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REGULAR RESEARCH ARTICLE

Why is Multi-Business Forestry Needed to Overcome the Low Performance of Forestry Governance and Food Security in Indonesia?

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ABSTRACT

The 0.6% contribution of the forestry sector to GDP is considered very low despite 64.1% of Indonesia's land area being allocated as forests. Most of the 64.8% production forest allocated is not yet optimized for strengthening national food security, in which Indonesia is ranked 65th in the world. Therefore, an innovative forest management system is needed to synergize timber and non-timber production. This paper presents a multi-business forestry (Mb-F) implementation strategy analyzed through a dynamic system-based multi-criterion decision-making tool named Super Model Mb-F (SM Mb-F). SM Mb-F is built based on a causal loop diagram (CLD), which describes the dynamic relationship between land typology suitability and decisions related to the type of business, commodities, land use area, workload, and financing for many variables relating to 5M business principles and sustainability. Results showed that CLD formulated in 280 sub-models in a total of 4,764 decision variables with an error deviation of 6.4%. The SM Mb-F simulation on two sample concession units produces a projected increase in wood supply, employment, and state revenue, plus the provision of new functions such as food, NTFP, and environmental services. These benefits are obtained by business feasibility. Assuming that gradually until 2030, the Mb-F can be implemented in 32% of Indonesia's production forests, then by 2045, it is projected that there will be an increase in wood production by 296.8%, state revenue by 654.3%, and labor absorption by 985.7%, as well as adding food production up to 19.36 M tons. This is because the land use efficiency of the current operation of forest concessions following the Annual Allowable Cut (AAC) under the selective cutting and replanting system in Indonesia (TPTI) is only about 3% of the total area of forest concession. Assuming the cutting cycle is 35 years, timber could be extracted in 1/35 of the total forest concession area. Implementing Mb-F will significantly improve the land use efficiency from about 3% to 90%. The Mb-F will also restrain the rate of decline in carbon stocks, which is deeper if governance is still under the BAU scenario. This research suggests further global research, emphasizing the importance of innovative models for sustainable forestry governance and food security worldwide.

KEYWORDS
Multi business forestry; Forestry governance; System dynamic; Multi-criterion decision-making; Land optimization.

1. INTRODUCTION

It is an anomaly that as an agricultural country and owner of vast forest areas, Indonesia faces three serious problems simultaneously: i) high forest degradation, ii) food deficit, and iii) low production of forest products (EIU, 2021; FAO, 2020; GFRA, 2020; Izraelov & Silber, 2019; Sahide et al., 2016; Susilastuti, 2017; Tsujino et al., 2016). This anomaly highlights the contrasting data that Indonesia's agricultural land area ratio is meager (0.19 ha/capita). In comparison, about 44.6 million ha or 64.8% of the 68.8 million ha have been allocated for production-forest land, which is not cultivated for co-production of crops (FAO, 2020; MoEF, 2019c; Suryanto & Sayektiningsih, 2020). Indonesia has a reasonably good application of technology to increase its forestry and agricultural productivity (Adalina et al., 2014; Duffy et al., 2021; Tan et al., 2016; Tothmihaly & Ingram, 2019; Mazya et al., 2023). Therefore, the main hypothesis that can be proposed is inefficient governance (Andrianto et al., 2019; Martauli, 2018; Nurfatriani et al., 2019; Nurrochmat et al., 2021; Nurrochmat et al., 2023; Prajanti et al., 2020; Purnomo et al., 2020; Rum & Rijoly, 2020; Sindy & Salam, 2019; Sugiharti et al., 2020). Inefficiencies result in poor governance performance (see Affandi et al., 2021; Fisher et al., 2017), causing the forest sector to contribute only 0.6% to the Gross Domestic Product (GDP) (BPS-Statistics Indonesia, 2019, 2020a; MoEF, 2019b; Suryanto & Sayektiningsih, 2020). This inefficiency is also seen in the agricultural sector, where only 32% of land has been allocated to agriculture, which is lower than the 44%-72% allocated by G-8 developed countries (FAO, 2020). This figure is insufficient to feed the world's 4th largest population (UNPF, 2021), with a growth rate of 1.31% per year (BPS-Statistics Indonesia, 2020a). This condition, among others, causes low food security as Indonesia is ranked 65th in the world (EIU, 2021; Izraelov & Silber, 2019; Susilastuti, 2017).

