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EXPLORING THE IMPACT OF NATURAL FARMING PRACTICES AND ITS GLOBAL PERSPECIVE: A BIBLIOMETRIC ANALYSIS LITERATURE REVIEW

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ABSTRACT
Natural farming is increasingly recognized as a sustainable alternative to conventional agricultural practices, emphasizing chemical-free cultivation methods that enhance soil health, biodiversity, and farm profitability. This study employs a bibliometric analysis to examine global research trends, key themes, and collaborative networks in natural farming. Data were retrieved from the Scopus database, applying systematic inclusion and exclusion criteria to ensure the selection of high-impact scholarly literature. Using R Studio and VOS viewer, the study visualizes co-authorship patterns, keyword co-occurrence, and citation networks to uncover major research areas and influential contributors. The results indicate that India leads global research efforts in natural farming, with strong contributions from European and Asian countries. The analysis highlights key research themes, including soil fertility enhancement, economic viability, climate resilience, and sustainable farming practices. Co-authorship and citation networks reveal well-established collaborations among leading researchers, while emerging studies focus on innovations in organic inputs and conservation techniques. While natural farming presents multiple benefits, its widespread adoption faces challenges such as inconsistent yield performance, knowledge dissemination barriers, and policy limitations. Future research should focus on long-term productivity assessments, digital learning platforms for farmer education, and interdisciplinary studies integrating agronomy, socio-economics, and policy development. Strengthening institutional frameworks and knowledge-sharing mechanisms will be essential in mainstreaming natural farming as a scalable and sustainable agricultural model. This study reinforces the importance of continued research, policy support, and collaborative efforts in advancing natural farming for global food security and environmental sustainability.

KEYWORDS: Natural farming, Sustainable agriculture, Soil health¸ Economic viability, Climate resilience, Biodiversity conservation.

INTRODUCTION
Natural Farming is gaining global attention as a sustainable and regenerative alternative to conventional, input-heavy agriculture. Drawing from India's rich tradition of agricultural wisdom and guided by modern agroecological principles, this approach avoids synthetic chemicals and instead focuses on self-reliant, low-input farming systems (FAO, 2019; Bhattacharyya et al., 2020; Kumar et al., 2021). Farmers practicing Natural Farming use materials readily available on their farms, like cow dung, cow urine, green manure, and mulching to enrich the soil and reduce external dependencies. Combined with techniques such as soil aeration and microbial enhancement, these practices help preserve soil fertility, boost biodiversity, and maintain ecological balance (Singh et al., 2020; Ramesh et al., 2019; Meena et al., 2022). With its low-cost and regenerative nature, Natural Farming offers smallholder farmers a viable path toward better incomes and reduced reliance on costly external inputs (Khadse et al., 2018; Parameshwarappa et al., 2021).
The roots of Natural Farming can be traced back to the ideas of Japanese farmer-philosopher Masanobu Fukuoka, who proposed a "do-nothing" approach—letting nature lead the way with minimal human interference (Fukuoka, 2009; LaCanne & Lundgren, 2018). In India, this philosophy evolved into Zero Budget Natural Farming (ZBNF), a model that eliminates input costs by using traditional, cow-based preparations and other locally sourced resources (Palekar, 2016; Kumar & Singh, 2020). Research shows that ZBNF not only sustains or even improves crop yields but also enriches the soil, boosts microbial life, and improves water retention (Gopinath et al., 2020; Babu et al., 2021; Venkatashwarlu et al., 2022).
On the policy front, the Indian government has shown strong support for Natural Farming through programs like the Bharatiya Prakritik Krishi Paddhati (BPKP), a part of the Paramparagat Krishi Vikas Yojana (PKVY). These

initiatives encourage chemical-free farming and promote the integration of traditional knowledge into modern agriculture (APEDA, 2021; Government of India, 2021). States like Andhra Pradesh, Himachal Pradesh, Odisha, Chhattisgarh, and Tamil Nadu have taken the lead in adopting Natural Farming, reporting positive outcomes such as improved soil health, reduced water use, and increased climate resilience (Rao et al., 2020; Chatterjee et al., 2021; Economic Survey, 2021). Finance Minister Nirmala Sitharaman (2022) reported that over 2.5 million farmers across India have embraced regenerative practices, highlighting the growing shift toward sustainable farming.

Natural Farming closely aligns with the principles of agroecology—a scientific approach that encourages biodiversity, nutrient recycling, ecological stability, and social equity (Altieri & Nicholls, 2020; Wezel et al., 2020; Gliessman, 2018). The FAO recognizes Natural Farming as a valuable tool in achieving the Sustainable Development Goals (SDGs), particularly those focused on climate action, food security, and environmental conservation (FAO, 2019; HLPE, 2019; IPES-Food, 2016). These practices not only help reduce environmental damage but also empower farmers by encouraging local knowledge exchange and self-sufficiency (Rosset & Altieri, 2017; Tittonell, 2020).

