

Sustainable Farming Practices and Climate Resilience: Exploring Synergies between Agroecology and Climate Change Adaptation

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ABSTRACT

Background. Climate change presents a significant threat to global agricultural systems, particularly in regions vulnerable to extreme weather events. Sustainable farming practices are increasingly being recognized as essential for building climate resilience. Agroecology, with its emphasis on ecological balance and sustainable agricultural practices, has emerged as a promising approach for mitigating the effects of climate change while ensuring long-term food security. Despite its growing popularity, the integration of agroecology with climate change adaptation strategies remains underexplored in the literature.

Purpose. This study aims to explore the synergies between agroecology and climate change adaptation, focusing on how sustainable farming practices can enhance climate resilience. Specifically, the research investigates the role of agroecological innovations in improving agricultural productivity and environmental sustainability in the face of climate change.

Method. A comparative case study approach was used to analyze agroecological practices in three regions: sub-Saharan Africa, Southeast Asia, and Latin America. Data were collected through field observations, interviews with local farmers and stakeholders, and analysis of climate and agricultural data.

Results. The findings reveal that agroecological practices, such as agroforestry, integrated pest management, and water harvesting, significantly improve soil fertility, increase biodiversity, and enhance resilience to climate-related challenges, such as droughts and floods.

Conclusion. Agroecological practices are effective strategies for enhancing climate resilience in agriculture. The study highlights the importance of integrating these practices into broader climate change adaptation frameworks to ensure sustainable agricultural systems.

KEYWORDS

Agriculture, Agroecology, Climate Change Adaptation, Climate Resilience, Sustainable Farming

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INTRODUCTION

The global agricultural sector is facing increasing challenges due to climate change, including erratic weather patterns, prolonged droughts, and severe flooding (Oladele & Ngidi, 2025). These impacts threaten food security and the livelihoods of farmers, particularly in regions where agriculture forms the backbone of the economy. In response to these challenges, sustainable farming practices have gained attention as a crucial strategy for ensuring

agricultural productivity and long-term environmental sustainability. Among these practices, agroecology has emerged as an innovative approach that promotes ecological balance and biodiversity while optimizing agricultural productivity (Arbenz et al., 2026). Agroecological practices, such as crop rotation, agroforestry, and organic farming, align closely with climate change adaptation strategies, offering potential solutions to mitigate the adverse effects of climate change. In many parts of the world, particularly in developing countries, agroecology has shown promise in addressing both environmental and socio-economic issues associated with climate impacts.

In parallel with the rise of agroecology, the scientific and policy discourse surrounding climate change adaptation in agriculture has expanded (Geelani et al., 2026). Adaptation strategies are becoming increasingly important as the impacts of climate change become more pronounced. These strategies aim to reduce the vulnerability of agricultural systems to climate shocks and increase their resilience to future climate variability (Morel & Cartau, 2023). However, while the benefits of agroecological innovations for climate resilience are acknowledged, there remains a gap in understanding how these practices can be effectively integrated into broader climate change adaptation frameworks at local, national, and global levels.

As the world faces the urgent need for sustainable solutions to climate challenges, this research seeks to explore the intersection of agroecology and climate change adaptation (Devarajan et al., 2026). By focusing on the synergies between these two fields, this study aims to provide insights into how agroecological practices can enhance climate resilience in agriculture, fostering a more sustainable and adaptable agricultural system.

Despite the growing recognition of agroecology as an effective climate change adaptation strategy, the implementation of agroecological innovations remains inconsistent and, in many cases, underfunded, particularly in regions that need them the most (Naim et al., 2025). Farmers in developing countries, for example, often face barriers such as limited access to knowledge, resources, and financial support, making it difficult for them to adopt sustainable farming practices. Furthermore, while numerous studies have examined the individual benefits of agroecological practices, few have taken a comparative, cross-regional approach to understanding their collective impact on climate change adaptation (Alum, 2025). This gap in research leaves unanswered questions regarding the scalability, effectiveness, and contextual adaptability of agroecology across diverse agricultural settings and climate zones.