Following Law 11/2020 as amended with Law 6/2023 on Job Creation, the Multi business Forestry (Mb-F) discourse is proposed to increase efficiency and strengthen performance through optimizing the use of production forest land in providing various environmental products and services, including timber, non-timber forest products (NTFPs), food, ecotourism, conservation, water management, and others (Kindler, 2016; Nölte et al., 2018; Pyatt, 1993; Simončič & Bončina, 2015; Rahmani et al., 2021). Santayana's quote that 'those who cannot remember the past are condemned to repeat it' is in line with anxieties about the effectiveness of Mb-F implementation relating to issues of deforestation (Miyamoto, 2020; Tsujino et al., 2016), employment and land cover change (Maladi, 2013; Margono et al., 2014; Suwarno et al., 2018), illegal logging and fire (Ekayani et al., 2015; Carlson et al., 2018; Schmitz, 2016) as well as land use, ecological, social and economic suitability (Roslinda et al., 2012; Astuti et al., 2020; Rossita et al., 2021), form and pattern (Kassa et al., 2017; Kremen, 2015; Loconto et al., 2020; Paul & Knoke, 2015; Phalan, 2018; Sharma et al., 2018; Szulecka et al., 2016). The anxiety in Mb-F implementation is because Mb-F contains high complexity and risk and provides many choices in its management. Therefore, the key question is how to obtain optimal decisions, namely choices following biophysical conditions, financial and other carrying capacity considerations, and fulfill the principles of sustainability based on ecological, economic, and social criteria and indicators (Barrette et al., 2014; Bonny, 2019; Lambin et al., 2011; Martin et al., 2020; Noer, 2016; Shen et al., 2020; Sheriffdeen et al., 2021). This paper addresses these key questions through a multi-criteria decision-making tool based on spatial analysis, system dynamics, and sustainability strategies.

2. MATERIAL AND METHODS

This paper belongs to the second part of the Mb-F research, where the first part defined sustainability criteria using the content analysis method (Figure 1). Figure 1 also shows the 10 Mb-F sustainability indicators that have been obtained. Through a soft systems methodology approach, the complexity of Mb-F is depicted in causal loop diagrams (CLD) and model formulation, which describes the dynamic relationship between governance issues and decisions that are rooted and formulated into the ten sustainability indicators of Mb-F (Suryanto et al., 2023; Bhatti et al., 2006; Holt & Osman, 2017).

Conceptualization and formulation of the system dynamics model were made using Stella 9.0.2 software. The formulated model was tested in two regional sample units in action research. Feedback was obtained through an iterative testing cycle consisting of simulations (using the Mb-F application model), discussions (with experts), in-depth interviews (with key stakeholders), structural interpretation (of the results of key stakeholder's interviews), disclosure of strategic assumptions (to improve the application model), and testing (testing the improved model in two selected forest concessions). This iterative testing cycle aims to develop and refine the model to make it more comprehensive, reliable, and effective. It also includes user testing to obtain feedback on interface techniques to produce a user-friendly model. The simulation accommodates and processes input data generated from the spatial and business opportunity analyses, including attribute data relating to business types, commodities, and land use areas, as well as workload and financing for data relating to the 5M business principles (method, material, machine, man, money) and sustainability. This simulation produces outputs that give users feedback to evaluate business alternatives and make comparisons (Bala et al., 2018; de Silva, 2020). A decision-making process is conducted using Promethee software to determine the best option based on preference ranking and additional information for evaluation and enrichment (Behzadian et al., 2010; Brans & De Smet, 2016; Fauzi, 2019; Gürlük & Uzel, 2016; Jablonsky, 2014; Taherdoost & Madanchian, 2023). Overall, the model is built through an action-oriented approach and serves as a learning process (Aryee & Hansen, 2022; Wu et al., 2021). Through Holon's approach (Tchappi et al., 2019; Trentesaux, 2009; Lihui Wang & Haghighi, 2016), the tested model results in an average absolute error below 0.1 (Willmott & Matsuura, 2005) and was used to develop and recommend the Mb-F implementation strategy for Indonesia's national scale. This was based on a moderate scenario and information from two other scenarios (pessimistic and optimistic).

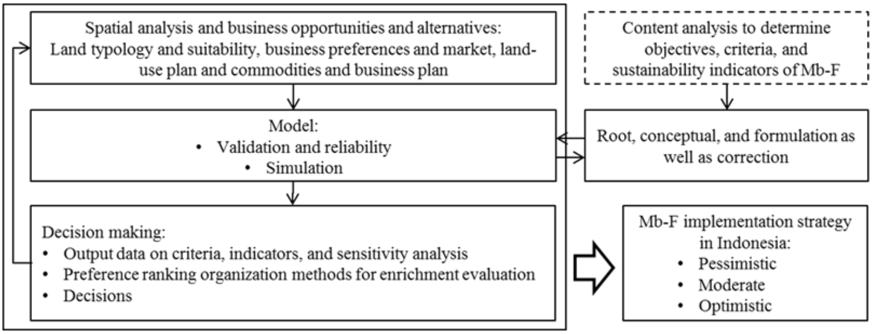

Figure 1. Research flow chart.

3. RESULTS AND DISCUSSION

3.1 Causal loops diagram and SM Mb-F

The overall inefficiency focuses mainly on timber-oriented governance practices in fragmented production forest areas in various typologies (MoEF, 2019a; Sahara et al., 2022; Suryanto et al., 2018; Suryanto & Wahyuni, 2016). The criteria that drive governance change towards Mb-F are technical, socio-economic, financial, legal, and environmental. The ten indicators representing these criteria are land use, timber, food, NTFP, employment, state revenue, company profits, biodiversity, climate change, and soil/water conservation (Suryanto et al., 2023). Accessibility is an essential variable of business feasibility (company profits) because it is considered the cost component of the business operation.

The model was built based on a causal loop diagram (CLD) (Grant, 1998; Isee, 2021) (Figure 2), which started by placing fragmentation and typological diversity as the main constraints, and quantifying the existing conditions of land cover, stand structure and composition, and topography in each forest cluster [8,66]. Inputs from ground-checking activities, soil analyses, market, business, and socio-economic preferences detail the Mb-F business options in each land use cluster.

