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Ecological Restoration and Sustainable Land Use Practices: Bridging the Gap between Biodiversity Conservation and Agricultural Development

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ABSTRACT

Background. Rapid agricultural expansion and unsustainable land-use practices have accelerated ecosystem degradation and biodiversity loss worldwide. Ecological restoration has emerged as a critical strategy to recover degraded landscapes, yet tensions remain between biodiversity conservation goals and agricultural development demands. Bridging this gap is essential to achieve sustainable land use that supports both ecological integrity and food production.

Purpose. This study aims to examine how ecological restoration can be integrated with sustainable land-use practices to harmonize biodiversity conservation and agricultural development. The research seeks to identify approaches that balance ecological recovery with productive land use, contributing to long-term environmental sustainability and rural livelihoods.

Method. A mixed-methods approach was employed, combining quantitative analysis of land-use and biodiversity indicators with qualitative case studies from agricultural landscapes undergoing restoration initiatives. Data were collected through field assessments, remote sensing analysis, stakeholder interviews, and reviews of land management policies to evaluate restoration outcomes and agricultural performance.

Results. The findings indicate that integrated restoration-based land-use practices, such as agroecological farming, reforestation buffers, and multifunctional landscapes, significantly enhance biodiversity while maintaining or improving agricultural productivity. Restored areas showed improved soil quality, ecosystem services, and resilience to environmental stressors.

Conclusion. Ecological restoration, when aligned with sustainable land-use practices, offers a viable pathway to reconcile biodiversity conservation with agricultural development. Integrative approaches are essential for achieving resilient landscapes that support both ecological and socio-economic objectives.

KEYWORDS

Agricultural Development, Biodiversity Conservation, Ecological Restoration, Ecosystem Services, Sustainable Land Use

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INTRODUCTION

Ecological degradation has become one of the most pressing global challenges as agricultural expansion, land conversion, and intensive resource exploitation continue to accelerate biodiversity loss (Morelli et al., 2026). Natural ecosystems that once supported diverse species and provided essential ecosystem services are increasingly

transformed into simplified production landscapes. This transformation has generated profound ecological consequences, including soil degradation, declining water quality, habitat fragmentation, and reduced ecosystem resilience (He et al., 2026). At the same time, agriculture remains fundamental to human survival, rural livelihoods, and economic development, creating a persistent tension between the need for food production and the imperative to conserve biodiversity. This dual pressure places ecological restoration and sustainable land-use practices at the center of contemporary environmental and agricultural debates.

Ecological restoration has emerged as a strategic response to landscape degradation, aiming to recover ecosystem functions, enhance biodiversity, and rebuild ecological resilience (Shiri et al., 2026). Restoration initiatives increasingly recognize that conservation efforts cannot be isolated from human land use, particularly in agricultural regions where livelihoods depend on productive landscapes. Sustainable land-use practices, including agroecological farming, integrated landscape management, and multifunctional land systems, offer opportunities to align restoration objectives with agricultural development (Guan et al., 2026). These approaches emphasize the coexistence of ecological integrity and productive land use rather than viewing conservation and agriculture as competing goals.

The growing recognition of nature-based solutions and ecosystem-based management highlights the importance of integrating ecological restoration into agricultural landscapes (Appau et al., 2026). Sustainable land-use practices that incorporate restoration principles can enhance ecosystem services such as pollination, soil fertility, water regulation, and climate resilience (Pratzer et al., 2024). These services are essential not only for biodiversity conservation but also for long-term agricultural productivity. Understanding how ecological restoration can be operationalized within agricultural systems is therefore crucial for achieving sustainable development goals that balance environmental protection with food security and socio-economic stability.

Despite increasing global commitments to biodiversity conservation and land restoration, agricultural development continues to be a major driver of ecosystem degradation (Kim et al., 2025). Large-scale monoculture farming, excessive chemical inputs, and land-use intensification often undermine restoration efforts by prioritizing short-term productivity over long-term sustainability. Many restoration projects remain spatially separated from agricultural production areas, limiting their effectiveness in landscapes dominated by farming activities (Dai et al., 2025). This separation reinforces the perception that ecological restoration and agriculture are inherently incompatible, perpetuating conflicts between conservation objectives and development priorities.