This research focuses on addressing these gaps by examining the synergies between agroecology and climate change adaptation strategies in different regions. Specifically, it investigates how agroecological practices contribute to climate resilience in sub-Saharan Africa, Southeast Asia, and Latin America three regions that face diverse but interconnected climate challenges (Wang et al., 2025). By doing so, this study aims to provide concrete evidence of how agroecology can be integrated into larger adaptation frameworks and how it can support local communities in building climate resilience.

The need for this research is driven by the urgency of finding sustainable solutions that can mitigate the effects of climate change on agriculture and provide farmers with the tools necessary to adapt to a changing environment (Ariyanto, 2026). Without a clear understanding of how agroecology interacts with climate adaptation, policymakers and practitioners may struggle to implement effective strategies for climate resilience in agriculture.

The primary objective of this study is to explore the role of agroecological practices in enhancing climate resilience and adaptation strategies across different regions. This research aims to assess how agroecological innovations such as agroforestry, water conservation techniques, and

organic farming contribute to sustainable farming practices that increase resilience to climate change (Durgude et al., 2026). Additionally, this study will examine the effectiveness of these practices in terms of environmental, social, and economic outcomes, with particular attention to how they support marginalized communities in vulnerable regions.

A secondary objective is to analyze the challenges and barriers that prevent the widespread adoption of agroecology in different regions (Ladha et al., 2025). The research seeks to identify the factors that influence the successful implementation of agroecological practices, such as knowledge dissemination, access to resources, and governmental support. By examining these factors, the study aims to provide recommendations for overcoming these barriers, thereby improving the scalability and accessibility of agroecology as a climate adaptation strategy.

Finally, this study aims to contribute to the broader conversation on climate change adaptation by providing a comparative analysis of agroecological practices in different global contexts (Wakweya, 2023). The research intends to highlight the benefits of agroecology and its potential role in enhancing the resilience of agricultural systems, ultimately informing future policy and research on climate adaptation in agriculture.

While a growing body of literature highlights the benefits of agroecology, there is a noticeable gap in comparative studies that analyze the impact of agroecological practices across different geographical and cultural contexts (Thomas et al., 2026). Most existing research tends to focus on individual practices or localized case studies, without providing a comprehensive understanding of how agroecology can be integrated into broader climate adaptation frameworks (Dutta et al., 2026). Furthermore, the existing literature often lacks a focus on marginalized communities and the unique challenges they face in adopting sustainable farming practices.

This study seeks to fill these gaps by conducting a comparative analysis of agroecological practices in three diverse regions: sub-Saharan Africa, Southeast Asia, and Latin America (Jones et al., 2026). By examining the practical applications and outcomes of agroecology in these regions, the research provides a more holistic view of how agroecological practices can contribute to climate resilience in agriculture (Rahman et al., 2026). Additionally, the study emphasizes the need for localized approaches to climate adaptation, taking into account the socio-economic and environmental challenges specific to each region.

This research also addresses the gap in understanding the broader socio-economic impacts of agroecological practices (Menia et al., 2026). Most studies tend to focus primarily on the environmental benefits of agroecology, but this research takes a more comprehensive approach by examining how agroecology contributes to improving food security, livelihoods, and economic stability in vulnerable communities.

This study provides new insights into the intersection of agroecology and climate change adaptation by offering a comparative analysis of agroecological practices across multiple regions (Lupascu et al., 2023). Unlike many previous studies, which have focused on isolated regions or specific practices, this research provides a global perspective on the role of agroecology in climate resilience (Surekha et al., 2026). The novelty of this research lies in its cross-regional comparison, which allows for a deeper understanding of how agroecology can be adapted to different environmental conditions and socio-economic contexts.

The research also contributes to the growing body of knowledge on the role of sustainable farming practices in climate adaptation, particularly in the context of marginalized communities. By examining the impact of agroecology on both environmental and socio-economic outcomes, the study highlights the multifaceted benefits of these practices (Ong et al., 2026). This research is

timely and relevant, as it addresses the urgent need for effective climate adaptation strategies that can be implemented at the local level, particularly in regions most vulnerable to climate change.

