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Research Article

Fodder Crop Integration in Forest Management as a Strategy for Strengthening Community Livelihoods and ESG Alignment

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Abstract.
Community forest management through agroforestry-based cooperatives plays a vital role in advancing environmental, social, and governance (ESG) objectives. This capstone project, a collaboration between the Research Team from Universitas Gadjah Mada and PT Kutai Timber Indonesia, explored how community forest cooperatives can enhance productivity within the Bromo Mandiri Cooperative in Ngepung Village, Sukapura, Probolinggo. The project proposed integrating biopharmaceutical plants and dwarf elephant grass for animal feed into the agroforestry system, offering potential environmental, social, and economic benefits. Using a participatory approach and principles of sustainable governance, the cooperative can improve farmer welfare, protect ecosystems, and build a more efficient production system. The findings demonstrate that ESG principles can be effectively integrated into cooperative strategies to promote food security and ecological sustainability.

Keywords: agroforestry, biopharmaceutical, carbon sequestration, capstone project, ESG

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1. Introduction

Community forest cooperatives are one of the institutional models that aim to manage natural resources collectively and sustainably [1]. In the context of agroforestry, cooperatives play an important role in integrating various ecological and economic components by maximizing forest and land functions. ESG (Environmental, Social, and Governance) performance becomes one of the benchmarks of the cooperative's success in carrying out its mission, especially in increasing productivity and sustainability [2]. In the context of agroforestry, cooperatives play an important role in integrating ecological and economic components [3]. By optimizing the multifunctionality of forests and land, cooperatives help increase agricultural productivity while conserving biodiversity and

ecosystem services [4]. Agroforestry systems managed by co-operatives can produce a variety of products, including timber, food, and medicinal plants while protecting soil health and improving water retention. This holistic approach creates sustainable livelihoods for members while contributing to environmental stewardship [5].

Governance in this activity is critical to ensure improvements in ESG performance and agroforestry productivity through community forest cooperatives are achieved. The capstone project acts as an integrative framework that comprehensively combines theory and practice [6]. In this context, the capstone project involves the application of ESG principles in cooperative management, agroforestry development based on biopharmaceuticals and fodder grasses, and sustainability analysis in agricultural value chains [7]. Good governance requires a transparent and participatory management system, where all stakeholders, including farmers, cooperatives, government, and farmer-partner companies, have an active role in every stage of implementation [8]. Rigorous monitoring and regular reporting on ESG impacts are also part of governance to maintain public trust and long-term sustainability. A key measure of the success of these cooperatives lies in their ESG (Environmental, Social, and Governance) performance. Strong ESG practices enable cooperatives to increase productivity and sustainability by complying with environmental standards, promoting social equity, and ensuring transparent governance [9]. Cooperatives that excel in ESG metrics are better able to attract investments and partnerships, further supporting their mission of sustainable resource management and increasing community resilience in the face of climate change.

Agroforestry systems that combine biopharmaceutical crops and fodder grasses are innovative models that not only increase agricultural yields but also strengthen ecosystem balance. Biopharmaceutical crops such as ginger, turmeric, and aromatic ginger have high economic value and growing market demand, while fodder grasses can support more environmentally friendly meat and milk production [10]. The involvement of community forest cooperatives in facilitating the implementation of these systems has the potential to accelerate the achievement of more comprehensive ESG [11].

2. Materials and Methods

The capstone project between the Department of Agricultural Industrial Technology, Faculty of Agricultural Technology, Universitas Gadjah Mada, and PT Kutai Timber Indonesia, Probolinggo, was conducted using a mixed-methods approach, combining qualitative and quantitative methods to understand the application of agroforestry,

biopharma, and carbon stock measurement in forest communities. Participatory Rural Appraisal (PRA) method was used to identify problems, potentials, and needs of the community related to the agroforestry program through their active participation. In-depth interviews were conducted to gain in-depth insight into the perceptions, experiences, and constraints faced by farmers in implementing biopharma agroforestry through surveys and observations in the Bromo Mandiri cooperative work area (Figure 1).

