Int.J.Curr.Microbiol.App.Sci (2024) *13*(10): 198-205

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 13 Number 10 (2024)**
Journal homepage: http://www.ijcmas.com

Review Article

https://doi.org/10.20546/ijcmas.2024.1310.024

Natural Farming: A Strategic Tool for Climate Change Adaptation

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Keywords

Natural farming, climate change, carbon sequestration, organic carbon, food production

Article Info

Received:
14 August 2024
Accepted:
25 September 2024
Available Online:
10 October 2024

A B S T R A C T

This paper examines the potential of natural farming as a tactical instrument for mitigating and adapting to climate change. Natural farming practices provide a sustainable alternative to conventional chemical farming methods by focusing on ecological balance, soil health, biodiversity, and water conservation. Natural farming enhances carbon sequestration and greatly lowers greenhouse gas (GHG) emissions by decreasing the use of synthetic fertilizers and agrochemicals. Techniques like crop rotation, mulching, and the use of chemical-free farm-made inputs lower the carbon footprint of agriculture while simultaneously improving soil fertility and water retention, which strengthens resilience to climate change. This paper summarizes findings from thirty scholarly studies that demonstrate the benefits of natural farming for increasing crop yields, improving soil organic matter, and advancing food security. Socially and culturally, natural farming improves social equity by lowering inequality, revitalizing traditional methods, and empowering smallholder farmers. Produce grown with natural farming practices has higher levels of vitamins, minerals, and antioxidants according to nutritional analysis, improving public health. Furthermore, natural farming increases food safety by reducing pesticide residues in food. Research shows that natural farming methods are more resilient to climate shocks like floods and droughts, promoting steady food production in vulnerable areas. Natural farming offers a comprehensive approach to solving interconnected concerns of climate change, food security, and environmental sustainability by encouraging biodiversity, decreasing soil erosion, and promoting ecosystem restoration. This essay argues that natural farming, especially in smallholder agricultural systems, should be a key component of global climate adaptation plans.

Introduction

One of the most pressing problems facing the world today is climate change, which has a profound impact on agriculture, the foundation of food security (Bharucha *et al.,* 2020). The negative effects of climate change—such as unpredictable weather patterns, prolonged droughts, floods, and rising global temperatures—are increasingly threatening the agricultural sector (Naresh *et al.,* 2018). According to Smith *et al.,* (2019), these variables have a

direct effect on food production, which can lead to crop failures, food shortages, and higher food prices. These issues are compounded by traditional farming methods that often rely heavily on monocultures, synthetic fertilizers, chemical pesticides, and intensive irrigation. These practices contribute to higher greenhouse gas (GHG) emissions, biodiversity loss, and environmental degradation (Scialabba *et al.,* 2010).

There has never been a more pressing need for sustainable farming practices that can mitigate and adapt to the changing climate. In response to these challenges, natural farming has emerged as a viable alternative. It emphasizes ecological balance, soil health, biodiversity, and water conservation (Li *et al.,* 2020). Instead of relying on external inputs like synthetic fertilizers and pesticides, natural farming focuses on harnessing the power of nature to create resilient ecosystems.

Techniques such as composting, crop rotation, mulching, and the use of organic inputs like cow dung and urine are central to natural farming (Naresh *et al.,* 2018; Lakhani, 2024). For example, the role of Bijamrut in Indian natural farming has been highlighted for its contribution to soil fertility and microbial activity, making it a key component in Indian sustainable agriculture systems (Lakhani, 2024). Jeevamrit, another indigenous practice, has also been recognized for promoting sustainable agriculture and contributing to resilient and eco-friendly farming (Lakhani, 2024).

These methods not only enhance soil structure and fertility but also improve its capacity to sequester carbon, thereby reducing the overall carbon footprint of agriculture (Senchowa *et al.,* 2022). The twin benefits of natural farming in mitigating and adapting to climate change are becoming more widely recognized (Bharucha *et al.,* 2020). By avoiding synthetic chemicals, natural farming significantly reduces GHG emissions (Scialabba *et al.,* 2010).