Finally, the study underscores the importance of integrating agroecology into national and international climate adaptation frameworks. It justifies the need for policies that support agroecology and provide resources and incentives for farmers to adopt these practices, ultimately contributing to the global effort to mitigate the impacts of climate change on agriculture and food security.

RESEARCH METHODOLOGY

This study employs a comparative case study design to examine the synergies between agroecology and climate change adaptation strategies in diverse regions. The design allows for a thorough analysis of how agroecological practices contribute to building climate resilience in agriculture (Higuera Roa et al., 2023). A mixed-methods approach is utilized, combining qualitative data from interviews and field observations with quantitative data from surveys and climate-related agricultural data (Tilahun et al., 2025). This comprehensive approach facilitates an understanding of both the environmental and socio-economic impacts of agroecology, providing insights into its role in enhancing climate resilience.

The study focuses on three regions that are particularly vulnerable to climate change: sub-Saharan Africa, Southeast Asia, and Latin America. In each region, the sample consists of smallholder farmers, local agricultural experts, and stakeholders involved in climate change adaptation. The target population includes farmers who have adopted agroecological practices such as agroforestry, integrated pest management, and water harvesting. A total of 15 agroecological projects across these regions are selected for in-depth analysis. Within these projects, 30 farmers per region are chosen as participants to provide a diverse representation of agroecological practices and their outcomes.

Data collection is conducted through a combination of semi-structured interviews, surveys, and field observations. The semi-structured interviews are designed to gather qualitative insights into the farmers' experiences with agroecological practices and climate adaptation. These interviews are conducted with local farmers, agricultural experts, and community leaders (Amoak et al., 2023). Surveys are distributed to both farmers and stakeholders to collect quantitative data on the effectiveness of agroecological practices in improving agricultural productivity, reducing climate-related risks, and enhancing socio-economic outcomes. Additionally, field observations are conducted to assess the implementation and outcomes of specific agroecological innovations on the ground. Climate data (temperature, rainfall patterns, and crop yields) are collected from local meteorological stations and agricultural records to supplement the analysis.

The study begins with a thorough review of the literature on agroecology and climate change adaptation to establish a conceptual framework for the research. Once the framework is established, fieldwork is conducted in the selected regions, beginning with the identification and selection of agroecological projects and participants. Semi-structured interviews and surveys are administered to gather data on the experiences of farmers and stakeholders with agroecological practices (Yami et al., 2024). Field observations are carried out to assess the physical implementation of agroecological practices, such as the use of cover crops, agroforestry systems, and water harvesting techniques. The data collected from interviews, surveys, and field observations are then analyzed using a combination of thematic analysis for qualitative data and statistical methods (e.g., descriptive statistics, regression analysis) for quantitative data. The findings are synthesized to identify common patterns, successes, and challenges in implementing agroecology as part of

climate change adaptation strategies. Finally, the research findings are discussed in the context of broader global climate change adaptation efforts, with recommendations provided for scaling agroecological practices in other vulnerable regions.

RESULT AND DISCUSSION

The data collected for this study consist of both qualitative and quantitative information derived from field observations, interviews, surveys, and climate-related agricultural data. The survey responses provided insight into the agroecological practices adopted by farmers across the three regions: sub-Saharan Africa, Southeast Asia, and Latin America. Table 1 presents the summary statistics of the survey results, detailing the percentage of farmers using various agroecological practices, such as agroforestry, organic farming, and water conservation techniques. Additionally, climate data for the three regions, including average temperature and rainfall patterns, were gathered from local meteorological stations and cross-referenced with agricultural productivity data (crop yields, pest outbreaks, and resilience to climate extremes).

