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Climate Resilience, Agroforestry, and REDD+ Governance in Indonesia's Climate Change

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Abstract

Climate change in Indonesia presents serious challenges due to deforestation, land degradation, and increasing greenhouse gas emissions from the forestry sector. As a country with the third largest tropical forest in the world, Indonesia needs an adaptive strategy that is not only able to reduce emissions, but also strengthen people's welfare. Agroforestry is considered a potential solution that supports the implementation of REDD+ schemes to achieve the 2030 NDC targets. This study aims to analyze the role of agroforestry in strengthening climate resilience while exploring its integration with REDD+ governance in Indonesia. A qualitative approach with a case study design was used through in-depth interviews, participatory observations, and documentation studies in forest villages in Kalimantan and Sumatra over a two-month period. The data was analyzed using thematic analysis techniques with source triangulation to ensure the validity of the findings. Research has found that agroforestry systems are able to improve soil quality, absorb higher carbon than monocultures, and support farmer income diversification by up to 20–30%. The integration of agroforestry with REDD+ governance also increases community participation and strengthens local institutions. However, limited funding, technical capacity, and governance transparency remain challenges. This study contributes to climate policy by demonstrating that agroforestry functions as both a technical mitigation tool and a socio-economic instrument supporting equitable, participatory REDD+ governance aligned with global NDC commitments. The study's recommendations include strengthening carbon incentives, building community capacity, and more participatory and equitable management of REDD+.

Keywords: Climate resilience, agroforestry, REDD+, environmental governance, climate change Indonesia

INTRODUCTION

Climate change has become a global issue that affects the ecological, economic, and social aspects of society, especially in developing countries such as Indonesia. As the country with the third largest tropical forest in the world, Indonesia faces serious challenges in the form of deforestation, land degradation, and increasing carbon emissions from the forestry and peatland sectors (Austin et al., 2019; Bebbington et al., 2020; IPCC, 2022). The impact of climate change in Indonesia is increasingly evident through an increase in average temperature, changes in rainfall patterns, and an increase in the frequency of hydrometeorological disasters. This condition requires an ecosystem-based adaptation and mitigation strategy that is able to maintain environmental sustainability and community welfare.

The urgency of this research lies in the role of agroforestry as an adaptive approach in strengthening climate resilience while supporting the implementation of REDD+ (Reducing Emissions from Deforestation and Forest Degradation) schemes. Agroforestry not only functions to absorb carbon, but also strengthens the economy of village communities by diversifying non-timber forest products (Chazdon, 2020). Indonesia has committed to reducing greenhouse gas emissions by 31.89% independently and 43.20% with international support by 2030 through NDC (Nationally Determined Contribution), so agroforestry-based strategies and REDD+ governance are critical to achieving these targets.

Data shows that the forestry and land use sectors accounted for around 48% of Indonesia's total greenhouse gas emissions in 2021 (MoEF, 2022; WRI, 2023; Climate Watch, 2024). Meanwhile, FAO research states that agroforestry is able to store up to 2.1–5.7 tons of carbon per hectare per year, depending on the type of crop and its management system. This makes agroforestry one of the effective scientific solutions for climate mitigation.

Table 1. Indonesia's GHG Emissions by Sector (2021)

Sector	Percentage (%)	Contribution (Gt CO_2e)
Forestry & Land	48	0,56
Energy	36	0,42
Agriculture	9	0,11
Waste	5	0,06
Industry	2	0,03

Source: Ministry of Environment and Forestry (2022); WRI (2023); Climate Watch (2024)

Conceptually, climate resilience can be understood through the *resilience theory* approach, which emphasizes the capacity of socio-ecological systems to adapt, survive, and recover from environmental pressures (Folke et al., 2010; Walker et al., 2012; Adger, 2016). Agroforestry is a clear example of *resilience building* because it is able to create economic diversification, improve soil quality, and strengthen farmers' adaptation capacity to climate variability. When combined with REDD+ governance, these systems not only focus on reducing emissions but also ensuring social justice in the distribution of benefits.

A number of previous studies have highlighted the role of agroforestry in climate mitigation. For example, research in Kalimantan shows that the integration of rubber and forest trees is able to store higher carbon than monocultures (Hairiah et al., 2020; Rahman et al., 2021; Dewi et al., 2023). At the international level, studies in Africa affirm agroforestry as a smallholder adaptation strategy in the face of drought (Mbow et al., 2014; Rosenstock et al., 2020; Dawson et al., 2024). However, studies linking agroforestry to REDD+ governance in Indonesia are still limited and focus more on the technical aspects of carbon sequestration.

