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Evaluating the sustainability of forest utilization in the protected areas of Mandalagiri Forest, West Java, Indonesia

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Abstract. *Mutaqin F, Nurrochmat DR, Supriyanto B. 2023. Evaluating the sustainability of forest utilization in the protected areas of Mandalagiri Forest, West Java, Indonesia. Biodiversitas 24: 2745-2755.* Forests have tangible and intangible benefits, which can be included accordingly in vital sectors for development. Currently, forest management mainly focuses on timber extraction while paying less attention to Non-Timber Forest Products (NTFPs) and environmental services. It causes timber production to decrease yearly and a decline in the forestry sector's contribution to the state's income. The Forest area covers more than 60% of the Indonesian land surface, but the sector's contribution to the national Gross Domestic Product (GDP) in 2022 was only 0.6%. It implies that there is a need for more efforts to increase the productivity of the forestry sector and its contribution to the national economy. One of the institutions that have the potential to optimize the utilization of forest areas is the Mandalagiri Forest Management Resort, West Java, Indonesia. Cultivated commodities come from NTFPs (pine gum and coffee) as the primary commodities. This area's management applies a social forestry system by cooperating with the community. These ongoing activities have not been able to significantly contribute to the regional stakeholders (government) or the community. Therefore, this study aimed to create an efficient concept of optimal forest utilization in running a business and managing social problems and describes the results of identifying enabling factors to encourage the application of multi-business forestry in protected areas. The feasibility of sustainable forest utilization was measured through an analysis of social acceptance, financial analysis (Net Present Value, Benefit-Cost Ratio, and Internal Rate of Return), and an analysis of the ecological feasibility of the model that has been built. The research ended with identifying enabling factors from a policy, social and environmental perspective. This study concluded that forestry multi-business could be carried out in this location because it can potentially restore biophysical conditions and support forest and land rehabilitation efforts. In addition, various selected plant species can contribute to strengthening the soil, reducing the rate of surface water run-off, and enriching the crop. Financially, the forest multi-businesses are feasible to apply with NPV>0, BCR>1, and IRR>I. Ecologically, these schemes can reinforce biophysical conditions.

Keywords: Forest multi-businesses, optimazion of area utilization, protected areas

INTRODUCTION

Indonesia's forest area is one of the largest in the world. According to the National Forestry Plan (revised RKTN 2022), the land forest area is 125.81 million ha. It consists of 27.40 million ha of conservation, 29.57 million ha of protected, 26.77 million ha of limited production, 29.22 million ha of fixed production, and 12.84 million ha of convertible production forests spread throughout all regions in Indonesia. Forests have tangible and intangible benefits, which can be included in vital sectors for development. Currently, in the management of forest use, there is still an overlap, causing many Non-Timber Forest Products (NTFP) to be wasted at the time of exploitation (Erbaugh et al. 2017) and might reduce the environmental services (Rossita et al. 2021).

The forestry sector's Gross Domestic Product (GDP) contribution to the National GDP in 2022 was 0.6% or IDR of 112 trillion (Indonesia Central Statistics Agency 2021). GDP is a record of the monetary value of the final goods and services produced by economic sectors in a country for one year (Nurrochmat et al. 2022). It shows that the forestry sector's contribution to state income is small. Therefore, more efforts are needed to optimize business in the forestry sector to increase the contribution from an economic point of view. Optimization must be based on sustainability principles, rules, and regulations, considering biophysical, social, and institutional aspects (Sukwika et al. 2016; Nurrochmat et al. 2020 and 2021b). One of the institutions with the potential to carry out optimization is *Perum Perhutani* because this company is a State-Owned Enterprise entity that operates business units in the forestry sector.

The Mandalagiri Forest Management Resort (RPH) is the smallest management unit in the Cikajang Sub-Forest Management Unit (BKPH) Section. It is included in the Garut Forest Management Unit (KPH Garut) and the category of protected forest areas. The pattern of forest area management at this location is classified as regressing with low productivity of forest products and the absence of other business options. These forest areas contribute less to Perum Perhutani's income, although it has sourced productivity from NTFPs (pine gum and coffee) as the primary commodities. This area's management applies a

social forestry system by cooperating with the community. These ongoing activities have not been able to contribute to regional stakeholders or the community significantly.

Furthermore, the poor biophysical situation of the area due to the rampant encroachment is an additional burden for managers in restoring the function. This location was selected as a case study for applying area utilization optimization with a forest multi-businesses model. Optimizing the use of the area does not focus on economic factors only but also considers the suitability of spatial patterns in the area, financial benefits, potential contributions to corporate income and community welfare, and the ideal policies that can be implemented.

Based on the Directorate General of Sustainable Production Forest Management (PHPL) No. P.1/PHPL/set/kum.1/5/2020, there is a need to carry out business activities and environmental services for optimal land productivity and NTFPs utilization. An efficient concept of optimal forest utilization will be created to run a business, manage social problems, and increase forest land's function and biophysical condition. The forest multi-business model will increase accountability and oversight in forest management, and this model can also reduce the overlap between forest utilization permits (Nurrochmat et al. 2021a). The optimization concept with forest multi-businesses is expected to increase land productivity and diversity, as well as the added value of forestry products, food security, ecotourism, and solve social problems. The forestry sector uses the optimization process to understand the best course of action for a given land scale, given limited resources (Kaya et al. 2016). However, the application of this concept needs to be further developed, analyzed, and tested for feasibility, especially its application in protected areas. Therefore, this study examined the feasibility of forest multi-businesses regarding social, economic, and ecological aspects. It also analyzed the possible factors that can encourage the application of forest multi-businesses in the Mandalagiri area, which has a protected function. Utilization of protected areas can be a connectivity solution between increasing economic value, social welfare, and forest protection (Diniz et al. 2022).