Furthermore, land use in each business and commodities option generates a specific volume of workload according to the chosen techniques and stages (*methods*) to produce production goods. It also generates impacts and flows of production material requirements in the form of seeds, fertilizers, bio-stimulants, buildings, fuel, and other materials (*material*), as well as vehicles, mobile, and immobile equipment (*machine*), labor (*man*) and income, financing, taxes, fees, and other money flows (*money*). This complexity is dynamically quantified over time to project ten sustainability indicators and a wealth of information as a multi-criteria decision-making tool (MCDM) based on regulatory, business, and sustainable development preferences.

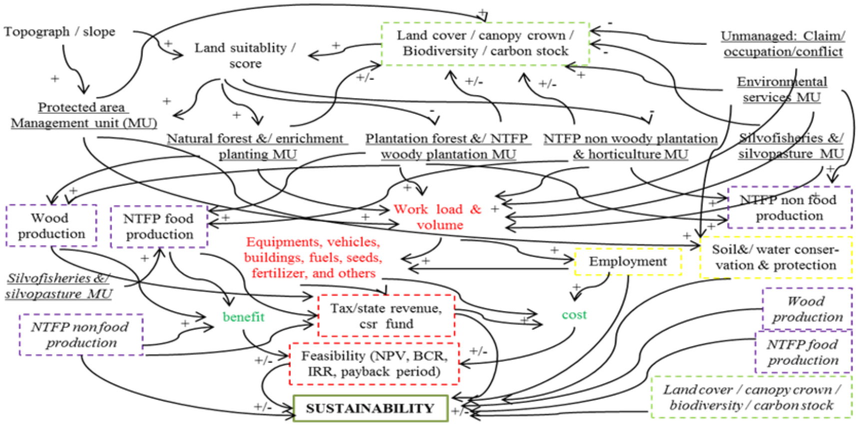

Figure 2. Casual loops diagram Mb-F

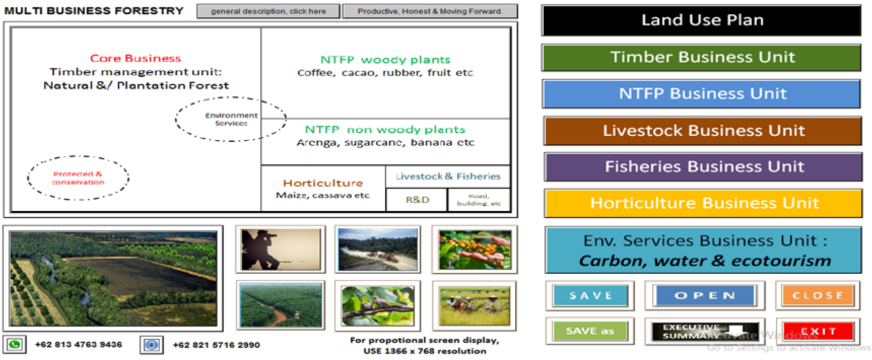

Figure 3. Startup interface SM Mb-F

CLD is formulated in 280 sub-sub-sub models (N-s3m; Table 1) with 4,764 data variables and a deviation value of 6.4%, later called the Super Model of Multi Businesses-Forestry (SM Mb-F). The SM Mb-F is presented systematically through 1 startup interface (Figure 3) and eight primary and eight auxiliary interfaces. Decision input devices are provided in 22 lists, nine sliders, and one knob input device. Meanwhile, the output data is presented in 167 table pads, 49 graph pads, and 48 numerical displays. The type, number, purpose, and function of the interfaces are described in Table 1.

Table 2. Contents of sub and sub-sub models of multi-business forestry

Content of model	N-s3m	Interface, product, and goal functions
Land use planning		Interface title: Land use typology and planning
Typology & suitability	8	Receive, verify, process, and notification (RVPN): 1. Distribution and extent of area clusters based on land cover type, topography, natural stand structure, and composition attributes. 2. Screening of protected, cultural, overlapping, social conflict, and other areas that cannot be effectively cultivated 3. land use plan for clear and clean areas based on business type, commodity, time, and cycle. 4. The road network plan is based on the type and density of roads in each business type. Primary output: net area of land use plan.
Land use plan	11	
Natural and plantation forest		Interface title: natural production and plantation forest management units. Commodity options provided (cop): 8 types of commodity type options
Method and material	18	RVPN: 1. type and timing of business activities to extract and/or cultivate wood-producing plants; 2. Biological attributes related to plant character, silviculture, and productivity. Key outputs: projected demand for raw materials and timber forest products by type, size, and time.
Workload & Employment	7	RVPN: input and output data related to workload, volume, and performance from 13 job types and seven worker levels. Key outputs: labor absorption.
Need for equipment, vehicles, etc.	13	RVPN: incorporates data, information, and outputs relating to land and crop nutrient requirements as well as the load, volume, and work performance of 13 types of equipment and vehicles and 13 types of buildings.
Finance	13	RVPN: Costs and revenues are based on the unit price of production and the costs of procuring, maintaining, and operating materials, equipment, vehicles, and buildings, as well as salaries, taxes, fees, and other costs. Outputs are a breakdown of revenues and costs by unit type, time, and information on investment and feasibility.
Non-timber forest products		Interface title: Non-Timber Forest Product (NTPSs) management unit. Cop: 8 specific commodity type groups (stem, bark, sap, resin, essential oil, leaf, and fruit producers)
Method and material	16	Similar to the objective function of natural/plantation forest management units, the main output is projected NTFPs raw material demand and production.
Workload & Employment	5	RVPN: input and output data related to workload, volume, and performance of 9-15 types of work according to the type of NTFP's business commodity and seven levels of workers.
Need for equipment,	13	RVPN: includes data, information, and outputs related to land and crop nutrient requirements as well as the load,