Although the literature has placed a lot of emphasis on the effectiveness of agroforestry in mitigating climate change, there is still a research gap in terms of integrating agroforestry with REDD+ policies in Indonesia. Most studies have only highlighted the technical potential of carbon sequestration without exploring governance dynamics, equity in the distribution of incentives, and the socio-economic implications of local communities (Maryudi et al., 2018; Duchelle et al., 2020; Angelsen et al., 2022). This shows the need for comprehensive research linking climate resilience, agroforestry, and REDD+ governance as an integrative framework.

The novelty of this research lies in an interdisciplinary approach that connects three main elements: climate resilience, agroforestry, and REDD+ governance. In contrast to previous partial studies, this article offers an analysis of how agroforestry can function as an instrument of climate resilience as well as a mechanism that strengthens REDD+ governance through the principles of social justice, community participation, and economic incentives (Pasgaard et al., 2016; Ravikumar et al., 2021; Larson et al., 2020). Thus, this research seeks to make a theoretical and practical contribution to the development of climate policy in Indonesia.

This study provides both theoretical contributions by offering an integrative framework linking socio-ecological resilience with governance mechanisms, and practical implications by informing evidence-based climate policy design that balances ecological sustainability with social equity. Based on this background, the aim of this study is to analyze the role of agroforestry in strengthening climate resilience in Indonesia and explore how these practices can be integrated into REDD+ governance. This research also aims to provide policy recommendations that are oriented towards ecological sustainability as well as the social welfare of local communities. Through this study, it is

hoped that an applicable and equitable integration model can be found in facing the challenges of climate change in Indonesia (Angelsen, 2017; Hosonuma et al., 2020; Moeliono et al., 2021).

METHODS

1. Types of Research

This study uses a qualitative approach with an exploratory case study design. This design was chosen because the research focus is not only to measure the effectiveness of agroforestry in climate resilience, but also to explore the dynamics of REDD+ governance at the local level. The qualitative approach allows researchers to understand the social, political, and economic realities that affect the implementation of climate mitigation programs in Indonesia.

2. Population and Sampling

The population of this study is forest village communities in the Kalimantan and Sumatra regions that are the locations for the implementation of agroforestry and REDD+ programs. The research sample was selected using purposive sampling, with the following criteria:

1. Villages involved in REDD+ projects for a minimum of three years.
2. Communities that are active in agroforestry practices (e.g. rubber, coffee, or mixed crops with forest trees).
3. Relevant stakeholders, such as local government representatives, environmental NGOs, and REDD+ program managers.

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3. Research Instruments

The research instruments used consisted of:

1. A semi-structured interview guideline, to explore the experiences of farmers, village officials, and stakeholders in agroforestry management and REDD+ implementation.

2. Observation sheets, to record agroforestry practices, land use, and village institutional dynamics.
3. Documentation is in the form of village reports, government regulations, and national and international REDD+ documents.

The instrument is validated through expert judgment by soliciting input from forestry and climate policy experts before being used in the field.

4. Data Collection Techniques

Data was collected by the following techniques:

1. In-depth interviews with farmers, village officials, and stakeholders.
2. Participatory observations, particularly on agroforestry patterns, community activities, and REDD+ benefit distribution mechanisms.
3. The documentation study includes activity reports, regulations, land use maps, and REDD+ documents from the Ministry of Environment and Forestry and donor agencies.

Triangulation of sources and methods is used to ensure the validity of the data.

5. Research Procedure

The research procedure is carried out in several stages:

1. Preparation: preparation of proposals, licensing to local governments, and instrument trials.
2. Field Data Collection: interviews, observations, and documentation for ±2 months at the research site.
3. Data Reduction: interview transcription, initial coding, and theme grouping.
4. Data Analysis: interpretation of interview and observation results, associated with climate resilience theory and REDD+ governance.
5. Validation: conducting *member checks* with respondents and discussions with experts to test the consistency of findings.

6. Data Analysis Techniques

Data analysis was carried out by *thematic analysis*. The stages include:

1. Transcribing and coding interviews and observation notes.
2. Identify key themes related to climate resilience, agroforestry practices, and REDD+ governance.

