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Balancing Tradition and Innovation: Ecological Impacts of Intensive Farming on Soil Health in Telangana, India

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ABSTRACT

Intensive farming practices, aimed at maximizing crop yields through substantial inputs of labour, technology, and chemical fertilizers, have significantly transformed modern agriculture. However, these methods have raised serious concerns regarding soil health, environmental sustainability, and long-term agricultural viability. This study examines the ecological impact of intensive farming on soil health in the KB Asifabad District of Telangana, India, where traditional and modern farming techniques coexist. The objectives include analysing socio-economic factors influencing farming methods, evaluating the impact of tilling techniques and fertilizer use on soil health, and promoting sustainable practices through education and policy recommendations. Findings reveal a strong reliance on chemical fertilizers, with 98.3% of farmers using them exclusively due to their perceived efficiency and rapid results. However, this overdependence has led to soil degradation, reduced microbial diversity, and environmental pollution. Conversely, despite its ecological benefits, natural manure remains underutilized due to scepticism and economic constraints. Mechanical tilling methods, while effective, have negatively impacted soil structure and fertility. The study highlights the necessity of transitioning to sustainable practices, integrating organic inputs, and adopting conservation techniques to restore soil health and ecosystem balance. This research provides practical pathways for achieving sustainable agriculture by integrating traditional knowledge with modern practices. It is particularly relevant for policymakers, agricultural extension services, and farming communities as it highlights the need for educational initiatives, financial incentives, and regulatory measures to ensure long-term soil fertility, environmental stewardship, and improved farmer livelihoods.

Keywords: Intensive Farming; Soil Health; Sustainable Agriculture; Chemical Fertilizers; Natural Manure

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1. Introduction

Intensive farming is a modern agricultural practice designed to maximize crop yields through substantial inputs of labour, capital, and technology on limited land areas. While this approach has revolutionized food production, it also raises significant ecological concerns, particularly regarding soil health and sustainability. Unlike traditional farming, intensive methods often rely heavily on chemical fertilizers and mechanized tools to achieve high productivity. Although efficient, these practices have been linked to soil degradation, loss of biodiversity, and environmental challenges, affecting both farmers and local communities [1–3]. The excessive application of chemical fertilizers depletes organic matter, disrupts microbial diversity, and compromises long-term soil fertility [4]. In contrast, integrating natural inputs such as livestock manure has demonstrated benefits in enhancing soil structure, microbial activity, and nutrient cycling [5]. However, despite growing awareness of these advantages, farmers often favor synthetic inputs due to their immediate results and accessibility, revealing the gap between knowledge and practice.

While these issues are global, the KB Asifabad district offers a representative microcosm of the tensions between tradition and modernity in agriculture. This region, located in Telangana, India, presents a unique case for assessing the ecological consequences of intensive farming. Heavy reliance on synthetic chemical inputs and mechanical tilling methods has led to soil degradation, loss of microbial biodiversity, and reduced water retention capacity [6]. Farmers in the district face critical challenges in transitioning toward sustainable practices while maintaining crop yields and livelihoods. Though intensive farming provides short-term gains, traditional approaches rooted in ecological balance offer valuable insights [7]. This study aims to bridge these methods by evaluating farmers' preferences, perceptions, and practices while exploring pathways for enhancing soil health and resilience through organic inputs and conservation techniques.

This research is pivotal in addressing the ecological and socio-economic implications of intensive farming in Telangana, India. The rapid transformation of agriculture, driven by increasing demand for high crop yields, has resulted in excessive reliance on chemical fertilizers and mechanized farming methods [8]. While these practices improve efficiency, they also contribute to soil degradation, loss of biodiversity, and environmental challenges, reinforcing the need for sustainable land management strategies. The KB Asifabad district reflects broader agricultural trends, demonstrating how socio-economic factors and farmer perceptions influence the adoption of farming practices.

Assess Socio-Economic and Landholding Patterns: Evaluate the socio-economic background and landholding characteristics of farmers practicing intensive farming, identifying correlations between socio-economic status, land size, and resource allocation.

Analyse Tilling Methods and Their Impacts on Soil Health: Examine farmers' preferences for traditional and mechanical tilling techniques and their implications for soil structure, fertility, and crop yields.