India's organic farming ecosystem, which includes Natural Farming, covers about 4.72 million hectares under certification. This includes around 0.6 million hectares of cultivated land and 4.12 million hectares used for wild collection (NPOP, 2014; APEDA, 2021). The National Programme for Organic Production (NPOP), managed by APEDA, oversees certification, accreditation, and export regulations while ensuring global standards are met, including those of the EU, USDA, Japan, and IFOAM (APEDA, 2021; Ghosh, 2021; Sharma et al., 2023). One standout success is Sikkim, which has transformed 75,000 hectares into fully organic farmland, setting an inspiring example for other regions (Ghosh, 2020; Bhattacharya et al., 2021).

Currently, Natural Farming is practiced across nearly 3.8 million hectares in India, representing about 2.7% of the country's total agricultural land (FAO, 2019; Sitharaman, 2022). This shift is seen as a timely response to critical issues like soil degradation, water scarcity, and climate change (Lal, 2020; Choudhary et al., 2022). Research supports its potential to sequester carbon, cut production costs, and increase farm profitability (Das et al., 2022; Dhawan & Yadav, 2021; Devi et al., 2023).

1. How as a research grown globally regarding natural farming in agriculture
2. To study the major Impact of Natural farming practices

METHODOLOGY

This study adopts a bibliometric approach to explore how research around natural farming has evolved over time. To begin, a well-defined search strategy was developed using a thoughtfully curated list of keywords that reflect the core principles and practices of natural farming. These keywords were applied to the Scopus database, allowing the retrieval of scholarly, peer-reviewed articles to ensure the quality and credibility of the data.

The goal of this bibliometric analysis is to identify key research trends, patterns in citations, and global collaborations among scholars in the field of natural farming. For better understanding and visualization, tools like R Studio and VOS viewer were used to map co-authorship connections, collaborations between countries, bibliographic linkages, and the shifting focus of research topics over time.

To complement the bibliometric approach, a systematic review was also carried out, following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. A step-by-step screening process was conducted based on clearly defined inclusion and exclusion criteria, ensuring that only the most relevant studies were selected for in-depth analysis. The specific criteria used for screening are detailed in Table-1.

Table-1. Shows the inclusion and exclusion creteria

Creteria	**Inclusion**	**Exclusion**
Year	2021	<2021
Document type	Articles	Book chapters, review, Editorial, Conference papers, Conference review, Book
Languages	English	Non- English and others all
Source type	Journal	Trade Journals Book series Book Conference proceeding
Publication stage	Final	Article in Press
Open access	All open access	Restricted access

Screenings		
Title & abstracts	Titles and abstracts included in the study contained preset keywords.	
Full text	The articles that address the selected key phrases are the most suitable ones that were included in this study.	

For this review paper, the Scopus database served as the primary source for gathering literature on natural farming. A mix of broad and focused keywords was used to make sure the search captured a wide range of studies. Search terms included "natural farming," "zero budget natural farming," "chemical-free farming," "low input farming," and "eco-friendly farming" to represent the spectrum of sustainable agricultural practices. Additional keywords like "impact," "encounter," and "effects" were added to home in on studies that assessed the real-world outcomes of these practices.

Using this structured approach, a total of 329 relevant articles were identified and formed the core dataset for bibliometric analysis. These articles offer valuable perspectives on global research trends, adoption patterns, and thematic areas in natural farming. The selected literature was then used to explore citation networks, keyword relationships, and emerging areas of interest within the field

A total of 329 records were initially gathered from the Scopus database using the selected keywords. The next step involved applying clearly defined inclusion and exclusion criteria, which resulted in the removal of 241 records that didn't meet the requirements. An automated filtering tool available within the database then helped narrow down the list to 88 potentially relevant articles. To refine the selection further, each of these records was carefully reviewed by examining their titles, keywords, and abstracts. This final screening led to a curated set of 71 studies that were considered highly relevant for the analysis. The entire selection process was guided by the PRISMA flow diagram, as shown in Figure-1, to maintain clarity and transparency throughout the review.