MATERIALS AND METHODS

Study area

The study was carried out from March to July 2021 at Mandalagiri Forest Management Resort and three villages surrounding the forest area, namely Margamulya, Simpang, and Cikandang Village, Cikajang Sub-District, Garut District, West Java, Indonesia, as indicated in Figure 1.

Study procedures

Tools and materials

The tools used in this study were GPS, Avenza maps, stationery, street boards, voice recorders, cameras, questionnaires, and a set of computers (laptops) integrated with Microsoft Office software, ArcMap 10.5, and ArcMap 10.8. Meanwhile, the materials used were data on measurement results in the field, interview data, reports and supporting documents from Mandalagiri RPH, Watershed Management Hall Cimanuk-Ciitanduy, and other supporting data obtained from other literature such as scientific articles including journals and proceedings, as well as books, and news.

Data collection

This study employed four techniques to gather data and information, namely: (i) Observation in the field, which included surveying potential NTFP-producing plants that can be developed; (ii) Direct interviews with selected respondents; (iii) Collecting secondary data from documents or reports belonging to the agency or company; and 4. Literature studies of scientific articles, books, and other relevant sources, as summarized in Table 1.

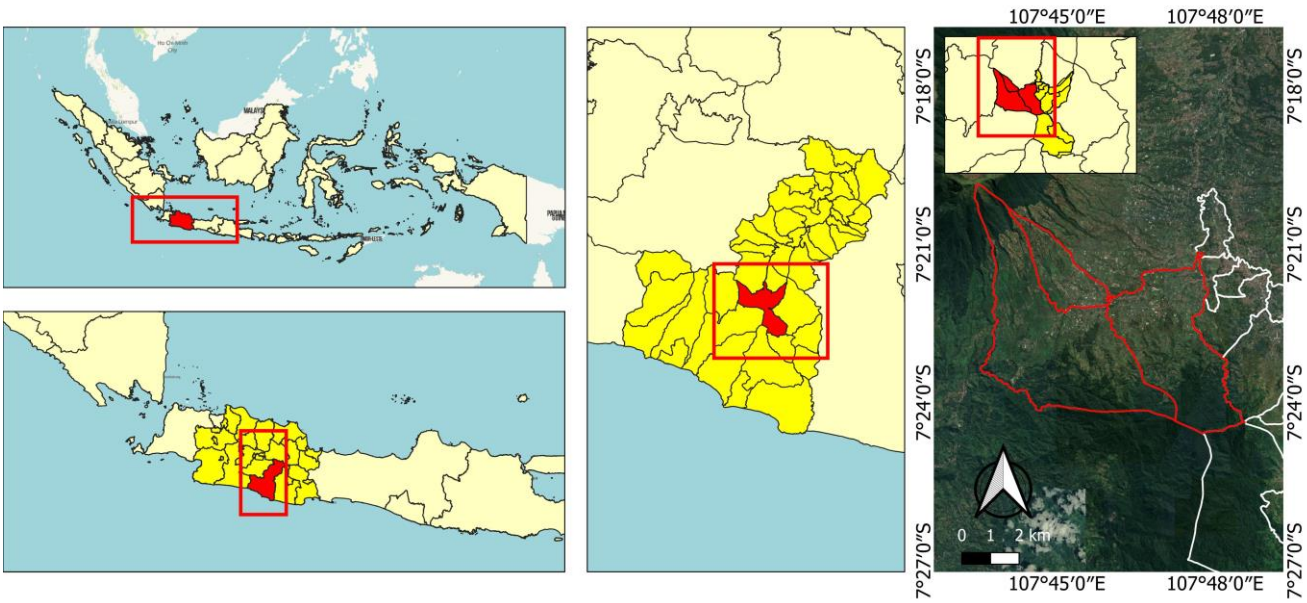

Figure 1. Study maps area in Cikajang Sub-District, Garut District, West Java, Indonesia

Respondents who were interviewed for points 1 and 2 totaled 51 people who were determined by purposive sampling with criteria that emphasized cultivators in forest areas and had a source of income from forest area utilization. In seeking information for points 3 and 4, in-depth interviews were conducted with key informants (Head of Mandalagiri Forest Management Resort, ranger, Village Head, Head of Forest Village Community Institution, and Head of Forest Farmers Group). Respondents were determined by the snowball method. Information search for points 3 and 4 was also carried out by analyzing regulations, scientific articles, and other sources related to forest utilization patterns in the Perum Perhutani area.

Data analysis

Implementing forest multi-businesses

In using forest areas, this study analyzed the social, economic, environmental, and supporting factors that can encourage the implementation of forest multi-businesses (Nurrochmat et al. 2021a). These stages are interrelated; hence, each process has a significant position, as illustrated in Figure 2.

Determination of potential plant types

The first screening was conducted by identifying the existing conditions of plants in the field, the growing site's feasibility, and the biophysical characteristics. Afterward, the proposed plants were viewed legally, and the screening was carried out with several social, economic, and environmental criteria in determining the plant types. The suitability and validity the plants selected was assessed by referring to the Regulation of Minister of Environment and Forestry (MoEF) No. 8 of 2021, No. 9 of 2021, and No. 23 of 2021. The social aspect was the potential of timber plants that the community and regional stakeholders can accept. These woody plants can be hardwood or Multi-Purpose Tree Species (MPTS). Another factor considered in determining the type of wood is the magnitude of its influence on the economy which was analyzed through financial feasibility analysis.

