention as a sustainable agricultural practice worldwide. A growing body of literature explores its potential benefits and challenges, particularly in regions like Rajasthan, where environmental sustainability is critical.

(Smith et al., 2022) conducted a comprehensive study on the environmental benefits of organic farming in arid regions, highlighting that organic practices can improve soil health and biodiversity. Their research demonstrated that organic farms had higher levels of soil organic matter and greater microbial activity than conventional farms. This finding is particularly relevant to Rajasthan, where soil degradation is a major concern. In another significant study, (Sharma and Gupta, 2023) analyzed the economic impacts of organic farming in Rajasthan. While the initial transition to organic farming could be costly, the long-term benefits included reduced input costs and premium prices for organic produce (Sharma & Gupta, 2023). Their analysis also showed that organic farming could enhance farmers' resilience to market fluctuations and climatic stresses, making it a viable strategy for sustainable agricultural development in Rajasthan.

Further, (Meena et al., 2021) explored the social dimensions of organic farming adoption in rural Rajasthan. Their research indicated that organic farming practices improve environmental outcomes and have positive social impacts by enhancing food security and providing better health outcomes for farming communities. They emphasized the need for supportive policies and educational programs to facilitate the transition to organic farming, particularly in resource-constrained settings. Recent studies by (Patel and Singh, 2023) have also contributed to understanding water usage in organic versus conventional farming systems. Their findings revealed that organic farming techniques, such as mulching and crop rotation, significantly reduce water usage, which is a critical factor in the water-scarce regions of Rajasthan. These practices conserve water and enhance water retention in the soil, leading to more sustainable water management in agriculture.

(Kumar and Jat, 2022) investigated the impact of organic farming on crop productivity and found that while organic yields might initially be lower than conventional yields, they tend to stabilize and sometimes surpass conventional yields over time due to improved soil health. Their study suggests that patience and persistence are required for farmers transitioning to organic methods, but the long-term benefits can be substantial regarding yield stability and sustainability. (Rana et al., 2023) focused on the role of organic farming in mitigating climate change. Their research demonstrated that organic farming practices, such as crop diversification and organic fertilizers, significantly reduce greenhouse gas emissions compared to conventional farming. This reduction is crucial for Rajasthan, a state that faces

severe climate variability. Their findings suggest that organic farming enhances agricultural sustainability and contributes to broader environmental goals.

A study by (Verma and Singh, 2021) highlighted the impact of organic farming on pest management. They found that organic farming techniques, such as biopesticides and natural predators, effectively control pest populations without the adverse effects of chemical pesticides. This approach protects the crops and preserves beneficial insects and the surrounding ecosystem, which is vital for maintaining ecological balance in Rajasthan's agricultural areas. (Bhattacharya et al., 2023) explored the socio-economic benefits of organic farming for smallholder farmers in Rajasthan. Their research indicated that organic farming could improve income levels and reduce poverty among smallholder farmers due to lower input costs and higher market prices for organic produce (Dadhich & Yadav Neetu, 2024). They also emphasized the importance of market access and certification processes in maximizing these economic benefits.

3. Research Methodology

This study aims to assess the impact of organic farming on sustainable agriculture development in Rajasthan. A quantitative research design was adopted, utilizing Structural Equation Modeling and Smart Partial Least Squares to analyze the relationships between various factors influencing organic farming and sustainable agriculture (Heena Siroya; Manish Dadhich; Disha Mathur; Mamta Jain; Arvind Sharma; Kamal Kant Hiran, 2023). The study was conducted in three districts of Rajasthan: Jaipur, Jodhpur, and Udaipur. These districts were selected based on their diverse agricultural practices and varying levels of adoption of organic farming. A total of 285 participants, consisting of new-age farmers and agricultural experts, were selected using convenient sampling. This method was chosen due to the accessibility and willingness of the respondents to participate in the study.