Sustainable land-use practices have been widely promoted as a solution to reconcile conservation and agriculture, yet their implementation remains uneven and context-dependent. Farmers and land managers often face economic, institutional, and knowledge-related barriers that hinder the adoption of restoration-oriented practices (Miao et al., 2025). Policy frameworks frequently treat restoration and agriculture as distinct sectors, resulting in fragmented land management strategies that fail to address ecological and productive goals simultaneously (Adamescu et al., 2026). The absence of integrated approaches exacerbates land degradation, weakens ecosystem services, and increases the vulnerability of agricultural systems to environmental change.

This study addresses the challenge of bridging the gap between biodiversity conservation and agricultural development by examining how ecological restoration can be integrated into sustainable land-use practices (Schweikart et al., 2026). The research focuses on identifying pathways that enable productive land use while restoring ecological functions within agricultural

landscapes. Clarifying these pathways is essential for developing land management strategies that are both ecologically sound and economically viable, particularly in regions where agricultural expansion and biodiversity conservation intersect most intensively.

The primary objective of this study is to analyze how ecological restoration can be effectively integrated with sustainable land-use practices to harmonize biodiversity conservation and agricultural development (Dutta et al., 2025). The research seeks to evaluate restoration-based land management approaches that enhance ecosystem services while maintaining or improving agricultural productivity. By examining restoration outcomes within agricultural contexts, the study aims to demonstrate how ecological and economic objectives can be jointly achieved through integrated land-use strategies.

The study also aims to assess the ecological and socio-economic impacts of restoration-oriented agricultural practices, including their effects on biodiversity, soil quality, ecosystem services, and farmer livelihoods (Zwerts, 2026). Understanding these impacts is critical for determining the feasibility and scalability of restoration-based land-use models. The research intends to identify key factors that influence successful integration, such as governance arrangements, land tenure systems, and stakeholder participation.

Another objective of the study is to provide evidence-based insights that can inform land-use policy and planning. By synthesizing empirical findings from restoration initiatives and sustainable agricultural practices, the research seeks to offer practical recommendations for policymakers, land managers, and development practitioners (Barman & Wani, 2026). These recommendations are expected to support the design of land-use strategies that contribute to long-term sustainability, resilience, and inclusive development.

Existing literature on ecological restoration and sustainable land use often addresses these themes separately, resulting in limited understanding of their interactions within agricultural landscapes. Restoration studies frequently prioritize ecological outcomes such as species recovery and habitat connectivity, while agricultural research tends to focus on productivity, efficiency, and economic returns (Yin et al., 2026). This disciplinary separation creates a knowledge gap regarding how restoration efforts can be embedded within productive land-use systems without compromising agricultural viability.

Research on sustainable agriculture has increasingly emphasized agroecological approaches and ecosystem services, yet empirical studies linking these practices explicitly to restoration outcomes remain limited. Many studies acknowledge the potential of multifunctional landscapes but do not systematically examine how restoration principles can be operationalized in everyday agricultural management (Ahmed et al., 2026). The lack of integrated frameworks makes it difficult to assess trade-offs and synergies between biodiversity conservation and agricultural development across different spatial and temporal scales.

Another gap in the literature concerns the socio-institutional dimensions of integrating restoration and agriculture. Limited attention has been given to governance mechanisms, incentive structures, and stakeholder dynamics that shape land-use decisions (Xie et al., 2025). Without addressing these dimensions, restoration-based land-use strategies risk remaining theoretical or localized experiments. This study seeks to address these gaps by providing an integrative analysis that connects ecological, agricultural, and governance perspectives, thereby contributing to a more holistic understanding of sustainable land-use transitions.

This research offers a novel contribution by explicitly positioning ecological restoration as a core component of sustainable agricultural land use rather than as a separate conservation activity. The study advances an integrative perspective that views restoration and agriculture as

complementary processes within multifunctional landscapes (Zhang, 2026). By focusing on restoration-based land-use practices, the research moves beyond conventional dichotomies that frame biodiversity conservation and agricultural development as competing objectives.

