

Cultivating Sustainability: Farmer Practices, Soil Degradation, and the Future of Agroecology

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Abstract

The rapid transformation of agricultural practices in India, particularly in regions like Kommaram Bheen Asifabad district, has led to a growing reliance on synthetic fertilizers, pesticides, and monoculture cropping systems. While these changes have contributed to increased yields and economic gains, they have also triggered significant environmental concerns—most notably the degradation of soil health, loss of biodiversity, and contamination of water resources. This study investigates the implications of Highly Intensive Agriculture (HIA) on soil quality and environmental sustainability, with a specific focus on farmer practices, perceptions, and policy gaps. The primary objective of the research is to examine the influence of synthetic chemical inputs on soil productivity, understand farmers' decision-making processes, and assess the economic viability of chemical-intensive agriculture. A descriptive survey was conducted among 382 farmers enrolled in the Telangana State's "Rythu Bandhu Scheme," supplemented by interviews, case studies, and focus group discussions. Data were analysed using IBM-SPSS software, incorporating both inferential and non-inferential statistical techniques. Key findings reveal a marked shift from traditional multi-cropping and livestock-integrated systems to monoculture and mechanization, resulting in soil compaction, reduced organic matter, and declining microbial activity. Despite awareness of sustainable agriculture practices, adoption remains minimal due to economic pressures and lack of institutional support. The study underscores the urgent need for integrated soil health management, policy enforcement, and farmer education. This research contributes to the broader discourse on environmental balance and sustainable agriculture, offering actionable insights for policy makers, extension agencies, and farming communities committed to long-term ecological resilience.

Key words: Soil Health Management; Sustainable Agriculture; Synthetic Fertilizers and Pesticides; Monoculture and Crop Diversity; Environmental Balance

BACKGROUND

The evolution of agricultural practices in India, particularly since the Green Revolution, has been marked by a dramatic shift in priorities, from ecological balance to yield maximization (Prabhakar & Brar, 2024). The Green Revolution, driven by an urgent need to increase food production, introduced high-yielding crop varieties and promoted the widespread use of synthetic fertilizers and pesticides. While this approach initially succeeded in boosting agricultural output and addressing food scarcity, it also laid the groundwork for long-term ecological challenges (Choudhary & Sharma, 2024). The relentless pursuit of productivity has led to unintended consequences, particularly the degradation of soil—the very foundation of sustainable agriculture (Pretty, 2018). Soil, often treated as an infinite resource, is in fact finite and non-renewable. Once depleted, it requires decades, if not centuries, to regenerate its natural fertility (Rhodes, 2017). As a critical component of the biosphere, soil supports not only food production but also biodiversity, water filtration, and carbon sequestration. Human dependence on soil extends beyond agriculture to shelter, economic livelihoods, and cultural identity (Rhodes, 2017). Yet, modern agricultural practices have increasingly undermined this vital resource.

The fertility of soil is sustained by a delicate balance of microorganisms, organic matter, and mineral nutrients (Biswas & Kole, 2017). However, the intensive use of synthetic chemicals has disrupted this equilibrium. Chemical fertilizers, while effective in the short term, often lead to nutrient imbalances, reduced microbial diversity, and physical degradation of soil structure (Pahalvi et al., 2021). Pesticides and herbicides, though designed to protect crops, also harm beneficial soil organisms and contribute to long-term ecological instability (Khan et al., 2023). The consequences of these practices are far-reaching. Soil erosion, salinization, and compaction have become common in many regions, reducing the land's capacity to support crops. Contaminated runoff from agricultural fields pollutes nearby water bodies, threatening aquatic ecosystems and human health (Weldeslassie et al., 2018). Moreover, the overuse of agrochemicals has led to the emergence of resistant pests and pathogens, creating a cycle of dependency that demands ever-increasing chemical inputs (Mitra et al., 2021).

In regions like Kommaram Bheen Asifabad district, these challenges are compounded by socio-economic pressures. Farmers, driven by market demands and financial incentives, have shifted from traditional multi-cropping systems to monoculture, particularly cotton and chili cultivation. This transition has intensified the use of synthetic fertilizers and pesticides, further straining soil health. The decline of livestock integration—once a cornerstone of organic nutrient cycling—has exacerbated the problem (Lemaire et al., 2023). Livestock manure, which naturally enriches soil and supports microbial life, has been largely replaced by chemical inputs. Mechanization (Liu & Wang, 2020), while improving efficiency, has contributed to soil compaction and reduced water retention. These changes reflect a broader trend toward Highly Intensive Agriculture (HIA), which prioritizes short-term gains over long-term sustainability.