Content of model	N-s3m	Interface, product, and goal functions
vehicles, etc.		volume, and performance of 12-15 types of equipment and vehicles and 12-15 types of buildings according to the type of business commodity.
Finance	12	same as the previous management unit.
Livestock		Interface title: Livestock management unit. Cop: 3 large mammal livestock species selection
Method and material	7	RVPN: data input information and business: 1. Type and timing of livestock business activities. 2. Biological attributes related to character, carrying capacity, population management, and productivity of livestock and silviculture of feed crops. Key outputs: projected raw material requirements, meat production, and by-products (feces and/or milk) over time.
Workload & Employment	3	RVPN: input and output data related to workload, volume, and performance of 6 types of work at seven worker levels
Need for equipment, vehicles, etc.	6	RVPN includes data, information, and outputs relating to feed, medicine, vitamin, and housing requirements, as well as the workload, volume, and performance of 10-13 types of equipment and vehicles and 9-12 types of buildings according to the choice of cultivation method (pasture and/or pens).
Finance	10	Same as the previous management unit.
Fishery		Interface title: Inland aquaculture management unit. Cop: 5 choices of fish species
Method and material	3	RVPN: data input information and business decisions: 1. type and timing of fisheries business activities, 2. type and timing of fisheries business as well as activities biological attributes related to character, pool carrying capacity, population, and productivity of inland aquaculture. Key outputs: projected material requirements and production of fish over time.
Workload & Employment	4	RVPN: input and output data related to workload, volume, and performance of 8 job types at seven worker levels.
Need for equipment, vehicles, etc.	13	RVPN: input data, information, and outputs relating to pond management, water treatment, population and size management, feed, medicine and vitamin requirements and workload, volume and performance 12-16 types of equipment and vehicles and 11 types of buildings.
Finance	12	Same as the previous management unit.
Horticulture		Interface title: Food crop cultivation management unit cycle maximum one year Cop: 6 choices of commodity types
Method and material	5	Similar to the objective function of the crop cultivation management unit with the main output of projected material requirements and horticultural production.
Workload & Employment	5	RVPN: input and output data related to workload, volume, and performance of 3-5 types of work according to the choice of commodity type and technique (non-mechanized or mechanized)
Need for equipment, vehicles, etc.	17	RVPN: includes data, information, and outputs related to land and crop nutrient requirements as well as the load, volume, and performance of equipment and vehicles and buildings according to the type of business commodity and cultivation technique (mechanized or non-mechanized).
Finance	7	Same as the previous management unit.

Content of model	N-s3m	Interface, product, and goal functions
Ecosystem services		Interface title: Environmental Services Management Unit Cop: 3 ecosystem service options (carbon, water, and tourism)
Method and material	9	RVPN: data input information and decisions on cultivated ecosystem service types: 1. Type and timeframe of ecosystem restoration activities. 2. Activity attributes related to MRV for carbon storage services, water collection for water supply services, and tourism for tourism services. Key outputs: projections of carbon mass, water volume, and tourist visits over time.
Workload & Employment	3	RVPN input and output data related to workload, volume, and performance according to the choice of ecosystem services cultivated.
Need for equipment, vehicles, etc.	6	The RVPN includes data, information, and outputs related to the need for materials, tools, vehicles, and buildings according to the choice of ecosystem service type being cultivated.
Finance	9	Same as the previous management unit.
Crown canopy	17	Process data on changes in tree canopy cover based on changes and growth dynamics of commodity types and cultivation methods.
Carbon stock	11	Process carbon stock change data through an allometric estimation approach for all individuals and stands by extract and/or cultivated type and method.
Water conservation	8	Processing data on water conservation efforts for water used, both for human consumption and plant/animal commodities that require water availability in cultivation.
Summary	9	Processing recapitulation data of all business units to present the primary data of 10 sustainability indicators.

3.2 Action research in two regional sample units

Action research was conducted in two regional sample units, namely in East Kalimantan and Central Sulawesi. The East Kalimantan sample unit is an active business unit with a license area of 93,425 ha and one timber utilization business unit, PT Ratah Timber Holdings (RTH). Meanwhile, the Central Sulawesi sample unit is a new area with 40,257 ha applied for by PT Nusantara Ekosistem Lestari (NEL), which has experience running the ecosystem restoration business concept.