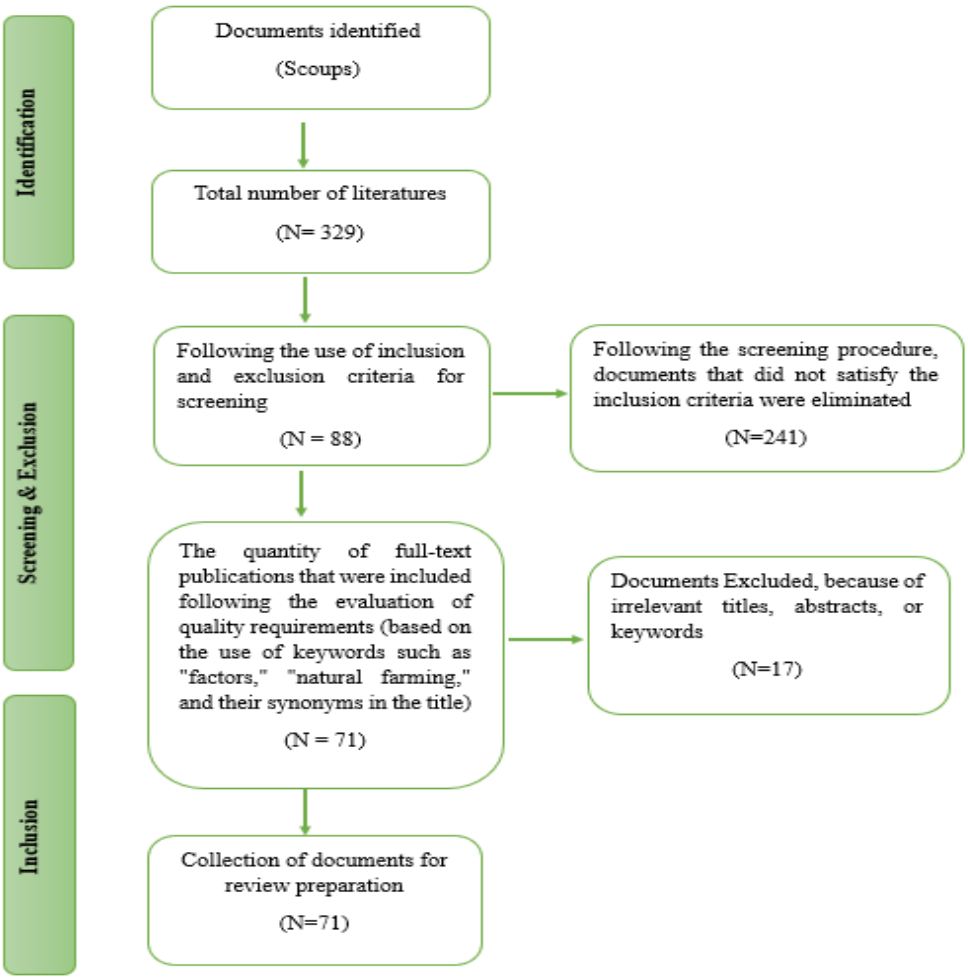


Figure-1. A visualisation of the search literature for a systematic evaluation of the Impact of natural farming using PRISMA flowcharts

For both the bibliometric analysis and systematic review, tools like R Studio and VOS viewer were used to visualize and interpret the data. These platforms helped explore research patterns in natural farming by mapping out key themes, identifying collaboration networks, and highlighting emerging areas of interest in the field.

3. RESULT AND DISCUSSION

3.1. Most relavent affilation

Research on natural farming is steadily gaining traction around the world, with numerous institutions playing a pivotal role in advancing this field. As shown in Figure-2, some affiliations stand out for their active involvement in natural farming research. Tamil Nadu Agricultural University (TNAU) leads the way with 22 published articles, reflecting its strong dedication to promoting sustainable agriculture through research efforts, extension initiatives, and policy engagement. Close behind are the University of Padova with 13 articles and Newcastle University with 12, both making meaningful contributions in areas like agroecology, soil health, and policy frameworks that support natural farming.

Other institutions such as Dr. YS Parmar University of Horticulture and Forestry, ICAR-NAARM, Institute of Agriculture, and Lovely Professional University—each contributing 8 articles demonstrate the multidisciplinary nature of this research. Their work spans from horticultural advancements and policy formulation to farmer education and training. Similarly, the International Rice Research Institute South Asia Regional Centre and the School of Agriculture and Rural Development, with 7 articles each, focus on rice-centric farming systems and rural development strategies.

This analysis highlights the dominant role of Indian universities and research organizations in pushing the frontiers of natural farming research, while also recognizing the important contributions from international institutions. The participation of both agricultural and horticultural bodies points to a comprehensive, integrated approach to promoting sustainable and regenerative farming practices globally.