Financial feasibility analysis

The financial feasibility of using the multi-business forestry model as an optimization effort was carried out using an approach to Net Present Value (NPV), Benefit Cost Ratio (BCR), and Internal Rate of Return (IRR) (Žižlavský 2014; You et al. 2016; Zhan et al. 2019).

Net Present Value (NPV)

NPV is a method used to calculate the difference between the current investment value or capital outlays of income and current costs/expenses or present value of proceeding, both from cash flow operations and terminals in the future during the life of the investment. Therefore, a project is feasible when NPV > 0 (Žižlavský 2014). The equation of such NPV is as follows:

$$NPV = \sum_{t=0}^{n} \frac{Bt - Ct}{(1+i)^t}$$

Where:

NPV : Net Present Value (IDR)
Bt : Benefits in the year-t
Ct : Costs in the year-t
I : Interest rate
T : Year
N : Project cycle

Investment criteria based on NPV are: (i) NPV: 0 means the project can return as much as usual production capital. In other words, the project is not profitable or not lost. (ii) NPV: 0 means a project has been declared profitable and can be implemented. (iii) NPV: 0 means that the project does not generate the value of the costs used.

Benefit Cost Ratio (B/C Ratio)

The gross B/C is the ratio between discounted total benefits and costs. A project is considered feasible when the B/C value > 1. BCR is also calculated as the Present Value (PV) of benefits divided by the Present Value (PV) of cost (Shively and Galopin 2013). The equation for calculating the B/C ratio is as follows:

$$BCR = \frac{\sum_{t=1}^{n} \frac{Bt}{(1+i)^t}}{\sum_{t=1}^{n} \frac{Ct}{(1+i)^t}}$$

Where:

B/C Ratio : Benefit Cost Ratio
Bt : Benefit in the year-t
Ct : Cost in the year-t
i : Interest rate
t : Year
n : Project cycle

The investment criteria based on the Net B/C Ratio are:

Net B/C = 1, then NPV = 0, the project does not profit and does not lose.

Net B/C > 0, then NPV > 0, profitable projects.

Net B/C < 0, then NPV < 0, the project is detrimental.

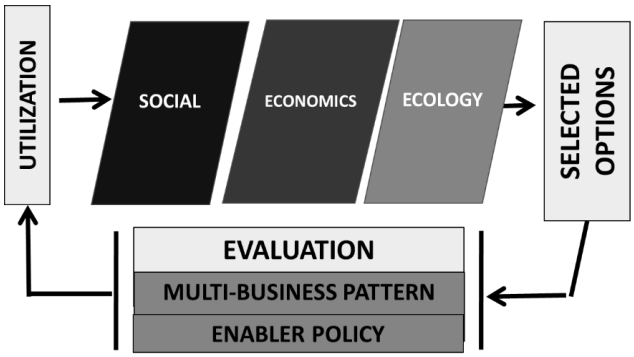

Figure 2. The concept of screening in forest utilization (Nurrochmat et al. 2021a)

Table 1. Stages of study, data types, sources, and collection techniques

Stages of study	Data type	Data sources	Data collection techniques
Interviewing the community's acceptance of potential types of plants that can be planted at the study site	• Interview notes	• Key-informants	• In-depth interview (purposive sampling with snowball method)
Searching data for the cost and operating income components of NTFP and environmental services	• Business components of costs and revenues	• Key-informants • Scientific articles and other sources	• In-depth interview • Literature study
Studying of the regulation on forest utilization in RPH Mandalagiri	• Substances of laws and regulations concerning forest utilization, including agreements with farmer groups	• Key-informants • Laws • - Regulation	• In-depth interview • Literature study
Analyzing the enabling factors of forest multi-businesses	• Data on enabling factors for the implementation of forest multi-businesses from a regulatory, social, and environmental perspective	• Key-informants • Scientific articles and other sources	• In-depth interview • Literature study

Internal Rate of Return (IRR)

The internal rate of return is an interest rate that makes NPV equal to zero because the present cash flow value at the interest rate is the same as the internal investment. IRR is widely used to rank capital budgeting projects and eventually accept or reject decisions (Dhavale and Sarkis 2018). The IRR method can calculate an interest rate that equates the present value of the investment with the present value of net revenue. This method is a tool to measure the rate of return on internal results and consider the time value of money. Hence, the cash flow can be discounted based on the cost of capital/interest rate/required rate of return. A project is feasible when the IRR > i. The IRR can be calculated with the following equation:

$$IRR = i1 + \frac{NPV1}{NPV1 - NPV2} \times (i1 - i2)$$

Where;

IRR : Internal Rate of Return
i1 : Interest rate that will produce a positive NPV
i2 : Interest rate that will produce a negative NPV
NPV1 : Positive NPV
NPV2 : Negative NPV

The criteria for decision-making using the IRR method are as follows:

The investment project is worth implementing when the IRR exceeds the level of capital costs.

The investment project is rejected when the IRR is less than the level of capital costs.

Measuring ecological feasibility

Two analyses were conducted to determine the feasibility of various plant types in ecology. The first analysis was performed through a literature study of the functions and benefits of selected plants for the environment, including resisting erosion, landslides, and floods. The second stage involved determining the degree of invasion for plant-chosen types. When the selected plant is not considered invasive, it is feasible to plant and cultivate. Invasive species are native or non-native species, which broadly affect their habitat, and may cause environmental damage, economic loss, or harm to humans. The invasive plant is a significant threat to ecosystem functions (Gallardo et al. 2017). The reduction of biodiversity may directly affect the carbon storage capacities of ecosystems (Lange et al. 2015) and their resilience to climate extremes (Isbell et al. 2015). In addition to reducing biological diversity, it significantly causes health and economic damage (Early et al. 2016). Alien species are not always invasive, while invasive species are not necessarily of external/foreign origin. Invasive Alien Species (IAS) combines alien and invasive species.