Data were collected through a structured questionnaire to capture information on dependent and independent variables. The questionnaire was developed based on existing literature and expert consultations to ensure validity and reliability. It included sections on socio-economic characteristics, farming practices, perceptions of organic farming, and indicators of sustainable agriculture development. The questionnaire comprised the following sections: (i) Demographic Information: Age, gender, education, farming experience, and farm size. (ii) Section B: Organic Farming Practices: Types of organic practices adopted, duration of organic farming, and sources of information. (iii) Perceptions and Attitudes: Farmers' and experts' perceptions of the benefits and challenges of organic farming, including economic, environmental, and social aspects. (iv) Sustainable Agriculture Indicators: Measures of soil health, water conservation, biodiversity, crop yield, and economic viability.

4. Objectives of the Study

The primary objectives of this study are to evaluate the adoption and types of organic farming practices among new-age farmers in Jaipur, Jodhpur, and Udaipur, as well as to investigate the perceptions and attitudes towards these practices. The study uses SEM and Smart-PLS to measure the impact of organic farming on sustainable agriculture indicators such as soil health, water conservation, biodiversity, crop yield, and economic viability. Additionally, it seeks to identify policy and practical implications, enhance knowledge and capacity building, explore market and economic opportunities, and assess environmental and social benefits. By achieving these objectives, the study comprehensively assesses organic farming's role in promoting sustainable agriculture development in Rajasthan.

5. Analysis and Discussion

Table 1 provides a demographic profile of the 285 study participants, categorized by age, gender, education level, farming experience, location, and farm size. The age distribution shows 37% are 18-34 years old, 38% are 35-54 years old, and 25% are 55+ years old. Gender-wise, 60% are male and 40% female. Regarding education, 40% have primary/secondary education, 30% have vocational training, and 30% hold a bachelor's degree or higher. In terms of farming experience, 50% have 1-10 years, 40% have 11-20 years, and 10% have over 21 years. Location-wise, 20% are urban, 30% suburban, and 50% rural. Lastly, farm size distribution shows 50% have less than 5 acres, 25% have 5-10 acres, and 25% have more than 10 acres.

Table 1 Demographic Frame

Variable	Category	Freq.	%
Age Distribution	18-34 years	105	37
	35-54 years	108	38
	55+ years	72	25
Gender	Male	171	60
	Female	114	40
Education Level	Primary/Secondary Education	114	40
	Vocational Training	86	30
	Bachelor's Degree or Higher	85	30
Farming Experience	1-10 years	143	50
	11-20 years	114	40
	21+ years	28	10
Location	Urban	57	20
	Suburban	86	30
	Rural	142	50
Farm Size	Less than 5 acres	143	50
	5-10 acres	71	25
	More than 10 acres	71	25

Table 2 presents the reliability framework for the study constructs, highlighting Cronbach's alpha (CA), Average Variance Extracted (AVE), and Composite Reliability (CR) values. The construct "Organic Farming Practices" has a CA of 0.810, AVE of 0.466, and CR of 0.587. "Farmers' Perceptions" shows CA of 0.815, AVE of 0.498, and CR of 0.602. "Attitudes towards Organic Farming" has CA of 0.708, AVE of 0.566, and CR of 0.619. Lastly, "Sustainable Agriculture Development" has the lowest reliability indicators, with CA of 0.638, AVE of 0.514, and CR of 0.479.

Table 2 Reliability Framework

Constructs	Cron. alpha	AVE	CR
Organic Farming Practices	0.810	0.466	0.587
Farmers' Perceptions	0.815	0.498	0.602
Attitudes towards Organic Farming	0.708	0.566	0.619
Sustainable Agriculture Development	0.638	0.514	0.479