Additionally, practices like mulching and organic soil management enhance water retention, making farms more resilient to climate extremes such as floods and droughts (Sharma *et al.,* 2023). In regions vulnerable to climate shocks, where conventional farming systems often fail, the resilience of natural farming methods proves especially beneficial. Zero-Budget Natural Farming (ZBNF), a popular model in India, has shown remarkable improvements in soil health, crop yields, and farmer income by minimizing input costs and maximizing the use of locally available resources (Naresh *et al.,* 2018; Bharucha *et al.,* 2020; Lakhani *et al.,* 2020). Beyond its environmental advantages, natural farming also offers significant social and cultural benefits. It revives traditional farming methods, which are often more aligned with local ecosystems and knowledge systems (Senchowa *et al.,* 2022). Natural farming preserves cultural heritage and strengthens community ties by promoting techniques passed down through generations (Gonzales *et al.,* 2019).

For example, natural farming models have been shown to play a crucial role in transforming Indian agriculture and promoting sustainable practices for a more resilient future (Lakhani & Geete, 2024). Moreover, for smallholder farmers, who form the majority of the agricultural workforce in developing countries, natural farming is economically feasible, reducing dependence on expensive chemical inputs (Naresh *et al.,* 2018). Natural farming addresses hunger and poverty by improving farmer livelihoods, promoting social equity, and reducing input costs while boosting yields (Bharucha *et al.,* 2020).

Another key advantage of produce grown using natural farming methods is its superior nutritional content. Studies have shown that naturally grown crops contain higher levels of essential nutrients such as vitamins, minerals, and antioxidants compared to those cultivated using conventional methods (Li *et al.,* 2020; Silva *et al.,* 2020).

This has significant public health implications, particularly in regions where dietary deficiencies and malnutrition are prevalent (Kumar *et al.,* 2021). Furthermore, reduced pesticide residue in naturally farmed produce means that consumers are exposed to fewer health risks (Smith *et al.,* 2019).

Given these numerous benefits, natural farming presents a holistic approach to both mitigating and adapting to climate change. By addressing the complex challenges facing modern agriculture through environmental, social, and economic lenses, natural farming offers a promising solution to the interconnected issues of climate change, food security, and sustainability (Senchowa *et al.,* 2022). This paper synthesizes data from thirty scholarly studies to provide quantitative insights into the ways in which natural farming enhances food security, builds climate resilience, and promotes sustainable development. Expanding the adoption of natural farming practices

could be crucial to achieving climate change goals, restoring ecosystems, and ensuring long-term food security.

Natural Farming and Carbon Footprint Reduction

Natural farming effectively lowers carbon footprint of agriculture by doing away with synthetic fertilizers and agrochemicals, which are significant sources of greenhouse gas emissions. Crop rotation, mulching, composting, and other practices improve soil carbon absorption, reducing greenhouse gas emissions and assisting in achievement of climate goals such as those outlined in Paris Agreement.

Table 1 presents a significant decrease in greenhouse gas (GHG) emissions attained by utilizing natural farming methods. According to data, natural farming can cut emissions by 35% to 50%. This is mostly because it does not use synthetic pesticides and fertilizers, which are significant contributors to agricultural emissions. Crop rotation, composting, and agroforestry are a few practices that enhance soil health and store carbon. Annual carbon sequestration rates vary from 1.6 to 2.0 tons of CO2 per hectare. By improving soil's capacity to absorb and hold carbon, these methods help to slow down global warming. Because natural farming uses fewer energy-intensive chemical inputs, it also saves energy, with energy savings ranging from 25% to 35%. This is in addition to lowering emissions. Variation among research is a reflection of crop types and farming practices that vary by region. For example, Assam region of India, where agroforestry is widely practiced, reported highest GHG reduction (42%) and carbon sequestration (2.0 tons CO2/ha) according to Senchowa *et al.,* (2022). This implies that ability of natural farming to mitigate climate change is greatly increased by incorporating trees into farming systems. Overall, these results highlight how crucial natural farming is to achieving global and national climate goals by increasing carbon absorption and lowering emissions.

Natural Farming as a Climate Change Adaptation Strategy

Natural farming has become a viable and sustainable approach for smallholder farmers, especially for those using Zero-Budget Natural Farming (ZBNF), which was developed in India. Utilizing readily available inputs from area, such as Jivamrut, Ghanjivamrut, Bijamrut by using cow urine, and cow dung, ZBNF enhances crop yields and soil health while lowering reliance on pricey synthetic fertilizers.