Identify enabling factors

In applying a model to contextual conditions in the field, it is necessary to consider various enabling factors, including policy, institutional, social, economic, and regional biophysical conditions. Those mean variables that are sufficient and necessary conditions or allow to facilitate a person's behavior or group of people (Gilmore 2013).

Knowledge is the basis of a policy (Wiradi 2017) and the basis of the government in running the program (Purwawangsa et al. 2022). Science can identify various variables that become obstacles and identify solutions that significantly influence socioeconomic conditions, and it can also engineer the physical requirements of an area. In this regard, this research identifies and analyzes enabling factors that can support how knowledge, in this case, the forest multi-businesses, can be applied by both the government as policymakers and entrepreneurs or communities as business actors in the forestry sector. The enabling factors are related to legal, social, and economic aspects. This enabling factor is also expected to encourage entrepreneurs and other actors in the forestry sector to understand better the economic context and how to emerge a proactive role in implementing this multi-business forestry model.

RESULTS AND DISCUSSION

Types of existing and potential commodities

Various potential plants that can be developed in the Mandalagiri Forest Management Resort area were identified at this stage. Existing plants are suitable for the biophysical conditions, including soil type, rainfall, altitude, as well as the contour and the ground slope of the

research site. The various types of plants commonly planted are perennials, MPTS, intercrops, and horticulture, as indicated in Table 2. There are six types of perennials, five MPTS plants, six perennials, and seven vegetables with grass plants.

The above-mentioned plants are allowed for forest utilization in MoEF Regulation Number 8 of 2021. These plants also have the variety for reforestation according to the allotment of forest areas and local agro-climates. They are in demand by the community based on MoEF Regulation Number 23 of 2021. Researchers collected input from respondents to measure feasibility from a social perspective using the method in Table 1. Most respondents choose to plant several types, including five perennials, one fruit-producing kind of plant, and three intercrops. Plants that have gone through the initial screening stage proceeded to the next step, namely, economic feasibility analysis.

Financial feasibility of forest multi-businesses in Mandalagiri Forest Management Resort

In this section, the use of areas with various selected plant species was re-measured for their feasibility from an economic standpoint through financial feasibility analysis. Three schemes were used in this analysis, namely: (i) Agroforestry and seasonal garden intercropping, (ii) Agroforestry with annual crops, and (iii) Annual crop commodity enrichment (Table 4). This simulation refers to MoEF regulation No. 8 of 2021, which states that in the agroforestry pattern, plantations of annual timber and timber forests and other types can be planted in a strip pattern, alternating plots, or a block system. The selection of agroforestry patterns can also be carried out by adjusting the conditions of the land/location and the local community's needs.

Based on the MoEF Regulation Number 2021 Article 118, Business activities for Utilization of Protected Forest Areas are carried out under the following conditions: (i) Do not reduce, change, or eliminate their primary functions; (ii) do not harm the biophysical and socioeconomic; (iii) do not use mechanical devices and heavy equipment; and (iv) not building facilities and infrastructure that change the landscape. The multi-business pattern is very suitable to be applied in protected forest areas in Mandalagiri Forest Management Resort because its implementation considers these principles. Thus, even though it is a protected area, optimizing the site can still be carried out to increase land value.

This simulation refers to the regulation of MoEF No. 8 of 2021 Article 117, which states that in the agroforestry pattern, woody forest, annual woody cultivated plants, and other types can be planted through paths, intermittent plots, or blocks. The selection of agroforestry patterns can also be made by adjusting to the suitability of the land/site conditions and the local community's needs. This study shows that, financially, the forest multi-businesses are feasible to be applied, either using schemes 1, 2, or 3 because all three have NPV>0, BCR>1, and IRR> I (Magni and Marchioni 2020) (Table 4).

Figure 3 shows a graph of the total costs and revenues of the three analyzed schemes. Based on the results, scheme-1 will experience profit in year 3, scheme-2 in 4-5 years, and scheme-3 in year 3. Scheme-1 and 2 tend to fall in the 15^{th}-17^{th} year because the citrus plants have begun replanting. Therefore, the costs incurred will be substantial at the beginning of the business/utilization because there are many variables of preparation and investment to be carried out.

Ecological feasibility

The first stage of analysis in measuring ecological feasibility was to identify the benefits and functions of the plant. The site's suitability for growing plants is the most critical ecological feasibility factor. Table 5 shows the ecological functions and benefits of selected plants.