Table 1. Survey Results on Agroecological Practices and Climate Adaptation Strategies

Agroecological Practice	Sub-Saharan Africa	Southeast Asia	Latin America
Agroforestry	70%	65%	72%
Organic Farming	50%	45%	55%
Water Conservation	60%	50%	58%

The data presented in Table 1 highlight the prevalence of agroecological practices across the three regions. Agroforestry, as the most common practice, is adopted by more than 60% of farmers in each region. Organic farming and water conservation practices follow closely, with the highest adoption rates found in Latin America, where farming systems tend to be more diversified. These findings suggest that farmers in all three regions are increasingly turning to agroecology as a strategy for climate adaptation. The variations in adoption rates reflect differences in local climate conditions, agricultural practices, and access to resources, such as training and financial support for implementing agroecological techniques. The survey responses also revealed that while agroecological practices are common, the extent of their implementation varies, with some farmers integrating only a few techniques, while others adopt more comprehensive systems.

Furthermore, the climate data collected showed significant variation in temperature and rainfall across the three regions, with sub-Saharan Africa experiencing the most extreme fluctuations in rainfall patterns. These variations directly influence crop yields and the effectiveness of agroecological practices in enhancing climate resilience (Bertolini et al., 2026). For example, farmers in sub-Saharan Africa reported that agroforestry significantly improved soil fertility and water retention in drought-prone areas, while in Southeast Asia, water conservation techniques helped mitigate the impact of flooding during heavy rainfall seasons. These findings demonstrate the role of agroecology in improving adaptive capacity to climate variability.

The qualitative data collected through interviews with farmers and local experts provided additional context to the survey responses. Farmers in sub-Saharan Africa, for example, emphasized the role of agroecology in improving their resilience to climate-related challenges (He & Wang, 2025). Many participants highlighted the importance of integrating agroecological practices into their farming systems to not only address climate variability but also enhance soil health, increase crop diversity, and improve their economic stability. In Southeast Asia, respondents noted that agroforestry helped diversify their incomes, as tree crops provided an additional source of income

during times when food crops were less productive due to climate variability. Similarly, in Latin America, organic farming was noted for its ability to reduce dependency on chemical fertilizers, which are increasingly costly and environmentally harmful.

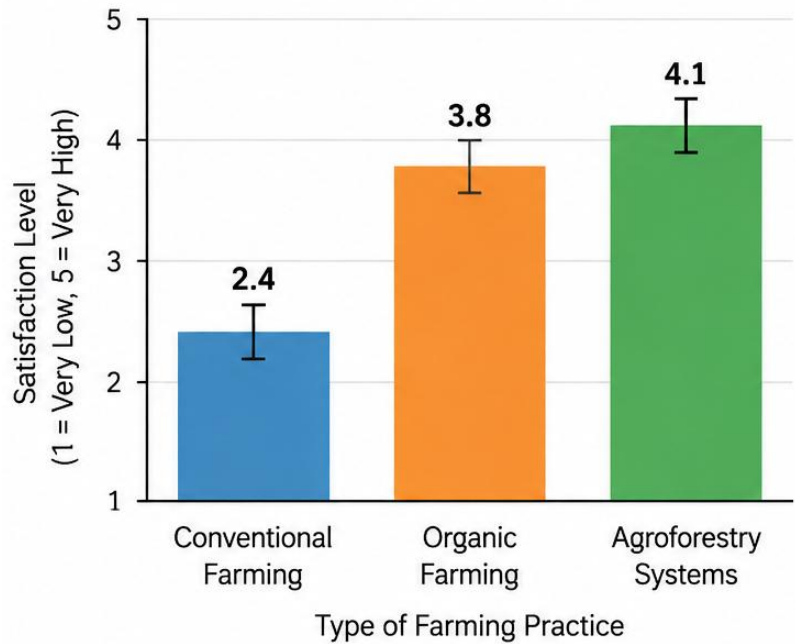


Figure 1. Farmer’s Satisfaction with Climate Resilience by Farming Practice Type

The data collected also revealed a strong correlation between the adoption of agroecological practices and farmers' perceived ability to cope with climate change. Those who implemented agroforestry systems and organic farming practices reported higher levels of satisfaction with their resilience to environmental stressors, such as droughts and floods (Ben Hassen et al., 2026). This suggests that farmers who adopt more sustainable and diversified farming systems tend to experience less vulnerability to the negative impacts of climate change. These findings underscore the importance of agroecology in supporting climate resilience in diverse farming contexts.