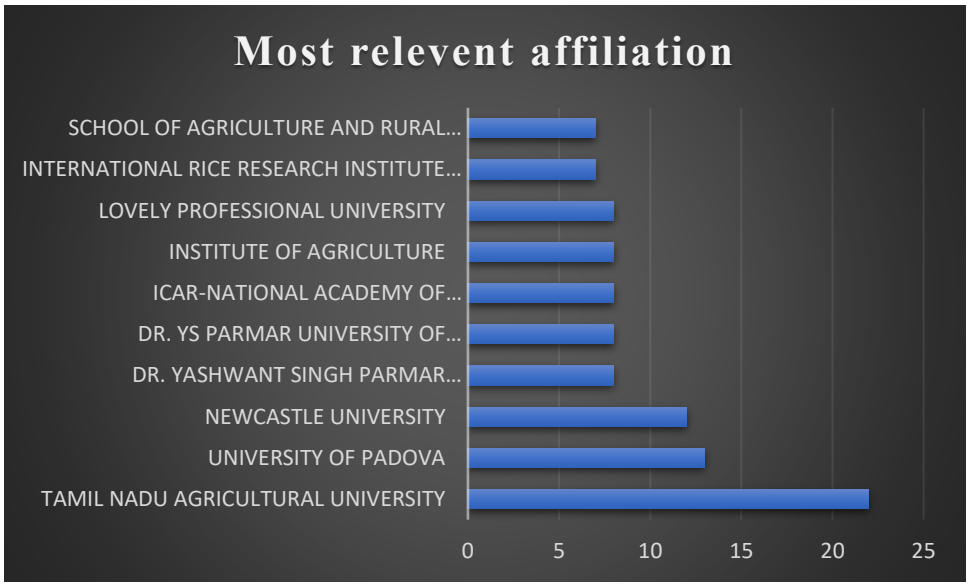


Figure-2. Highlights the most relavent affilation

3.2. Most cited countries

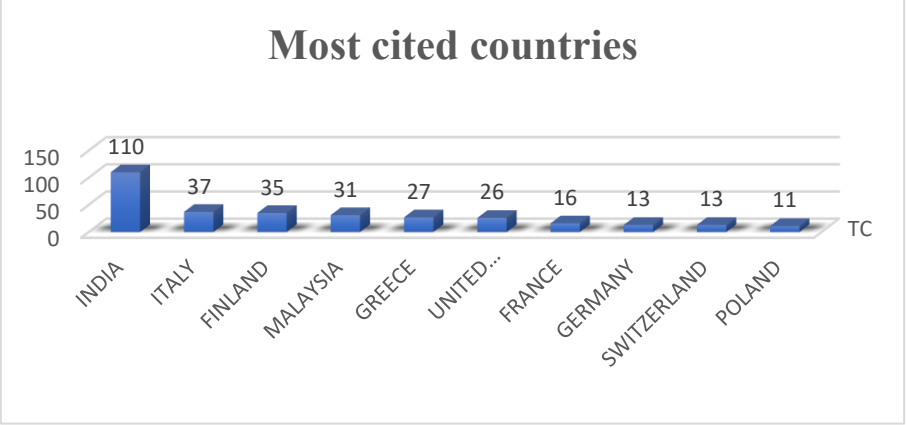


Figure-3. Shows the most cited countries

Figure-3 showcases the countries that have made the most notable contributions to natural farming research, as reflected by the number of citations. India stands at the forefront with a remarkable 110 citations, clearly demonstrating its leadership in this field. This strong performance highlights India's ongoing efforts to promote natural farming through active research, robust policy frameworks, and on-ground implementation. The country's academic institutions, research organizations, and government-led initiatives have played a key role in advancing sustainable agricultural practices and fostering awareness among farming communities.

Italy and Finland follow with 37 and 35 citations, respectively, underlining a strong European commitment to the principles of natural and ecological farming. Research from these countries often emphasizes the integration of agroecological practices, innovations in organic farming, and environmentally conscious policy measures. Their contributions are helping to shape the global discourse on sustainable agriculture, providing valuable insights and strategies that resonate across diverse farming systems.

Malaysia and Greece also emerge as influential contributors, with 31 and 27 citations each. This reflects the growing relevance of natural farming across Asian and Mediterranean regions. Malaysian research often focuses on adapting natural farming methods to tropical environments, while Greece explores sustainable practices suited to arid and semi-arid landscapes. These country-specific studies offer unique perspectives and solutions that support the global expansion of natural farming.

Further contributions come from countries such as the United Kingdom, France, Germany, Switzerland, and Poland, with citation counts ranging from 11 to 26. These nations continue to play a significant role in advancing the science and practice of sustainable agriculture. Their research often bridges the gap between theoretical innovations and practical implementation, with a focus on regulatory systems, organic certification, and policy integration that supports natural farming on a broader scale.

Altogether, this analysis highlights the truly global nature of natural farming research. While India leads with strong momentum, countries across Europe and Asia are making meaningful contributions. The citation data reflects the widespread interest and growing impact of natural farming in promoting environmental sustainability, improving soil health, and offering viable alternatives to conventional agriculture worldwide.

3.3. Co - occurrence authors keywords

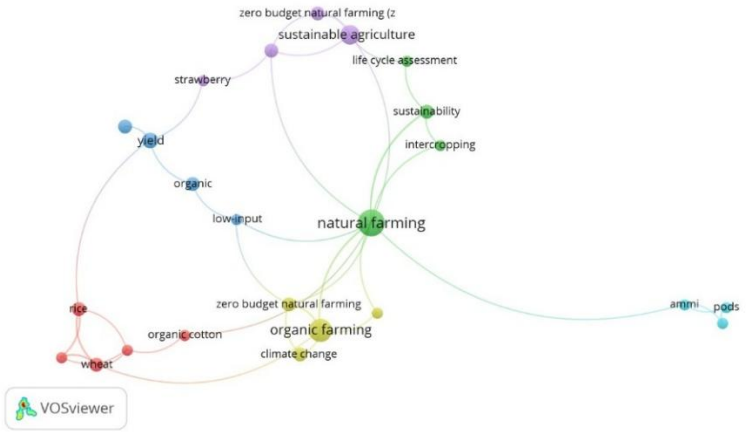


Figure-4. Shows the Co - occurrence authors keywords in the natural farming

Figure-4 illustrates the co-occurrence network of author keywords related to natural farming research, providing meaningful insights into the central themes and emerging areas of interest within this field. Created using VOS viewer, the visualization maps out how different concepts are connected, revealing the multi-dimensional nature of natural farming studies.

At the heart of the network, “natural farming” appears as the main theme, closely linked with important ideas such as sustainability, organic farming, crop productivity, and environmental health. The strong connection with “sustainable agriculture” underscores natural farming’s role in promoting environmentally responsible and resource-efficient practices.

Keywords such as “zero budget natural farming” (ZBNF) and “life cycle assessment” suggest a growing interest in evaluating both the environmental and economic aspects of natural farming methods. The recurring appearance of ZBNF reflects the increasing attention towards affordable, chemical-free practices that support soil health and reduce dependency on external inputs.