In addition, Focus Group Discussions (FGDs) were applied to test and validate the results of the interviews by gathering opinions from a wider group of communities [12], providing quantitative data on the level of community awareness and support for the carbon measurement program and collaboration with companies, estimation of biopharma productivity, carbon sequestration, and economic impacts. It explored social behavior and community interactions with the environment, including the role of women in land management and their level of understanding of biopharmacology. With this design, the research provides a comprehensive picture of the implementation of ESG (Environmental, Social, Governance) and sustainability strategies of forest community-based agroforestry (Figure 2).

3. Results and Discussion

The implementation of the capstone project between academics and timber mills in fostering forest community cooperatives to develop biopharma agroforestry was carried out through several technical stages. ESG concept diffusion was conducted to strengthen the potential and sharpen the community's needs for biopharma plants that are suitable for agroforestry in the local ecosystem. After that, the UGM capstone research team and PT Kutai Timber Indonesia collaborated to provide technical training to the Community for agroforestry scenarios of biopharma plants. Through the cooperative, the community will be facilitated in managing agroforestry products with a sustainable system, including aspects of processing, marketing, and distribution of biopharma plant products. This project scenario will integrate carbon sequestration monitoring as an effort to strengthen environmental sustainability, with technological assistance and academic assistance to record carbon contributions from agroforestry. These measures are designed to improve the economic welfare of the community through the added value of biopharma and support climate change mitigation through increased carbon sequestration (Table 1).

Table 1: Resource Map for Biopharmaca Agroforestry Scenarios and Carbon Sequestration.

Aspects Researched	Parameters	Quantitative Data	Description
Agroforestry Land Area	Total agroforestry land area (hectares)	1,329.76 Ha	2,348 hectares of land
Number of Farmers Involved	Total participating farmers	8 people	from 1,450 members, with areas spread across 6 sub-districts and 24 villages for the biopharma agroforestry program plan.
Size of conservation area that can be utilized	Number of biopharma plants planted	10.00% of the total management area or about hectares consisting of 66.64 ha or 5.00% protected area and 66.39 hectares or 5.00% conservation area.	The total conservation area is 133.03 Ha. The members' land is divided into 16 groups and under the supervision of 8 regional coordinators for crop scenarios including ginger, Curcuma, and turmeric.
Type of current production crops	Sengon (Paraserianthes falcataria). Enrichment species are jabon (*Anthocephalus cadamba*) and balsa (*Ochroma sp.*) Gmelina (*Gmelina arborea*), Jaran (*Lannea coromandelica*) Edge plants are used jabon, banana, terrace plants are used Gliricidia, Indigofera, and elephant grass.	Collaboration of biopharma plants with plants for riparian areas using bamboo, cloves, durian, and Multi-Purpose tree species (MPTS).	Intercropping planting system using crops developed by the community with 3x3m and 6x2m spacing arrangements.
Welfare Level	Percentage of people whose welfare increases	55-70%	Increased income and access to agroforestry products compared to the previous year.
Carbon Reserves in Agroforestry Land	Estimated carbon sequestration per year	Closed to 500 tonnes CO_2e	Results from participatory measurements using simple tools to estimate carbon stocks.
Land Use for Animal Feed	Land area for dwarf elephant grass (hectares)	22-34 hectares	Fodder crops such as dwarf elephant grass are integrated into the agroforestry system for local livestock.

Source: Observation data (2024)

Community involvement and contribution in this capstone project are crucial as a form of feedback to ensure the success and sustainability of the program. The community actively participated in every stage, from the selection of biopharma plant species to management techniques that are suitable for their land conditions. Their contribution in the form of land provision, labor, and local insights into environmental conditions is an important foundation. In addition, they provide direct feedback on the effectiveness of the training provided, as well as challenges faced in implementing new techniques, such

as limited access to water during the dry season or lack of processing tools. One of the problems that often arises is that adaptation to new techniques in agroforestry requires additional time and money. To address this, periodic evaluations and adjustments to the methods are necessary so that the program can be truly beneficial and sustainable (Table 2).

