IMPLEMENTATION OF MULTI-SYSTEM SILVICULTURE (MSS) TO IMPROVE PERFORMANCE OF PRODUCTION FOREST MANAGEMENT: A CASE STUDY OF PT. SARPATIM, CENTRAL KALIMANTAN

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IMPLEMENTATION OF MULTI-SYSTEM SILVICULTURE (MSS) TO IMPROVE PERFORMANCE OF PRODUCTION FOREST MANAGEMENT: A CASE STUDY OF PT. SARPATIM, CENTRAL KALIMANTAN. To date, performance of the management of Indonesian production forests are discouraging. The concession areas, timber production and employment have been decreasing over time. To concern on these matter and to improve management, a research was conducted for six years (2008-2013) and resulted in recommendations to implement the Multi-System of Silviculture (MSS) systems. Two products were generated in MSS; criteria and indicator to guide the selection of appropriate silvicultural system and supersilvik, a model to develop the best business plans. This paper evaluates and strengthens the recommendations through the simulation of MSS products in PT. Sarmiento Parakantja Timber (Sarpatim), Central Kalimantan, Indonesia. Various data variables were used, such as thematic maps of forest areas, data of stand, materials, equipments, labors, finances and incomes. Data were processed in a variety of formulations which were connected to each other in model systems to produce a variety of outcomes, such as production, finance, employment and tax contributions. Results offer four options to improve PT. Sarpatim performance, one of which is the best choice. Compared to the former business model under limited silvicultural systems, MSS projected an increase in the use of land, timber production and employment by 151-753%. Implementing MSS will provide a better and healthier finance for company with an increase of NPV up to 193%; as well as for government tax revenues with an increase up to 308%. This MSS case study strongly suggests using the new theory that the management of production forests is a land and plant-based enterprises, which should put the land as the major capital and silvicultural aspects as the driving engine for production. The policy makers should be able to use these results as a reference in implementing MSS widely as part of Sustainable Forest Management (SFM) practices.

Keywords: Multi-system silviculture, production forest, supersilvik, model, simulation

IMPLEMENTASI MULTI SISTEM SILVIKULTUR (MSS) UNTUK MENINGKATKAN PERFORMA PENGELOLAAN HUTAN PRODUKSI: STUDI KASUS DI PT. SARPATIM, KALIMANTAN TENGAH. Performa pengelolaan hutan produksi di Indonesia saat ini memprihatinkan. Luas konsesi, produksi kayu dan penyerapan tenaga kerja mengalami penurunan dari waktu ke waktu. Peduli untuk kebutuhan ini, telah dilakukan penelitian selama enam tahun (2008-2013) dan menghasilkan rekomendasi untuk menggunakan Multisistem Silvikultur (MSS). Dua perangkat MSS telah berhasil disediakan, yaitu kriteria dan indikator sebagai pedoman dalam memilih

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sistem silvikultur dan supersilvik, sebuah perangkat model untuk membantu menyusun rencana kelola terbaik. Tulisan ini bertujuan untuk mengevaluasi dan memperkuat rekomendasi melalui simulasi penggunaan dua perangkat MSS tersebut di PT. Sarmiento Parakantja Timber (Sarpatim), Kalimantan Tengah, Indonesia. Beragam data digunakan, meliputi peta tematik tentang kawasan serta data tegakan, bahan, peralatan, tenaga kerja, pembiayaan, dan pendapatan. Data tersebut diolah dengan menggunakan berbagai formulasi rumus yang saling terhubung satu sama lain dalam sistem model untuk menghasilkan data luaran berkenaan dengan produksi, finansial, serapan tenaga kerja dan kontribusi pajak. Studi ini menghasilkan empat pilihan untuk peningkatan performa usaha kelola PT. Sarpatim, dimana salah satunya adalah pilihan terbaik. Jika dibandingkan dengan usaha kelola menggunakan sistem silvikultur yang terbatas, diproyeksikan bahwa dengan menggunakan MSS diperoleh peningkatan penggunaan lahan, produksi kayu dan penyerapan tenaga kerja sebesar 151-753%. Penerapan MSS akan berdampak baik dalam membangun usaha yang lebih sehat, ditandai dengan peningkatan NPV hingga 193%. MSS juga berdampak baik dalam meningkatkan penerimaan pajak hingga 308%. Studi kasus ini mendorong penggunaan teori baru bahwa pengusahaan hutan produksi berkenaan dengan tata kelola lahan dan tanaman, yang menempatkan lahan sebagai faktor modal dan silvikultur sebagai faktor penggerak produksi. Pengambil kebijakan dapat menggunakan hasil penelitian ini sebagai acuan dalam implementasi MSS secara luas untuk meningkatkan kinerja pengelolaan hutan produksi sebagai bagian dari praktik pengelolaan hutan secara lestari.

Kata kunci: Multisistem silvikultur, hutan produksi, supersilvik, pemodelan, simulasi

I. INTRODUCTION

Performances of the management of production forests in Indonesia are currently discouraging (Suryanto & Wahyuni, 2016). Only 30.3% of production forests are actively managed under forest concessions (SoFS, 2016a) and produces timber less than forty-five million cubic meter per year in 2016 (MoEF, 2017; SoFS, 2017). Hence, interest is currently decreasing for investment in logging concession. In 1993, the number of natural forest production concessionaires, namely IUPHHK-HA, was 575 covering 61.7 million ha area concession (MoF, 2012), but only 251 IUPHHK-HA were left covering 19 million ha in 2016 (MoEF, 2017). Furthermore, Indonesia has begun granting licenses for industrial forest plantation business, namely IUPHHK-HT, as an effort to build new timber resources by converting some natural forests to forest plantation. It was started in 1990 with 30 thousand hectares licensed area of IUPHHK-HT outside Java (MoF, 2012), and then the number increased to 286 IUPHHK-HT in 2016 (including Java). However, the investment just only covers 10.8 million ha (MoEF, 2017), and this is less than the sum of the natural production of forest loss. Subsequently, only 188 IUPHHK-HA and 189 IUPHHK-HT have actively used their licenses in the field and they only cover 25 million ha of concession areas (SoFs, 2016a). The worsening performance was due to two problems: i.e. limited use of relevant silvicultural systems, and fragmented concession area (Suryanto & Wahyuni, 2016). It has also resulted in that approximately 43.8 million ha of the 68.8 million ha production forests available in Indonesia are not managed properly (MoEF, 2017; SoFS, 2016a).

Considering that problem, a continuous study was conducted during the period of 2008-2013 in 10 forest concessions in Kalimantan and Sumatera. Through the study, the concept ideas of Multi-System Silviculture (MSS) which was initiated by the National Workshop on Implementation of Multi Silvicultural System, Bogor, August 23, 2008 were developed. MSS which is actually driving to the MFM Concept (Multiple-use Forest Management) bring to improve the performance of production forest management (Kusmana, 2011a) by using more than one silvicultural system in a single forest concession, particularly in natural production forest concession. Through policy briefs, Suryanto, Nurrochmat, Prijono, Budiaman and Suyana (2010) and supported by other experts

(Kusmana, 2011b), MSS concept has come to influence a change in government policy (MoF, 2014). However, MFM implementation has been lacking behind expectations (Fernández, Pérez, & Wunder, 2008). MSS has not been implemented in the field level yet. Therefore, scientific evidence to expose the effectiveness of the MSS is required and to be promoted.