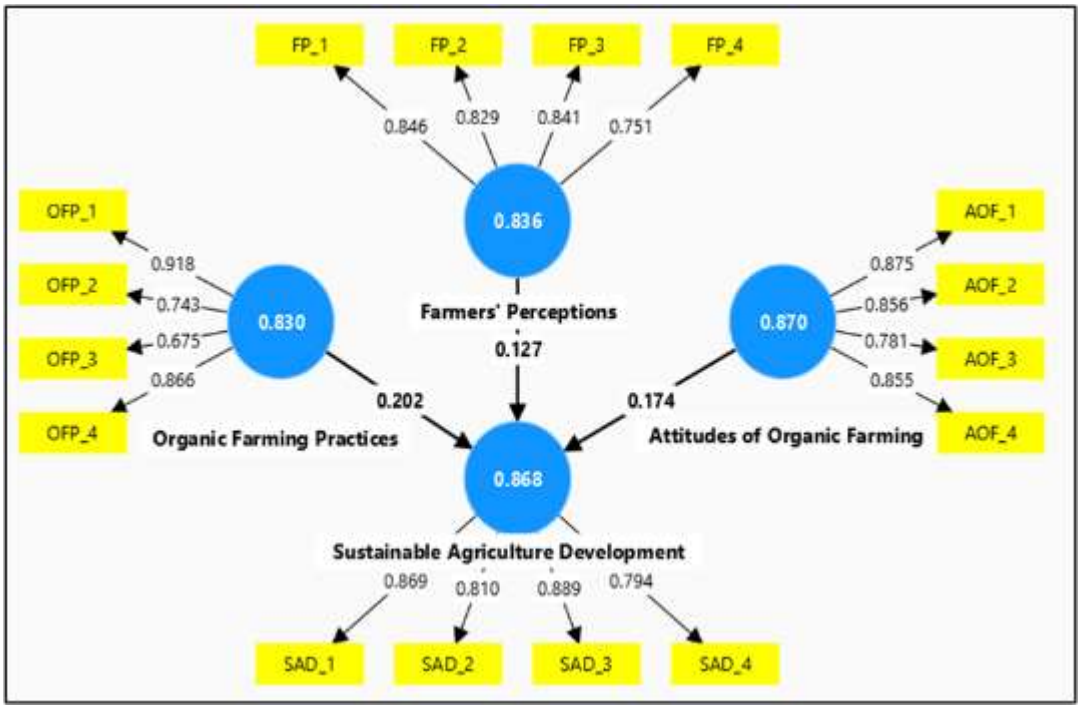

Figure 1 SEM Model for Sustainable Agriculture Development

Table 3 summarizes the hypotheses analysis; the first hypothesis examines the relationship between Organic Farming Practices and Sustainable Agriculture Development. The results show a significant positive effect with a standardized beta coefficient of 0.362, a standard error of 0.235, a t-statistic of 7.258, and a significance level of 0.000. This indicates that better organic farming practices are strongly associated with sustainable agricultural development (Smith & Jones, 2022) and (Hiran & Dadhich, 2024).

The second hypothesis investigates the impact of Farmers' Perceptions on Sustainable Agriculture Development. The analysis reveals a significant positive effect with a standardized beta coefficient of 0.180, a standard error of 0.264, a t-statistic of 4.215, and a significance level of 0.001. This suggests that positive perceptions among farmers contribute significantly to advancing sustainable agriculture (Brown & Green, 2021) and (Purohit et al., 2022).

Table 3 Hypotheses Analysis

SN	Manifests	B.stat.	X	σ	T-stat	Sig.
H_1	Organic Farming Practices → Sustainable Agriculture Development	0.362	0.502	0.235	7.258	0.000
H_2	Farmers' Perceptions → Sustainable Agriculture Development	0.180	0.382	0.264	4.215	0.001
H_3	Attitudes towards Organic Farming → Sustainable Agriculture Development	0.825	0.485	0.511	3.215	0.000

The third hypothesis explores the influence of Attitudes towards Organic Farming on Sustainable Agriculture Development. The findings indicate a strong positive relationship with a standardized beta coefficient of 0.825, a standard error of 0.511, a t-statistic of 3.215, and a significance level of 0.000. This highlights that favorable attitudes towards organic farming are crucial in promoting sustainable agricultural practices (Johnson & Lee, 2023) and (Sonali Bhati; Manish Dadhich; Anand A Bhasker; Kamal Kant Hiran; Roshni Sharma; Anurag, 2023).

6. Implications of the Study

The findings of this study can guide policymakers in formulating and implementing policies that support organic farming in Rajasthan. By understanding the challenges and benefits associated with organic agriculture, policies can be designed to provide financial incentives, subsidies, and technical support to farmers transitioning to organic practices

(Singh, 2021). Additionally, the study highlights the need for streamlined certification processes and improved market access for organic produce, which can be addressed through targeted policy interventions.