The existing RTH area is divided into four classes of initial standing potential: high (potential >60 m3/ha) with an area of 66,245 ha, medium (40-60 m3/ha; 9,671 ha), low (20-40 m3/ha; 9,103 ha), very low and non-forested (<20 m3/ha, 8,405 ha). About 93.5% (87,335 ha) has moderate topography. The overlay process of the two typologies resulted in land availability and suitability by a scoring method as presented in Figure 4a. Then, the delineation process resulted in a total land area for natural forest management units of 55,063 ha, natural forest management units with intensive enrichment planting of 11,742 ha and cultivation units of 12,084 ha. In addition, 4,544 ha were identified as expansion clusters, 1,860 ha were allocated as permanent research and development plots, and 8,132 were protection areas. Based on the match between available land and commodity options as well as business and market preferences, one business-as-usual (BAU) alternative and 9 Mb-F alternatives were simulated. Three of them are shown in Table 2, where alternative H is the alternative that fulfills the sustainability aspects (Table 2).

Alternative H is an alternative with the core business of natural forest management covering 66,805 ha and cultivation covering 12,084 ha. The learning process through simulation of various decision variables resulted in the decision to utilize the available land for cultivation with six management units (Figure 3b), namely plantation forest cultivation to produce Jabon wood products, *Melaleuca cajuputi* cultivation to produce cajuput oil products, *sereh wangi* cultivation to produce citronella oil products, *arenga* cultivation to produce brown sugar products, large mammal livestock cultivation to produce meat and dung products, and inland aquaculture to produce shrimp 30-40 medium-large size (30-40 pieces of shrimp in a pound) and tilapia products size 10. With an additional investment of IDR 46.77 billion and a delayed payback period of 0.26 years, the business shift from the timber-oriented BAU to the H Mb-F alternative improves the role and performance of the business from technical, economic, social, and ecological aspects (Figure 5-7). It includes an increase in timber supply with a projected value of 392.5%, employment of 392.9%, and NPV of 518.6%. In addition to contributing to the provision of 0.5 M tonnes of food NTFPs and 0.18 M tonnes of non-food NTFPs (accumulated over 50 years), alternative H also provides an increase in state revenue of up to 579.6% compared to BAU. The Mb-F business concept in alternative H also contributes to restraining the rate of decline in carbon stocks and increasing canopy cover and water conservation (Table 2 and Figure 7a).

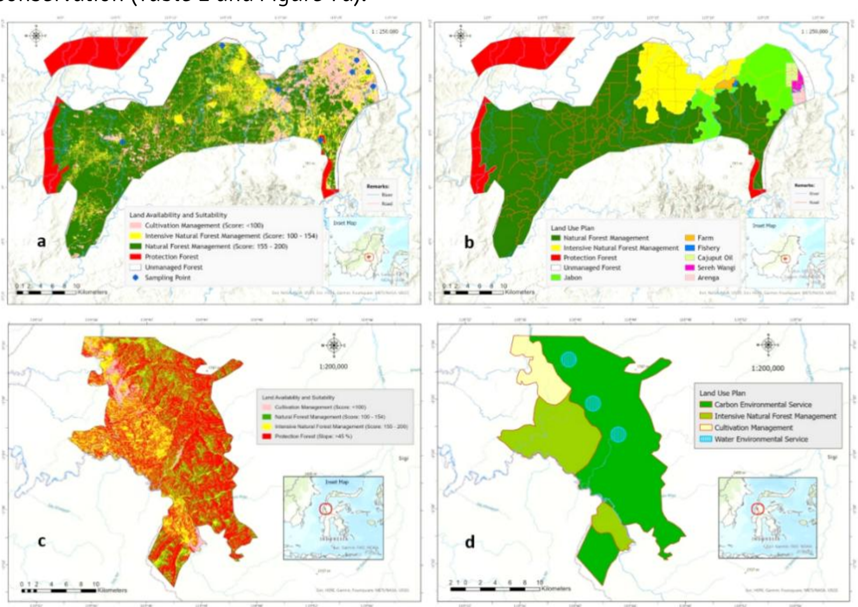

Figure 4. Land use availability and suitability are based on the scoring method and the land use plan decision-making process.

Furthermore, the NEL area is fragmented into three potential forest cover classes, namely medium (5,536 ha), low (32,637 ha), and very low and non-forested (2,084 ha). Unlike the RTH sample unit, the area in the NEL sample unit is dominated by severe topography, with 34,909 ha (86.7%) of steep and very steep topography. The overlay process of these two typologies results in the availability and suitability of land, mainly for protection management (Figure 4. c), which corresponds to the proposer's business and experience preferences for restoration management and environmental services. These preferences are assumed to be BAU. The cultivation business opportunity on 3,453 ha and natural forest management on 9,782 ha resulted in 3 alternatives of Mb-F. Two of them are shown in Table 2, where alternative C is an alternative that fulfills sustainability aspects.