The new notion of forest industry cluster is in line with the conception of MSS/MFM, which will depend on establishing silvicultural land uses that inflict low disturbance regimes (Chazdon et al., 2016; Hernández, Pingarroni, & Ramos, 2016; Payn et al., 2015). Forest industry cluster (FCI) opens the concept of adding management unit of Non-Timber Forest Products (NTFPs) in the Forest Management Unit of Production Forests and Services (Chen & Innes, 2013; Dalemans et al., 2015; Rist et al., 2012; Shackleton & Pandey, 2014). In this regard, the evaluation of MSS in IUPHHK-HA PT. Sarmiento Parakantja Timber (PT. Sarpatim) in Central Kalimantan, which focuses on the development of timber based product was re-simulated by adding the unit development of NTFPs for rubber and sugar palm (Mochlis, 2013; Suryanto & Andriansyah, 2013). This paper evaluates and strengthens the MSS recommendation through re-simulation of MSS product in IUPHHK PT. Sarpatim. It is hoped that this paper strengthening the notion of MSS as a solution to increase the performance of forest production in Indonesia.

II. MATERIAL AND METHOD

A. Material

Two outcomes have been produced to support MSS; a criteria and indicator to guide selection of the appropriate silvicultural system and, supersilvik, a model to help develop the best business plans in production forest venture. The results of analysis and validation have been finished for the study cases of PT. International Timber Corporation Indonesia Kayan Hutani (PT. IKANI), PT. Balikpapan Forest Industries (PT. BFI) (Suryanto, 2010) and PT. Sarpatim (Suryanto & Andriansyah, 2013; Mochlis, 2013). In 2013-2015 period, supersilvik models were upgraded by integrating NTFPs management unit as part of the data processing operation. Simulation and validation have been completed by Suryanto and Wahyuni (2015) for the case study at PT. International Timber Corporation Indonesia Kartika Utama (PT. ITCIKU). The next simulation presented in this study was the result of analysis and validation of the data collected in 2012 in PT. Sarpatim, Central Kalimantan. Some of other data, especially with regard to the financial data is adjusted to match updated unit price and finance of the year 2016.

B. Methods

Both primary and secondary data were collated for this study. Secondary data were obtained from the documents of business workplan, annual workplan and periodical comprehensive forest inventory (PCFI) as well as digital maps including operational maps, land cover maps, PCFI maps and topographic maps. Primary data were ground checked for forest potency in four 4-ha sample plots to represent each type of forest cover (Peck, Zenner, Brang, & Zingg, 2014). The data were collected from the identification of species and measurements of tree diameter and height. Field measurement data were processed into data structure including composition, height dominant trees, form factor and correction factors. Other primary data were the minutes of in-depth discussion with practitioners in forest concession of PT. Sarpatim and some experts. The ArcGIS program had been run for the analyses of criteria and indicators while Stella 9.0.2 for processing data entry and analysis using *supersilvik* modeling.

C. Data Analysis

1. Criteria and indicator

Seven criteria and its associated indicators were used in the process of area delineation and silvicultural system selection. These include topography, forest production potential,

Table 1. Indicators and score in the topography criteria and the forest production potential criteria as well as, the selection of silvicultural system based on the total scores

a. Topography

Slope Class	Level	Weighting	Score
0-8% (Flat)	1	15	15
9-15% (Sloping)	2	15	30
16-25% (Light Steep)	3	15	45
26-40% (Steep)	4	15	60
40% Up (Very Steep)	5	15	75

b. Forest Production Potential (FPP)

FPP Class (m^2/ha)	Level	Weighting	Score
0-20 (Very Low)	1	35	35
20-40 (Low)	2	35	70
40-60 (Medium)	3	35	105
60 Up (High)	4	35	140

c. Total Score

Silviculture System, Protection area	Score	Remarks
Clear Cutting With Planting (THPB) and or Non Timber Forest Products (NTFPs)	< 90	Low stand potency zone and topography of 0-25% Low stand potency zone and flat topography
Selective Cutting and Line Planting (TPTJ)	90-155	Very low potency zone along with steep slope Low stand potency zone along with topography of 9-40% Medium stand potency zone along with topography of 0-25%
Indonesian Selective Cutting and Replanting (TPTI)	155-200	Medium stand potency zone along with steep slope High stand potency along with topography of 0-40%
Protection Area	-	Very steep slope zone Other area with protection typology

Source: Muchlis (2013)

soil type, annual rainfall, village distribution, accessibility and regulator or owner decisions.

In the early stages, topography and forest potency criteria were used in the processing of area delineation into business units that correspond to the natural carrying capacity. The materials used were topography and land cover maps that were digitized with the data of forest production potential from PCFI and sampling results. The criteria of topography and forest production potential were classified into five and four indicators respectively. Map data processing used the scoring system with overlay techniques and followed by weighting and summing the value scores as presented in Table 1.

Criteria of soil type, rainfall, village distributions and accessibility, subsequently were used as consideration in several alternative forms of management, such as alternative of plant species, harvesting techniques, labor and others (Mochlis, 2013; Suryanto & Andriansyah, 2013). Lastly, the decision criterion was used to select an alternative form of management. This decision criterion includes two indicators in two repetitive processes, namely the decision regulator (The Ministry of Environment and Forestry, MoEF) and the decision of the board of directors (owners). The system accomodates the subjective nature of expert judgment to select the best option (FOERDIA-MoEF, 2015a).