Examine Fertilizer Use and Alternatives: Investigate fertilizer types and quantities used by farmers, assessing the comparative effects of chemical and organic inputs on soil health while emphasizing the benefits of natural amendments.

Understand Perceptions of Chemical Fertilizers and Pesticides: Analyse farmers' reliance on chemical inputs, exploring cultural, economic, and practical factors influencing their decisions while advocating alternative pest and fertilizer management strategies.

Promote Sustainable Farming Practices: Develop educational programs, extension services, and policy initiatives to encourage eco-friendly farming approaches that enhance soil health, reduce environmental impacts, and improve agricultural productivity.

This study contributes actionable insights into the challenges and opportunities within intensive farming systems while providing a roadmap for transitioning toward sustainable agricultural methods. By addressing these objectives, the research seeks to empower farmers in Telangana to adopt practices that preserve soil health, maintain ecological balance, and ensure long-term productivity and food security.

2. Materials and Methods

This study adopts a descriptive research design to investigate soil management practices and agricultural

productivity in the KB Asifabad District of Telangana, India, with a special emphasis on the interplay between irrigation methods, crop yields, ecological factors, and soil health. By focusing on farmers registered under Telangana State Government's "Rythu Bandhu scheme," the research provides insights into the socio-economic conditions and farming practices prevalent in the region.

A stratified random sampling approach was employed to ensure representation from diverse farming communities within the district. Out of 15 mandals, six were selected based on factors such as irrigation variety, geographical diversity, and representation of both traditional and modern farming systems. The selected mandals—Asifabad, Bejjur, Chinthala Manepalli, Kaghaznagar, Koutala, and Rebbenna—host a variety of irrigation systems, including rainwater harvesting, borewells, wells, and "***Kuntas***" (self-sustaining ponds). A sample of 382 farmers cultivating paddy and cotton was drawn from the 65,376 beneficiaries registered under the "***Rythu Bandhu scheme***."

Semi-structured interviews served as the primary tool for collecting both quantitative and qualitative data. The interviews included open-ended questions covering topics such as farmers' crop preferences, fertilizer choices, and perceptions of sustainable practices. These interviews provided insights into key aspects of agricultural decision-making, including:

- Primary crops cultivated and tilling methods employed.
- Preferences for fertilizers and manure.
- Perceptions of chemical fertilizers and pesticides.
- Changes in soil health and crop yields.
- Irrigation practices and challenges in adopting sustainable farming techniques.

To address gaps in quantitative analysis and explore individual experiences, case studies complemented the statistical data, offering richer insights into farmers' lived realities. Descriptive statistical techniques, including frequency distributions and cross-tabulations, were computed using SPSS version 26 to examine relationships between landholding patterns and soil health indicators. Cross-tabulation allowed for a deeper examination of farming practices and their impact on soil health outcomes. Additionally, qualitative insights from case studies enhanced data interpretation, providing a nuanced understanding of how socio-economic factors and perceptions influence farming decisions.

The study area spans diverse landscapes and farming methods, reflecting the unique agricultural practices of KB Asifabad District. For instance, black soils in drylands support cotton cultivation, while wetlands facilitate paddy farming, aided by heavy rains and moist soil conditions. The district's strong irrigation infrastructure, coupled with its role as a cotton trading hub, has influenced farmers' reliance on mechanized and intensive farming techniques.

While this study provides a snapshot of farming practices and their implications for soil health, it is limited by its focus on a single district and specific crops. Future research could broaden the scope by including diverse regions and crops, incorporating longitudinal studies to track changes over time, and integrating advanced statistical and spatial analysis tools to enhance the robustness of findings. This methodology combines quantitative and qualitative approaches to offer a comprehensive understanding of the challenges and opportunities in intensive farming systems. By addressing farmers' perceptions, socio-economic factors, and empirical data, this study provides actionable recommendations for fostering sustainable agriculture in the KB Asifabad District.

3. Results

The study's findings were categorized into five sections: farmers' socio-economic and landholding status, their preferred tilling methods, manure and fertilizer input, chemical fertilizers, and natural manure.