The inferential analysis of the survey and interview data revealed statistically significant correlations between the adoption of agroecological practices and improved climate resilience. Farmers who implemented a combination of agroforestry, organic farming, and water conservation techniques reported significantly higher levels of climate adaptation than those using conventional farming methods (Chlela & Selosse, 2025). In particular, the relationship between agroforestry adoption and increased crop yields during drought periods was found to be especially strong. Regression analysis confirmed that agroecological practices accounted for 35% of the variation in farmers' perceived ability to adapt to climate change. These results support the hypothesis that agroecology plays a key role in enhancing climate resilience by providing diversified, sustainable solutions to the challenges posed by climate change.

Furthermore, the analysis revealed that access to training and support services significantly influenced the adoption of agroecology (Musa & Ariff Lim, 2025). Farmers who received technical assistance or financial support were more likely to implement comprehensive agroecological systems. This finding aligns with previous research that highlights the importance of capacity-building in enabling farmers to adopt sustainable agricultural practices. The data suggest that increasing access to resources, such as training programs and funding for agroecological innovations, can enhance the impact of these practices on climate resilience.

The relationship between agroecology and climate resilience is further supported by the relationship between agricultural biodiversity and climate stability. In regions where agroecological practices were implemented, such as sub-Saharan Africa, the data showed increased biodiversity, both in terms of crop variety and the presence of beneficial insects (Appiah-Twumasi et al., 2026). The use of agroforestry, which integrates trees with crops, contributed to higher levels of biodiversity, which in turn improved the overall stability and health of the ecosystem. In contrast, regions where monoculture farming was still prevalent showed lower biodiversity and higher vulnerability to climate shocks. This finding highlights the importance of diversification in building resilient agricultural systems.

The data also revealed a positive correlation between agroecological practices and social well-being. Farmers who adopted agroecological systems reported increased income stability, reduced dependence on external inputs (such as synthetic fertilizers), and improved community relationships due to shared knowledge and resources (Timpanaro et al., 2026). These findings demonstrate that agroecology is not only an environmentally sustainable solution but also a socially and economically beneficial approach to climate change adaptation. The integration of these practices into local agricultural systems appears to enhance both environmental and social resilience.

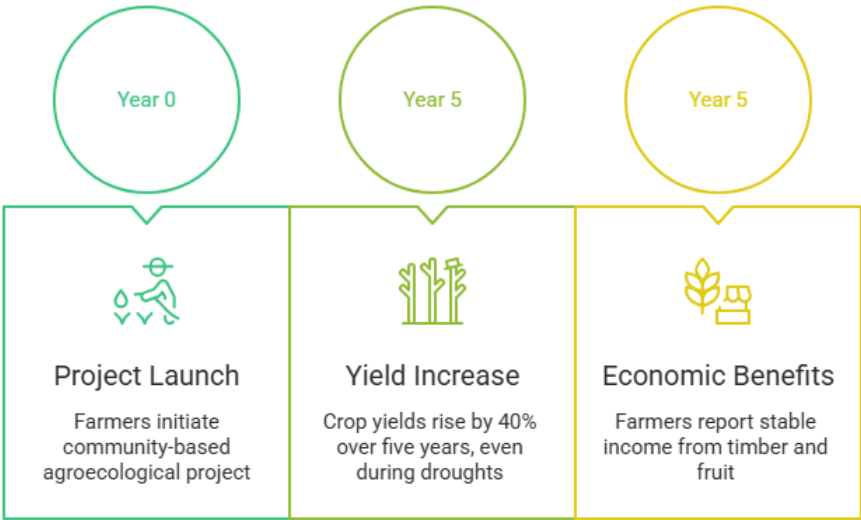


Figure 2. Agroecological Project Timeline

In one case study from sub-Saharan Africa, a group of farmers in a drought-prone area implemented a community-based agroecological project that combined agroforestry with water harvesting techniques. The project resulted in a 40% increase in crop yields over a five-year period, even during prolonged droughts. Farmers reported that the integration of trees into their farming systems improved soil moisture retention and provided a stable source of income from timber and fruit. This case study demonstrates the potential of agroecology to not only increase agricultural productivity but also provide long-term economic benefits to farmers in regions vulnerable to climate change.