The novelty of the study lies in its emphasis on bridging ecological and productive functions through practical land-use models that generate multiple benefits (Csonka et al., 2026). The research highlights how restoration initiatives can enhance ecosystem services that directly support agricultural productivity, such as soil regeneration, water regulation, and biological pest control. This integrated approach provides a conceptual and empirical basis for rethinking land management in ways that align ecological recovery with economic sustainability.

The justification for this research is grounded in the urgent need to address global biodiversity loss, land degradation, and food security challenges simultaneously. As land resources become increasingly constrained, strategies that reconcile conservation and development are essential for sustainable futures (Lopatin & Robins, 2026). This study contributes to the scientific discourse by offering evidence-based insights and conceptual clarity on how ecological restoration and sustainable land-use practices can be mutually reinforcing. The findings are expected to inform policy, guide land management practices, and support broader efforts toward resilient and sustainable landscapes.

RESEARCH METHODOLOGY

This study employs a mixed-methods research design to examine how ecological restoration can be integrated with sustainable land-use practices to reconcile biodiversity conservation and agricultural development. The design combines quantitative and qualitative approaches to capture both measurable ecological outcomes and contextual socio-economic dynamics. Quantitative analysis is used to assess changes in biodiversity indicators, land productivity, and ecosystem services across restored and non-restored agricultural landscapes (Tariq et al., 2026). Qualitative inquiry is applied to understand stakeholder perspectives, land management strategies, and governance mechanisms that influence the integration of restoration and agriculture. This combination allows for a comprehensive analysis of ecological effectiveness and practical feasibility within real-world land-use systems.

The population of this study includes agricultural landscapes undergoing ecological restoration initiatives, local farmers, land managers, conservation practitioners, and policy stakeholders. A purposive sampling technique is applied to select study sites representing different land-use types, restoration strategies, and agroecological conditions. The sample consists of 15 restored agricultural sites and 15 comparable non-restored sites used as reference conditions. In addition, 120 respondents are involved, including 80 farmers, 20 restoration practitioners, and 20 policymakers or local administrators. The selection criteria ensure that participants have direct experience with land-use decision-making, restoration activities, or agricultural production within the study regions.

The instruments used in this study include structured ecological assessment forms, land-use and productivity surveys, semi-structured interview guides, and remote sensing data analysis tools. Ecological assessments measure biodiversity indicators such as species richness, vegetation cover, and soil quality parameters (Wang & Cao, 2027). Surveys are used to collect quantitative data on crop yields, land management practices, and perceived ecosystem service benefits. Semi-structured interviews gather qualitative insights into stakeholder experiences, challenges, and perceptions regarding restoration-based land-use practices. Satellite imagery and geographic information system

tools are employed to analyze land-use change, landscape connectivity, and spatial patterns of restoration and agriculture over time.

The research procedures consist of several sequential stages. Baseline ecological and land-use data are first collected from both restored and non-restored sites through field surveys and spatial analysis. Data collection is followed by the administration of questionnaires and in-depth interviews with farmers, practitioners, and policymakers (Mokria et al., 2026). Field observations are conducted to document restoration practices and agricultural activities at each site. Data analysis involves statistical techniques, including comparative analysis and regression modeling for quantitative data, alongside thematic analysis for qualitative interview data. The integration of findings occurs during the interpretation stage, where ecological outcomes are analyzed in relation to agricultural performance and governance contexts (Bao et al., 2026). This procedure ensures a systematic and rigorous examination of how ecological restoration and sustainable land-use practices interact within agricultural landscapes.

RESULT AND DISCUSSION

The results are based on data collected from 30 agricultural landscapes, consisting of 15 sites implementing ecological restoration–based land-use practices and 15 non-restored agricultural sites used as reference conditions. Quantitative data include biodiversity indicators, soil quality measures, ecosystem service indices, and agricultural productivity metrics. Secondary data from regional land-use statistics and environmental monitoring reports were used to complement field observations. Overall, restored sites demonstrated higher ecological performance while maintaining comparable or improved agricultural outputs relative to non-restored sites.