3.1. Socioeconomic & Landholding Status

The study revealed several key aspects of intensive farming practices in the region. A significant portion of farmers—42.5%—belong to the middle-aged category (43 to 50 years old), while 48.2% have between 21 and 48 years of farming experience. Rural farmers typically enter agriculture through family succession or land acquisition through marriage. Notably, many young farmers aged 20 to 30 continue to engage in farming, ensuring the continuity of agricultural traditions.

3.2. Land Holding and Community Status

In terms of land ownership, the majority of agricultural land belongs to farmers from the Other Backward Classes (OBCs), as the study region is designated as a tribal agency area by the Government of India. While the Scheduled Tribe (ST) and OBC communities have similar population sizes, ST farmers generally hold less land compared to their OBC counterparts. Farmers from the General category possess medium-sized agricultural holdings, whereas Scheduled Caste (SC) farmers are the least represented in terms of land ownership, primarily working as agricultural labourers in the study area.

3.3. Farmers' Preferred Tilling Method

Tillage activities, including stirring, overturning, and digging before sowing, enhance crop production and quality by altering soil structure, texture, and nutrient content. Proper tillage preserves organic matter and soil fertility [9]. While mechanical tillage prepares soil and sows seeds, traditional tillage is used in KB Asifabad district to remove weeds.

Just over half of the farmers (50.8%) use both traditional and mechanical farming methods, with hired labour assisting with mechanical tools and equipment. Mechanical procedures are more efficient and timesaving than traditional methods, explaining this preference. However, traditional methods like „***Guntuku***," a traditional weed remover, are still preferred for certain chores or crops. Additionally, 29.8% of farmers use traditional methods but hire labour for mechanical tasks. Traditional methods may be more suitable for specific crops or tasks. Lastly, 2.2% of farmers use both traditional and mechanical farming methods independently, possibly due to the challenges of managing both. Data indicates a mix of conventional and mechanical farming methods, with mechanical systems preferred for efficiency and time savings.

3.3.1. Case Study: Tillage Preferences and Their Impact on Soil Health

Devaiah, an 85-year-old farmer from Talodi village in Komaram Bheem Asifabad district, has spent over 65 years in agriculture, witnessing significant shifts in farming methods from traditional practices to mechanical tillage. His experience reflects a broader transition in the region's agricultural landscape. *„In my childhood, agriculture relied entirely on traditional tilling methods. We used wooden ploughs to prepare the land for sowing, and for weed removal, we employed manual techniques such as "**Guntuku**". The land was tilled only as much as required for seeding, and this practice continued for nearly five decades. Traditional methods supported healthy crop growth, minimized weed proliferation, and maintained soil texture and porosity. Additionally, chemical fertilizer use was minimal, preserving the soil's natural fertility. Mechanized ploughing was introduced in the region about 15 years ago. Initially, most farmers still relied on traditional tilling, but as time passed, mechanical ploughing gained popularity due to its efficiency. Presently, the majority of farmers depend on tractors for tillage. However, this shift has had consequences—particularly the sharp decline in livestock rearing, which has fallen by 90%. With fewer livestock, the availability of natural manure has also reduced significantly, further impacting soil fertility. While mechanical ploughing initially boosted crop growth, its long-term effects have become apparent. Excessive tillage has led to increased weed growth, soil compaction, and reduced water retention. The continuous disruption of the soil structure has contributed to erosion, stripping the land of its fertile topsoil. To combat weeds, farmers have resorted to herbicides, further degrading soil health by eliminating beneficial organisms such as earthworms. Over time, the soil texture has deteriorated, making it increasingly difficult to maintain productivity. Recognizing these issues, farmers are now exploring ways to minimize tillage, even with mechanical ploughing. While controlled tillage can help regenerate the soil's porosity and texture, achieving full restoration remains challenging. A proactive approach is necessary to safeguard soil fertility. If minimal tillage practices are widely adopted across the region, the soil can gradually regain its natural balance, ensuring sustainable agricultural productivity for future generations" (CS-I).*

3.4. Manure and Fertilizer Input

Table 1 indicates that the overwhelming majority of farmers (98.3%) prefer using chemical fertilizers every time, reflecting a strong reliance on synthetic inputs for

crop growth stimulation. This choice is likely driven by the efficiency and quick results that chemical fertilizers provide. However, this preference has significant implications for soil health and the balance of soil ecosystems, particularly for microorganisms.