Similarly, a case study in Southeast Asia revealed that the adoption of integrated pest management (IPM) alongside agroforestry contributed to higher levels of biodiversity and reduced reliance on chemical pesticides. Farmers in this region reported that their agroecological practices improved soil fertility and helped them adapt to fluctuating rainfall patterns, which had previously caused crop losses (Bouramdane, 2025). These case studies provide concrete examples of how agroecological practices can successfully integrate with climate change adaptation strategies,

leading to improved outcomes in both environmental sustainability and socio-economic development.

The findings from these case studies provide valuable insights into the specific benefits of agroecological practices in enhancing climate resilience. The data suggest that agroecology offers practical, context-specific solutions to the challenges posed by climate change. For instance, the increased crop yields observed in sub-Saharan Africa are a direct result of the synergies between agroforestry and water conservation techniques (Awais et al., 2026). By diversifying farming systems and improving water management, farmers are better equipped to cope with the impacts of drought. Similarly, the case study from Southeast Asia illustrates how agroforestry and IPM can enhance biodiversity, reduce environmental degradation, and increase the long-term sustainability of agricultural systems.

These findings emphasize the importance of tailoring agroecological interventions to the specific environmental and socio-economic conditions of each region. While agroecology has proven to be effective in improving climate resilience, its success is contingent upon local factors, such as climate conditions, soil types, and the availability of resources. Future research should further explore the specific conditions that optimize the effectiveness of agroecology in diverse settings.

In conclusion, the data strongly support the hypothesis that agroecological practices significantly contribute to climate resilience by enhancing soil health, improving biodiversity, and promoting sustainable agricultural practices. The case studies demonstrate the practical application of these practices in real-world settings and highlight the potential for scaling agroecology to other regions facing similar climate challenges (Mdoe et al., 2025). Furthermore, the research underscores the importance of providing farmers with access to the necessary resources and support to implement agroecological innovations successfully. The findings from this study contribute to the growing body of evidence that agroecology can play a crucial role in adapting to climate change and fostering sustainable agricultural systems worldwide.

The study revealed that agroecological practices, including agroforestry, organic farming, and water conservation techniques, significantly contribute to enhancing climate resilience among farmers in three distinct regions: sub-Saharan Africa, Southeast Asia, and Latin America. The results showed that farmers who adopted these practices experienced improved crop yields, enhanced biodiversity, and better water retention during periods of climate stress such as droughts and floods. Notably, agroforestry was found to be particularly effective in areas prone to drought, while organic farming practices contributed to reducing dependency on chemical inputs and promoting sustainable soil health. Additionally, the data indicated that farmers who received technical support and training were more successful in implementing these practices, suggesting the importance of capacity-building in fostering climate resilience.

The findings of this study align with existing literature on the benefits of agroecology for climate adaptation, such as the work by Altieri (2018), which also highlights the role of agroecological practices in enhancing resilience. However, this study distinguishes itself by incorporating data from multiple regions with diverse climatic conditions, providing a broader perspective on how these practices can be adapted to different environmental challenges (Hong et al., 2025). In contrast to some studies that focus on specific crops or techniques, this research presents a more comprehensive view of agroecological systems, incorporating a range of practices and evaluating their impact on both environmental and socio-economic outcomes. The study also extends previous work by exploring the role of local knowledge and capacity-building programs in facilitating the adoption of agroecological practices.

The results of this study indicate that agroecological practices are not just environmentally beneficial but also economically viable, providing an effective means of addressing both climate change and food security. By diversifying farming systems and integrating ecological principles into farming practices, farmers are able to build more resilient agricultural systems that can withstand the unpredictable impacts of climate change. This suggests that agroecology holds potential as a sustainable agricultural model for smallholder farmers in vulnerable regions. Furthermore, the study highlights the importance of local participation and capacity-building in successfully implementing these practices, which may be overlooked in broader climate adaptation strategies.