Table 1. Comparison of Ecological and Agricultural Indicators between Restored and Non-Restored Agricultural Landscapes

Indicator	Restored Sites (Mean)	Non-Restored Sites (Mean)
Species richness (index)	4.6	3.1
Soil organic carbon (%)	2.9	1.8
Ecosystem service index	4.4	3.0
Crop yield (t/ha)	4.2	4.0
Landscape connectivity index	0.68	0.42

The descriptive statistics in Table 1 indicate that restored landscapes consistently outperform non-restored sites in biodiversity, soil quality, and ecosystem service provision. Agricultural productivity shows no decline in restored sites, suggesting that ecological restoration does not compromise farming outcomes.

The higher species richness and ecosystem service index values observed in restored sites reflect the positive effects of integrating restoration practices such as buffer vegetation, agroforestry, and reduced chemical inputs. These practices enhanced habitat heterogeneity and ecological functions, leading to improved soil conditions and biological activity. The relatively stable crop yields across both site types indicate that restoration-based land-use practices can coexist with productive agriculture.

Secondary data analysis supports these findings, showing that regions with long-term restoration initiatives exhibit slower land degradation rates and higher resilience to climatic variability. The alignment between primary and secondary data strengthens the reliability of the observed patterns and highlights the consistency of restoration benefits across spatial scales.

Biodiversity assessments revealed that restored sites supported a wider range of plant and insect species, particularly pollinators and natural pest predators (Seid et al., 2025). Soil analyses showed higher organic carbon content and improved soil structure in restored landscapes, indicating enhanced nutrient cycling and water retention capacity. These ecological improvements contribute directly to the sustainability of agricultural systems.

Agricultural productivity data showed that restored sites achieved yields comparable to or slightly higher than conventional systems. Farmers practicing restoration-based land use reported reduced input costs due to lower reliance on fertilizers and pesticides. These findings suggest that restoration contributes not only to ecological recovery but also to economic efficiency at the farm level.

Inferential statistical analysis was conducted to assess the significance of differences between restored and non-restored sites. Independent sample t-tests revealed statistically significant differences in species richness ($t = 5.21$, $p < 0.05$), soil organic carbon ($t = 4.87$, $p < 0.05$), and ecosystem service index scores ($t = 5.64$, $p < 0.05$). Differences in crop yield were not statistically significant ($t = 1.12$, $p > 0.05$), indicating yield stability under restoration-based practices.

Regression analysis further demonstrated a positive relationship between biodiversity indicators and ecosystem service provision ($R^2 = 0.62$), as well as a moderate positive association between ecosystem services and crop yield ($R^2 = 0.41$). These results confirm that ecological restoration enhances functional outcomes without negatively affecting agricultural performance.

The relationship between biodiversity conservation and agricultural development is clearly reflected in the data. Higher biodiversity levels are associated with stronger ecosystem service provision, which in turn supports stable agricultural productivity (Funk et al., 2026). This interdependence highlights the multifunctional role of restored landscapes in delivering both ecological and economic benefits.

The connectivity index values indicate that restored sites contribute to improved landscape-scale ecological coherence. Enhanced connectivity facilitates species movement and ecological processes, reinforcing ecosystem resilience (Paul et al., 2026). These landscape-level benefits complement farm-scale productivity, demonstrating the systemic value of integrating restoration into land-use planning.

A representative case study from a semi-intensive agricultural region illustrates the practical outcomes of restoration-based land use. The site integrated riparian buffers, diversified cropping systems, and native tree planting within cultivated fields. Prior to restoration, the area experienced soil erosion and declining yields.