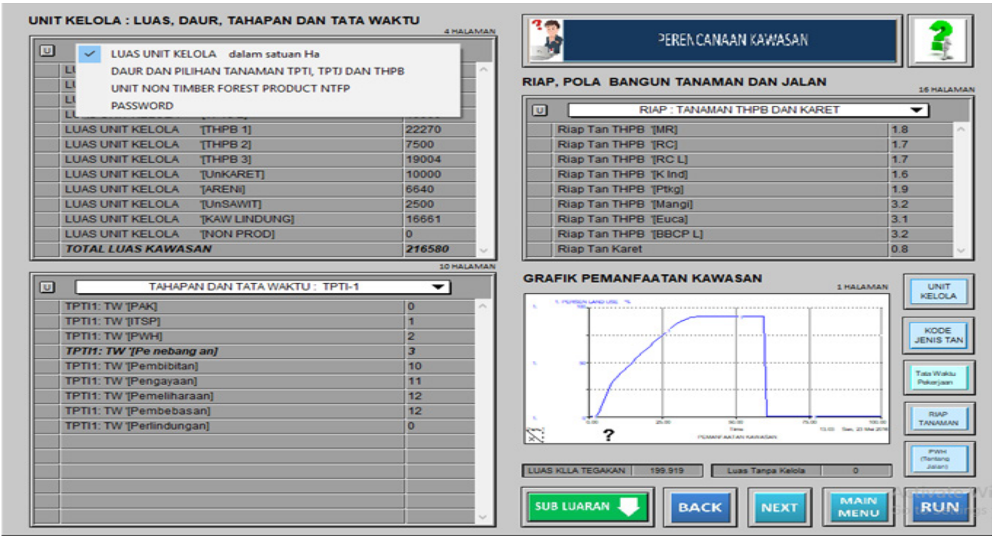
2. ***Supersilvik*** modelling

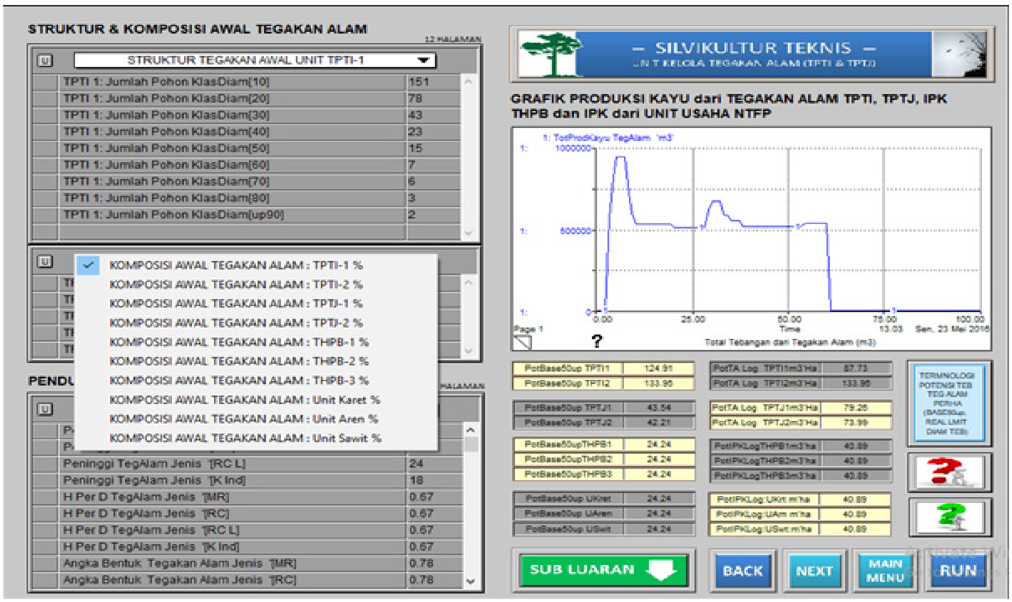
Supersilvik stands for *Suryanto Permodelan Silvikultur* (Suryanto Model's on Silviculture), which is a model built using stella software. The model is formulated applying variety of differential equations to project future outcomes based on business planning inputs of the present and other factors as feedback (Jo, Lee, Suh, Kim, & Park, 2015). It receives input of various data related to forest production ventures by groundwork of natural forests, timber estate and NTFPs (FOERDIA-MoEF, 2015b; Taylor, Chen, & Vandamme, 2009). *Supersilvik* models were used to simulate all business alternatives (Madureira, Nunes, Borges, & Falcão, 2011). Simulation produces five primary data output needed, namely:

a. Land use, including three output data i.e., land use (%LU), land productivity for wood products (PL-HHK) and land productivity for non-timber products (PL-NTFPs) (Bouchard & Garet, 2014; Payn et al., 2015).
b. Contribution to provision of production, includes 4 output data, the cumulative production of wood (Pd-KumHHK) and NTFPs (Pd-KumHHBK) over a span of utilization and average annual production (μPd-HHK and μPd-NTFPs) (Kartodihardjo, 2009; Kastner, Erb, & Nonhebel, 2011; Obidzinski & Dermawan, 2012; Szulecka, Obidzinski, & Dermawan, 2016; Warman, 2014).
c. Contributions to the company, comprise of four output data i.e., NPV, BCR, IRR and supplemented with data on annual average of margin between revenue (benefit) and financing (cost) before discount (μ (B-C)) (Buongiorno, Rougieux, Barkaoui, Zhu, & Harou, 2014; Hildebrandt & Knoke, 2011; Jo, Lee, Suh, Kim & Park, 2015).
d. Contributions to the state from the tax sector and others, includes two data outputs, which are the average annual (μTax) and present value of the cumulative amount of tax (PV-KumTax) during the time span of exploitation (Lebedys & Li, 2014; Locke & Rissman, 2012; Nurfatriani, Darusman, Nurrochmat, Yustika, & Muttaqin, 2015).
e. Employer contributions to employment, comprised of one output data, i.e., the average annual employment (SerTK) (Purnomo & Prasetyo, 2006; Whiteman, Wickramasinghe, & Piña, 2015).

The model is a complex model, yet comprehensive, good layout (Figure 1), easy to use (user friendly) and using variables that are familiar in the business of forest production. In addition to the five main groups of data output, the supersilvik model also provides other output data which could be query and provide more detailed information related to


SUPERSILVIK
Suryanto Permodelan Silvikultur
Sebuah perangkat model yang membantu anda menetapkan rencana pengelolaan terbaik
suryantoflitce@gmail.com ; +62 821 5716 2990
Supersilvik adalah perangkat pemodelan yang membantu mendetailkan rencana pengelolaan kawasan hutan produksi dalam konsep Multisistem Silvikultur
DAFTAR ISI
klik untuk proses masukan data
PERENCANAAN KAWASAN
SILVIKULTUR TEKNIS
ALAT & BANGUNAN
TENAGA KERJA
FINANSIAL
SAVE
OPEN
CLOSE
SAVE as
EXECUTIVE SUMMARY
EXIT
untuk tampilan layar yang proposional, disarankan menggunakan resolusi komputer 1024 x 768
klik untuk ringkasan data luaran


UNIT KELOLA : LUAS, DAUR, TAHAPAN DAN TATA WAKTU
LUAS UNIT KELOLA dalam satuan Ha
DAUR DAN PILIHAN TANAMAN TPTI, TPTJ DAN THPB
UNIT NON TIMBER FOREST PRODUCT NTFP
PASSWORD
LUAS UNIT KELOLA [THPB 1] 22270
LUAS UNIT KELOLA [THPB 2] 7500
LUAS UNIT KELOLA [THPB 3] 19004
LUAS UNIT KELOLA [UnKARET] 10000
LUAS UNIT KELOLA [AREN] 6640
LUAS UNIT KELOLA [UnSAWIT] 2500
LUAS UNIT KELOLA [KAW LINDUNG] 16661
LUAS UNIT KELOLA [NON PROD] 0
TOTAL LUAS KAWASAN 216580
TAHAPAN DAN TATA WAKTU : TPTI-1
TPTI1: TW [PAK] 0
TPTI1: TW [ITSP] 1
TPTI1: TW [PWH] 2
TPTI1: TW [Pe nebang an] 3
TPTI1: TW [Pembibitan] 10
TPTI1: TW [Pengayaan] 11
TPTI1: TW [Pemeliharaan] 12
TPTI1: TW [Pembebasan] 12
TPTI1: TW [Perlindungan] 0
PERENCANAAN KAWASAN
RIAP, POLA BANGUN TANAMAN DAN JALAN
RIAP : TANAMAN THPB DAN KARET
Riap Tan THPB [MR] 1.8
Riap Tan THPB [RC] 1.7
Riap Tan THPB [RC L] 1.7
Riap Tan THPB [K Ind] 1.6
Riap Tan THPB [Ptkg] 1.9
Riap Tan THPB [Mangi] 3.2
Riap Tan THPB [Euca] 3.1
Riap Tan THPB [BBCP L] 3.2
Riap Tan Karet 0.8
GRAFIK PEMANFAATAN KAWASAN
UNIT KELOLA
KODE JENIS TAN
SUB LUARAN
BACK
NEXT
MAIN MENU
RUN