Table 2. Various types of existing plants at the study site (in Latin name and Indonesia local names)

Existing plants			
Perennials	**MPTS plants**	**Interlacing plants**	**Horticulture**
Pinus merkusii (Pinus)	*Persea americana* (*Alpukat*)	*Coffea arabica* (*Kopi Arabica*)	*Brassica oleracea var. capitata* (*Kol*)
Eucalyptus (Eucalyptus)	*Artocarpus heterophyllus* (*Nangka*)	*Coffea canephora* (*Kopi Robusta*)	*Solanum tuberosum* (*Kentang*)
Altingia excelsa (*Rasamala*)	*Syzygium aqueum* (*Jambu Air*)	*Citrus limon* (*Jeruk lemon*)	*Daucus carota* (*Wortel*)
Toona sureni (*Suren*)	*Cinnamomum verum* (*Kayu Manis*)	*Citrus × aurantiifolia* (Jeruk Nipis)	*Capsicum frutescens* (*Cabai*)
Swietenia mahagoni (*Mahoni*)	*Psidium guajava* (*Jambu Batu*)	*Citrus hystrix* (*Jeruk Purut*)	*Brassica rapa* subsp. *Pekinensis* (*Sawi Putih*)
Schima wallichii (*Puspa*)		*Citrus nobilis* (*Jeruk Siam*)	*Solanum lycopersicum* (*Tomat*)
			Pennisetum purpureum (*Rumput odot*)

Table 3. Types of expected plants to cultivate (in Latin and local names)

Perennials	**NTFP producing plants**	**Interlacing plants**
Eucalyptus (*Eucalyptus*)	*Persea americana (Alpukat)*	*Coffea arabica (Kopi Arabika)*
Altingia excelsa (*Rasamala*)		*Citrus Nobilis (Jeruk Siam)*
Toona sureni (*Suren*)		*Pennisetum purpureum (Rumput odot)*
Swietenia mahagoni (*Mahoni*)		
Schima wallichii (*Puspa*)		

Table 4. The results of the calculation of NPV, BCR, and IRR of forest multi-businesses in Mandalagiri Forest Management Resort, West Java, Indonesia

Indicators	Utilization patterns		
	Agroforestry of long-term and medium-term crops combined with intercropping of annuals	Agroforestry of long-term and medium-term crops	Enrichment of perennial plants
NPV (IDR)	726,327,782.13	373,798,077.61	194,822,961.38
BCR	1.26	1.12	1.17
IRR (%)	40.64	21.64	28.65
Revenue per month (IDR)	36,148,632.38	36,866,361.94	13,210,576.92
Monthly Profit (IDR)	9,182,120.60	7,349,081.13	2,852,698.40

Table 5. Functions and ecological benefits of plants to be developed in Mandalagiri Forest Management Resort, West Java, Indonesia

Plant species	Functions	Benefits	Source
Persea americana (*Alpukat*)	• Having a robust root system which can bind the soil	• Increasing biodiversity • Able to withstand erosion and surface flow again	(BNPB 2021)
Coffea arabica (*Kopi Arabica*)	• Having a robust taproot to a depth of 3 meters and lateral roots up to 2 meters deep, with a thickness of about 0.5 meters from the soil surface and forming a webbing in all directions. This property can protect and hold the soil from the erosion power of rainwater.	• Strengthening ecological cycle processes • Slowing down the flow of rainwater in the ground • Conserving utilization zone • Improving forest cover strata	(Méndez et al. 2016) (BNPB 2021) (Suwarno et al. 2022)
Citrus nobilis (*Jeruk Siam*)	• Conserving utilization zones	• Able to withstand the surface flow rate.	(BNPB 2021)
Eucalyptus (*Eukaliptus*)	• Able to grow in general edaphic conditions and is quite good, especially for reforesting on dry and wet soils.	• Growing fast and adapting well to various conditions. Hence, it can bind the soil and absorb water well	(Latumahina and Lihawa 2020)
Altingia excelsa (*Rasamala*)	• Having good resistance to various climatic conditions. • Widely used for the rehabilitation of protected forests	• Having a powerful root system, which can bind the soil.	(Istomo and Sari 2019)
Toona sureni (*Suren*)	• Used for pest control of plant diseases and serving as natural biopesticides for surrounding plants	• Able to withstand the surface flow rate.	(BNPB 2021)
Swietenia mahagoni (*Mahoni*)	• Forming buttress and surface roots that weave each other when the soil is dense. • Establishing nutrient safety networks in various layers of the soil	• Shedding leave in the dry season for their defense and forms series to lower surface flow • Functioning as a shade plant • Having a deep root for binding the soil and has a low evapotranspiration rate.	(BNPB 2021)
Schima wallichii (*Puspa*)	• At the time of the collapse, the saplings will overgrow, especially when the rain falls to wet the forest floor	• Having thick bark, making it fire resistant	Rana et al. 2021
Pennisetum purpureum (*Rumput odot*)	• Having symbiotic relationship with other plants through its roots to provide nutrients	• Conserving soil, especially in mountainous areas, contour areas and steep terrain.	Zaini et al. 2021

Table 5 indicates that various selected plants were ecologically suitable. They cover lands and prevent them from erosion and flooding (BNPB 2021). The second stage in the analysis of this section was to examine the degree of invasion for the selected plants. Based on the literature study, these plants are not considered invasive and will not damage the ecosystem or the interdependence of plants. In other words, the selected plants are not invasive and disrupting other plants. Invasive plants have the characteristics of fast growth and reproduction, high spreading ability, wide tolerance to environmental conditions, ability to live with diverse types of feeding, asexual reproduction, and association with humans. In addition, these plants are not included in the worst invasive

alien species, according to the International Union for Conservation of Nature and Natural Resources (IUCN). Hence, they are not harmful to other plants.

One of the functions of protected areas in Mandalagiri is as a Forest and Land Rehabilitation (RHL) area. Consequently, its existence protects the surrounding area from natural disasters such as floods, landslides, and droughts. Furthermore, RHL can be carried out based on community welfare through forest multi-businesses in utilization blocks. Such conditions align with the study's purpose and objectives, namely, to provide an optimal pattern of space utilization by considering ecological, economic, and social feasibility.