Despite the existence of environmental regulations and policy frameworks aimed at curbing chemical use, enforcement remains inconsistent. Many policies exist only on paper, with limited practical implementation. Farmers often lack access to training, resources, and incentives to adopt sustainable practices (Bopp et al., 2019). As a result, the region faces a growing disconnect between agricultural productivity and ecological resilience. The need to restore soil health and balance environmental priorities with economic viability has never been more urgent (Timmis & Ramos, 2021). This study emerges from that context—seeking to understand the lived experiences of farmers, the impact of current practices on soil and environmental health, and the pathways toward more sustainable agricultural futures.

Objective of Study

This research paper seeks to explore the actual agricultural practices of farmers, focusing on their ground-level implementation and perspectives. Specifically, the article aims to investigate the influence of synthetic chemicals on soil productivity, understand farmers' decision-making processes regarding high-input practices, and assess the economic viability of chemical-intensive agriculture. The widespread use of synthetic chemicals has raised concerns about soil health and ecosystem sustainability (Tripathi et al., 2020). By examining farmers' practices, we can identify areas for improvement and sustainable alternatives. As stewards of the land, farmers face the challenge of maximizing yields while safeguarding the environment (Altieri et al., 2012). This study aims to uncover strategies that strike this delicate balance. Despite existing regulations, practical enforcement remains inconsistent. By understanding farmers' perspectives, we can propose effective policy measures that protect both soil and economic prosperity. This research contributes to our collective efforts in promoting responsible soil management and ensuring a harmonious coexistence with nature.

METHOD AND MATERIALS

The study investigated 382 farmers from the Kommaram Bheen Asifabad district who were enrolled in the Telangana State's "*Rythu Bandhu Scheme*." This scheme aims to provide financial assistance to farmers during two cropping seasons—Kharif and Rabi—offering up to ₹7,500 per season. The research employed a descriptive survey method to collect primary data directly from the farmers. Additionally, an interview schedule tool was used to gather information. The study also included case studies and focused group discussions to obtain relevant insights into farmers' practices and perspectives. The collected data underwent analysis using IBM-SPSS software, employing both inferential and non-inferential statistical techniques.

RESULTS

The study encompasses various social communities, including General Categories (GC), Backward Classes (BC), Scheduled Tribes (ST), and Scheduled Castes (SC). Among the total 382 samples, 26.16% were from each GC and SC, while 29.84% were from each BC and ST social community. Although the area falls under the Scheduled Tribal Agency Area (STAA) as per legal classification, most farmers and farm holdings come from the Backward Classes, followed by Scheduled Tribes. The primary occupation in the study area revolves around the agriculture sector, with 87.6% of people directly or indirectly dependent on agriculture for their livelihood. Specifically, 65.97% of individuals rely directly on agriculture, while 12.4% have indirect dependence. Furthermore, within the farming community, either 65.97% or 12.4% hold smaller to medium-sized land holdings (less than 2 acres and 4 acres of wet and dry land, respectively). Among these farmers, 12.4% also work as agricultural labourers on other farmers' lands, and some from the 65.97% group pursue shared and leased cropping arrangements, constituting 13.9% (shared croppers) and 4.19% (leased croppers). Notably, most farmers have over 30 years of experience, even at the age of 50. While they previously cultivated diverse crops, monoculture cultivation currently dominates, albeit with some leniency.

Rajaiah, a seasoned 58-year-old farmer with 32 years of experience, resides in Buruguda village within the K.B. Asifabad district. His observations shed light on the shift from traditional diversified cropping practices to monoculture in agriculture. Previously, farmers adhered to a diverse crop rotation pattern based on seasonal variations. Narsaiah, a 40-year-old farmer from Ada village, recalls that during the Kharif season (June to October), they cultivated paddy in wetlands and white sesame, flaxseeds, soybeans, corn, and pulses in drylands. In the Rabi season (October to March), sunflower, chickpea, wheat, and vegetables were grown in wetlands, while red gram, black sesame, sorghum, and sunflower thrived in drylands. Some farmers also opted for whole-season crops like cotton and chili. Venkatasam, a marginal farmer from Chirapelli village, owns 10 acres of wetland and has 15 years of experience. He exclusively cultivated cotton, initially relying on livestock manure and minimal synthetic fertilizers—approximately 150 kg of DAP and 100 kg of urea per acre—yielding 7 to 8 quintals per acre. However, the landscape has transformed. Presently, they utilize approximately 250 kg of DAP, 175 kg of urea, and 100 kg of potassium per acre. The market offers a variety of chemical fertilizers that attract farmers. Insecticides, fungicides, pesticides, and herbicides are now commonplace in cotton farming, resulting in increased yields—around 11 to 14 quintals per acre—despite the absence of livestock. Narayana, another farmer from the same village, also practices monocropping. He acknowledges the economic benefits of this intensive approach but raises concerns about health and soil degradation due to chemical pesticide application. Without these chemicals, productivity seems unattainable, making them an indispensable part of modern agricultural production.