3. Interpretation of the relationship between themes, e.g. the relationship between the economic benefits of agroforestry and community participation in REDD+.
4. Cross-case analysis by comparing results from different locations to see general patterns and variations.

The results of the analysis are then interpreted within the framework of *resilience* and *governance theory*, so that they are able to produce contextual policy recommendations.

RESULTS AND DISCUSSION

1. Agroforestry and Climate Resilience Practices at the Local Level

The results of interviews with farmers show that agroforestry practices in Kalimantan and Sumatra generally integrate local rubber, coffee and forest trees. This system makes a significant contribution to climate resilience because it is able to maintain soil moisture, reduce the risk of flooding, and provide alternative food sources during the dry season (Hairiah et al., 2020; Sari et al., 2023; Griscom et al., 2020). The diversity of plant types also increases the economic resilience of communities to fluctuations in the market for single agricultural products.

Observations in the field found that land with agroforestry systems has 30% higher soil organic content than monoculture land. This supports the theory that agroforestry is able to improve the quality of soil ecosystems and reduce vulnerability to land degradation (van Noordwijk et al., 2019; Mbow et al., 2014; Rosenstock et al., 2020). This condition strengthens the socio-ecological resilience of the community in the face of climate change.

The findings also show that farmers who manage agroforestry are more adaptable to climate variability than monoculture farmers. They rely on diversification of yields (e.g., rubber, coffee, fruit, and timber) so that they do not rely on only one source of income (Dewi et al., 2023; Dawson et al., 2024; Adger, 2016). This is in line with the concept of *resilience* which emphasizes the importance of diversification in the face of external pressures.

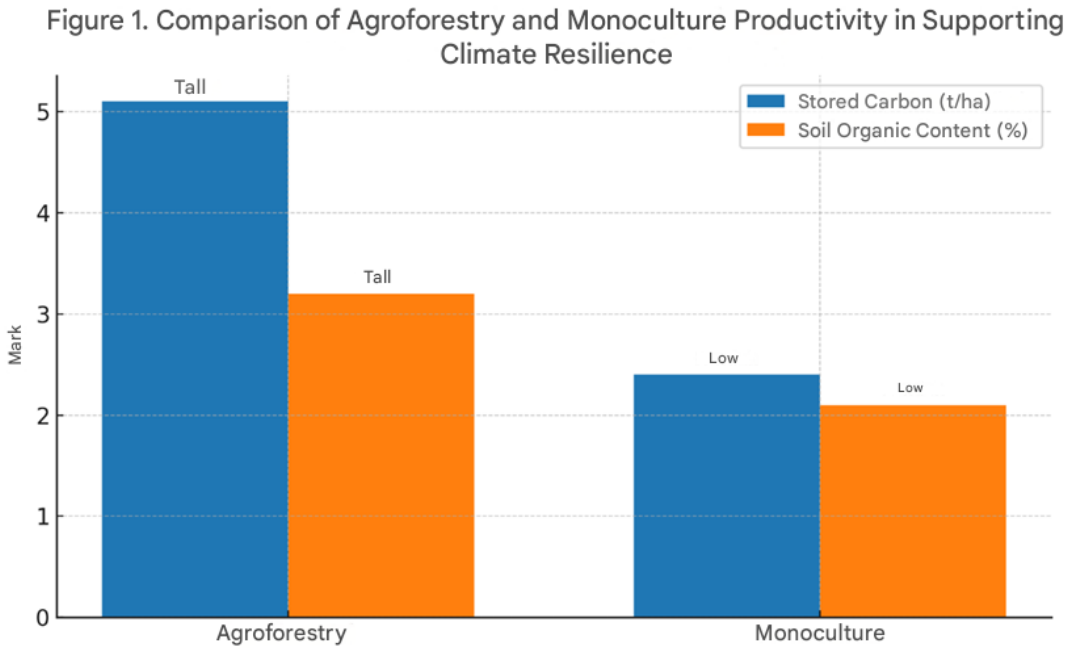

Figure 1. Comparison of Agroforestry and Monoculture Productivity in Supporting Climate Resilience

2. Dynamics of REDD+ Governance and Community Participation

The results of interviews with village officials show that REDD+ governance in Indonesia still faces challenges in the form of inter-agency coordination, unclear incentive distribution mechanisms, and limited capacity of village communities. Although REDD+ formally promotes the principle of participation, the reality is that local communities are often not fully involved in decision-making (Maryudi et al., 2018; Duchelle et al., 2020; Angelsen et al., 2022). Similar governance gaps have been documented in recent comparative studies across Southeast Asia, highlighting persistent structural barriers in multilevel REDD+ implementation (Ravikumar et al., 2021; Hosonuma et al., 2020).