Based on the MoEF Regulation No. 23 of 2021 Article 4, rehabilitation can be carried out to restore the hydrological function of the watershed and increase the production of NTFP and environmental services. Figure 4 below shows that forest multi-businesses can produce various benefits by selecting the appropriate type and field criteria for its designation or utilization block.

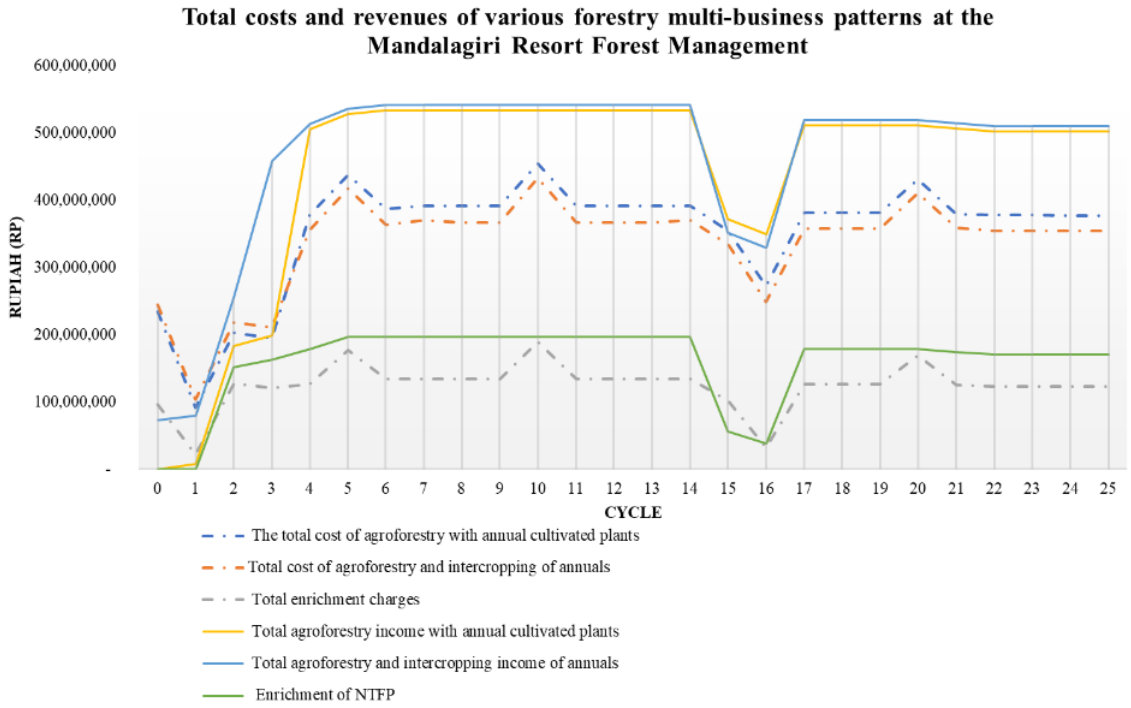

Figure 3. Total costs and revenues of various forest multi-business patterns in Mandalagiri Forest Management Resort, West Java, Indonesia

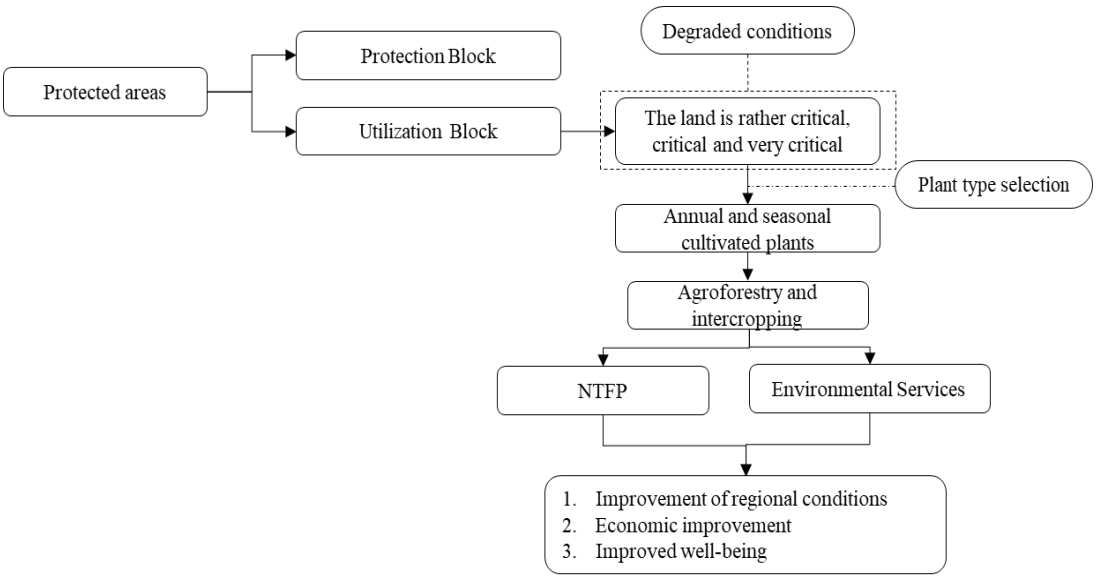

Figure 4. The multi-business scheme in efforts to rehabilitate forests and land

Enabling factors for forest multi-businesses

Regulative factors

Some regulations were identified as enabling factors for forest multi-businesses:

(i) Regulations at the central government level:

- Government Regulation of the Republic of Indonesia No. 23 of 2021 concerning the Implementation of Forestry.
- Government Regulation of the Republic of Indonesia No. 24 of 2021 concerning Procedures for Imposing Administrative Penalties and Procedures for Non-Tax State Revenues Derived from Administrative Fines in the Forestry Sector
- Government Regulation No. 43 of 2021 concerning the Settlement of Non-Conformities in Spatial Planning, Forest Areas, Permits, and Land Rights.