Over the years, the adoption of monocrops and the widespread use of synthetic chemicals have significantly transformed agricultural practices. Farmers now prioritize economic gains and efficiency in cultivation and harvesting. Meanwhile, assessing the land quality over the past decade reveals a complex picture. Fifteen years ago, the soil quality was high, but production and irrigation remained relatively low. However, the present scenario tells a different story. Soil quality has degraded, while irrigation and production have increased substantially. This shift can be attributed to the excessive application of synthetic fertilizers and intensive irrigation—a hallmark of Highly Intensive Agriculture (HIA) practices. Interestingly, some study areas exhibit crop diversity, although not always translating into profitable production. Despite adequate irrigation and chemical fertilizer use, the overall impact on soil health is concerning. The relentless pursuit of higher yields has compromised soil organic matter, ultimately affecting production capacity. As we grapple with these challenges, it becomes crucial to strike a balance between economic incentives and sustainable soil management.

A decade ago, every family in the study area-maintained livestock, typically consisting of at least two bulls and one cow or buffalo. However, the current landscape has undergone significant changes. Only 12.4% of farmers now possess the minimum required number of livestock. This decline poses a serious threat to agriculture, particularly concerning soil fertility, as livestock play a crucial role in enhancing natural soil health. When livestock interact with the soil, decomposition processes occur, fostering the development of beneficial microorganisms. These microorganisms contribute to nutrient cycling and the release of essential elements, including carbon dioxide (CO₂), which supports plant life. Traditionally, farmers heavily relied on manual labour and traditional equipment for tilling the soil. However, due to reduced livestock numbers and time constraints, an increasing number of farmers have shifted to mechanical methods for soil preparation. Presently, 87.6% of farmers utilize mechanical aids for tilling, while only 8.54% continue to employ traditional methods. Unfortunately, this transition has led to several adverse consequences. Soil compaction has intensified, unwanted weed growth has proliferated, water retention capacity has diminished, and carbon dioxide (CO₂) levels in the soil have declined. In response to rampant weed growth, farmers have turned to herbicides as effective weed removal agents. Despite their efficiency in saving time and labour costs, herbicides come with a significant drawback—they harm essential microorganisms and macro-organisms in the soil, which are vital for maintaining soil fertility.

In the current agricultural landscape, chemical fertilizers dominate, with 90.5% of farmers preferring their use. Only a small fraction (9.61%) relies on natural manure in conjunction with chemical fertilizers. Remarkably, an even smaller percentage (0.26%) practices entirely chemical-free farming. Farmers' perspectives on sustainable agriculture practices (SAP) reveal interesting insights. While 34.29% believe SAP enhances crop and soil fertility, no one actively follows these practices; it remains an assumption. Furthermore, 88.22% of farmers consistently apply chemical fertilizers, bypassing manual labour or bio-fertilizers for weed removal. In contrast, 11.52% opt for manual weed removal without herbicides. Interviews with senior farmers shed light on the impact of livestock on crop production. A significant majority (73.56%) doubts that livestock manure alone can yield expected

production levels. Conversely, 26.70% acknowledge its potential but recognize that it falls short of chemical fertilizers' efficacy.