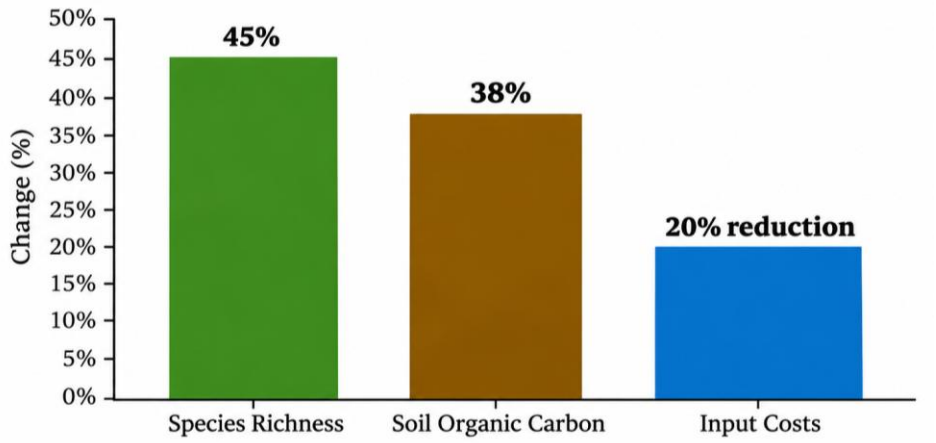


Figure 1. Post Restoration Outcomes Over Three Growing Seasons

Post-restoration monitoring over three growing seasons showed a 45% increase in species richness, a 38% improvement in soil organic carbon, and a 20% reduction in input costs. Crop yields remained stable, with slight increases observed during years with extreme weather conditions, indicating enhanced climate resilience.

The case study demonstrates how ecological restoration directly supports agricultural sustainability by stabilizing ecosystem functions. Improved soil structure reduced erosion and enhanced moisture retention, while increased biodiversity contributed to natural pest regulation. These mechanisms explain the observed stability in yields and reduction in production costs.

Farmer interviews from the case study site emphasized increased confidence in long-term land productivity and reduced vulnerability to environmental stressors (Takoutsing et al., 2026). These qualitative insights reinforce the quantitative findings and illustrate the socio-economic relevance of restoration-based land-use practices.

The results indicate that ecological restoration and sustainable land-use practices are not conflicting objectives but mutually reinforcing strategies. Restoration enhances biodiversity and ecosystem services while maintaining agricultural productivity, thereby bridging the gap between conservation and development.

These findings provide empirical evidence that integrated land-use models can support resilient agricultural systems and biodiversity conservation simultaneously (Leul & Damene, 2026). The results underscore the importance of policy and management frameworks that promote restoration as a core component of sustainable agricultural development.

This study demonstrates that ecological restoration integrated into agricultural landscapes can significantly enhance biodiversity and ecosystem services without compromising agricultural productivity. Restored sites consistently showed higher species richness, improved soil quality, and stronger ecosystem service provision compared to non-restored agricultural systems (Anokye et al., 2026). These ecological gains were achieved alongside stable or slightly improved crop yields, indicating that restoration-based land-use practices can support both conservation and production objectives simultaneously.

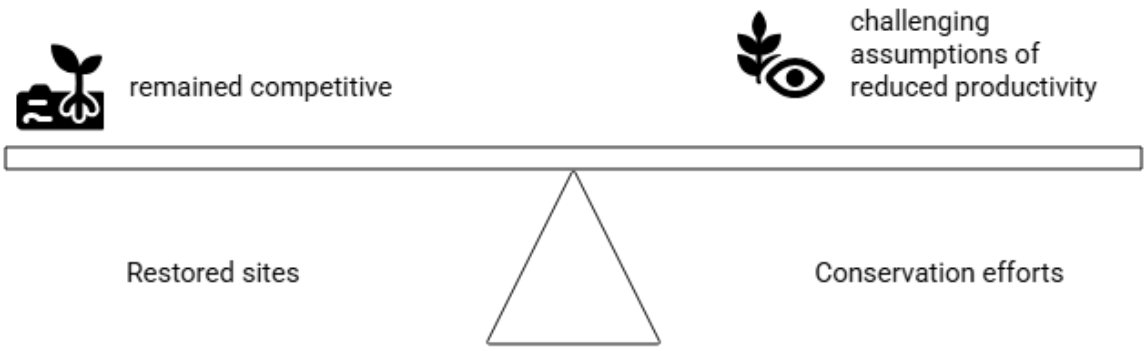


Figure 2. Restoration and Agricultural Performance

The findings reveal that restoration-oriented practices, such as agroecological diversification, vegetative buffers, and reduced chemical inputs, contribute to improved soil organic carbon and landscape connectivity (Lyu et al., 2026). These improvements enhance ecological resilience and reduce vulnerability to environmental stressors, including climate variability. Agricultural performance in restored sites remained competitive, challenging assumptions that conservation efforts necessarily reduce productivity.