STRUKTUR & KOMPOSISI AWAL TEGAKAN ALAM
STRUKTUR TEGAKAN AWAL UNIT TPTI-1
TPTI 1: Jumlah Pohon KlasDiam[10] 151
TPTI 1: Jumlah Pohon KlasDiam[20] 78
TPTI 1: Jumlah Pohon KlasDiam[30] 43
TPTI 1: Jumlah Pohon KlasDiam[40] 23
TPTI 1: Jumlah Pohon KlasDiam[50] 15
TPTI 1: Jumlah Pohon KlasDiam[60] 7
TPTI 1: Jumlah Pohon KlasDiam[70] 6
TPTI 1: Jumlah Pohon KlasDiam[80] 3
TPTI 1: Jumlah Pohon KlasDiam[up90] 2
KOMPOSISI AWAL TEGAKAN ALAM : TPTI-1 %
KOMPOSISI AWAL TEGAKAN ALAM : TPTI-2 %
KOMPOSISI AWAL TEGAKAN ALAM : TPTJ-1 %
KOMPOSISI AWAL TEGAKAN ALAM : TPTJ-2 %
KOMPOSISI AWAL TEGAKAN ALAM : THPB-1 %
KOMPOSISI AWAL TEGAKAN ALAM : THPB-2 %
KOMPOSISI AWAL TEGAKAN ALAM : THPB-3 %
KOMPOSISI AWAL TEGAKAN ALAM : Unit Karet %
KOMPOSISI AWAL TEGAKAN ALAM : Unit Aren %
KOMPOSISI AWAL TEGAKAN ALAM : Unit Sawit %
Peninggi TegAlam Jenis [RC L] 24
Peninggi TegAlam Jenis [K Ind] 18
H Per D TegAlam Jenis [MR] 0.67
H Per D TegAlam Jenis [RC] 0.67
H Per D TegAlam Jenis [RC L] 0.67
H Per D TegAlam Jenis [K Ind] 0.67
Angka Bentuk Tegakan Alam Jenis [MR] 0.78
Angka Bentuk Tegakan Alam Jenis [RC] 0.78
SILVIKULTUR TEKNIS
GRAFIK PRODUKSI KAYU dari TEGAKAN ALAM TPTI, TPTJ, IPK THPB dan IPK dari UNIT USAHA NTFP
Total Tebangan dari Tegakan Alam (m3)
SUB LUARAN
BACK
NEXT
MAIN MENU
RUN