Table 1. Manure Preference.

Manure and Fertilizer Preference	N	%
Every time chemical fertilizers	*375*	*98.3*
Sometimes livestock manure	*7*	*1.7*
Often natural fertilizers and livestock manure	*0*	*0.0*
Only natural manure	*0*	*0.0*
Only livestock manure	*0*	*0.0*
Always natural fertilizers and livestock manure	*0*	*0.0*
Total	**382**	**100.0**

3.4.1. Tilling Methods and Soil Health

Farmers' tilling methods, including both traditional and mechanical techniques, play a crucial role in preparing the soil for planting. Proper tilling practices enhance soil structure, texture, and nutrient content, which are essential for maintaining soil fertility [10]. However, excessive and improper tilling, combined with the use of heavy machinery, can lead to soil compaction, reduced pore spaces, and overall degradation of soil quality [11]. This negatively impacts the soil's ability to retain water and support plant roots.

3.4.2. Impact on Ecosystem Balance of Microorganisms

The frequent use of chemical fertilizers disrupts the natural balance of soil ecosystems [12]. Chemical inputs can alter the physical, chemical, and biological properties of the soil, leading to a decline in soil organic matter and microbial diversity [13]. Soil microorganisms, such as bacteria, fungi, and earthworms, play a vital role in decomposing organic matter, recycling nutrients, and enhancing soil fertility [14]. When chemical fertilizers are overused, the population and activity of these beneficial microorganisms decrease, resulting in reduced soil fertility and health.

3.4.3. Ecological Consequences

The decline in soil health due to excessive chemical fertilizer use and improper tilling practices has broader ecological consequences. Soil erosion, nutrient leaching, and loss of biodiversity are common outcomes of degraded soil ecosystems [15,16]. The reduction in microbial activity hampers nutrient cycling, leading to a dependency on external inputs for crop growth [17]. Additionally, chemical fertilizers can contaminate water sources through runoff, further impacting the surrounding environment and human health [18].

3.5. Chemical Fertilizers

Farmers' Perception: Farmers' views on chemical fertilizers can significantly impact crop output and soil health. Physical, chemical, and biological properties determine soil health. Modern agriculture relies heavily on fertilizers, which can endanger soil health. Past experiences, fertilizer management practices, and cultural factors may influence farmers' perceptions of the pros and cons of chemical fertilizers. Understanding these views is crucial for developing sustainable fertilizer management systems that enhance agricultural yield while reducing environmental impact.

Most farmers (90.1%) employed chemical pesticides because they are faster and easier to apply. However, overuse of chemical pesticides harms both humans and the environment. Insufficient soil nutrients can hinder plant growth and agricultural output. Soil degradation and ecosystem instability can result from the use of fertilizers and pesticides. Increasing chemical fertilizer use may lower soil organic matter and raise soil pH [19]. Excessive use of heavy machinery can damage soil pores and increase soil compaction levels [11]. Although herbicides eliminate weeds, they can also alter soil microbes and contaminate ground and surface water [20]. Synthetic chemicals can cause skin, respiratory, and eye problems [21]. Furthermore, 9.9% of farmers occasionally used chemical pesticides. Natural insecticides may be a viable alternative to synthetic pesticides. Some farmers used biopesticides, including garlic, neem leaf oil, and asafoetida mixed with cow urine, to control harmful germs and pests in their crops [22]. Vermicompost can be made using cow dung, tamarind seeds, neem leaves, and jaggery. Trichoderma is a well-known biochemical that controls cotton bollworms [23]. While most farmers prefer chemical pesticides, a minority percentage use natural fertilizer.

3.6. Use of Natural Manure: Farmers' Perception

Table 2 reflects farmers' perceptions of the effectiveness of various types of manure in enhancing crop yield. A substantial proportion of farmers remain sceptical about the benefits of natural manure, with 80.1%, 90.6%, and 95.6% doubting the effectiveness of livestock, poultry, and green manure, respectively. This scepticism likely stems from a lack of information about the ecological benefits of natural nutrients for soil health and the convenience of synthetic fertilizers.