Table 2 shows beneficial effects of natural farming in various regions on crop yields, soil health, and water retention. Soil organic matter (SOM), which is essential for preserving soil fertility and promoting sustainable agricultural practices, is greatly increased by natural farming. According to data, SOM improvements range from 12% to 18%. These changes improve structure and moisture-retention capacity of soil, which improves water retention (20% to 30%) and drought resistance. Crop yields have increased as a result of these soil improvements; increases of 10% to 20% have been observed in areas like Uttar Pradesh, Andhra Pradesh, and Maharashtra. Improved water retention and organic matter help offset consequences of climate change in areas with degraded soils and limited water resources, which is why natural farming is beneficial for soil health. Introduction of drought-resistant crops and organic soil amendments resulted in greatest improvements in water retention (30%) and agricultural yields (20%), according to Sharma *et al.,* (2023) in Maharashtra. Data highlights how natural farming may stabilize food production in fragile areas, improve soil health, and increase water efficiency.

Social and Cultural Impacts of Natural Farming

Natural farming has major positive social and cultural effects in addition to promoting environmental sustainability. By bringing back old farming methods, it aids rural communities in rediscovering their agricultural roots. It also advances social justice by lowering barrier to entry and increasing affordability of farming for smallholders.

Table 3 outlines numerous social and cultural benefits of implementing natural farming, particularly for smallholder farmers in nations like China, India, and Brazil. Using readily available natural inputs like compost and cow dung instead of pricey synthetic fertilizers and pesticides has several advantages, chief among them being cost savings. For farmers, many of whom have slim profit margins, these cost savings, which range from 30% to 40%, are a financial comfort. Furthermore, traditional agricultural methods—which are frequently more resource-efficient and better adapted to local environment—are being revived and preserved thanks in large part to natural farming. In places like

Assam, India, where 80% of farmers have reverted to using traditional ways, revival of ancient traditions is apparent and serves to reinforce farmers' ties to their cultural heritage.

Additionally, data demonstrates that natural farming gives farmers more financial clout—between 60% and 70% of farmers report higher earnings. Natural farming encourages social justice through encouraging sustainable techniques that increase food security, make farming more feasible and accessible for smallholders, and lessen dependency on costly outside inputs.

Nutritional Quality of Natural Farming Produce

Because organic compost is used to increase quantities of vitamins, minerals, and antioxidants, and because there are no synthetic chemicals used, produce cultivated utilizing natural farming techniques typically has a better nutritional content.

Comparison between nutritional value of crops cultivated conventionally and with natural farming methods is shown in Table 4. Results show that vegetables grown using natural farming had higher levels of important nutrients, including vitamin C, iron, fiber, and antioxidants. In particular, naturally farmed vegetables have 52% more vitamin C, 50% more iron, 31% more antioxidants, and 29% more fiber. Improved soil conditions brought about by natural farming, which improves crop nutrient uptake, are primarily responsible for these increases.

Plants are able to build more robust nutrient profiles when synthetic chemicals are absent and organic inputs are prioritized, which results in better food. Because naturally cultivated crops have more important vitamins and minerals than their conventionally farmed equivalents, this benefits consumers' health. In instance, higher antioxidant levels can lower risk of chronic diseases and reduce oxidative stress. Available research indicates that natural farming has ability to yield food with higher nutritional value and to support environmentally sustainable practices.

Climate Resilience and Food Security

Natural farming increases agricultural resilience to climate change by improving biodiversity, soil health, and water conservation. This makes farms more resilient to extreme weather events like floods and droughts. Food security is aided by this resilience, particularly in areas that are susceptible. Table 5 shows how increasing crop production stability, drought resistance, and general food availability in climate-vulnerable areas are ways that natural farming improves food security and climate resilience. In places like Bangladesh, Brazil, and Andhra Pradesh, crop yield stability ranges from 78% to 82%, suggesting that natural farming practices are efficient in sustaining regular crop yields despite challenges given by climate fluctuation.

Significant progress has been made in drought resilience, a crucial component in areas vulnerable to water scarcity, with resilience levels ranging from 70% to 75%. These gains are ascribed to techniques like crop variety, organic mulching, and water conservation, which shield crops from drought. Table also emphasizes gains in food security of 45% to 50%, highlighting significance of natural farming in guaranteeing consistent food supplies. Highest rates of crop output stability (82%) and drought resilience (72%), as reported by Johnson *et al.,* (2021) in Bangladesh, show how effective natural farming is in building resilient agricultural systems that can endure climatic shocks.

Ecosystem Restoration through Natural Farming

By increasing biodiversity, decreasing soil erosion, and improving soil health, natural farming increases resilience of ecosystems. These elements lessen effects of climate change and enhance water retention.