Table 2. Alternative land use plans and sustainability indicator and total score of sustainability

Description	Unit	*Ratah Timber Holding*			*Nusantara Ekosistem Lestari*		
		BAU	Alt A	Alt H	BAU	Alt A	Alt C
Type of management unit Timber							
Natural forest	Ha	66,805	66,805	55,063	-	-	-
Natural forest with enrichment		-	-	11,742	-	-	9,782
Plantation forest		-	12,084	10,054	-	-	-
NTFP							
Commodity A	Ha	-	-	416	-	3,453	3,453
Commodity B		-	-	679	-	-	-
Commodity C		-	-	472	-	-	-
NTFP non plant							
Livestock	Ha	-	-	400	-	-	-
Fishery		-	-	63	-	-	-
Environmental services							
Carbon trading	Ha	-	-	-	40,257	36,804	26,080
Water trading					-	-	942
Protected, research & development		9,992	9,992	9,992	40,257	36,804	27,022
Non-use (conflict, etc.)		16,626	4,544	4,544	-	-	-
Investment							
Nett investment	Bill IDR	43,03	83,90	89,80	1,91	24,36	28,54
Payback period	year	1,99	2,11	2,25	1,05	3,55	3,54
Sustainability indicators							
Land use optimize	%	71,02	83,86	83,86	99,73	99,73	99,73
Total wood [1]	M m3	5,08	17,95	19,94	-	-	3,52
Total NTFP food [1]	M ton	-	-	0,50		0,19	0,19
Total NTFP non-food [1]	M ton	-	-	0,18		-	-
Total carbon traded: [1]	M ton	-	-	-	2,97	5,37	3,87
Total water traded: [1]	G lit	-	-	-	-	-	15,34
Employment	Person	213	334	837	31	342	433
State revenue [1]	Bill IDR	69,81	333,30	404,59	9,41	102,64	212,89
Finance							
NPV	Bill IDR	298,81	917,81	1.549,77	19,52	402,11	511,74
BCR	-	1,39	1,66	1,72	1,47	2,03	1,77
IRR	%	80,66	66,08	77,92	123,46	60,87	60,00
Carbon stock [2]	M ton	6,31	8,21	9,64	5,98	8,29	7,20

Description	Unit	*Ratah Timber Holding*			*Nusantara Ekosistem Lestari*		
		BAU	Alt A	Alt H	BAU	Alt A	Alt C
Crown canopy [2]	%	32,76	46,64	55,25	64,16	60,87	63,91
Water use/ conservation [1]	G lit	0,14	0,22	42,09	0,01	0,23	2,53
Sustainability score		(0,6812)	(0,4771)	0,3729	(0,5152)	0,0403	0,4208

Note: [1] total accumulated over the 50 years of analysis, [2] totals in the 50th year.

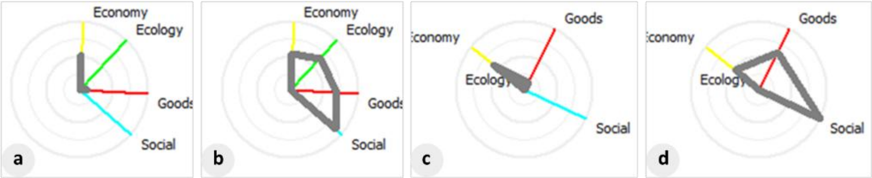

Figure 5. Geometrical Analysis for Interactive Aid (GAIA): a. RTH BAU, b. RTH decision, c. NEL BAU, d. NEL decision.

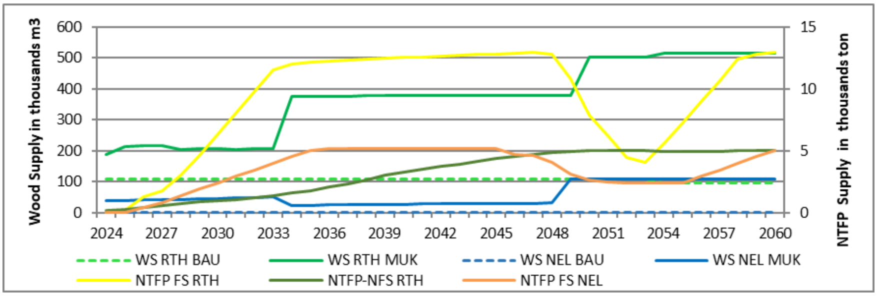

Figure 6. Graph of timber supply dynamics (WS), non-timber forest product (NTFP) supply, and non-food NTFP supply in RTH and NEL sample units.

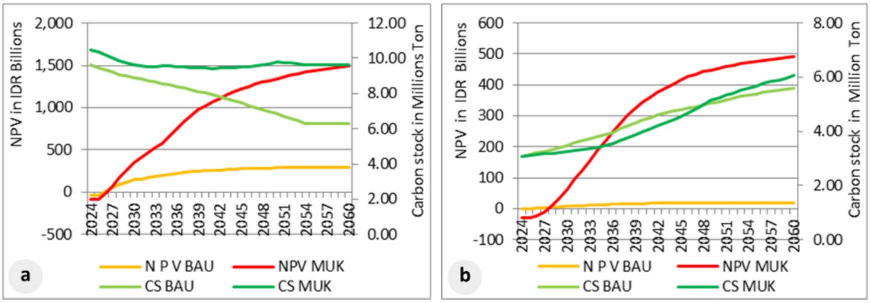

Figure 7. Comparison graph of net present value (NPV) and carbon stock at RTH and NEL