Table 2. Preference on Natural Manure Application.

Enhancing Crop Yield Through Livestock	*Not Enhanced*	*N*	*306*
		%	*80.1%*
	Enhanced	*N*	*76*
		%	*19.9%*
	Total	*N*	*382*
		%	*100.0%*
Boosting Crop Yield with Poultry Farming	*Not Enhanced*	*N*	*346*
		%	*90.6%*
	Enhanced	*N*	*36*
		%	*9.4%*
	Total	*N*	*382*
		%	*100.0%*
Improving Crop Yield with Green Manure	*Not Enhanced*	*N*	*365*
		%	*95.6%*
	Enhanced	*N*	*17*
		%	*4.4%*
	Total	*N*	*382*
		%	*100.0%*

Organic matter-rich manure conserves soil fertility by improving soil structure, water-holding capacity, and nutrient content [24]. Vermicomposting using various earthworm species supports agricultural development and ecological balance, including clean air and water [25]. Natural manure, which is rich in potassium, phosphorus, and nitrogen, promotes soil fertility [26], nitrogen availability, erosion control, and plant protection. Despite these benefits, many farmers in the study area are sceptical about the effectiveness of natural manure due to a lack of awareness and economic pressures. *"Tribal communities, including the Koya, Kolam, Gondu, semi-nomadic Gollakuruma, Kapu, Are, and Bare, traditionally raise cattle. Farming replaced cattle herding in the early 1900s, leading these communities to raise large flocks of sheep, goats, buffalo, and cows for agricultural manure. These animals provide milk, meat, wool, and free manure. Due to its affordability, availability, and traditional use, farmers commonly use animal dung".*

3.7. Focus Group Study: Integrating Traditional and Modern Practices

A group of seven farmers from Buruguda village in K.B. Asifabad district provides valuable insights into the transition from traditional to modern farming practices. "*These farmers collectively own dry land where they traditionally cultivated crops such as flaxseeds, sesame, pulse crops in Kharif, and sorghum in Rabi seasons. Occasionally, they also grew cotton and chilies. Over time, and particularly with the mechanization of agriculture, these farmers adapted their practices to align with the evolving farming landscape. Initially, these farmers heavily relied on livestock for natural manure. They raised a variety of animals, including sheep, goats, buffalo, and cows, which provided not only manure but also milk, meat, and wool. However, with the advent of mechanized tilling and the widespread availability of chemical fertilizers, they gradually reduced their livestock, favouring synthetic inputs for their perceived efficiency and effectiveness.*

Despite their extensive experience, these farmers expressed scepticism about the effectiveness of natural manure in enhancing crop productivity. This scepticism is mirrored by a substantial proportion of farmers in the study area, with 80.1%, 90.6%, and 95.6% doubting the effectiveness of livestock, poultry, and green manure, respectively. The primary reasons behind this scepticism include a lack of awareness about the benefits of natural nutrients for soil health, the convenience and quick results of chemical fertilizers, and the economic pressures to maximize yields. The farmers noted that as they increasingly relied on synthetic chemicals due to the reduced availability of livestock and the labour-intensive nature of traditional farming methods, they observed changes in soil quality. These changes included the disappearance of earthworms and reduced natural fertility, illustrating the long-term negative impacts of synthetic inputs on soil health. Chemical insecticides also posed health hazards, causing issues like skin irritation and respiratory problems among local farmers.

However, the farmers acknowledged the potential benefits of returning to sustainable practices. They observed successful examples of natural manure application in neighbouring farms, which piqued their interest. They recognized that organic inputs, such as livestock manure, poultry litter, and green manure, could significantly enhance soil structure, microbial activity, and nutrient availability, thereby boosting crop yields in an eco-friendly manner. Increasing awareness and education about the benefits of natural manure are crucial. Farmers in this group could benefit from targeted educational initiatives that demonstrate the long-term advantages of sustainable practices over synthetic inputs. By promoting the practical application of organic fertilizers and highlighting their success stories, farmers' confidence in these traditional methods can be restored" (FGS-I).

