



Socio-Ecological Approaches for Sustainable Cocoa Agroecosystems in Kulon Progo Yogyakarta

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Abstract

The cocoa agroecosystem is a farming system vulnerable to various pressures, including ecological factors such as climate change, pests, and diseases, as well as social factors such as farmer institutional dynamics and external support. This study aims to analyze the socio-ecological factors that influence the sustainability of cocoa agroecosystems in Kulon Progo, Yogyakarta. A qualitative approach was employed through participatory observation, in-depth interviews, and questionnaires, involving five respondents: a group leader, an elderly farmer, a young farmer, a male farmer, and a female farmer. Data were analyzed descriptively through data reduction, classification, interpretation, and triangulation to enhance the validity of the findings. The results indicate that social factors play a crucial role in supporting the resilience of cocoa agroecosystems, particularly through the roles of farmer groups, cooperatives, as well as training and extension programs provided by the government and universities. Such support enhances farmers' adaptive capacity in pest management, organic fertilization, and crop diversification. From an ecological perspective, the use of shade trees, intercropping systems, and efforts to maintain biodiversity significantly contribute to the stability of cocoa farming ecosystems. However, several challenges remain, including decreased yields during the rainy season, pest attacks, and limited farmer knowledge regarding the importance of natural pollinators. Overall, this study highlights that the sustainability of cocoa agroecosystems in Kulon Progo is not solely determined by ecological factors, but is also significantly influenced by social support and institutional arrangements. Therefore, strengthening socio-ecological approaches is essential as a strategy for adapting to and managing sustainable cocoa farming.

Keywords: *cocoa agroecosystem, Kulon Progo, socio-ecological, sustainability*

INTRODUCTION

Cocoa is one of Indonesia's most important plantation commodities, contributing not only to the national economy but also to the livelihoods of rural communities. In Kulon Progo, Yogyakarta, cocoa farming plays a crucial role in sustaining farmers' incomes and supporting local agricultural development. However, the cocoa agroecosystem faces complex challenges arising from both ecological and social aspects, which interact and shape the sustainability of the system.

Cocoa agroecosystems in Kulon Progo, Yogyakarta, face interconnected ecological and social challenges that shape their sustainability. Ecologically, cocoa is highly sensitive to climate variability, rainfall fluctuations, and outbreaks of pests or diseases. Unpredictable seasonal patterns disrupt planting and harvesting, resulting in reduced yields. Although productivity remains relatively stable, low water-use efficiency poses a threat to long-term resilience (Setiawan et al., 2021). Additional issues, such as soil degradation from unsustainable practices and declining biodiversity, further weaken ecosystem balance. Agroforestry has been identified as an effective adaptation strategy, enhancing resilience through the provision of shade, improved soil fertility,

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and climate change mitigation ([Rahman et al., 2024](#)).

Social factors are equally critical. Farmers possess diverse knowledge, experiences, and social networks that shape their adaptive capacity. Participation in farmer groups, cooperatives, and extension programs strengthens their ability to cope with external pressures. Research on certification schemes in Indonesia indicates that institutional interventions can enhance smallholder welfare when accompanied by technical assistance and ongoing facilitation ([Arifin et al., 2025](#)).

The concept of social-ecological systems (SES) highlights the inseparability of social and ecological factors in resource management. Studies indicate that integrating ecological practices with social institutions yields greater resilience than single-dimensional approaches ([Dewi & Nugroho, 2022](#)). Strengthening these linkages is crucial to the sustainability of cocoa agroecosystems.

Based on this background, this study focuses on analyzing the socio-ecological factors that influence the sustainability of cocoa agroecosystems in Kulon Progo, Yogyakarta. This approach emphasizes the interplay between farmers, the environment, and institutional support in developing adaptive capacity to climate change and socio-economic dynamics. The findings of this research are expected to provide tangible contributions to the development of sustainable cocoa management strategies, particularly in strengthening the synergy between ecological practices and the empowerment of farmer institutions so that cocoa management not only increases productivity but also maintains ecosystem balance and farmer welfare sustainably.