(ii) Regulations at the level of the Ministry of Environment and Forestry:

- Regulation of the Minister of Environment and Forestry of the Republic of Indonesia No. 8 of 2021 concerning Forest Management and Preparation of Forest Management Plans, as well as Forest Utilization in Protected Forests and Production Forest;
- Regulation of the Minister of Environment and Forestry of the Republic of Indonesia No. 9 of 2021 concerning Social Forestry Management;
- Regulation of the Minister of Environment and Forestry of the Republic of Indonesia No. P.39/Menlhk/Setjen/Kum.1/6/2017 concerning Social Forestry in the Perum Perhutani Work Area.
- Regulation of the Minister of Environment and Forestry No. 23 of 2021 concerning the Implementation of Forest and Land Rehabilitation.
- Regulation of the Minister of Environment and Forestry of the Republic of Indonesia No. 3 of 2021 concerning Business Activity Standards in implementing Risk-Based Business Licensing in the Environment and Forestry Sector.

(iii) Regulations at the Perum Perhutani level:

- Decree of the Chairman of the Supervisory Board of Perum Perhutani No. 136/Kpts/Dir/2001 concerning Community Base Forest Management (CBFM) as a form of Social Forestry.
- Decree of the Board of Directors No. 268/Kpts/Dir/ 2007 concerning Guidelines for CBFM PLUS;
- Surat Decree of the Board of Directors of Perum Perhutani No. 682/Kpts/Dir/2009 concerning CBFM Guidelines.

Socioeconomic and environmental factors

The essential socioeconomic factors enabling the implementation of forest multi-businesses are the commodities that provide economic benefits at low operational costs. Coffee is one of the proposed commodities that is socially acceptable and economically feasible for forest multi-businesses. Mandalagiri area is currently one of the best coffee producers in West Java Province. Socioeconomic factors are essential in successfully implementing community-based forest multi-business in protected areas (Adalina et al. 2014). To ensure the implementation of the forest multi-business concept, operational costs it is necessary to ensure that operational costs must be based on the ability of the community or partner investor. The market should be accessible, and price stability must be maintained.

In principle, the community is willing to protect the forests in Mandalagiri Resort as long as they benefit economically and environmentally through water availability, preventing erosion, floods, and landslides. Increasing income and prosperity are the main economic factors the community considers for participating in forest multi-businesses. The community expectations include expanding agroforest land and forming long, medium, and short-term plant strata ecosystems. Long-term crops have the primary protection function in the area, and other functions include providing economic value, for example, the Multi-Purposes Tree Species. Medium-term crops, such as coffee and orange, provide economic and ecological functions. These crops have a good protection function and provide a considerable income in the medium term. Meanwhile, short-term crops are expected to have the primary function of providing economic value and minor ecological functions, for example, *Odot* grass.

The concept of the three strata of plants discussed is a form of agroforestry that affects the plant strata and three types of income. Short-term crops can provide economic benefits within a year, while medium-term crops provide additional economic benefits in the second and third cycles. In the local language, this is often called *"Jangka panjang, jangka pendek, dan jangka dapur"*.

Discussion

Social appropriateness

The study results indicate that the potential for developing existing plants at the research location can be implemented after conducting a social, economic and environmental feasibility analysis. In addition, generated plants based on the community's wishes will increase plant biodiversity and species enrichment, strengthening the landscape and increasing people's income. The intersection between the existing plants and the intended plants by the community consists of trees (eucalyptus, *rasamala*, *suren*, *mahoni*, and *puspa*), MPTS (*alpukat*, *nangka*, and *kayu manis*), intercrops (*kopi arabika*/arabica coffee and *jeruk siam*/siamese orange) and annual crops (*kentang/potato* and *rumput odot/odot* grasses). Respondents chose these various types of plants because the selected plants were seen as necessary by the community for increasing fertility, land cover, canopy percentage, soil binding ability and water retention (de Figueirêdo et al. 2016). In addition, crops have clear market access and relatively stable prices. Based on the results, the study could be continued at the financial feasibility analysis stage.

Economic feasibility

Three schemes were used in the financial analysis in scheme-1; the types of plants chosen include long-term crops, medium-term crops, and short-term crops (annuals). Scheme-2 types of plants selected include long-term and medium-term plants, while in scheme-3, the enrichment of NTFP-producing plant species. Scheme-3 was built for

plant enrichment with a spacing of 4 x 4 (625 plants/ha) using annual NTFP-producing plants. The third scheme built is a utilization pattern in the form of agroforestry. According to (Octavia et al. 2022), agroforestry offers an excellent opportunity to support the SDGs for synergy in the agricultural and commodity sectors in food, energy, air, and income.

This study concludes that the most optimal combination of agroforest plants is intercropping of annual crops (scheme-1), with NPV of IDR 726,327,782.13, BCR 1.26, and IRR 40.64%. This scheme provides a potential income of IDR 36,148,632.38 and a profit of IDR 9,182,120.60. The agroforestry scheme of long-term wood perennials and medium-term seasonal crops (scheme-2) provides an NPV of IDR373,798,077.61, BCR 1,12, and IRR 21.64%. Scheme-3 provides an NPV of IDR 194,822,961.38, BCR 1.17, and IRR 28.65%. This scheme had the lowest income of IDR 13,210,576.92 and a profit of IDR 2,852,698.40.