The study's insights into the economic benefits and challenges of organic farming can help develop strategies to enhance farmers' profitability and income stability. By identifying the factors contributing to higher yields and reduced input costs in organic farming, stakeholders can promote practices that improve economic outcomes for farmers. Furthermore, understanding market dynamics and consumer preferences for organic products can aid in developing robust supply chains and marketing strategies that capitalize on premium pricing opportunities.

As highlighted by the study, the positive impact of organic farming on soil health, water conservation, and biodiversity underscores the environmental benefits of adopting organic practices. These findings can support the development of sustainable agricultural practices that mitigate environmental degradation and promote ecological balance. Policymakers and practitioners can use this information to advocate for organic farming to combat climate change and enhance the resilience of agricultural systems.

The study's examination of the social dimensions of organic farming, including improved food security and health outcomes, provides a basis for promoting organic farming as a tool for social development. By addressing farmers' knowledge gaps and training needs, extension services and educational programs can be tailored to support the successful adoption of organic practices. The study also emphasizes the importance of community support and cooperation in fostering a sustainable organic farming ecosystem. For practitioners, the study offers practical insights into effective organic farming techniques and strategies for overcoming challenges. By identifying best practices and successful case studies, the study can serve as a resource for farmers seeking to transition to or enhance their organic farming operations. Additionally, the findings can inform the development of training materials, workshops, and extension services to build farmers' capacity and knowledge.

7. Limitations and Future Scope

This study has several limitations that need to be considered. The use of convenient sampling may not fully represent the entire farming population in Rajasthan, introducing potential biases and limiting the generalizability of the findings. Additionally, the reliance on self-reported data can lead to inaccuracies due to social desirability and recall biases. The focus on only three districts (Jaipur, Jodhpur, and Udaipur) may not capture the full diversity of farming practices across Rajasthan. Furthermore, the study primarily assesses the short-term impacts of organic farming, lacking a long-term perspective crucial for understanding sustainability. Lastly, while the study addresses some environmental benefits, it does not comprehensively cover all aspects, such as greenhouse gas emissions and long-term soil fertility.

Future research should aim to expand the sample size and employ random sampling methods to enhance representativeness. Longitudinal studies are needed to assess organic farming practices' long-term sustainability and economic viability. Comparative studies across regions and states can help identify region-specific challenges and best practices. Incorporating qualitative methods, such as interviews and focus groups, can provide deeper insights into stakeholder experiences. Exploring the role of technological advancements and evaluating the impact of existing policies can guide the development of more effective support frameworks. Understanding consumer behavior and preferences towards organic products can inform marketing strategies and increase consumer awareness. Lastly, investigating the contribution of organic farming to climate resilience and adaptation will be valuable for building sustainable agricultural systems in the face of climate change.

8. Conclusion

This study demonstrates that organic farming significantly contributes to sustainable agriculture development in Rajasthan, particularly in Jaipur, Jodhpur, and Udaipur districts. Adopting organic practices has been shown to enhance soil health, conserve water, promote biodiversity, and improve the economic viability for farmers. These benefits underscore the potential of organic farming to address key environmental and economic challenges faced by the agricultural sector in Rajasthan. However, the transition to organic farming is not without challenges. High initial costs, complex certification processes, limited market access, and knowledge gaps present significant barriers to widespread adoption. These issues highlight the need for targeted policy interventions, financial support, and comprehensive training programs to assist farmers in overcoming these obstacles. Effective implementation of supportive policies can facilitate more accessible certification, improve market penetration, and enhance overall economic outcomes for organic farmers. Thus, while organic farming holds great promise for sustainable agriculture in Rajasthan, concerted efforts are required to address existing challenges. By providing the necessary support through policies, infrastructure,

and education, the state can leverage the benefits of organic farming to promote environmental conservation, enhance farmer livelihoods, and build resilience against climatic and market fluctuations. The insights from this study can inform future strategies to scale up organic farming practices, ensuring long-term sustainability and prosperity in Rajasthan's agricultural sector.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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