LITERATURE REVIEW

Socio-Ecological Approach in Agroecosystems

The socio-ecological approach emphasizes the close interconnection between social and ecological factors in the management of natural resources. In agricultural systems, particularly in cocoa farming, these two aspects interact to shape the resilience of agroecosystems. [Folke et al. \(2002\)](#) introduced the concept of social-ecological systems (SES), which highlights that society and the environment are inseparable entities. Within sustainable agriculture, SES provides a framework for understanding how social interventions, such as policies or institutions, can strengthen ecosystems, and conversely, how ecological stability can reinforce social structures.

Resilience of Cocoa Agroecosystems

Agroecosystem resilience is defined as the ability of farming systems to withstand, adapt, and remain productive despite disturbances. These disturbances may include ecological stressors, such as climate change, drought, pests, and diseases, as well as socio-economic pressures, including limited access to capital, technology, and markets. [Walker et al. \(2004\)](#) noted that ecosystem resilience consists of two dimensions: ecological resilience and social resilience. In cocoa systems, ecological resilience depends on biodiversity, soil health, and environmentally friendly farming practices, while social resilience is determined by social networks, institutional strength, and farmers' adaptive capacity.

Ecological Factors: Biodiversity and Agroforestry

Agroforestry has long been recognized as a system that enhances the sustainability of cocoa agroecosystems. According to [Rahman et al. \(2024\)](#), agroforestry not only improves productivity but also strengthens cocoa farms' capacity to cope with climate change. The presence of shade trees helps maintain soil moisture, reduce heat stress, and provide habitats for pollinators. Intercropping systems, including crops such as banana, porang, or parkia, also increase biodiversity and soil fertility. A local study in Yogyakarta demonstrated that shade trees and mixed cropping patterns

improve farm microclimates, helping to stabilize cocoa yields despite unpredictable weather conditions ([Setiawan et al., 2021](#)).

Social Factors: Institutions and External Support

Social factors also play a critical role in strengthening the resilience of cocoa agroecosystems. Farmer organizations, such as farmer groups and cooperatives, serve as platforms for sharing knowledge, accessing assistance, and fostering solidarity among farmers. [Arifin et al. \(2025\)](#) highlighted that corporate-driven cocoa certification schemes bring tangible benefits to smallholder farmers when accompanied by continuous training and technical support. This finding suggests that institutional interventions succeed not merely through regulations or programs, but through active participation by farmers and relevant assistance.

Extension services and training are also essential. Farmers with access to training show higher capacity to manage pests, adopt organic fertilizers, and apply sustainable technologies. External support from government, universities, and NGOs accelerates the adoption of sustainable innovations. In the case of Kulon Progo, extension and training programs facilitated by the local government have significantly improved farmers' skills in environmentally friendly practices while fostering optimism about the long-term viability of cocoa farming.

Social-Ecological Interactions

The relationship between social and ecological factors is dynamic and mutually reinforcing. For instance, strong farmer institutions can promote the adoption of agroforestry practices, thereby enhancing ecological resilience. Conversely, ecological sustainability supports farmers' socio-economic well-being by improving yields and income. [Dewi and Nugroho \(2022\)](#) emphasize that integrating ecological practices with social institutions is crucial for enhancing the resilience of smallholder farming systems, including cocoa farming.

Research Gap

Although many studies have discussed cocoa resilience from technical or ecological perspectives, research that integrates both social and ecological dimensions in a balanced manner remains relatively limited, especially at the local level, such as Kulon Progo. However, a comprehensive understanding of these interactions is essential for designing adaptive and sustainable agroecosystem management strategies.

RESEARCH METHOD

This study employed a qualitative approach, incorporating participatory observation, to gain an in-depth understanding of socio-ecological interactions within cocoa agroecosystems in Kulon Progo, Yogyakarta. Such an approach enabled the researcher to explore the experiences, practices, and dynamics of farmers that shape the sustainability of agroecosystems.

Research Subjects and Location

The subjects were five purposively selected cocoa farmers who actively manage their farms and participate in farmer groups or cooperatives. They represented diverse profiles—a group leader, an elderly farmer, a young farmer, a male farmer, and a female farmer—to capture a range of perspectives. Kulon Progo was chosen because it remains a major cocoa production center in Yogyakarta, where community-based farming traditions are still prevalent.