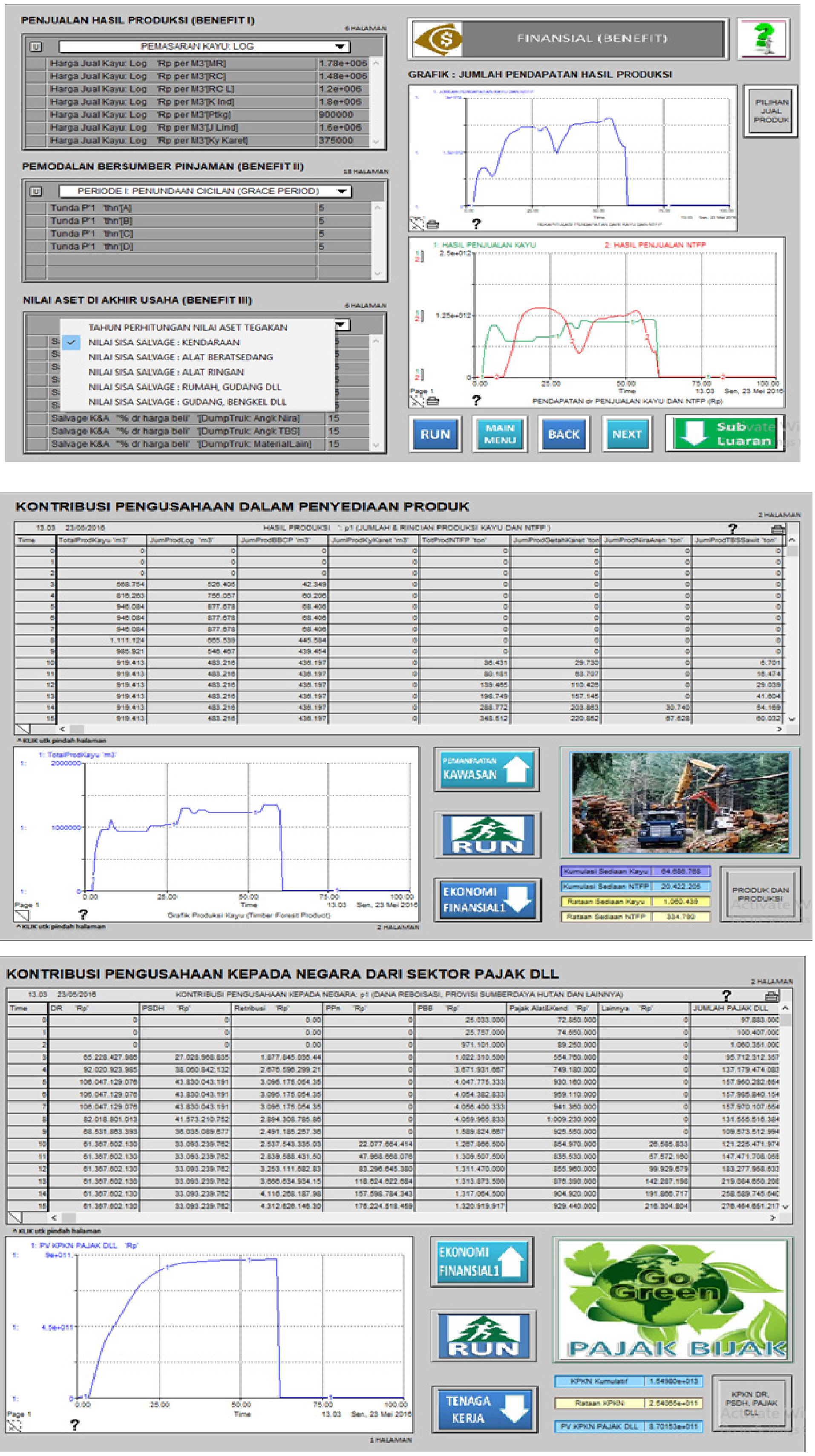


Figure 1. Six examples of 165 display screen in supersilvik model

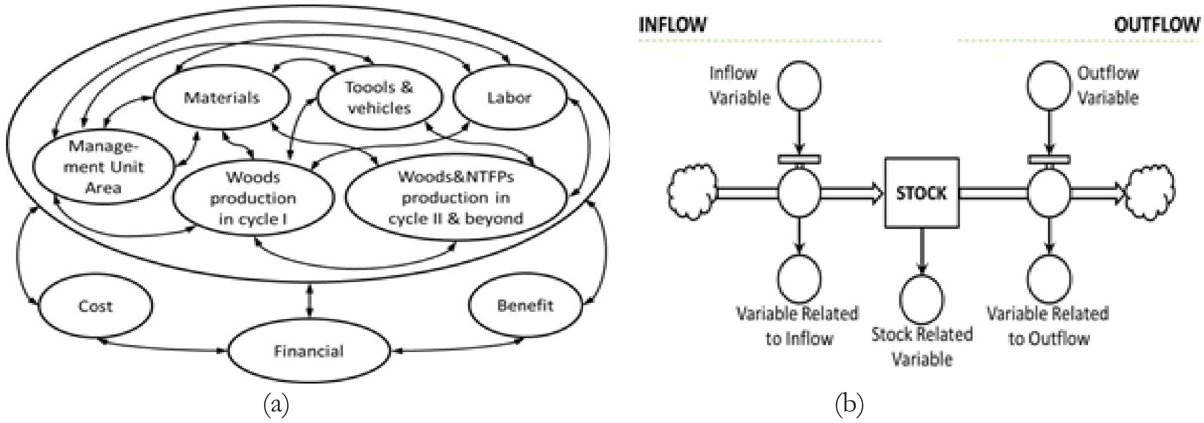


Figure 2. Model conceptualization (a) and notation and basic structures used in model construction (b)

all aspects of the enterprises (presented in 165 output data tables and 31 output data graphs).

Supersilvik model was constructed by the conceptualization as presented in Figure 2a. The model specification used some notations to describe the stock, inflows, outflows, source, discharge, flow of information and variables (Figure 2b). Conception and specification is based on the results of literature studies, validation and in-depth discussions with many experts and practitioners in relation to the production of forest exploitation. Model was finished in 2013 and enhanced in 2014 by supplementing numerous sub models of NTFPs exploitation. The model was built by incorporating more than 200 functions of differential equations for interconnected data processing, which were grouped into basic functions and many sub-models.

3. Sub-model of area management

The managed forest area in year *t* (LK_t) was formulated at equation 1 that it is function of time span of exploitation (d_u), cutting cycle (d_i), cluster size in the i^{th} business unit (LK_i), and road density in the i^{th} business unit (Kj_i).

$$LK_t = \int_{t=1}^{du} \sum_{t=1}^{n} \left(\frac{LKli}{d_i} x \left(1 - Kj_i \right) \right) \text{.............(1)}$$

Where:

LK_t	:	Managed forest area in year t
du	:	time span of exploitation
d_i	:	cutting cycle/plantation for wood production business unit or biological cycle for NTFP business unit
n	:	Number of business units
LKl_i	:	Cluster size in the i^{th} business unit
Kj_i	:	Road density in the i^{th} business unit

The sub-model of area management was provided with sub of sub model that processing the data on real time activity is a variable with the use of silviculture system of Indonesian Selective Cutting and Replanting (TPTI), Selective Cutting and Line Planting (TPTJ), Clear Cutting With Planting (THPB) and NTFPs.

4. Sub-model of production

The sub-model of production collects calculation functions for timber production based on natural and plantation stands as well as primary production and its products for NTFP commodities. Some of the basic functions used in this sub model are as follows.

a. *Timber production from business unit of natural stands*

Timber production comes from log-size wood harvested from the business unit of

TPTI and TPTJ throughout the span of the operations and all sizes of timber on land clearing of natural stands at the establishment of THPB, NTFPs and line planting of TPTJ. Timber production of TPTI and TPTJ unit in between path was calculated based on the volume of every single tree, and was approached by limit felling variable, stand structure and composition as well as the total management area of each business unit. Stand structure (*kd*) is divided into 10 diameter classes (*y*), covering 0-10 cm, 10-20 cm, ..., >100 cm and species composition (*kj*) divided into four groups (*z*), covering meranti, mixed forest, other mixed forest and fancy wood. Some used important variables are kd^{th} middle class diameter (*Dt*) into kj^{th} species groups of that contained in the logging limit, height (*Pt*), number of trees (*JP*), tree form factors (*AB*) of each species group, a safety factor *(FP*) and the exploitation factor (*FE*). The calculation of wood production from business unit of natural stand in year *t* ($Ptta_t$) is assembled in the following function (Equation 2).

$$Ptta_t = \int_{t=1}^{du} \sum_{i=1}^{n} \left(\sum_{kd;kj=1}^{y;z} \frac{1}{4} \pi \left(Dt_{kd;kj} \right)^2 \times Pt_{kj} \times JP_{kj} \times AB_{kj} \right) \times FP_i \times FE_i \times LK_i \quad \cdots(2)$$

b. *Wood production from business unit of plantation stands*

Wood production data were obtained from harvesting standing trees in the THPB unit of short of crop medium or long cycle; either thinning or final harvest cycle. Final production cycle is corrected by thinning percentage if the thinning was done between crop cycles. Production calculations based on the data processing of every single tree volume that was approached by calculation of the projected number of crop plants per ha (*Jt*), percentage of tree survival (*Jtp*), increment (*r*), thinning age or plant cycle (*dup*) as well as height (*Pt*), form factor (*AB*), safety factor (*FP*) and exploitation factor (*FE*) according to the plant species and the planted area. Sub of sub models offer nine choices (*w*) of plant species (*j*) with cycle and increment variables that follow the chosen species. Species selection that available are meranti, mixed forest, other mixed forest, fancy wood, other furniture wood, Eucalyptus, Acacia, other wood producing raw materials for chips/pulp and rubber. The timber production from business unit of plantation stand in year *t* ($Pttt_t$) is assembled in the following functions (Equation 3).