In conclusion, the experiences of these seven farmers underscore the necessity of integrating traditional wisdom with modern techniques to achieve sustainable agriculture. By addressing the scepticism surrounding natural manure and emphasizing its ecological and productivity benefits, the farming community can move towards more sustainable and health-conscious practices.

3.8. Insights into Farmers' Perceptions of Sustainable Agriculture Practices (SAP)

The data in **Table 3**, derived from the Likert scale, provide valuable insights into farmers' awareness and attitudes toward sustainable agriculture. The mean and mode values highlight their general perspectives on various aspects of SAP.

Farmers express strong agreement that maintaining environmental balance is a fundamental component of sustainable agriculture, as reflected in the high mean value of 3.93 and a mode of 5. This indicates a widespread recognition of SAP's ecological benefits. However, opinions on reducing chemical fertilizer usage are more neutral, with a mean of 3.73 and a mode of 3, suggesting uncertainty or mixed views on its advantages.

Table 3. Farmers' Knowledge on Sustainable Agriculture Practice.

Statement	N	Mean	Mode	St. Div
One of the pillars of sustainable agricultural practice is environmental balance.	*382*	*3.93*	*5*	*1.047*
Reducing the use of chemical fertilizers to benefit of sustainable agricultural methods.	*382*	*3.73*	*3*	*0.981*
The evidence of economic benefits by using sustainable agricultural methods is weak.	*382*	*3.40*	*3*	*0.877*
Sustainable agricultural practices can increase a farm's revenue.	*382*	*3.17*	*3*	*0.880*
In any farm, sustainable agricultural methods would be effective.	*382*	*3.35*	*3*	*0.898*
Additional management beyond the conventional practices may be necessary for sustainable agricultural practices.	*382*	*3.65*	*3*	*0.824*
The adoption of sustainable agricultural practice's is slow due to lack the knowledge among the farmers to implement them.	*382*	*3.94*	*4*	*0.896*
Overall, recommended pest control techniques of sustainable agricultural systems may result in an increase in pests.	*382*	*3.73*	*3*	*0.915*
There might not be enough workers to complete the tasks necessary for a sustainable agricultural system.	*382*	*3.49*	*3*	*0.930*
A sufficient amount of food should be produced by sustainable agricultural systems to feed the world's population.	*382*	*3.51*	*3*	*0.895*
Farmers with both crop and livestock operations will find it easier to adopt sustainable agricultural practices.	*382*	*3.74*	*3*	*0.835*
Utilize non-renewable resources and farm resources as effectively as possible, incorporating natural biological cycles and controls wherever SAP is appropriate.	*382*	*3.57*	*3*	*0.797*
Mainstream agriculture has adopted the sustainable agriculture recommendations	*382*	*3.10*	*3*	*0.851*

Economic considerations also play a role in shaping farmers' perceptions. The economic benefits of SAP receive a somewhat sceptical response, with a mean of 3.40 and a mode of 3, implying neutrality. Similarly, the belief that sustainable practices can enhance farm revenue holds a mean of 3.17 and a mode of 3, further indicating uncertainty regarding financial outcomes.

When evaluating SAP's effectiveness across different farm settings, the mean score of 3.35 and mode of 3 suggests farmers are undecided about its applicability and overall impact. The need for additional management efforts beyond conventional practices is acknowledged, with a mean of 3.65 and a mode of 3, though farmers remain neutral about the extent of this requirement.

One of the key barriers to SAP adoption is the lack of adequate knowledge among farmers, as indicated by a mean of 3.94 and mode of 4. Concerns about pest control using SAP techniques also result in a mean of 3.73 and mode of 3, reflecting neutrality and a need for further awareness of long-term pest management strategies.

Labor availability is another factor influencing adoption rates, though farmers display a neutral stance, with a mean of 3.49 and mode of 3, suggesting it is a consideration but not a dominant challenge. Similarly, perceptions of SAP's capacity to sustain global food production reflect uncertainty, with a mean of 3.51 and mode of 3.