Types and Sources of Data

Primary data were gathered through direct observation, in-depth interviews, and

participatory interactions focusing on cultivation practices, climate adaptation, the role of farmer institutions, and efforts to maintain ecosystem sustainability. Secondary data were obtained from documents, reports, and studies relevant to the socio-ecological resilience of cocoa agroecosystems. These were selected for their direct relevance to agroforestry, cocoa resilience, and farmer institutions, as well as for their recency (published within the last 1–5 years) and credibility (based on scientific journals, official reports, and government or international policy documents).

Research Instruments

Observation sheets, in-depth interview guides, and semi-structured questionnaires were employed to explore agroforestry practices, on-farm biodiversity, institutional support, and resilience factors. Questions were adapted from prior studies on cocoa agroforestry adoption and climate resilience, adjusted to the Kulon Progo context. Examples included: What management practices do you apply? Which shade or intercrop plants are used and why? To what extent do you participate in training? What are the main challenges in sustainable cocoa production? The questionnaire addressed cultivation methods (organic vs. chemical fertilizers), biodiversity maintenance, farmer group participation, and perceptions of farm resilience.

Data Analysis and Validity

Data were analyzed qualitatively and descriptively through reduction, classification into social and ecological themes, interpretation of relationships, and triangulation to enhance validity. Questionnaire responses verified observations (e.g., fertilizer use). Source and method triangulation—comparing information from multiple sources, including documents and field notes—ensured the credibility of the findings. Active field engagement gave a comprehensive understanding of farmers' practices and experiences in building cocoa agroecosystem resilience.

FINDINGS AND DISCUSSION

Respondents' Demographic Profile

The characteristics of respondents involved in this study are presented in Table 1. This table provides contextual information about the informants to help readers understand the research findings.

Table 1. Characteristics of Respondents

No.	Respondent Code	Role	Gender	Age (years)	Education Level	Farming Experience (years)
1	R1	Farmer Group Leader	Male	45	Senior High	20
2	R2	Elderly Farmer	Male	60	Primary School	35
3	R3	Young Farmer	Male	28	Bachelor	5
4	R4	Male Farmer	Male	40	Junior High	15
5	R5	Female Farmer	Female	38	Senior High	12

Summary of Interview and Questionnaire Findings

In addition to observation, in-depth interviews and semi-structured questionnaires were used to explore farmers' perceptions and experiences.

Table 2. Summarizes the field findings.

Theme / Indicator	Summary of Field Findings
Agroforestry Practices	All respondents practice intercropping with shade trees (petai, durian, banana, lamtoro, coconut, avocado). Two respondents still use chemical fertilizers, while three have switched to organic fertilizers such as compost or manure.
Biodiversity & Environment	Most respondents emphasize the importance of shade trees for soil fertility, but only one explicitly mentions the importance of pollinating insects.
Farmer Institutional Support	All respondents are active in farmer groups. The leader and young farmer frequently attend training provided by government/universities, while the elderly farmer notes training is still limited.
Socio-Economic Factors	Main constraints include limited capital, market access, and technical knowledge. The female farmer highlights the importance of information access for business diversification.
Resiliensi	Most respondents are optimistic that their cocoa farms can withstand seasonal changes, although they acknowledge yield reductions during the rainy season and increased pest problems.

In addition to the summary of qualitative findings, the semi-structured questionnaire data were also analyzed descriptively to show the frequency of respondents' answers. The results are presented in Table 3 below:

Table 3. Summary of Respondents' Questionnaire Answers (n=5)

Indicator	Respondents / Frequency	Percentage (%)
Using organic fertilizer	3 respondents	60%
Using chemical fertilizer	2 respondents	40%
Understanding the importance of natural pollinators	1 respondent	20%
Active in farmer groups	5 respondents	100%
Attended government/university training	3 respondents	60%
Reporting difficulties in capital/market access	4 respondents	80%

These data indicate that most farmers have begun to switch to organic fertilizers, are active in farmer groups, and have attended training; however, their understanding of natural pollinators remains low. These findings complement the results of in-depth interviews and field observations,

providing a clearer picture of the social and ecological conditions of cocoa agroecosystems in Kulon Progo.