$$Pttt_t = \int_{t=1}^{du} \sum_{i=1}^{n} \left(\sum_{j=1}^{w} \frac{1}{4} \pi \left(r_j \times dup_j \right)^2 \times Pt_j \times AB_j \right) \times Jt_i \times Jtp_i \times FP_i \times FE_i \times LK_i \quad \ldots(3)$$

c. *Primary production (and its by product) of the NTFPs*

Supersilvik model was developed by offering three choices (*w*) of plant species (*j*) and nine choices (*y*) of primary/derivate product (*k*), namely: rubber plantation with latex and/or wood, sugar palm plantation with nira (sweet liquid) and oil palm plantation with fresh fruit bunches (*FFB*) as primary production. The derivatives product is processed sap, nira X_1 and nira X_2 as well as core palm oil and crude palm oil (CPO). The production calculation is based on processing data from primary production of every single tree, which was approached by the productivity of each commodity. Productivity is divided into three periods, i.e. the initial productivity, peak productivity and an end-cycle productivity. The calculations used the basic functions, such as Equation 4.

$$Pntfp_t = \int_{t=1}^{du} \sum_{i=1}^{n} \left(\sum_{j;k=1}^{w;y} \left(Prph_y \times Jt_j \times Jtp_j \right) \right) \times \left(LK_i + LKpr_i \right) \quad ..(4)$$

where *Jtj* is the number of plants per ha; Jtp_i is the percentage of survival rate; $Prph_j$ is a species productivity and $Lkpr_i$ is harvesting progressive area. Progressive area is the total area change of harvesting that was fitted with time of harvesting from block to block of plantation.

d. *Sub-models of materials, equipment, vehicles, buildings and labor*

Each material, equipment, vehicle, building and labor ($V_{bakbtkt}$) is calculated by using the basic functions of performance, i.e. the volume and/or workload ($VB_{bakbtkt}$) divided by job performance ($VB_{bakbtkt}$), as Equation 5.

$$V_{bakbtkt} = \frac{VB_{bakbtkt}}{Pk_{bakbtkt}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

Materials are defined into five groups comprising plant materials (provide 11 alternatives; appropriate species selection); fuel (1 type: diesel), fertilizer and means of enhancing plant growth (4 type; LiquidJell, NPK, TSP, herbicides), 9 staple food and other materials every single items were calculated.

Equipments are defined into four groups, comprises of five types in heavy equipment (machine for road construction, log extraction, land preparation, loading and timber extraction); 1 type of medium for planting; four types of lightweight (chainsaw and others). Vehicle is defined in six types, namely logging truck, dump truck, small cars, motorcycles, buses and other transportation.

Building is defined into 12 types, namely the head office, the base camp office, officer housing, residence barracks, working barracks, public facilities, nurseries, workshops, warehouses, fire tower and fuel depot. Further, labors are defined into seven groups adapted to the level of the workforce, namely commissioners, directors, managers, supervisors, staff, contract worker and daily workers. All calculations connected with the variable output of the other sub-models which presents the amount of volume and workload of each variable that requires the need of materials, equipments, vehicles, buildings and labors.

The basic functions in the financial sub model; consists of sub of sub models as follow:

e. Financing

Financing covers all financial in detail associated to all types of work at each stage of work at each business unit and time unit. Some examples include cost of rearranging plots, stands inventory, forest clearing, harvesting and enhancement of natural stands, planting and improvement of plantation stands, harvesting and post-harvest processing. Further financing is the procurement, maintenance and operational materials, equipments, vehicles and buildings. Labors financing includes salary, benefits, bonuses, ration and medical benefits. Other financing is procurement financing and documents processing, stationery and office equipment, human resources development, payment of interest on debt and loan, reforestation funds, commission, fees, taxe, and others. All financing is calculated based on the basic functions of multiplication and addition, also the unit price. The unit price used in this paper is the unit price at the beginning of the project, which is the year of 2016.

f. Revenue

Revenue is including income from loans, sale of products, salvage of tools and vehicles that was rejuvenated in-business cycle time. All revenue is calculated based on multiplication of volume and unit price that was adjusted to the time analysis at the beginning of the project.

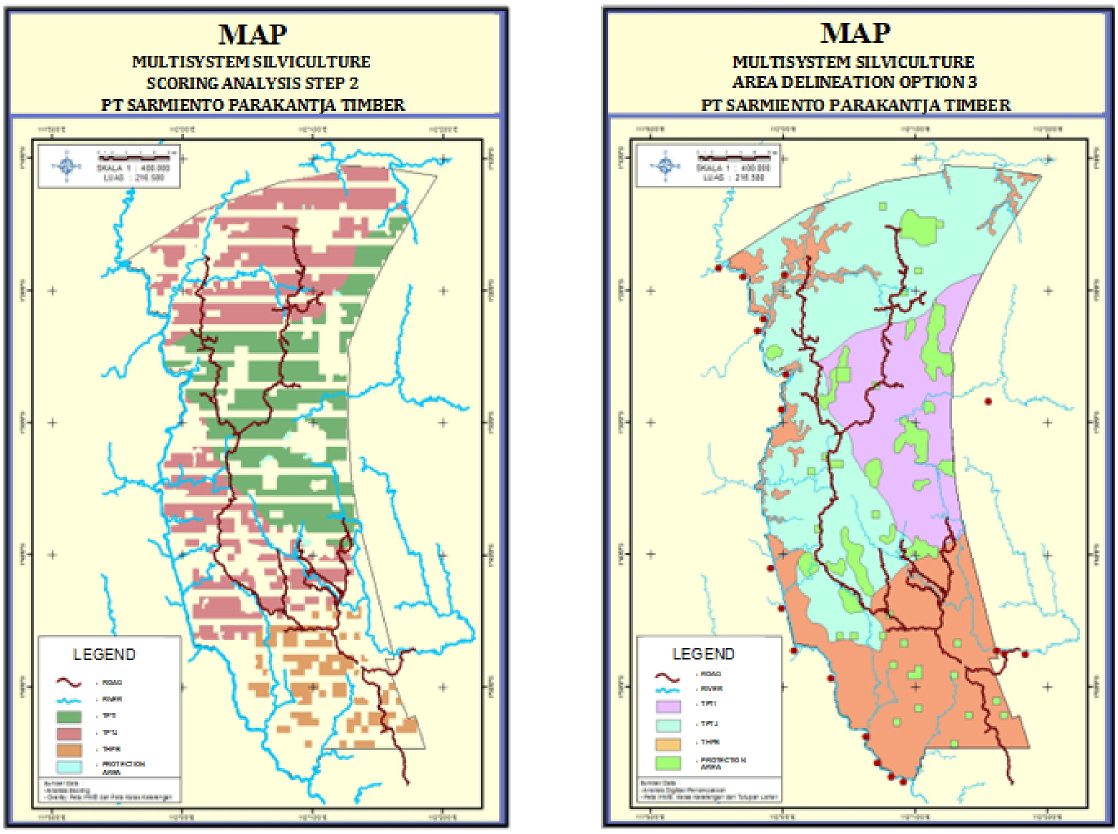
g. The asset value at the end of the business

The asset value is at the end of the business, including the residual value of tools, vehicles, buildings and value of stand asset is at the end of the business (project). Net Present Value (NPV), Benefit Cost Ratio (BCR) and Internal Rate of Return (IRR) were calculated using the common basic functions in the calculation of NPV, BCR and IRR.