A key focus in current research is how natural farming affects crop yields and supports low-input farming systems. Terms like “organic” and “low-input” point to comparisons between organic and natural farming approaches, especially in maintaining soil fertility and ensuring consistent crop performance. Interestingly, the presence of the keyword “strawberry” indicates a shift toward crop-specific studies, exploring how natural farming can be tailored for fruits and high-value crops.

Natural farming's role in addressing climate change is also gaining traction. Research points to practices like composting and mulching as effective ways to boost soil carbon content and build resilience against extreme weather conditions. The repeated appearance of ZBNF in these discussions shows a growing recognition of its potential to offer climate-smart, low-cost solutions for modern agricultural challenges.

The network also highlights research on staple crops such as rice, wheat, and organic cotton, showing that natural farming is being tested on a larger agricultural scale. This suggests a broad interest in understanding how these methods influence productivity, soil health, and overall sustainability. In addition, the inclusion of keywords like "Ammi" and "pods" hints at emerging interest in lesser-known or underutilized crops—possibly those that contribute to soil enrichment, like nitrogen-fixing legumes.

3.4. Co - author ship author networks

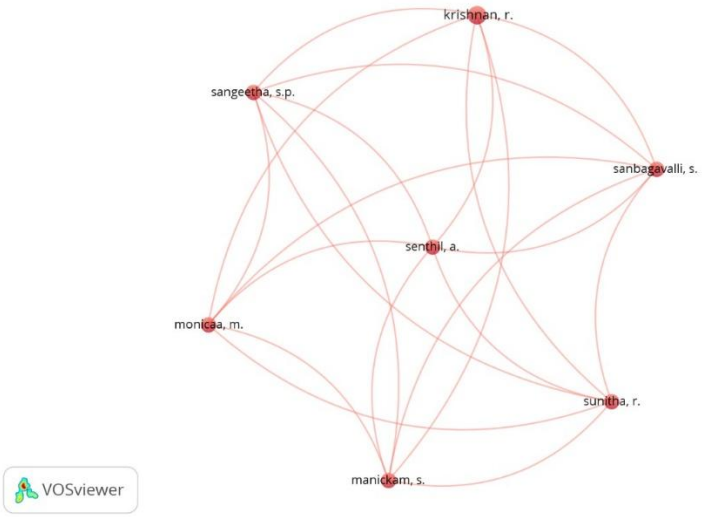


Figure-5. Highlights the Co - author ship author networks

Figure-5 showcases the co-authorship network, offering a clear view of how researchers are collaborating in the field of natural farming. This visualization brings to light the web of connections between different authors, highlighting how they work together and contribute to the academic conversation. The numerous links connecting various scholars reflect a vibrant, collaborative research environment one where ideas are shared, studies are co-authored, and collective knowledge is built over time. It's evident that research in natural farming is very much a group effort, enriched by diverse insights and expertise.

Within the network, certain researchers such as Senthil A., Krishnan R., and Sanbagavalli S. stand out as central figures. These authors appear to be well-connected, suggesting they play key roles either by leading projects or regularly collaborating across multiple studies. Their presence at the centre of this network hints at their active involvement in shaping the field, likely through consistent partnerships and ongoing contributions. Other researchers like Monicaa M., Sunitha R., and Manickam S. also show strong collaborative links, indicating their participation in various joint research efforts. This close-knit web of relationships paints a picture of a lively academic community where ideas are continuously exchanged and built upon.

Interestingly, the network doesn't show dominance by any single individual. Instead, it reflects a balanced distribution of collaboration, where multiple researchers are contributing equally to the field. This kind of teamwork is particularly important in areas like natural farming, which draw on knowledge from many disciplines like agronomy, sustainability, rural development, and more. The visualization hints at structured, purposeful collaboration, likely supported by institutional ties, interdisciplinary teams, or interactions at academic gatherings and conferences.

In summary, the co-authorship network paints a picture of a dynamic and cooperative research landscape. The strong ties between authors highlight the power of collaboration in pushing the boundaries of natural farming. This shared approach not only strengthens the credibility and depth of the research but also ensures that the field keeps growing through the exchange of ideas, expertise, and mutual learning