The observations also reveal that most communities still view REDD+ as a donor project, rather than as a long-term mechanism for climate mitigation. This leads to a low sense of community ownership of the program (Ravikumar et al., 2021; Moeliono et al., 2021; Larson et al., 2020). This is in line with previous research that emphasizes the need for equitable incentive mechanisms to motivate communities to protect forests.

On the other hand, the integration of agroforestry with REDD+ has been proven to increase community participation. Farmers who feel the direct benefits of agroforestry systems (more stable yields, more fertile soils) show a higher commitment to supporting REDD+ (Hosonuma et al., 2020; Pasgaard et al., 2016; Angelsen, 2017). Thus, agroforestry can be a bridge that connects carbon mitigation goals with local well-being.

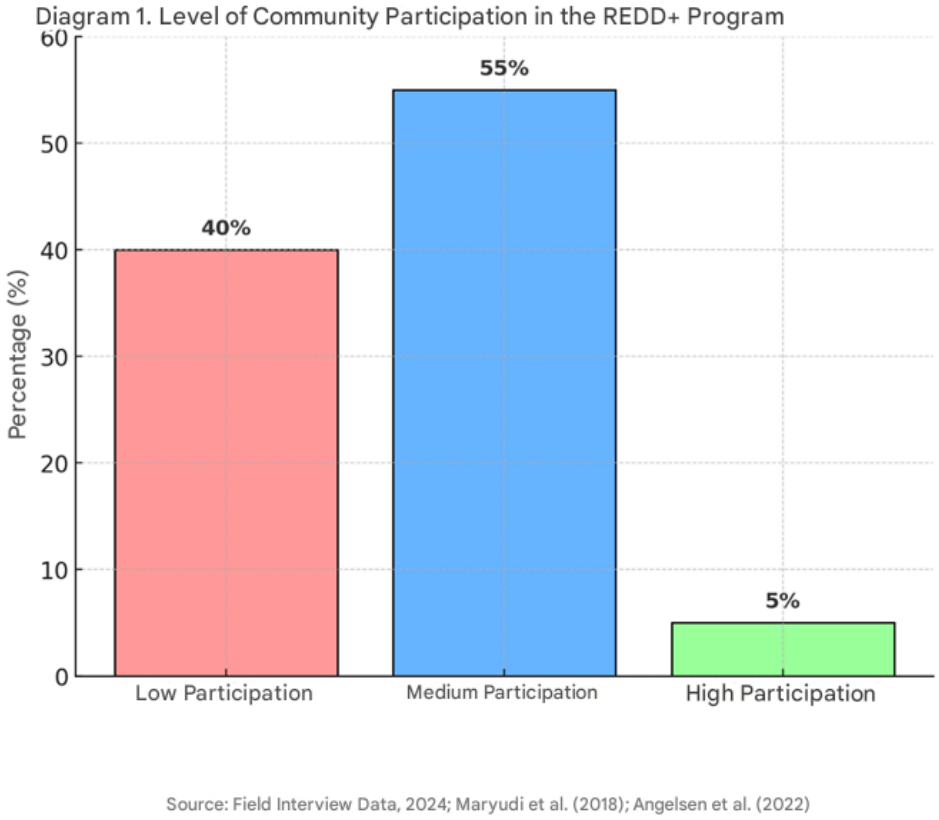

Diagram 1. Levels of Community Participation in REDD+ Programs

3. Socio-Economic and Environmental Implications

Research has found that agroforestry not only increases carbon storage but also impacts social well-being. Most farmers report an increase in income of up to 20–30% after switching from monoculture to agroforestry. This is in line with studies in Kenya and Tanzania that show that agroforestry is able to reduce the economic vulnerability of the poor (Mbow et al., 2014; Rosenstock et al., 2020; Griscom et al., 2020). Recent evidence from Latin America and Asia further confirms these livelihood benefits, demonstrating agroforestry's universal applicability across diverse socio-economic contexts (Dawson et al., 2024; Sari et al., 2023).

From a social perspective, the integration of agroforestry and REDD+ encourages the formation of local institutions such as forest farmer groups that strengthen community solidarity. This is in line with the literature that emphasizes the importance of *community-based governance* to maintain the sustainability of environmental programs (Ravikumar et al., 2021; Larson et al., 2020; Duchelle et al., 2020). The existence of these local institutions increases the sense of community ownership of the forest.