Alternative C is an alternative with the core business of environmental service management in the form of carbon trading covering 26,080 ha and water trading covering 942 ha. The learning process through the simulation of several variables resulted in the decision of business development to choose a natural forest with intensively managed enrichment planting covering 9,782 ha and cocoa cultivation covering 3,453 ha of the total available land. Through an additional investment of IDR 26.63 billion and a delayed payback period of 2.49 years, the shift from the BAU to the Mb-F C alternative improves financial performance that strongly supports the core business. This support even increased restoration efforts by increasing the number of enrichment plants from 50 seedlings/ha to 100 seedlings/ha. This decision increased the amount of carbon stock (Figure 7b.). Alternative C fulfils technical, economic, social, and ecological aspects of sustainability (Figures 5-7). It includes an increase in the amount of carbon traded by 130.3%, employment by 1,396.7%, and NPV by 2,621.6%. Besides contributing to 3.52 Mm3 of wood products and 0.19 M tonnes of NTFPs (accumulated over 50 years), alternative C offers an increase in state revenue of up to 2,262.4% compared to BAU. The Mb-F business concept of alternative C even increases carbon stocks, canopy cover, and water conservation (Table 2 and Figure 7b).

3.3 Projected benefits of implementing multi-business forestry in Indonesia

Forest allocation for production purposes is 68.8 million ha out of 125.9 million ha of national forest allocation (Figure 8) (BPS-Statistics Indonesia, 2020b). In 1993, the total area of production forest managed through business utilization permits was 61.78 M ha, which has subsequently decreased, and only 30.58 M ha was managed in 2022. Of this amount, only 24.19 M ha are still actively implementing the licenses obtained, while 6.39 ha are suspended. The remaining 38.22 ha of production forest is unmanaged and does not attract investment.

Figure 8. Map of Indonesian Forest and others in 2023.

The scenario was built based on the existing conditions of available land and target results to be achieved, namely improving the performance of production forest management to produce wood products and increasing the role of forest management to produce food products and other NTFPs and other economic, social and ecological benefits (Fanelli, 2019; Foley et al., 2011; Fisher et al., 2019; Sahara et al., 2022; Tilman et al., 2011). The simulation uses the SM Mb-F modeling tool with a tiered technique according to the scenario constructed and key assumptions as follows:

1. Using the typology data of 2 sample units and four other area units (Suryanto & Sayektiningsih, 2020; Suryanto & Wahyuni, 2016), the distribution of land availability and suitability by management unit group is 35.8% natural forest

management, 28.2% natural forest management with intensive enrichment planting, 25.5% for cultivation management, and 10.5% as protected and or unmanaged areas.
2. Cultivation management consists of 70% natural and plantation forest management, 20% NTFP management, 6% horticulture management, and 4% non-crop cultivation management (livestock and fisheries).
3. Commodities cultivated in plantation forests include three groups of types, namely 75% for short-cycle crops (4-6 years), 15% for medium-cycle crops (10-15 years), and 10% for long-cycle crops (25-30 years).
4. The commodities cultivated in NTFP, and horticulture management are from 6 main food crop groups and popular crops, including sugar cane (sugar raw material), corn (maize raw material), cassava (tapioca raw material), potatoes, soybeans, agarwood, essential oils, rubber, and two combinations of fruits with the same percentage.
5. In the three scenarios (pessimistic, moderate, and optimistic) and implementation phases, namely 2024, 2027 and 2030.

From the existing condition, Indonesia's timber production (BAU) in 2011-2023 was in the range of 36.6-61 M m3/year, far from the timber production projection target set in the National Forestry Plan (Figure 9) (BPS-Statistics Indonesia, 2019, 2020b; MoEF, 2019b). In agriculture, Indonesia is the third-largest rice-producing country and the second-largest rice-importing country globally (FAO, 2020). Complementing the three food commodities with the highest consumption levels, Indonesia also imports maize and soybean (FAO, 2020; Malik & Nainggolan, 2020; Permadi, 2015). In 2018, Indonesia imported 2,253.7 and 737.2 thousand tons of rice and corn, while Indonesia's soybean production was only 924 thousand tons (FAO, 2020), an amount that only meets 47.7% of Indonesia's soybean needs (Malik & Nainggolan, 2020) with projected demand growth of 6.81% per year due to population growth (Malik & Nainggolan, 2020; Permadi, 2015). In addition to being the largest wheat importer, Indonesia also imports sugar and potatoes, thus failing to become a producing country for the world's six primary agricultural commodities. Three Mb-F implementation scenarios with adequate sustainability aspects were developed based on two studies on sample units. Mb-F implementation targets until 2030 are: a). 16.38 M ha in the pessimistic scenario where 12.75 M ha are new concessions, b). 21.99 M ha and 15.95 M ha in the moderate scenario, and c). In the optimistic scenario, 31.35 M ha and 21.68 M ha (Table 3).

Table 3. Current condition and implementation scenario of Mb-F

Content	Existing	Strengthening strategy with Mb-F								
		Pessimistic			Moderate			Optimistic		
		2024	2027	2030	2024	2027	2030	2024	2027	2030
Concessions inactive	24,19	5%	5%	5%	5%	10%	10%	10%	15%	15%
	M ha	1,21	1,21	1,21	1,21	2,42	2,42	2,42	3,63	3,63
Concessions suspended	6,39	10%	20%	20%	20%	40%	40%	20%	40%	40%
	M ha	0,64	1,28	1,28	1,28	2,56	2,56	1,28	2,56	2,56
No concession permit	38,22	5%	10%	10%	5%	10%	10%	10%	15%	15%
	M ha	1,91	3,82	3,82	1,91	3,82	3,82	3,82	5,73	5,73
MB-F's new concession will be active in 2030	M ha	12,75			15,95			21,68		
Total Mb-F in 2030	M ha	16,38			21,99			31,35		

The simulation projections show that if governance continues at the current rate, timber production will stagnate below 75 M cubic m per year, widening the gap between the timber production target set in the National Forestry Plan and the projected demand for timber due to population growth (Figure 9). This is because governance will not be able to increase land productivity for timber production under current conditions of fragmentation and mainstreaming.