3.5. Author citation networks

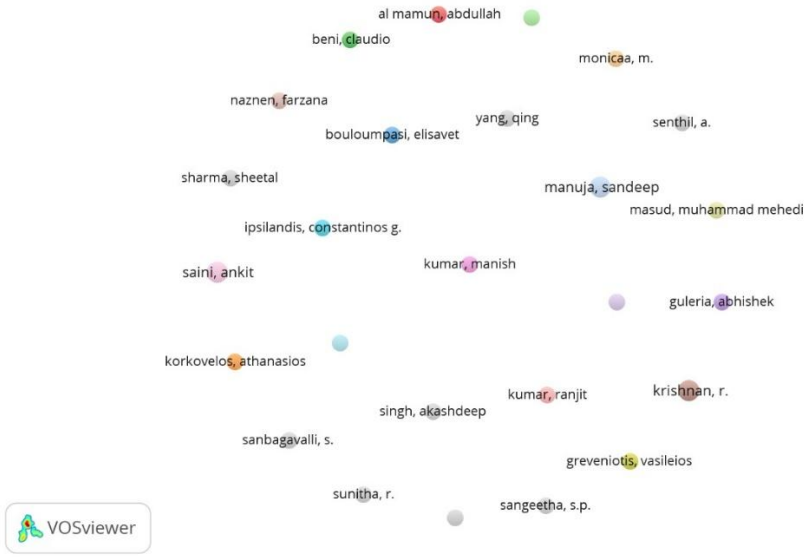


Figure-6 shows the Author citation networks

Figure-6 offers a visual representation of the author citation network, mapping out how researchers in the field of natural farming are connected through citations. In this network, each node represents an individual author, and the lines between them show how often they cite one another. The spread-out structure of the network suggests that while some researchers are frequently cited and closely linked to others, there are also many who remain on the fringes, with fewer citation connections. This reflects a range in influence across the academic community. The various coloured clusters in the network point to thematic or regional groupings, where authors are more likely to reference those working on similar topics or within their professional networks.

Among the more prominent figures in this network are Krishnan R., Senthil A., and Sanbagavalli S., whose names stand out due to the frequency with which their work is cited. Their visibility in the network suggests they are influential voices in the field, helping shape the direction of current research. On the other hand, some authors appear more isolated, with fewer or no direct citation links this may indicate newer areas of study or less widely referenced research. The variety of names across the network, reflecting different linguistic and cultural backgrounds, speaks to the global interest in natural farming and the widespread academic contributions from around the world.

This network helps us understand how knowledge flows within the academic community, showing which authors are helping to move the conversation forward through their work. The presence of disconnected authors doesn't mean their research is less valuable—it may simply be that their studies are highly specialized or still gaining visibility. Nonetheless, their inclusion in the map shows they are part of the broader dialogue. The distinct clusters also point to the interdisciplinary nature of the field, where different groups of scholars are focusing on unique aspects of natural farming, sustainability, and agricultural innovation.

In essence, Figure-6 highlights how research ideas spread and evolve through citation networks. It shows who the key thought leaders are, how interconnected the field has become, and where there might be opportunities to bring in new voices or bridge gaps in the literature. This visualization serves as a reminder of the collaborative and ever-growing nature of academic research in sustainable agriculture.

3.6. Major Impacts of Natural Farming Practices

1. Enhancing Soil Health and Fertility

One of the standout benefits of natural farming is its remarkable ability to improve soil health. By promoting microbial activity, increasing organic carbon levels, and enhancing the availability of essential nutrients, natural farming creates a thriving, sustainable ecosystem beneath the soil. This stands in stark contrast to conventional farming, which can often degrade soil health due to over-reliance on chemical fertilizers.

Several studies emphasize how natural farming practices, like the use of biofertilizers such as Jeevamrit, Beejamrit, and organic mulching (Achhadana), contribute significantly to soil quality. For instance, Saharan et al. (2023) discovered that using Jeevamrit increased soil organic carbon by 46%, while also making phosphorus and potassium more available, with an impressive increase of 439% and 142%, respectively. This boost in nutrient cycling not only improves soil fertility but also ensures that plants have access to the vital nutrients they need to thrive.

In another study, Kaushal et al. (2024) found that the populations of beneficial soil microbes, including bacteria, fungi, and actinomycetes, increased substantially. These microbes are essential for breaking down organic matter

and improving the overall structure of the soil. Specifically, the number of bacteria rose by 26.33%, and fungal populations grew by 18.92%, creating a more balanced and nutrient-rich soil environment.

The impact of organic mulching on soil health has also been well-documented. Rossi et al. (2024) highlighted that mulching not only improves organic carbon levels but also helps water infiltrate the soil more efficiently, reducing the risk of soil compaction and erosion. This practice is particularly valuable in areas experiencing fluctuating weather patterns, as it helps retain moisture and maintains soil fertility.

Globally, natural farming is showing great promise in enhancing soil health and boosting crop productivity. For example, Al Mamun et al. (2023) found that food waste composting in natural farming systems in China significantly improved both soil quality and crop yield. In India, researchers like Vincent & Balasubramani (2021) and Veena Ghuriani et al. (2023) found that Zero Budget Natural Farming (ZBNF) contributed to greater microbial diversity in the soil, which in turn reduced costs for farmers while improving their bottom line. Furthermore, Mishra et al. (2024) stressed how organic farming practices help promote microbial health, increase organic carbon, and enhance nutrient cycling, ensuring that soil remains fertile for years to come.

Collectively, these studies reinforce the notion that natural farming isn't just an alternative—it's a necessity for regenerating soil health. By aligning farming practices with nature, farmers can minimize their dependence on synthetic fertilizers and build a more resilient, productive agricultural system.

2. Impact on Crop Yield and Performance

A common concern among farmers who are considering switching to natural farming is whether it can sustain or even improve crop yields. The good news is that research suggests natural farming can maintain or even boost productivity, especially when paired with sustainable soil management practices.