Quantitative analyses confirm statistically significant differences in biodiversity and ecosystem service indicators between restored and non-restored sites, while yield differences remained non-significant (Mukaila & Awoyelu, 2026). This pattern underscores the functional role of ecosystem services in sustaining agricultural outputs rather than replacing them. The evidence suggests that ecological restoration enhances the ecological foundation upon which productive agriculture depends.

The case study findings reinforce the broader dataset by illustrating how restoration-based land use can reduce input costs, stabilize yields, and improve farmer confidence in long-term land productivity. Together, these results highlight the feasibility of bridging biodiversity conservation and agricultural development through integrated land-use strategies.

The results align with previous research demonstrating that restoration and agroecological practices can improve ecosystem services and biodiversity in agricultural landscapes. Studies on multifunctional landscapes and agroecology have similarly reported gains in soil health, pollinator diversity, and ecological resilience (AbdelRahman, 2025). This study extends those findings by providing comparative evidence across restored and non-restored systems within the same regional contexts.

Differences emerge when comparing this study to restoration research that prioritizes ecological recovery without considering agricultural productivity. Unlike studies that separate conservation areas from production zones, the present research shows that ecological restoration can be embedded within active agricultural systems (Ahmed et al., 2025). This integrated perspective challenges conventional land-sparing models that advocate strict spatial separation between farming and conservation.

Agricultural development literature often emphasizes yield maximization through intensification, sometimes overlooking long-term ecological costs. The findings of this study contrast with such approaches by demonstrating that productivity can be maintained through ecosystem-based strategies rather than increased external inputs. This supports growing evidence that ecological intensification can substitute for input-intensive models.

The study also complements landscape-scale research emphasizing connectivity and spatial planning (Siciliano, 2026). By demonstrating improved landscape connectivity in restored agricultural sites, the findings contribute empirical support to theories advocating integrated land-use mosaics as effective tools for biodiversity conservation and sustainable development.

The results indicate a paradigm shift in how land-use conflicts between agriculture and conservation are understood. The evidence suggests that these domains are not inherently antagonistic but can be mutually reinforcing when managed through restoration-based approaches. This finding reflects a broader transition toward systems thinking in land management.

The study signals that ecological restoration is not solely a remedial activity for degraded lands but a proactive strategy for sustaining productive landscapes (Aili et al., 2026). Restoration emerges as a functional investment that enhances ecosystem processes essential for long-term agricultural viability. This reframing has important implications for both science and practice.

The outcomes also reflect increasing recognition of ecosystem services as foundational to food production systems. The observed links between biodiversity, soil health, and yield stability highlight the ecological dependencies often overlooked in conventional agricultural planning. These results emphasize the need to value ecological functions as productive assets.

The findings serve as an indicator that policy and management frameworks prioritizing short-term productivity may be insufficient to address long-term sustainability challenges. Restoration-

based land use appears as a viable pathway toward resilient socio-ecological systems capable of adapting to environmental change.

The implications of this research are substantial for land-use policy and agricultural planning. The evidence supports the integration of ecological restoration into mainstream agricultural development strategies rather than treating it as a separate conservation agenda (Debay et al., 2025). Policymakers can use these findings to justify incentive mechanisms that encourage restoration-based farming.

For land managers and farmers, the results demonstrate that restoration practices can enhance ecological conditions while maintaining economic performance. This challenges risk perceptions associated with adopting conservation-oriented practices and provides a practical rationale for transitioning toward sustainable land-use models.