Overview of Field Findings

Fieldwork in Kulon Progo revealed that a dynamic interplay of social and ecological factors shapes cocoa agroecosystems. Observations and interviews with farmers revealed that cultivation practices, adaptation strategies, and institutional support have a significant impact on the resilience and sustainability of cocoa farming. Participatory observation identified five key aspects: (1) cultivation practices, (2) adaptation to climate change, (3) farmer institutions, (4) external support, and (5) local ecosystem resilience. Questionnaire responses further enriched the analysis by capturing farmers' perceptions of social and ecological aspects, as well as their confidence in the resilience of their farms.

Cocoa Cultivation Practices

Farmers in Kulon Progo employ a combination of integrated pest management (IPM), chemical inputs, and organic farming methods. While some still rely on synthetic pesticides and fertilizers, an increasing number are adopting organic practices such as composting and manure-based fertilizers to reduce costs and improve soil health. Maintaining shade trees is viewed as essential for both ecological and economic reasons, with intercropping like petai, durian, avocado, lamtoro, coconut, and banana diversifying income and regulating microclimates. This aligns with research indicating that agroforestry enhances ecosystem resilience through improved soil fertility, moderation of microclimates, and provision of pollinator habitats. However, pest control remains a significant challenge during the rainy season, when disease outbreaks and fruit rot reduce yields, reflecting limited technical knowledge and inconsistent IPM application.

Adaptation to Climate Change

Farmers reported shifting planting and harvesting times in response to changing rainfall patterns. Adaptive measures, such as discarding diseased pods during wet periods, are standard but often lack systematic planning and implementation. Awareness of natural pollinators is particularly low, with only a minority recognizing their ecological role. This gap highlights broader inefficiencies in resource utilization and underscores the need for climate-resilient agricultural practices and education on ecosystem services.

Farmer Institutions and Social Capital

Farmer groups and cooperatives strengthen adaptive capacity by enabling collective discussions, knowledge sharing, and labor division. Respondents highlighted youth participation as a positive sign for generational continuity. Cooperatives also facilitate access to external support, including seedlings, fertilizers, and training, from government and universities, echoing evidence that institutional interventions improve smallholder welfare when combined with technical assistance. Active participation in meetings highlights the importance of social networks in enhancing adaptive capacity and influencing ecological practices, including pest control and the use of organic fertilizers.

External Support and Extension Services

Government agencies, universities, and NGOs have provided training, inputs, and technical guidance, enhancing farmers' capacity to manage pests, produce organic fertilizers, and diversify crops. However, support is often project-based and intermittent. Farmers expressed concerns about program continuity, highlighting the need to institutionalize ongoing extension services

rather than relying on ad-hoc interventions.

Local Ecosystem Resilience

Biodiversity from shade trees and intercrops helps maintain soil fertility, regulate the microclimate, and promote ecological balance. Some farmers even apply an “adaptive threshold,” tolerating 40 % pest presence before intervention. Nonetheless, challenges such as fruit rot and yield decline persist despite diversification. Questionnaire responses showed that farmers are generally optimistic about the sustainability of their farms, yet this optimism contrasts with observed vulnerabilities and limited knowledge of ecosystem services, highlighting the need for continued education and capacity building.

Discussion: Interplay of Social and Ecological Factors

The findings illustrate that the sustainability of cocoa agroecosystems in Kulon Progo depends on the dynamic interaction between social and ecological dimensions. On one hand, ecological resilience is shaped by biodiversity, shade trees, and adaptive pest management. On the other hand, social resilience is reinforced through farmer groups, cooperative structures, and external support.

The interplay between these factors creates both synergies and gaps. Strong farmer institutions encourage the adoption of agroforestry and organic practices, while these ecological practices, in turn, support social well-being through stable yields and diversified income. However, gaps in ecological knowledge, particularly regarding pollinators and long-term climate adaptation, limit the effectiveness of social structures.

These findings support the socio-ecological systems framework, which views sustainability as the product of both social and ecological resilience. As [Dewi & Nugroho \(2022\)](#) argue, resilience emerges from the integration of social institutions and ecological practices, not from isolated efforts.

The frequency analysis of the questionnaire responses reinforces the qualitative findings that the social aspects (such as participation in farmer groups and training) are relatively stronger than the ecological aspects (such as understanding of natural pollinators). Therefore, strengthening ecological capacity through education and extension becomes a priority in sustainable cocoa management strategies.