Table 2: Willingness to Contribute to Society Estimation.

Aspects Researched	Parameters	Estimation	Description
Farmer Involvement in Agroforestry	Percentage of farmers who understand agroforestry	85%	From a total of 50 farmers interviewed, 85% stated that they understood the concept of agroforestry and biopharma.
Acceptance of Biopharmaceuticals	Percentage of farmers who agree with biopharmaceuticals	90%	The majority of farmers interviewed supported the planting of biopharmacia as part of agroforestry.
Main Constraints Faced by Farmers	Percentage of cost constraints	65%	From the total interviews, 65% of the farmers mentioned limited capital as the main constraint in agroforestry.
Knowledge of Carbon Reserves	Percentage of farmers who know the importance of carbon measurement	40%	Only 40% of farmers understood the importance of carbon measurement in agroforestry systems.
Effect of Agroforestry Programme on Income	Increase in the average income of farmers	20%	On average, farmers reported a 20% increase in income from biopharmaca agroforestry.

Source: Social Innovation and Community Engagement Workshop 2024

Table 3 shows that community awareness of the importance of the carbon sequestration measurement and enhancement program in this capstone project is built through ongoing education and socialization that involves explaining the positive environmental and economic impacts of agroforestry [13]. This activity also supports climate action (SDG 13) by prioritizing plants that act as carbon sequestration, which helps reduce the impact of climate change while increasing community resilience to extreme weather conditions [14]. By understanding that biopharmaca agroforestry not only increases income but also plays a role in climate change mitigation, communities are motivated to be more actively involved in maintaining and developing their land [15]. This education includes an explanation of the process of carbon sequestration by plants, as well as its impact in reducing global carbon emissions. Through trainings and discussions guided by academics, communities are invited to participate in carbon sequestration monitoring activities as part of their collective responsibility. This awareness also encourages their commitment to conserving terrestrial ecosystems (SDG 15) with a focus on soil

restoration and reducing the use of chemical fertilizers, which play an important role in maintaining biodiversity and the sustainability of forest environments [16]. With an integrated ESG approach, this capstone project is a concrete step in achieving all three SDGs.

Table 3: Support and Collaboration Level for Capstone Project.

Aspects Researched	Parameters	Results	Description
Community Participation in Discussion	Number of FGD participants	30 respondents	Total participants who attended FGDs on agroforestry and biopharma.
Environmental Awareness	Percentage of participants who are aware of the importance of environmental conservation	70%	From the FGDs, 70% of participants expressed awareness of the importance of protecting the environment with agroforestry.
Support for the Carbon Measurement Programme	Percentage of participants who support carbon measurement	60%	60% of participants expressed the importance of including carbon measurement in agroforestry programs.
Collaboration with Timber Company	Percentage of participants who agree with Collaboration	75%	Most FGD participants stated that collaboration with timber companies is important for sustainability.
Sustainability of the Agroforestry Programme	Percentage of participants who believe agroforestry program can be sustainable	80%	80% of participants were optimistic that agroforestry programs supported by biopharmaca would be sustainable.

Source: Social Innovation and Community Engagement Workshop 2024

The flow of this capstone project is designed to strengthen ESG (Environmental, Social, Governance) aspects through several stages of activities (Figure 3). Firstly, forage quality testing is conducted to ensure that the crops produced are highly nutritious for livestock. Through increased crop and feed productivity, the program promotes inclusive economic growth (SDG 8) for forest communities with a dynamic relationship between eco-innovation and biopharmaca agroforestry [11]. Furthermore, biological N fixation is applied to improve soil fertility without the need for chemical fertilizers, thereby reducing environmental pollution. Soil restoration efforts are implemented to restore degraded land, which in turn supports increased crop productivity and feed production [17]