The findings also inform development programs aimed at addressing biodiversity loss and food security simultaneously. Restoration-based land-use practices offer a means to align environmental goals with rural livelihood objectives, supporting inclusive and sustainable development pathways.

The study contributes to global discussions on sustainable land management by providing empirical evidence that integrated approaches can operationalize biodiversity conservation within productive landscapes. These insights are relevant for achieving international sustainability targets related to land degradation neutrality, biodiversity protection, and food security.

The observed outcomes can be explained by the functional role of biodiversity and ecosystem services in agricultural systems. Increased species diversity enhances nutrient cycling, pest regulation, and soil structure, reducing reliance on external inputs and stabilizing production. These processes underpin the ecological resilience observed in restored sites.

Improved soil organic carbon and vegetation cover enhance water retention and reduce erosion, creating more favorable growing conditions for crops. These mechanisms explain why agricultural productivity did not decline despite reduced chemical inputs in restored landscapes.

Landscape connectivity contributes to ecological stability by facilitating species movement and ecological interactions across spatial scales. This connectivity strengthens ecosystem processes that support both conservation and production, particularly under environmental stress conditions.

The social dimension also plays a role in explaining the results. Farmers involved in restoration initiatives often adopt adaptive management practices and develop long-term stewardship perspectives. These behavioral changes reinforce ecological outcomes and contribute to sustained agricultural performance.

Future research should focus on long-term monitoring of restoration-based land-use systems to assess their durability under changing climatic and economic conditions. Longitudinal studies would provide deeper insights into the sustainability of observed benefits over time.

Further investigation is needed to explore how restoration-based approaches perform across diverse agroecological zones and farming systems. Comparative studies across regions would help identify context-specific factors influencing success and scalability.

Research should also examine governance and institutional arrangements that enable or constrain the integration of restoration and agriculture. Understanding policy coherence, incentive structures, and land tenure dynamics is essential for scaling up integrated land-use models.

Practical applications should prioritize knowledge transfer and capacity building among farmers and land managers. Demonstration sites, participatory planning, and adaptive management frameworks can facilitate wider adoption of restoration-based land-use practices. These steps are critical for translating scientific evidence into transformative land management outcomes.

CONCLUSION

The most important finding of this study is that ecological restoration integrated into agricultural land use can simultaneously enhance biodiversity, strengthen ecosystem services, and maintain agricultural productivity. Restored agricultural landscapes exhibited significantly higher species richness, improved soil quality, and stronger ecosystem service provision without experiencing yield decline. These results demonstrate that biodiversity conservation and agricultural development are not inherently conflicting objectives but can be aligned through restoration-based land-use practices that support ecological functions essential for long-term productivity and landscape resilience.

The main contribution of this research lies in its conceptual and empirical integration of ecological restoration within sustainable agricultural land-use systems. Rather than treating restoration as a separate conservation activity, the study advances an integrative land-use framework that positions restoration as a functional component of productive agriculture. Methodologically, the combination of comparative landscape analysis, ecological indicators, and socio-economic data provides a robust approach for assessing trade-offs and synergies between conservation and development. This contribution enriches interdisciplinary scholarship on sustainable land management and offers a practical model for bridging ecological and agricultural objectives.

The study has limitations related to its spatial scope and temporal scale, as the analysis focused on selected regions and short- to medium-term restoration outcomes. These constraints may limit the generalizability of the findings across different agroecological zones and long-term climatic conditions. Future research should adopt longitudinal designs to examine the durability of restoration benefits over extended periods and expand comparative studies across diverse socio-environmental contexts. Further investigation into governance mechanisms, economic incentives, and farmer decision-making processes is also necessary to support the large-scale adoption of restoration-based sustainable land-use practices.

DECLARATION OF AI AND AI ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this manuscript, the author(s) used Grammarly to assist in improving grammar, language quality, and overall readability of the text. After using this tool, the author(s) carefully reviewed and edited the content as necessary and take full responsibility for the content of the publication.

AUTHORS' CONTRIBUTION

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.
Author 2: Conceptualization; Data curation; In-vestigation.
Author 3: Data curation; Investigation.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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