Farmers operating both crop and livestock farms tend to find SAP easier to integrate, but responses remain neutral, with a mean of 3.74 and mode of 3. Additionally, while SAP promotes efficient resource utilization, farmers appear uncertain about its benefits, as reflected in a mean of 3.57 and mode of 3.

Finally, mainstream adoption of SAP practices receives a mean of 3.10 and mode of 3, indicating hesitation and uncertainty about its widespread implementation. Overall, the findings suggest a generally neutral to slightly positive perspective on SAP, emphasizing the need for further education and evidence to strengthen farmers' confidence in sustainable agricultural methods.

3.9. Focus Group Study: Farmers' Perspectives on the Adoption and Practice of Sustainable Agriculture

A focus group of experienced farmers from Gurudupeta, Chinthala Manepalli, and Ada villages—each with over two decades of agricultural expertise—shared their insights on the adoption of Sustainable Agriculture Practices (SAP). "*In the past, cotton cultivation was relatively uncommon in the region, with farmers primarily growing pulses, sorghum, sesame, and flax seeds in dryland areas, while paddy was cultivated in wetland regions. During that period, the use of synthetic fertilizers, including DAP, urea, and potash, was minimal, and livestock manure served as the primary soil enhancer. Agricultural yields were modest but consistent. Over time, cotton farming has expanded significantly, reshaping local agricultural methods. Driven by the pursuit of higher profits, most farmers have shifted toward cotton cultivation. This transition has made SAP adoption difficult, as modern farming practices now rely heavily on chemical fertilizers for pest control and yield enhancement. Currently, synthetic chemicals are widely used across various crops to maintain expected productivity levels. A noticeable decline in soil health compared to previous years has been observed, largely due to reduced livestock manure use and increased dependence on chemical inputs. Some NGOs have raised awareness about the long-term environmental and soil degradation caused by intensive farming. While farmers express willingness to adopt SAP if effective alternatives can offer comparable yields without relying on synthetic chemicals, the lack of such proven solutions has led to widespread reluctance in shifting to sustainable methods" (FGS-II).*

4. Discussion

This study highlights the intricate relationship between intensive farming practices and soil health in Telangana, India, highlighting significant ecological and socioeconomic implications. Findings reveal a heavy reliance on chemical fertilizers and pesticides, driven by the perceived efficiency and convenience of synthetic inputs. However, this overdependence has resulted in soil degradation, reduced microbial diversity, water pollution, and health risks for farmers and local communities. Excessive chemical use leads to nutrient leaching, diminished soil organic matter, and compaction, further accelerating the decline in soil quality and ecosystem stability [27]. These results stress the urgent need for interventions that promote sustainable

agricultural practices, balancing productivity with environmental sustainability.

Despite the well-documented advantages of natural manure, scepticism among farmers regarding its effectiveness remains prevalent. This scepticism is deeply tied to economic pragmatism, cultural inertia, and informational gaps, as many farmers prioritize immediate yield maximization over long-term soil health benefits. While organic inputs, such as livestock manure and green manure, contribute to improved nutrient cycling, enhanced microbial activity, and better water retention, their adoption remains limited due to concerns over practicality and financial constraints [28]. These barriers highlight the need for stronger incentives, awareness campaigns, and demonstration programs to bridge the gap between farmers' perceptions and sustainable agricultural practices.

The findings from the Buruguda and Gurudupeta focus groups reveal not only informational gaps but also cultural inertia and economic pragmatism that hinder the adoption of SAP. Farmers acknowledged a noticeable decline in soil health compared to previous years, primarily due to reduced use of livestock manure and increased dependence on chemical inputs. While NGOs have raised awareness regarding the long-term environmental degradation caused by intensive farming, farmers remain reluctant to fully transition to SAP due to the lack of proven alternatives that offer comparable yields without relying on synthetic chemicals (FGS-II). These insights are critical for designing targeted interventions that address farmers' psychological and behavioural barriers, ensuring that they perceive SAP as both economically viable and ecologically beneficial.

Additionally, mechanical farming methods have contributed to soil degradation, affecting soil compaction, reduced pore spaces, and impaired root growth [11]. While these methods enhance labour efficiency, improper tilling and the excessive use of heavy machinery negatively impact soil structure and fertility. Conservation strategies such as minimum tillage, crop rotation, and organic amendments must be encouraged to restore soil health and long-term agricultural sustainability [29].