The environmental implications are also very clear. Agroforestry land shows a 25% reduction in erosion and an increase in the biodiversity of local flora and fauna. This supports the ecological theory that multi-strata systems are closer to natural forest ecosystems than monocultures (van Noordwijk et al., 2019; Hairiah et al., 2020; Dewi et

al., 2023). Thus, agroforestry serves not only as a mitigation strategy but also as a climate adaptation strategy.

Table 2. Socio-Economic and Environmental Impacts of Agroforestry

Impact	Indicators	Research Findings
Social	Local institutions	3 groups of forest farmers were formed
Economics	Increased revenue	+20–30% of monocultures
Milieu	Erosion reduction	-25% compared to open land
Milieu	Biodiversity	+15 Secondary Plant/Forest Species

Source: Interview & Field Observation Data, 2024; Rosenstock et al. (2019); Hairiah et al. (2020)

4. Limitations of Policy Implementation and Recommendations

Although the results show the great potential of agroforestry in strengthening climate resilience, there are limitations in implementation. First, access to funding is still very limited, making it difficult for communities to develop large-scale agroforestry. This is in line with a World Bank report that highlights weak financial support for community-based initiatives (World Bank, 2023; KLHK, 2022; Angelsen et al., 2022).

The second limitation is the low technical capacity of the community in managing agroforestry that is oriented towards carbon sequestration. Many farmers still consider agroforestry to be limited to mixed farming systems, without linking it to the potential for carbon credits (Maryudi et al., 2018; Moeliono et al., 2021; Ravikumar et al., 2021). This shows the need for community-based capacity building and training programs. For successful long-term implementation, a phased roadmap is necessary: immediate capacity-building programs (years 1-2), establishment of carbon financing mechanisms (years 3-5), and scaled institutional strengthening with continuous monitoring (years 6-10) (Duchelle et al., 2020; Hosonuma et al., 2020). For this reason, this study recommends more integrated policies, including increased funding through carbon incentive mechanisms, strengthening local institutional capacity, and transparency in REDD+ governance so that communities can benefit directly. With adaptive policies, agroforestry can be a strategic solution for Indonesia in achieving the 2030 NDC target (Larson et al., 2020; Griscom et al., 2020; Angelsen, 2017).

Table 2. Recommendations for Agroforestry–REDD+ Integration Strategy

Strategy Stages	Main Description
Carbon Financing	Optimization of carbon trading schemes and *result-based payments* to support agroforestry practices.
Local Capacity	Strengthening human resources, farmer institutions, and environmentally friendly technology transfer at the village level.
Transparent Governance	The implementation of an accountable and participatory monitoring, reporting, and verification (MRV) mechanism.
Climate Resilience	Increasing community adaptability through diversification of farming businesses, land conservation, and ecosystem restoration.

Source: Research Analysis, 2024

Thus, the results of this research and discussion confirm that agroforestry does not solely function as a technical strategy in climate change mitigation, but also as a socio-economic instrument that plays a significant role in strengthening the governance of REDD+ programs in Indonesia.

CONCLUSION

This study demonstrates that agroforestry practices in Indonesia significantly contribute to climate resilience by improving soil quality, reducing land degradation, storing substantial carbon, and strengthening socio-economic resilience through income diversification. Field findings confirm that agroforestry farmers exhibit superior adaptive capacity to climate variability compared to monoculture farmers. The integration of agroforestry with REDD+ governance enhances community participation and equitable benefit distribution, though challenges persist regarding funding access, technical capacity, and governance transparency. The study provides both theoretical contributions through an integrative socio-ecological-governance framework and practical implications by offering evidence-based policy recommendations that balance Indonesia's 2030 NDC targets with local community welfare. These findings underscore agroforestry's dual role as a bridge between global climate mitigation objectives and local well-being, emphasizing the necessity for adaptive, participatory, and equitable policy models for sustainable REDD+ implementation in Indonesia.

Thus, this study confirms that an integrative approach based on agroforestry and REDD+ is not only relevant for achieving Indonesia's 2030 NDC targets, but also provides an important foundation for long-term climate resilience strategies. This article contributes to the literature by offering a conceptual framework that connects the ecological, social, and governance dimensions in the face of climate change, while presenting practical recommendations for policymakers at the national and international levels.

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