Table 6 lists major advantages of natural farming for soil repair and biodiversity. Biodiversity increases in natural farming systems range from 20% to 30%; highest increases are seen in areas that combine crop diversification and agroforestry. Increased biodiversity is essential for developing climate-adaptive ecosystems since a variety of species are essential for pollination, pest management, and soil health maintenance. Natural farming techniques like composting and less tillage not only increase biodiversity but also significantly lower soil erosion rates, which can drop by 30% to 40%.

Additionally, water use efficiency increases by 20% to 25%, demonstrating natural farming's ability to use less water by retaining more soil moisture. An Indian study conducted by Senchowa *et al.,* in 2022 showed a 25% rise in biodiversity and a 30% decrease in soil erosion, demonstrating value of natural farming in preserving ecosystems and advancing environmental sustainability.

Table.1 GHG Emissions Reduction in Natural Farming

Study	GHG Emissions Reduction (%)	Carbon Sequestration (tons CO2/ha)	Energy Savings (%)
Naresh *et al.*, 2018	35%	1.7	25%
Bharucha *et al.*, 2020	40%	1.9	28%
Li *et al.*, 2020	38%	1.6	30%
Senchowa *et al.*, 2022	42%	2.0	35%
Scialabba *et al.*, 2010	50%	1.8	28%

Table.2 Impact of Natural Farming on Soil Health and Crop Yields

Study	Region	Soil Organic Matter (%)	Water Retention Capacity (%)	Crop Yield Increase (%)
Naresh *et al.*, 2018	India (Uttar Pradesh)	+15%	+20%	+10%
Bharucha *et al.*, 2020	Andhra Pradesh	+12%	+25%	+18%
Pathak *et al.*, 2024	India (Punjab)	+14%	+23%	+15%
Sharma *et al.*, 2023	Maharashtra	+18%	+30%	+20%
Rajan *et al.*, 2022	Karnataka	+13%	+22%	+12%

Table.3 Social and Cultural Benefits of Natural Farming

Study	Region	Cost Savings (%)	Traditional Practice Revitalization (%)	Farmer Economic Empowerment (%)
Gonzales *et al.*, 2019	Brazil	35%	75%	60%
Senchowa *et al.*, 2022	India (Assam)	40%	80%	70%
Naresh *et al.*, 2018	India (Uttar Pradesh)	38%	78%	68%
Li *et al.*, 2020	China	30%	70%	65%

Table.4 Nutritional Content of Crops (Natural vs. Conventional Farming)

Nutrient	Natural Farming (mg/100g)	Conventional Farming (mg/100g)	Improvement (%)
Vitamin C	28.5	18.7	+52%
Iron	4.2	2.8	+50%
Antioxidants	105.0	80.0	+31%
Fiber	7.2	5.6	+29%

Table.5 Impact of Natural Farming on Food Security and Climate Resilience

Study	Region	Crop Yield Stability (%)	Drought Resilience (%)	Food Security Improvement (%)
Bharucha *et al.*, 2020	Andhra Pradesh	80%	75%	45%
Gonzales *et al.*, 2019	Brazil	78%	70%	50%
Johnson *et al.*, 2021	Bangladesh	82%	72%	48%

Table.6 Biodiversity and Soil Restoration in Natural Farming Systems

Study	Biodiversity Increase (%)	Soil Erosion Reduction (%)	Water Use Efficiency Improvement (%)
Senchowa *et al.*, 2022	+25%	-30%	+20%
Niggli *et al.*, 2008	+20%	-35%	+22%
Chimi *et al.*, 2022	+30%	-40%	+25%
Li *et al.*, 2020	+28%	-32%	+24%

Table.7 Impact of Natural Farming on Groundwater Levels

Study	Region	Water Table Decline (cm/year) (Conventional)	Water Table Decline (cm/year) (Natural Farming)	Irrigation Water Use Reduction (%)
Singh *et al.*, 2019	Punjab, India	-25 cm/year	-10 cm/year	40%
Thakur *et al.*, 2020	Gujarat, India	-22 cm/year	-8 cm/year	35%
Rodriguez *et al.*, 2021	California, USA	-30 cm/year	-12 cm/year	45%
Zaman *et al.*, 2022	Pakistan	-28 cm/year	-11 cm/year	38%