There are four categories of plant species: hardwood plants, MPTS plants, intercrops, and seasonal plants. Scheme one has the highest economic value because of the four categories of plants. Three categories (MPTS plants, intercrops, and seasonal crops) can provide very high economic value. While scheme two only has two varieties (MPTS crops, intercrops) of plants that can produce financial results, scheme three can create economic value from only one category of crops (enrichment with intercrops).

Hardwood plants (*eucalyptus, rasamala, suren, and mahoni*) exist at the study site, while the community chooses Puspa plants for species enrichment. Using these plants for their wood is not recommended because they are used to improve land cover and environmental conditions in protected areas. MPTS plants are types of plants that produce wood and non-timber. In this study, the MPTS referred to are Cinnamon, Avocado, and Jackfruit. Cinnamon is the most abundant plant in the study area, while avocado and jackfruit are not plentiful in the study area. Then the intercrops in question are Coffee and Siamese Oranges, the most cultivated plants at the research location. Researchers also recommend planting seasonal crops, namely Odot Grass, in the research area; apart from providing direct benefits such as animal feed, it is ideal for providing nutrients for livestock growth (Alvarenga et al. 2022). These plants can stabilize slopes, reduce run-off, prevent erosion (Negi et al. 2015; Bhatt et al. 2020), and have a relatively stable and high selling price. MPTS crops, intercrops, and seasonal crops are three categories of plants that can provide economic value to the community because they have a reasonably clear market and relatively stable prices.

Environmental feasibility

Based on measurements of environmental impacts, the concept developed can be applied to this location because it can potentially restore biophysical conditions and support forest and land rehabilitation efforts. Various selected plant species can contribute to strengthening the soil, reducing the rate of surface water run-off, and enriching the crop. These plants are also not considered invasive, so they are very safe to cultivate and cultivate. The multi-business model can support the success of Forest and Land Rehabilitation, considering that the Ministry of Environment and Forestry has designated this area as an indicative area for Forest and Land Rehabilitation. The selected plants have been assessed for the risk of adverse impacts. It is based on studies of invasiveness, such as not having negative interdependence with other plants, and is not a parasitic plant either. In the utilization of protected areas, the diversity of plant species is an essential factor. Case studies on China shows that increasing biodiversity can increase lignin in plants (Wang et al. 2022); plant species diversity is a crucial factor determining the structure, function, and stability of terrestrial ecosystems in arid and semiarid environments (Qian et al. 2022). The research location with an area of 2495.64 is mainly degraded land (849.97 ha) and very degraded (949.43 ha) or approximately 34.06% and 38.04%, respectively, of the total area; therefore, improvement of forest area becomes essential. Using species according to community expectations will benefit protected forest areas positively. Protected forests are intended to protect life support systems by regulating water management, preventing flooding, controlling erosion, preventing seawater intrusion, and maintaining soil fertility (The Minister of Environment and Forestry Republic of Indonesia regulation Number 8 of 2021).

Enabling factors

Four enabling factors were measured: regulatory, social, economic, and environmental. The regulatory aspects are various supporting policies at the central government, ministries, and companies. The social and ecological elements are the habits and expectations of the community to be generated in implementing the multi-business forestry concept. Based on the legal aspect, there are three government regulations, four ministerial regulations, and three regulations from the directors of Perum Perhutani.

The various regulations reflect the government's encouragement to increase the economic value of land through optimized use of forest areas by considering aspects of regional function. In practice, the regulation is constantly undergoing development and adjustment. It is related to the completion of the tenure of forest areas, the efficiency of management by forestry State-Owned Enterprises with a focus on state revenues, company effectiveness, reduction of work areas, and dynamic tenure problems (Suradiredja 2021). Based on these legal aspects, the use of forest areas in Mandalagiri has been implemented since the introduction of the land CBFM policy. Even before the regulation, the community was accustomed to carrying out businesses in forest areas owned by Perhutani.

Another aspect that must be considered is that the forestry sector's GDP is currently very low at 0.66% in 2021 (Indonesia Central Statistics Agency 2021). One of the factors that can encourage increased income from the forestry sector is Social Forestry and multi-business. The products of Social Forestry are currently not included in the

Indonesian Standard Classification of Business Fields. Hence, they are not recorded as forestry products. When products produced from community-based forest management enter the forestry sector and can be claimed as state revenue, policies will be made to strengthen Social Forestry and multi-business.

In principle, the community is willing to protect the forest in the Mandalagiri Forest Management Resort Area, provided they can benefit from economic income and environmental benefits (water availability, erosion and flooding prevention, and landslides). However, the financial income factor is the main focus. In guaranteeing the implementation of this concept, from the social, economic, and environmental aspects, the community hopes that operational costs must be based on the ability of the community or sourced from investors/financiers, easy market access, and stable prices for the products to be cultivated.

The results showed that the community could accept the developed mode with a note of the aspirations they received in selecting plant species. Financially, the basic multi-business pattern was feasible to implement, whether using scheme-1, scheme two, or scheme three, because all three had NPV> 0, BCR> 1, and IRR> i values. From an environmental perspective, this pattern was feasible because it was proven to benefit the environment. Based on the probability factor, there was policy supports at the central government level, policies and companies, and community aspirations regarding environmental sustainability. The community also hoped that investment costs and capital were affordable or could be obtained from investors. These conclusions have implications for conservation while providing stable income opportunities for communities and regional stakeholders.

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