Studies have shown that natural farming can yield crops at levels comparable to, or sometimes even higher than, conventional methods, under the right conditions. For example, Monicaa et al. (2023) found that cotton yields were impressive in natural farming systems, with 1287 kg/ha in 2021-22 and 1364 kg/ha in 2022-2 results that were very similar to those of organic farming. Similarly, Kumar et al. (2023) showed that integrating farmyard manure (FYM) with natural farming practices led to higher yields than conventional farming, highlighting the benefits of a balanced approach to nutrient management.

A noteworthy analysis by Duddigan et al. (2022) examined 20 field experiments and found that Zero Budget Natural Farming (ZBNF) didn't result in significant short-term yield losses. This was especially true in drier regions, where mulching proved essential for preserving soil moisture and preventing yield reductions due to water stress. These findings suggest that natural farming can provide consistent, reliable crop yields without an overdependence on synthetic inputs.

3. Crop Productivity and Yield Variability

The effect of natural farming on crop yield is not uniform across all regions, crops, and farming systems. Garima Thakur et al. (2023) highlighted specific linseed genotypes that are well-suited to natural farming in the North-Western Himalayas, with Palampur identified as the optimal location for achieving the best yield performance. Similarly, Kumar et al. (2020) observed that transitioning to natural farming resulted in increased crop yields and a reduced reliance on synthetic inputs, which ultimately improved the livelihoods of farmers.

However, not all studies show universally higher yields. Ankit Saini et al. (2024) reported that in Himachal Pradesh, grain yields (2134 kg/ha) and straw yields (4053 kg/ha) under natural farming were lower than those achieved with conventional tillage, mainly due to lower nutrient uptake. Likewise, Zieliński et al. (2024) acknowledged that while organic and natural farming methods foster sustainability, they sometimes result in lower yields compared to conventional farming practices.

In contrast, other research, such as the study by Duddigan et al. (2023) in South-East India, found that natural farming improves soil health over time, leading to better yields in the long run. This indicates that while initial yields may be lower in certain contexts, the long-term benefits, including enhanced soil quality and ecosystem resilience, may outweigh the short-term yield reductions.

4. Environmental and Ecological Benefits of Natural Farming

Natural farming plays a vital role in advancing environmental sustainability by boosting biodiversity, improving soil and water conservation, and reducing greenhouse gas emissions. In contrast to conventional farming, which often depends on synthetic inputs that can degrade ecosystems over time, natural farming nurtures a balanced and resilient environment, benefiting both agriculture and the wider ecosystem.

One of the primary ecological advantages of natural farming is its ability to promote biodiversity and support essential ecosystem services. Höglind et al. (2021) found that low-input ecological farming systems contribute to biodiversity by creating habitats that sustain various plant and animal species. Schärer et al. (2022) further emphasized that organic and natural farming systems help retain soil moisture by reducing excessive plant water use, thus enhancing farm resilience to drought conditions.

Regarding climate impact, natural farming proves environmentally efficient by lowering greenhouse gas emissions. Zhao et al. (2024) discovered that moderate-sized farms (0.45–0.58 km²) in China emitted the least greenhouse gases per unit area, indicating that scaling natural farming in optimal land sizes could significantly enhance sustainability. Similarly, Zanon et al. (2025) highlighted that low-input dairy farming notably reduced marine eutrophication while maintaining high environmental efficiency, showcasing that sustainable livestock management can alleviate ecological damage.

The elimination of chemical pesticides and synthetic fertilizers in natural farming offers another significant environmental benefit, helping restore ecological balance, prevent soil degradation, and protect water bodies from contamination. Patel et al. (2024) pointed out that biofertilizers like Jeevamrit and Beejamrit not only foster plant growth but also strengthen plant resistance to environmental stresses, reducing the need for chemical interventions.

Beyond its direct environmental effects, natural farming also influences farmer behavior and societal attitudes toward sustainability. Yang et al. (2024) emphasized the importance of cultivating green trust among farmers to encourage the widespread adoption of eco-friendly farming practices, ultimately mitigating environmental degradation. Moreover, Najafabadi & Jalilian (2022) discovered that natural farming techniques improved the quality of oil crops, boosting beneficial fatty acid content and reducing undesirable compounds, making agricultural produce healthier for consumers.

5. Economic Viability and Profitability for Farmers

Natural farming is increasingly recognized for its economic benefits, as it significantly reduces production costs while maintaining or even increasing farm incomes. By eliminating or minimizing synthetic fertilizers and pesticides, farmers can cut down on cultivation expenses, making farming more financially sustainable in the long run.

Research strongly supports the profitability of natural farming. Laishram et al. (2022) found that in Solan District, Himachal Pradesh, natural farming led to a 19.68% increase in net returns during the Kharif season and a 24.64% increase in the Rabi season. This was achieved while reducing cultivation costs by 30.73% in Kharif and 11.88% in Rabi, demonstrating how lower input costs translate into higher earnings. Similarly, Monicaa et al. (2023) reported that in cotton farming, natural methods provided higher net returns and a superior benefit-cost (B:C) ratio compared to organic and integrated farming approaches. These findings affirm that natural farming not only sustains productivity but also enhances farm-level profitability.