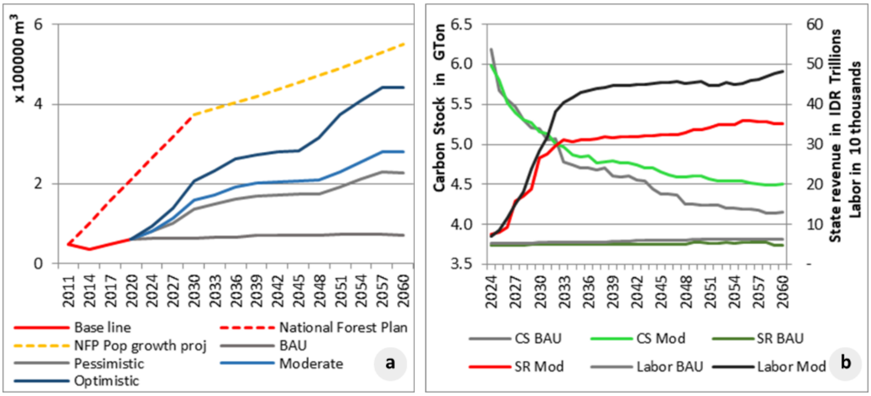

Figure 9. The impact of implementing Multi Forestry Business in Indonesia is a. increasing timber supply, and b. increasing state revenue and arresting the rate of decline in carbon stock.

Assuming a gradual change until 2030, Mb-F can be applied to 32% of Indonesia's production forests. By 2045, it is projected that there will be an increase in wood production by 296.8% compared to BAU. The increase in timber production in Mb-F scenarios was obtained from additional production from new timber estates or *Hutan Tanaman Industri* (HTI) units and increased land productivity through enrichment planting in intensive natural forest business units (Figure 9a). Some timber is obtained from land clearing activities in intensive natural forest business units and land clearing in cultivation business units. The loss of some stands in both activities results in a decrease in cover and carbon stocks but can be restored or even increased for the amount of cover and carbon stocks along with the growth of new stands. As presented in Figure 9b and Table 4, implementing Mb-F through the moderate scenario increases carbon stock loss in the early stages of implementation. So, implementing Mb-F will restrain the decline in carbon stocks if governance is still BAU (Power, 2010).

Table 4. Projected benefits of implementing Mb-F in Indonesia.

Content	BAU					Moderate				
	2024	2027	2030	2045	2060	2024	2027	2030	2045	2060
Wood production (Mm3)	64.09	64.34	64.56	69.84	71.71	81.23	138.46	206.49	207.31	279.37
Labor absorption (Labor)	51,614	53,046	53,832	59,399	61,295	71,778	182,371	364,567	585,524	618,661
AddNTFP Food Supply (MTon)						0.73	4.34	10.58	19.36	16.88
AddNTFP Non Food Supply (MTon)						0.01	0.05	0.15	0.27	0.20
State Revenue (Trillion IDR)	4.77	4.84	4.95	4.95	4.77	7.43	15.75	26.57	32.39	35.27
Carbon Stock (Gton)	6.19	5.48	5.20	4.38	4.16	5.98	5.39	5.16	4.66	4.51
New add investment (Present value in Trillion IDR)						15.24	19.95	14.37		

From a food security perspective, implementing Mb-F will increase the food provisioning role of production forest governance according to the type and scenario chosen (Wang et al., 2019). In the example of this analysis, the moderate scenario contributes to the provision of 19.36 million tons of food by 2045. Furthermore, from the perspective of Job Creation, implementing Mb-F will add a role in providing Mb-F, which will provide business opportunities, employment, and state revenue in the forestry sector. The additional role of the forestry subsector is obtained from an increase in employment by 985.7% and state revenue by 654.3% compared to BAU. The total investment value in this scenario is projected to be IDR 49.56 trillion. The Ministry of Environment and Forestry can use this projected investment value as a policy in stimulating the implementation of Mb-F, both as a basis for determining scenarios and achievement targets and as a policy related to incentive mechanisms or equity participation (Vergarechea et al., 2023).

4. CONCLUSION

Implementing the multi-business Forestry model in Indonesia offers an attractive solution to address the challenges of forest governance and food security. An approach that integrates different aspects of forestry, such as timber production, food production, and environmental services, can significantly improve forest sector performance, increase national income, boost food production, and support environmental conservation. It underscores the need for a holistic strategy to address the issues at hand, making it essential for policymakers and practitioners in Indonesia to consider and implement Mb-F. It also suggests the way for pursuing further research in this area on a global level, emphasizing the importance of this innovative model for sustainable forestry governance and food security elsewhere, and at different scales.

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