III. RESULT AND DISCUSSION

A. Site Delineation and Business Unit Development

Tropical natural forests have declined over time (Brandt, Nolte, & Agrawal, 2016; Gunggut, Saufi, Zaaba, & Liu, 2014; Keenan et al., 2015). In Indonesia, this matter was caused by unsustainable management (Tsujino, Yumoto, Kitamura, Djamaluddin, & Darnaedi, 2016), deforestation (Gaveau et al., 2016; Margono, Potapov, Turubanova, Stolle, & Hansen, 2014), occupation (Gatto, Wollni, & Qaim, 2015; Maladi, 2013), illegal logging (Linkie, Sloan, Kasia, Kiswayadi, & Azmi, 2014; Maryudi, 2016; Schmitz, 2016), forest fires (Herawati & Santoso, 2011) or other damage have resulted in fragmented forests, including those happened in production forest concessions (MoEF, 2017). Many experts have identified earlier



(a) (b)

Figure 3. The raw data as a result of overlaying (a) and the assumed allowable alternative by MOEF (b)

Table 2. Four options of concessions in multisystem silviculture (MSS) used and the control

No.	Unit	Details	The options and area (Ha)				
			Control	Option I	Option II	Option III	Option IV
1.	TPTI	TPTI 1	92,835	92,835	92,835	92,835	92,835
2.	TPTJ	TPTJ 1	39,170	39,170	39,170	39,170	39,170
3.	THPB / HHBK	THPB1	-	67,914	48,910	29,770	29,770
		THPB 2	-	-	19,004	38,144	19,004
		NTFP 1 (rubber)	-	-	-	-	12,500
		NTFP 2 (sugar palm)	-	-	-	-	6,640
4.	KL&PL	-	16,661	16,661	16,661	16,661	16,661
5.	Un-used Land		67,914	-	-	-	-
		Total	216,580	216,580	216,580	216,580	216,580

that there were many non-forested clusters in the Indonesian production forest concessionk known as fragmented forest and the number is increasing (Faculty of Forestry IPB, 2003; Rusli, 2008). At present in Sumatera, the fragmented forest reached 63.28% while in Kalimantan reached 37.22% (MoEF, 2015). In natural production forest concessions, exploitation under limited use of the selective silvicultural cutting system (MoF, 2009a, 2009b) in the fragmented condition caused the deforested cluster without treatment because there was no valuable tree to cut which is not possible to exploit.

Even though the conditions were slightly better than the other common condition, forest exploitation at PT. Sarpatim conducted since 1969 has also resulted in fragmented forest. About 83.88% of their forested area was divided into four classes of production potentials, namely high, medium, low and very low. High and medium potency was dominant in the north with small patches of primary forest. Meanwhile, the southern side was dominated by low and very low potency.

In terms of topography, up to 68% of the concession area was flat. The finding of the overlay of topography criteria and forest potency is presented in Figure 3a. These results illustrate that a portion in the southern part of the area was unfavorable to development of business unit for planting with silviculture system of THPB or enrichment planting with NTFPs commodity. The soil type and rainfall supports the enrichment planting, which is also supported by the existing social typology. Over four decades, most of the company's activities were assessed from the southern part (Ferraz et al., 2014). Consequently, demographic and social conditions were developed faster in the southern part then in the northern part. The negative side of this typology is a higher social pressure. So, developing a business unit for planting with THPB or NTFPs directly creates a high work volume that provides many employment opportunities for local residents. Employment indirectly reduces the social pressure for TPTI or TPTJ business unit in the north.

Based on the six criteria analysis, further delineation produce three alternatives were selected namely, business unit of TPTI in the north, TPTJ in the middle and THPB or NTFPs in the south. It is recommended that the selected alternatives are endorsed only by the authority of MoEF as regulator. However, the value of the forest ecosystem services is at best an indication of the different multifunctional objectives that should be met by the management (Edwards, Tobias, Sheil, Meijaard, & Laurance, 2014; Hansen & Malmaeus, 2016). In this paper, the selected alternative are assumed as the delineations presented in Figure 3b, which are in details as follows: 92,835 ha for TPTI unit, 39,170 ha for TPTJ unit, 67,914 ha for THPB/ NTFPs unit and 16,661 ha for protected areas and unproductive land.

Further in-depth discussions with experts produced four development options to improve the performance as compared to "business as usual" (control option) (Table 2.) Options I, II and III were optional to develop timber estate cluster on un-used land (67,914 ha) due to the low yield potency of commercial timber i.e., 24.24 m^3 per ha. Option I is an option to convert all un-used cluster to become timber estate of acacia of 1650 tree per ha with six years of cutting cycle. In this case diameter increment rate of 3.2 cm per year were used to estimate the yield. Target and other asumptions were discussed with personel of forest planning division.

Options II and III were options to develop timber estate on the very low potency cluster by using two species of short cutting cycles i.e, acacia and eucalyptus. Meanwhile, option IV is the most challenging option i.e., by using part of the un-used land especially in the south side which were near to the village with access to develop NTFP of rubber (12,500 ha) and sugar palm (6,640 ha). Projected duration to establish the two clusters of NTFP was five years along with colaboration scheme to the surrounding community.

B. Recommended Five Options

Four options and the control are available for further analysis using the *supersilvik* model. Several groups of important variables were used as data input as described below. Simulation that is often used in natural resource management planning provides a projection as shown in Table 3 (Bouchard & Garet, 2014; Thompson et al., 2011).

1. **Land use**

The land use at TPTI and TPTJ units only used one variant venture each with 35 and 25 years cycle. TPTJ unit using, row spacing and line width of 5 m x 5 m x 5 m. Meanwhile THPB/NTFPs units offer four development options. THPB 1 for trees crops for production of chip and pulp with eucalyptus species, six years cycle and the total number of 1320 plants. THPB 2 was using meranti, 200 plants per ha and 30 years cycle to produce timber. NTFPs commodity include rubber and sugar palm (Arenga), the cropping pattern 143 plants per ha which was built in the 5-year and a time for rejuvenation was respectively 25 and 30 year.

2. **Production**

Diameter limit for cutting of TPTJ and TPTI were 50 and 40 cm up respectively. Using the equations of improvement, *fe*, *fp* and others, the potential harvest in TPTI and TPTJ unit cycle I is 124.91 and 71.64 m^3 per ha of commercial timber. Meanwhile, the potential harvest from land clearing in THPB/NTFPs unit cycle I amounted to 33.31 m^3 per ha for all tree species. Planting meranti is in TPTJ unit with diameter increment of 1.9 cm per year, in THPB1 2.5 cm per year and THPB2 1.8 cm per year. Meanwhile, rubber and sugar palm after five and eight years old respectively were assumed to start production, with peak production per tree per year at 55 kg and 400 liters.

3. **Financial**

Total or time range of analysis is 60 years with an interest rate of 15% and without borrowing investment.