One of the most widely studied models of natural farming is Zero Budget Natural Farming (ZBNF), which has shown promising economic results, particularly for smallholder farmers. Galab et al. (2018) in Andhra Pradesh, India, found that ZBNF significantly lowered input costs while improving soil fertility, making it an economically viable alternative to conventional farming. Additionally, Harini et al. (2021) demonstrated that ZBNF techniques enhance soil fertility and sustain cropping systems, allowing farmers to be less financially dependent on costly synthetic inputs.

Beyond cost savings, natural farming also improves resource efficiency and sustainability. Denora et al. (2023) highlighted that variable rate nitrogen fertilization in Italy improved energy efficiency while minimizing environmental impact, reinforcing that resource-efficient farming methods can enhance profitability while reducing ecological harm. Similarly, Gorripati et al. (2023) concluded that ZBNF serves as a sustainable and cost-effective alternative to conventional agriculture by reducing production costs, improving resource efficiency, and maintaining stable agricultural productivity.

6. Seed Sustainability and Crop Adaptation

Another key aspect of natural farming is its emphasis on seed sustainability and adaptation to natural conditions. Katsu et al. (2021) conducted research in Japan and found that self-produced open-pollinated (OPN) seeds in natural farming exhibited higher germination rates compared to hybrid and conventional seeds. Additionally, the root fresh weight of these seeds was comparable to that of hybrid seeds, suggesting that they are well-adapted to natural farming conditions. Sarkar et al. (2024) further demonstrated that integrated natural and organic farming improved critical soil health indicators, such as organic carbon levels and microbial diversity, leading to enhanced crop adaptability and resilience. These findings reinforce the idea that natural farming, when paired with sustainable seed management, can contribute to long-term agricultural viability.

7. Social and Institutional Factors Driving Adoption

Beyond agronomic and economic aspects, the adoption of natural farming is influenced by social and institutional factors. Several studies highlight the role of farmer awareness, peer influence, and government policies in shaping adoption decisions. Pradhananga et al. (2022) noted that farmers' conservation behaviours are often driven by personal norms and social influence, while Yang et al. (2024) emphasized that policy interventions play a crucial role in encouraging farmers to transition toward sustainable practices. These studies indicate that effective policy support, financial incentives, and community-based learning initiatives can accelerate the widespread adoption of natural farming.

8. Influence of Farming Practices on Crop Quality and Nutritional Value

Natural farming has been shown to enhance crop quality, nutritional value, and soil biodiversity. Chiara Stella Colì et al. (2024) found that biodynamic and organic farming significantly influenced grape metabolite profiles, leading to increased organic acid and amino acid content, which improved grape quality. Colì et al. (2024) further reported that biodynamic and organic farming enhanced soil biodiversity, which is crucial for long-term soil fertility and plant health. Hasanaliyeva et al. (2025) found that organic potato farming in the UK resulted in lower yields but improved soil health and increased nutrient content in tubers. Additionally, Li et al. (2021) in Germany observed that organic maize varieties retain beneficial root traits for efficient phosphorus uptake, improving nutrient use efficiency.

9. Role of Technology and Integrated Systems in Natural Farming

Technological innovations and integrated farming approaches have further enhanced the efficiency and effectiveness of natural farming. Rathod Kumara et al. (2023) demonstrated that Integrated Multi-Trophic Aquaculture (IMTA) using bivalves helped improve water quality and reduce microbial load while enhancing fish and shrimp growth rates. In China, Zhang & Zhang (2025) highlighted that digital rural construction plays a vital role in promoting eco-friendly farming practices and optimizing land use efficiency. Saini et al. (2024) found that conservation tillage improved soil water retention and increased soil organic matter, further supporting sustainable agricultural practices. Devilliers et al. (2024) in Switzerland demonstrated that low-input farming systems effectively reduced pesticide uses while maintaining reasonable productivity, reinforcing the environmental and economic benefits of natural farming.

The analysis of various studies underscores the multifaceted benefits of natural farming in promoting agricultural sustainability. The research reveals that natural farming not only enhances soil fertility and microbial diversity but also sustains crop productivity, reduces input costs, and improves farmers' economic well-being. Additionally, its environmental advantages, such as reduced chemical dependency and improved soil conservation, make it a promising alternative to conventional farming. However, the long-term success of natural farming depends on continued farmer awareness, scientific validation, and policy support. While regional variations in yield outcomes exist, the overall benefits, such as better soil health, lower cultivation costs, and increased profitability - position natural farming as a key strategy for sustainable agriculture in the future.

CONCLUSION

Natural farming is emerging as a promising approach to sustainable agriculture, offering benefits such as improved soil health, reduced dependency on synthetic inputs, and resilience against climate change. This review highlights how global research trends reflect a growing interest in natural farming, with collaborative efforts expanding across different regions. However, widespread adoption still faces hurdles, including knowledge gaps, economic viability concerns, and policy limitations. Addressing these challenges requires a collective effort from researchers, policymakers, and farming communities. Moving forward, long-term studies should focus on assessing the productivity and economic benefits of natural farming across various agro-climatic zones. Strengthening farmer education through digital tools, including podcasts and mobile advisory services, can enhance knowledge sharing and accelerate adoption. Additionally, interdisciplinary research combining agronomy, socio-economics, and policy analysis will be essential to create supportive frameworks that make natural farming a viable and scalable option for farmers worldwide.

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