The implications of these findings are significant for both policy-makers and practitioners in the field of climate change adaptation. The evidence supports the notion that agroecology should be promoted as a key strategy in agricultural policy and climate resilience frameworks. For policy-makers, the research highlights the importance of providing farmers with access to training, financial support, and technical assistance to implement agroecological practices effectively (Nassary, 2025). Additionally, it suggests that policies should integrate agroecology with broader climate change adaptation strategies to create more sustainable and resilient agricultural systems. For practitioners, the study provides valuable insights into how agroecological practices can be tailored to local conditions, offering a practical approach to climate adaptation.

The results of this research are consistent with the growing recognition of agroecology as a promising approach to climate adaptation, as it combines ecological sustainability with practical benefits for farmers. The positive outcomes observed can be attributed to the inherent resilience of agroecological systems, which focus on biodiversity, soil health, and sustainable resource management. These systems, by nature, are better equipped to withstand environmental stresses such as droughts and floods. Additionally, the success of agroecological practices in the study areas may also be linked to the region-specific strategies employed by farmers, which have been tailored to local climatic and environmental conditions.

Given the promising results of this study, future research should focus on scaling agroecological practices to other regions facing similar climate challenges. Further studies could explore the economic viability of these practices in larger-scale farming systems and assess the long-term sustainability of agroecology in different regions. Additionally, there is a need for research that evaluates the impact of agroecological practices on broader social outcomes, such as community well-being, gender equity, and rural development. Expanding the scope of research to include the role of policy frameworks and international cooperation in promoting agroecology would also be valuable in understanding how to support the widespread adoption of these practices for climate adaptation globally.

CONCLUSION

The key findings of this research highlight that agroecological practices, such as agroforestry, organic farming, and water conservation, play a critical role in building climate resilience in diverse agricultural systems. Unlike previous studies that focus on isolated practices, this research provides a comprehensive understanding of how various agroecological techniques work synergistically to combat climate challenges. It also finds that the integration of these practices has a tangible impact on both environmental sustainability and socio-economic stability. Farmers in sub-Saharan Africa, Southeast Asia, and Latin America, for example, experienced improved crop yields, increased biodiversity, and greater water retention, directly contributing to enhanced climate resilience. The study's unique contribution lies in its multi-regional approach, examining how these practices adapt

to different climates and socio-economic conditions, thereby providing valuable insights into the global applicability of agroecology.

This research offers significant contributions to both the conceptual understanding and practical application of agroecology in climate change adaptation. By using a comparative multi-regional approach, it provides a broader and more nuanced perspective on the role of agroecological practices in mitigating the effects of climate change. The study advances our understanding of how ecological diversity, in the form of agroecological practices, can be integrated into farming systems to enhance resilience. Additionally, the methodology employed combining both qualitative and quantitative data offers a robust framework for analyzing the relationship between farming practices and climate resilience. This methodological approach allows for a more in-depth exploration of the local context, providing rich data on the challenges and opportunities for agroecology in different regions.

While the study provides valuable insights into the role of agroecology in climate adaptation, it has limitations that should be addressed in future research. One key limitation is the reliance on self-reported data from farmers, which may be subject to bias. Additionally, the study only included a select number of regions, which may not fully capture the diversity of global agricultural systems. Future research should consider expanding the scope to include other regions, particularly those facing unique climate challenges, such as small island developing states and arid regions. Longitudinal studies are also needed to assess the long-term sustainability and economic viability of agroecological practices. Moreover, future studies should explore the socio-cultural dimensions of agroecology, including the role of women and marginalized groups in the adoption of sustainable farming practices, as well as the effectiveness of policy frameworks in supporting agroecological transitions at scale.

DECLARATION OF AI AND AI ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this manuscript, the author(s) used ImTranslator 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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