4. **Tax and others**

As a large business, production forest enterprises in Indonesia have to pay many kind of taxes and fees as contribution to the government and surrounding communities (CSR fund). Each of them was defined in the form of goods and services used and product generated. For example for each cubic meter of meranti wood extracted from natural forest is charged reforestation fund amounting to IDR 148,000 and provision of natural resources amounting to IDR 66,000. The tariff is different from mixed forest type, which are IDR 120,900 and IDR 48,800. In this analysis, all taxes and other expenses are calculated, including calculated property tax and value added tax (VAT) of buildings, vehicles, equipment and services and CSR fund in the form of levy and grant.

5. **Labor**

An example is the employment for planting THPB 1 with a performance of 500 ha/team/year with six people in a team. The simulation found that existing forest stand was in good condition indicating that business performance of PT. Sarpatim was still good. However performance was not reaching the optimum level yet. Therefore, the improvement by developing some other business units can be accomplished. As shown in Table 3, control options as a form of light development scale, was projected to yield an annual average timber production (µ Pd-HHK) of 488 thousand m^3, an increase of 270 thousand m^3/year (interview data) from the existing average production. The total production obtained from TPTI and TPTJ cutting up to the 25^{th} year is expected at 334 thousand m^3 per year, after the 25^{th} year, the additional cutting in planting lines of TPTJ generates an average annual production of 556 thousand m^3. Projected control option provides a healthy performance of the financial aspects. Benefit and cost provides an average profit margin (µ (B-C)) of up to 86 billion rupiah a year (before the discount interest factor). The NPV along 60 years of analysis is IDR 1,066 billion with the BCR value of 1.9 and an IRR of 48.81%.

The production forests ventures are closely linked to the land and silviculture of the plant. Table 3 shows that the control options are not at the most optimal operation. This option is still ignoring the area of 67,914 ha of non-forested land and could be occupied by local resident. Furthermore, the employment is still low, only up to 490 persons. Simulation shows that the

Tabel 3. Concession indicators in five primary data output

No.	Indicator	Detail	Unit of measurement	Control	Development options with MSS			
					Option I	Option II	Option III	Option IV
1.	Land use	% LU	%	60.95	92.3	92.3	92.3	92.3
		PL-HHK	m^3/ha	123.13	146.50	152.27	161.37	151.37
		PL-HHBK	ton/ha	-	-	-	-	18.65
2.	Production	Pd-HHK Kum	million m^3	29.79	121.81	101.99	82.29	78.29
		Pd-HHBK Kum	million m^3	-	-	-	-	20.38
		μ Pd-HHK	thousand m^3	488	1,999	1,671	1,344	1,283
		μ Pd-HHBK	thousand m^3	-	-	-	-	334
3.	Financial	BCR	-	1.90	1.66	1.71	1.78	1.58
		IRR	%	48.81	69.86	65.38	60.63	64.43
		NPV	IDR. billion	1,066	1,931	1,759	1,592	2,062
		μ (B-C)	IDR. billion	351.77	539.70	592.67	647.84	814.34
4.	Tax for State	PV-KumTax	IDR. billion	361.09	667.42	598.78	529.56	850.83
		μTax	IDR. billion	86.47	127.45	128.47	129.45	266.78
5.	Labor absorption	μ Ser-TK	person/year	490	1,820	1,534	1,235	3,690

four other options could be used to overcome the employment problem. Development of non-forested land into THPB/NTFPs business unit results an increased use of land from 132,005 ha into 199,919 ha (151% increment). This additional land use directly not only increases the amount of production (μ Pd-HHK in 263-410% of increment) and employment (μ Ser-TK in 252-753% increment) but also increases the indicators of healthy financial (NPV in 181-193% increment) and tax contributions to the state (147-308% increment). Out of the four additional options, option IV is recommended to be used. When being compared with the control options, option IV increase the total production of wood over 60 years (Pd-Kum HHK) by 236% that were obtained from additional production of THPB1 and THPB2 business unit. Parts of wood production were obtained from land clearing for timber estate and NTFPs, which can be used as capital at the beginning of the venture. Although, BCR is decreasing, option IV will increase the profit margins (μ (B-C)) up to IDR 814.34 billion per year (an increase of 232%) and total NPV over 60 years amounted to IDR 2,062 billion (an increase of 193%).

Land is the one enduring asset the value of land for forest uses necessarily stems from the future forest crop or other services it can produce (Mattheus, 1935 as cited in Davis & Johnson, 1987). In response to changing societal pressures, it depends on various socio-economic reasons and has many adverse effects on the sustainability of forest and forest existence (Özden & Ayan, 2016). Simple forests are now being managed to meet multifunctional objectives including biodiversity, recreation and landscape values (Mason & Zhu, 2014).

The simulation results in PT. Sarpatim concession illustrates that the potential wealth of production forests in Indonesia are actually quite high. The simulation was also promoted to leave the old viewpoint of "natural forest stands (trees) as a factory". The old theory lead to pessimistic forest venture when existing natural forest stands were not sufficiently available. It has become an expert concern, which states that the Indonesias production forest productivity is very low, in 2007 no more than 1 m^3/ha/year (Petrokofsky et al., 2015; SoFS, 2015; SoFS, 2016b; SoFS, 2017; Soekotjo, 2009). Then, Soekotjo (2009) brought the concept of intensive silviculture (SILIN) as a solution. In this case, MSS which also accommodate the concept of SILIN therein, intends to strengthen the theory that the management of production forests is a land and plant-based enterprises, which should put a "land as factory or major capital; and silviculture aspects as the driving engine for production". Build stands and other forest services in forest land are the spirit.

MoEF as the regulator has the opportunity to reawaken interest in investing with regulations that propel the implementation of MSS in the field. In developed countries, the MSS concept has been applied in Canada (LORC, 1999), in the Province of Ontario three silviculture systems are used, i.e. selection system, the shelter wood system and clear-cut system. The key factors are against a variety ranging from intricate technical trade-offs to economies of scale in forestry production, and marketing (Fernández et al., 2008). At the end, it provides better results in terms of timber production (Baskent, Keles, & Yolasigmaz, 2008). According to MFM, MSS lead to better foreign exchange, as shown in the simulation in the sample concession above (Dalemans et al., 2015; Herrero-Jáuregui et al., 2013). The implementation of MSS concept will increase state revenue from taxes and non-tax sector and increase the number of employment. In the example of a comparison between control option and the option IV above, the annual average foreign exchange (µTax; before discounts) increased to 308%, or if calculated with present value, total tax over a span of 60 years (PV-KumTax) it increases up to 236%. While, employment increased by 753%. These impacts also bring ripple effect to other good effects. Among them are wood industry that will regain the excitement due to better supply of raw materials, improving the welfare of communities around the concession and more importantly, re-position the forestry sector as a sector that contributes significantly to Indonesian development.

IV. CONCLUSION

Conception of MSS affirms the principle of production forest governance which puts lands and crops as capital factors and aspects of silviculture as a driving factor. The application of this concept is projected to increase the performance of production forest management in Indonesia. MoEF as the regulator needs to encourage the implementation of MSS in each concession unit to better improve the management and productivity of forests. Improved performance for each concession is certainly influenced by the typology and business development selection respectively.

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