Table.8 Pesticide Residue Levels in Conventional vs. Natural Farming

Study	Region	Pesticide Residue (mg/kg) (Conventional)	Pesticide Residue (mg/kg) (Natural Farming)	Reduction in Contamination (%)
Kumar *et al.*, 2021	Haryana, India	0.45 mg/kg	0.02 mg/kg	95%
Smith *et al.*, 2019	California, USA	0.52 mg/kg	0.03 mg/kg	94%
Li *et al.*, 2022	Yunnan, China	0.40 mg/kg	0.01 mg/kg	98%
Silva *et al.*, 2020	Sao Paulo, Brazil	0.48 mg/kg	0.04 mg/kg	92%

Water Management in Natural Farming

Natural farming uses practices like mulching, collecting rainwater, and growing crops resistant to drought to encourage water conservation. This method lessens demand for irrigation, improves soil moisture retention, and lessens consequences of excessive rainfall.

Table 7 demonstrates beneficial effects of natural farming, especially in areas with water constraint, on groundwater levels and water conservation. Reduced tillage, mulching, and rainwater collection are examples of natural farming techniques that dramatically slow rate of groundwater depletion. According to data, water table declines in natural farming systems between 8 and 12 cm/year, while it decreases between 22 and 30 cm/year in conventional agricultural systems. Furthermore, irrigation water use is decreased by 35% to 45%, with Pakistan and California experiencing largest decreases. These results show that natural farming preserves groundwater resources by enhancing soil structure, retaining more soil moisture, and lowering demand for excessive irrigation. A study conducted in California by Rodriguez *et al.*, (2021) shows a 45% decrease in irrigation water use, demonstrating potential of natural farming to support sustainable water management and lessen effects of water shortages brought on by climate change.

Food Safety and Contamination Risks

Comparing natural farming to conventional farming, food produced has much less pesticide residues, lowering danger of contamination and improving food safety.

Table 8 shows a considerable reduction in contamination obtained through natural farming practices, since it compares levels of pesticide residue in crops grown under conventional farming with natural farming. According to data, pesticide residues in natural farming

systems range from 0.01 mg/kg to 0.04 mg/kg, however in conventional farming, residues can reach as high as 0.52 mg/kg. With a 92% to 98% reduction in contamination, natural farming is now a safer option for customers. In addition to lowering health hazards connected with chemical residues, removal of synthetic pesticides from natural farming also keeps soil and water habitats from becoming contaminated. Li *et al.,* (2022) observed a 98% reduction in pesticide residues in Yunnan, China, highlighting significance of natural farming in generating cleaner, safer food. Because fewer chemicals are introduced into ecosystems, reducing pesticide residues also improves environmental health.

Combined problems of food security, environmental sustainability, and climate change adaptation can be fully addressed through natural farming. Natural farming techniques distinguish themselves as a competitive substitute for traditional methods, which are frequently resource-intensive and negatively impact environment, by emphasizing ecological balance, soil health, biodiversity, and water conservation. Natural farming is effective in lowering greenhouse gas emissions, increasing carbon sequestration, and boosting soil fertility—all vital components of climate change mitigation—according to studies this paper reviews. Furthermore, because natural agricultural systems are more resistant to temperature extremes, farms can survive increasingly common catastrophes like droughts and floods brought on by global climate change.

There are numerous social and cultural advantages to natural farming. Natural farming enhances rural economies, supports social justice, protects cultural heritage, and empowers smallholder farmers by bringing back traditional agricultural methods. This is particularly crucial in areas where conventional agricultural practices have created economic and social inequality and where agriculture is main source of income.

Benefits to nutrition and a lower chance of pesticide contamination for crops farmed naturally emphasize importance of this strategy for improving public health. Several advantages discussed in this research, such as increased food safety and ecosystem resilience, make natural farming an effective instrument for sustainable development.

Globally expanding use of natural farming methods could be essential to meeting climate change goals, repairing damaged ecosystems, and guaranteeing long-term food security. Adopting sustainable agricultural practices, such as natural farming, will be essential to creating resilient food systems that can prosper in an unpredictable future as climate threats worsen.

Author Contributions

Hardik Lakhani: Investigation, formal analysis, writing—original draft. Shivakumar: Validation, methodology, writing—reviewing. Mandar Geete:—Formal analysis, writing—review and editing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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How to cite this article:

Hardik Lakhani, Shivakumar Chinchure and Mandar Geete. 2024. Natural Farming: A Strategic Tool for Climate Change Adaptation. *Int.J.Curr.Microbiol.App.Sci.* 13(10): 198-205. **doi:** https://doi.org/10.20546/ijcmas.2024.1310.024