Implications for Sustainable Cocoa Farming

The case of Kulon Progo demonstrates that sustainable cocoa farming requires strengthening both social and ecological dimensions simultaneously. Key strategies include:

1. Expanding agroforestry practices to enhance biodiversity and climate resilience.
2. Strengthening farmer institutions to ensure collective learning and resource access.
3. Institutionalizing extension services to provide continuous support rather than project-based assistance.
4. Increasing farmer awareness of ecosystem services such as pollination and natural pest regulation.
5. Promoting organic practices to reduce input costs and improve soil health.

By integrating these strategies, cocoa agroecosystems in Kulon Progo can achieve greater resilience, ensuring both environmental sustainability and the livelihoods of farmers.

The research highlights that the resilience of cocoa agroecosystems in Kulon Progo is co-produced by social and ecological factors. While farmer optimism and institutional strength provide a strong social foundation, ecological challenges such as pests, diseases, and climate variability remain significant. Bridging the gap between social capacity and ecological knowledge is essential for achieving sustainability. Strengthening socio-ecological approaches offers a pathway to resilient

and sustainable cocoa farming systems in Yogyakarta and beyond.

CONCLUSIONS

This study demonstrates that the resilience of cocoa agroecosystems in Kulon Progo, Yogyakarta, stems from the dynamic interplay between social and ecological factors. Ecologically, agroforestry practices, shade trees, and crop diversification help maintain soil fertility, stabilize the microclimate, and promote biodiversity. However, significant challenges persist during the rainy season, when pest and disease outbreaks, as well as fruit rot, reduce yields. Farmers' limited understanding of ecosystem services, particularly pollination, further constrains effective adaptation.

Socially, farmer groups and cooperatives play a pivotal role in strengthening adaptive capacity. They facilitate knowledge sharing, collective problem-solving, and access to seedlings, fertilizers, and training from government agencies and universities. Farmers expressed optimism about long-term sustainability, supported by social solidarity, external assistance, and simple adaptive practices such as organic fertilization. However, this optimism does not always align with ecological realities. Overall, resilience depends not only on technical innovations but on integrating ecological practices with strong social institutions.

Based on these findings, this study recommends several steps for sustainable cocoa management in Kulon Progo, including:

1. Expanding the implementation of agroforestry practices to enhance biodiversity and resilience to climate change;
2. Strengthening farmer institutions to ensure more equitable collective learning and access to resources;
3. Institutionalizing continuous extension services rather than project-based ones;
4. Increasing farmers' awareness of ecosystem services such as pollination and natural pest control; and
5. Promoting the use of organic fertilizers to reduce input costs and improve soil health.

These recommendations are expected to provide practical input for local governments, extension agencies, and other stakeholders in formulating sustainable cocoa management strategies.

LIMITATIONS & FURTHER RESEARCH

This study has several limitations. First, the number of respondents was relatively small, consisting of only five individuals: a group leader, an elderly farmer, a young farmer, a male farmer, and a female farmer; therefore, the findings cannot be generalized to all cocoa farmers in Kulon Progo. Second, data collection was conducted qualitatively through interviews and observations, which are influenced by respondents' openness and perceptions at the time of the study. Third, the research primarily focused on the socio-ecological aspects of cocoa agroecosystems, rather than exploring in depth the economic dimensions, such as value chains or market prices. Future research with a larger sample size and a mixed-methods approach is recommended to expand on these findings.

Although this study provides valuable insights into socio-ecological interactions, several areas warrant further exploration. First, more detailed quantitative assessments of ecological services—such as pollination, pest regulation, and soil fertility—would complement the qualitative findings presented here. Second, longitudinal studies are necessary to assess the impact of climate variability and long-term adaptation strategies on cocoa productivity and the livelihoods of farmers. Third, future research should examine generational perspectives, particularly the role of youth in sustaining cocoa farming systems and adopting innovative practices.

Additionally, investigating the effectiveness of institutional interventions, such as

certification schemes, farmer group programs, and continuous extension services, will provide a clearer understanding of how social structures shape ecological outcomes. Finally, comparative studies between Kulon Progo and other cocoa-producing regions in Indonesia could reveal context-specific and transferable strategies for building resilient and sustainable cocoa agroecosystems.

By addressing these research gaps, future studies can provide stronger evidence-based recommendations for policymakers, institutions, and farming communities to enhance both ecological resilience and social well-being in cocoa production systems.

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