Over the past decade, the agricultural landscape in the study region has witnessed a significant shift—from wetlands to drylands. This transformation primarily caters to the cultivation of commercial crops, notably cotton and chili. Cotton crops enjoy popularity among all farmers. In the past, wetland farmers predominantly cultivated paddy as their major crop, while dryland farming involved a diverse range of crops such as sesame, soybeans, flaxseeds, sorghum, and pulses. However, the present scenario reflects a major shift, with cotton emerging as the primary crop in dryland areas. Cotton is a year-round crop, with cultivation beginning in June and extending until March, yielding production primarily from November to February. Farmers have adapted their practices to maximize production efficiency and minimize labour. This transition involves moving from multi-cropping to monoculture, traditional methods to mechanization, and a shift from bio-fertilizers to chemical fertilizers. In the past, farmers relied mainly on diammonium phosphate (DAP) and urea for crop harvesting, occasionally using insecticides for cotton, red gram, and chili crops. However, recent trends indicate a move toward Highly Intensive Agriculture (HIA) practices. An overwhelming 98.2% of farmers now rely on DAP, urea, and potassium for every crop. Additionally, various types of insecticides, fungicides, and herbicides are employed across crops—whether paddy, cotton, or chili. Unfortunately, this intensified approach poses risks to human health and the environment, warranting careful consideration of sustainable alternatives.

DISCUSSION

The significant shift in agricultural practices towards monoculture, chemical fertilizers, and mechanization in this region has undoubtedly brought economic benefits (Crews et al., 2018). However, we must acknowledge the potential risks these practices pose to soil health and the environment. To ensure long-term sustainability, a multifaceted approach is required—one that prioritizes both economic viability and environmental protection (Hariram et al., 2023). One crucial step is promoting crop diversity. Encouraging farmers to move beyond cotton and chili through crop rotation and intercropping can significantly enhance soil fertility (Lv et al., 2023). This not only reduces pest pressure but also fosters a more sustainable agricultural ecosystem. Furthermore, educating farmers about the importance of organic manure and bio-fertilizers is essential (Katherasala et al., 2025). A balanced approach that combines the use of chemical fertilizers with these natural inputs can optimize yields while safeguarding soil health (Katherasala, 2024).

Similarly, advocating for Integrated Pest Management (IPM) practices offers a promising solution (Katherasala, 2024). By implementing strategies like utilizing beneficial insects, trap crops, and cultural practices, we can effectively manage pests without jeopardizing soil organisms—a significant advantage over relying solely on herbicides and insecticides. Reviving livestock integration presents another opportunity. Encouraging livestock rearing not only provides economic benefits but also contributes to soil health by replenishing organic matter, improving structure, and enhancing nutrient cycling (Tully & McAskill, 2019). Livestock manure, when properly managed, can restore microbial diversity and improve soil aeration, which are critical for long-term fertility (Bhunja et al., 2021). To effectively disseminate knowledge about these sustainable practices, collaboration with agricultural universities and extension agencies is vital. Farmer training programs and field demonstrations can significantly promote the adoption of these methods amongst the agricultural community (Mgendi et al., 2022). These institutions can also help develop region-specific guidelines that consider local soil types, climate conditions, and cropping patterns.

Finally, establishing a system for regular monitoring and assessment of soil health, water quality, and crop productivity allows for data-driven decision-making. Implementing adaptive management strategies based on this empirical data ensures continuous improvement and addresses any unforeseen challenges. Soil testing services, mobile labs, and digital platforms can be leveraged to make this process accessible and farmer-friendly (Singh et al., 2025). Fostering sustainable agriculture requires a comprehensive approach that balances economic goals with environmental stewardship (Nath, 2024). By implementing the recommendations outlined above, we can empower farmers, mitigate the negative impacts of intensive practices, and ensure the long-term well-being of both agricultural livelihoods and the surrounding ecosystem. Moreover, policy makers must revisit existing regulations and ensure their enforcement is not just theoretical but practical. Incentives for sustainable practices, subsidies for organic inputs, and penalties for excessive chemical use can help shift the agricultural paradigm toward sustainability.

CONCLUSION

By embracing these multifaceted solutions—promoting crop diversity, balancing inputs, adopting IPM, reviving livestock integration, and establishing robust monitoring—we can pave the way for a future of sustainable agriculture. This approach will not only empower farmers with knowledge and practices that ensure long-term soil health and environmental protection, but also guarantee the continued economic viability of the region's agricultural sector. In essence, achieving a sustainable future requires a collaborative effort that prioritizes both economic prosperity and environmental well-being. The insights from this study underscore the urgency of rethinking current agricultural models and embracing practices that restore ecological balance. As we move forward, integrating traditional wisdom with scientific innovation will be key to building resilient farming systems that nourish both people and the planet.

Conflict of Interest

The authors declare no conflicts of interest in publishing this work, and no financial support has been provided by any institution or organization

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