i The program also focuses on developing climate resilience by selecting crops that can withstand extreme weather conditions. In addition, the plants in this agroforestry act as significant carbon sequestration, supporting climate change mitigation and fertilizer saving through improving the natural fertility of the soil [18]. Finally, bio-pharmacology security is guaranteed through quality control of medicinal plants, which become an

alternative source of income for the community [19]. Some recommendations for further activities that need to be carried out to strengthen ESG as the foundation of this capstone project include:

ii Provision of a series of workshops and focused research that supports implementation and social and economic development [20]. Workshops could focus on practical training in several key areas, such as forage quality monitoring techniques, biological N fixation methods, and best practices in soil restoration. Workshops should also involve the community and academics to build a thorough understanding of the long-term impacts of these activities [21], especially about climate resilience and bio-pharmacology security.

iii Environmental impacts are related to the cooperative's role in maintaining the sustainability of the forest ecosystem through the ESG approach [22]. Through integrated agroforestry management, the cooperative helps protect and restore forest ecosystems by planting biopharmaca plants that have soil conservation functions and enrich biodiversity. Planting fodder grass under forest trees also prevents erosion and improves soil fertility [23]. Co-operatives can establish environmental monitoring systems that track changes in soil and water quality as part of ESG reporting [24].

iv Further research could be directed at monitoring the effectiveness of agroforestry in increasing carbon sequestration and fertilizer saving to ensure the sustainability of community forest cooperatives [25]. By applying the principles of transparency, accountability, and participation, cooperatives create an inclusive governance system. Collective decision-making involving all cooperative members enables agreements that support sustainability and increased agroforestry productivity [26].

v Long-term environmental impact studies (environmental pollution) as well as crop productivity and feed production analyses can also be conducted to measure sustainability and economic added value [27]. These studies will provide evidence-based data to support program sustainability while increasing community awareness and capacity in agroforestry-based environmental management. [28].

To strengthen this project, collaboration between industry and academia is crucial. Academia can contribute through research on innovative technologies, environmental impact analysis, and ESG-based supply chain management. On the other hand, industry can support through funding, technology transfer, and providing markets for agroforestry products. The main recommendations for strengthening this collaboration are to increase industry immersion programs, where academics actively participate in

the industrial process, and to facilitate applied research that directly addresses industry needs related to sustainable natural resource management. This synergy will strengthen ESG implementation in community forest cooperatives and support sustainable agroforestry growth. Challenges that must be overcome include limited market access for biopharmaceutical products and odot grass for animal feed, lack of supporting infrastructure, and the need to increase the managerial capacity of cooperatives [30]. However, great opportunities still exist through collaboration with the private and government sectors, as well as access to smart agricultural technologies that can increase efficiency and production yields

4. Conclusion

The achievement of Sustainable Development Goals (SDGs) 8, 13, and 15 is highly dependent on the active involvement of communities around the forest, especially in the implementation of biopharmaceutical agroforestry practices. Through various research methods, such as Participatory Rural Appraisal (PRA), In-Depth Interviews, Focus Group Discussions (FGD), Case Study Analysis, and Ethnographic Study, it was found that community participation in natural resource planning and management can improve economic welfare, climate change mitigation, and biodiversity conservation. The success of this agroforestry program not only contributes to the achievement of SDG targets but also strengthens community resilience to environmental challenges.

To improve the effectiveness of the biopharmaceutical agroforestry program and the achievement of SDGs, it is recommended that the government and related organizations develop training and extension programs that are based on local needs and values. Extension of sustainable agricultural practices and climate change mitigation techniques should be an integral part of these initiatives. In addition, building cooperative networks among farmers can improve access to markets, strengthen bargaining positions, and increase community incomes.

It is important for all stakeholders, including governments, non-governmental organizations, and academics, to work together to develop policies and strategies that support the sustainability of agroforestry. This collaboration must take into account the social and cultural context of local communities to achieve optimal results. Strengthening community capacity in natural resource management, together with advocacy for policies that support sustainability, will make a significant contribution to achieving SDGs 8, 13, and 15, as well as creating a more sustainable environment for future generations.

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