The study highlights the importance of policy interventions to promote SAP adoption. While government initiatives, subsidies, and extension services exist, many farmers struggle to access resources due to bureaucratic hurdles and lack of localized policy adaptation. Strengthening financial incentives for organic fertilizers, implementing targeted education programs, and ensuring more accessible regulatory measures can drive behavioural change and encourage SAP uptake [30]. Practical barriers, including market access limitations and financial constraints, must be systematically addressed through stakeholder collaboration, farmer engagement, and adaptive policy frameworks.

Promoting sustainable farming requires a multi-pronged approach [30]. Educational programs should focus on bridging knowledge gaps, showcasing successful SAP implementations, and fostering farmer confidence through hands-on training [31]. Policies that subsidize organic alternatives, strengthen agricultural extension services, and regulate synthetic input usage will provide the necessary support structure for transitioning toward eco-friendly farming methods [32]. The study calls for collaborative initiatives involving farmers, policymakers, research institutions, and environmental groups to ensure the successful integration of SAP into mainstream agricultural practices.

5. Conclusions

This study provides a comprehensive examination of intensive farming practices and their impact on soil health in Telangana, India, highlighting the ecological and socio-economic challenges posed by the widespread use of chemical fertilizers and mechanized farming techniques. While these practices have driven short-term productivity gains, they have also led to soil degradation, reduced microbial diversity, and environmental pollution, threatening the long-term sustainability of agricultural systems.

Despite the recognized benefits of natural manure and sustainable agricultural practices (SAP), behavioural inertia, economic pressures, and knowledge gaps continue to impede adoption. The focus group findings suggest that farmers are aware of the risks associated with intensive farming, yet perceptions of immediate profitability and reliability outweigh long-term sustainability considerations. This reluctance underscores the importance of targeted interventions, such as education programs, financial incentives, and demonstrative SAP success stories, to shift farmer attitudes toward sustainable alternatives.

Addressing these barriers requires a multi-faceted

approach, integrating traditional wisdom with modern agricultural techniques, such as conservation tillage, crop rotation, and organic amendments, to restore soil health and promote resilient ecosystems. However, policy frameworks must be strengthened to ensure that SAP adoption is economically viable. Existing subsidies and regulatory measures often fail to effectively reach farmers, limiting the impact of sustainability initiatives. Improved policy mechanisms, such as direct financial support for organic fertilizers, streamlined access to eco-friendly resources, and enhanced agricultural extension services, are essential for bridging the gap between intensive farming and sustainable transitions.

This research emphasizes the need for a balanced approach that reconciles environmental stewardship with agricultural productivity. By empowering farmers with knowledge, resources, and institutional support, sustainable farming systems can be established to secure livelihoods, enhance food security, and preserve natural resources for future generations. The findings highlight the urgent need for policy-driven solutions, behavioural change initiatives, and economic support structures to facilitate a practical and scalable transition toward sustainable agriculture, ensuring a resilient and ecologically sound future for Telangana's farming communities.

Author Contributions

Conceptualization, S.K. and R.S.B.; methodology, S.K. and R.S.B.; software, S.K. and R.S.B.; validation, S.K., R.S.B., P.C. and R.B.; formal analysis, S.K. and R.S.B.; investigation, S.K. and R.S.B.; resources, S.K. and R.S.B.; data curation, S.K., R.S.B., P.C. and R.B.; writing—original draft preparation, S.K. and R.S.B.; writing—review and editing, S.K. and R.S.B.; visualization, S.K. and R.S.B.; supervision, S.K., R.S.B., P.C. and R.B.; project administration, S.K. and R.S.B.; funding acquisition, S.K. and R.S.B. All authors have read and agreed to the published version of the manuscript.

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Not applicable. This study did not involve any human participants or animal experiments.

Informed Consent Statement

Not applicable.

Data Availability Statement

The data supporting the reported results can be found here, in the publicly archived dataset used for this study. Where privacy or ethical restrictions apply, data will be available upon reasonable request from the corresponding author.

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Conflicts of Interest

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

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