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Managing The Last Frontier of Indonesian Forest In PAPUA

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Chapter 1

PAPUA: THE LAST FRONTIER FOREST

Papua[1] is one region in the east-end which gives the biggest contribution towards the richness of the tropical rain forest resources in Indonesia. With a total forest area of 40,803,132 ha, its contribution reached 32.8% towards the total area of Indonesian forests. The ecosystem of the forest in Papua consists of the diversity of both flora and fauna which combine the elements of bioregion areas; namely, South East Asia and Australia.

Based on the Decree of the Minister of Forestry, number 891/Kpts-II/1999 dated 14 October 1999, the total area of forest covers 95.50% of the total area of Irian Jaya Province (what is now called Papua and West Papua). It comprises Conservation Forest, Protected Forest, and Production Forest (Table 1). Such a vast forest area stores an enormous potency of endemic flora and fauna, which is unequalled. There are more than 70 kinds of trading woods with merbau (Intsia spp.) as its superiority; therefore, this type of wood becomes the major target for wood business in Papua. Other trading woods found in this area are, among others, Meranti group, consisting of: Matoa *(Pometia spp.)*, Mersawa *(Anisoptera spp.)*, Kenari *(Canarium spp.)*, Nyatoh *(Palaquium spp.)*, Resak *(Vatica spp.)*, Pulai *(Alstonia spp.)*, Damar *(Agathis spp.)*, Araucaria *(Araucaria spp.)*, Kapur *(Dryobalanops spp.)*, Forest Mango *(Mangifera spp.)*, Celthis *(Celthis spp.)*, and Kayu Cina *(Podocarpus spp.)*. Those belong to mixed woods are: Ketapang *(Terminalia spp.)*, Binuang *(Octomeles sumatrana)*, Bintangur *(Callophylum inophylum)*, Terentang *(Campnosperma auriculata)*, Kayu Bugis *(Koordersiodendron pinnatum)*, and Pala hutan *(Myristica Spp)*. Furthermore, the group of *Kayu Indah* includes: Dahu *(Dracontomelum edule)* and Linggua *(Pterocarpus spp.)*. Most of these woods belong to the non dipterocarpacea group a fact that differs Papua from Kalimantan which is dominated by dipterocarpacea forests.

[1] Papua is a piece of land in the west of New Guinea Island. It is divided into two provinces; namely Papua province with Jayapura as its capital, and West Papua Province with Manokwari as its capital. In this paper, the term Papua is used to refer to both Papua and West Papua.

Table 1. The regions of Papua forest based on its functions

Functions of the Area	Total area of Papua (Ha)	Province	
		Papua	West Papua
Conservation Forest Area (KSA + KPA)	± 9,704,300	± 7,070,346	± 2,633,954
Protected Forest Area (HL)	± 10,619,090	± 7,638,676	± 2,980,414
a. Limited Production Forest (HPT)	± 2,054,110	±1,856,685	± 197,425
b. Permanent Production Forest (HP)	± 10,585,210	± 8,354,283	± 2,230,927
c. Conversion Production Forest (HPK)	± 9,262,130	± 6,486,673	± 2,775,457
Total area	**± 42,224,840**	**31,406,664**	**10,818,176**

Source: Forest Planning Agency, Forestry Department (2004)

The formations/types of vegetation grown in a variety of habitat spread out from the coastal area to the alpine zone, so that Papua is best known to have "the largest and most complete tropical rain forest ecosystem", apart from other tropical forests in Amazon and Congo. Also, Papuan forest holds more than 30,000 kinds of wooden trees, 330 kinds of reptiles and amphibians, 650 kinds of birds, 164 kinds of mammalians, and 700 kinds of butterflies (CI, 2000). The aspects of climatic and edaphic of Papuan region play an important role in determining these vegetation formation and species diversity formed. From all of the resource potency of this forest, many kinds of benefits can be obtained, particularly from the extract of timber forest products.

The history of forest resource utilization in Papua is as old as the age of Papuan human civilization. The phase of life commencing from primitive life patterns - hunter gatherer, shifting cultivation, peasant community to the modern stage is also influenced by the role played by forest resources. For the Papuan, forest is a "mother" who gives birth, raises and gives lives; accordingly they depend almost entirely to this forest. This means that the existence of forest resources has become a pilar for the systems of economy, ecology, socio culture, and even religion for the Papuan life perpetuity from one generation to another.

Ever since the collapse of natural forests in Sumatera, Java, and Kalimantan regions due to the excessive extraction, the forests of Papua have become a target of timber for businessmen in Indonesia. In fact, businesses on forests in Papua offer immense benefits for them; as a result, it opens opportunities for investors to locate their money here. In 1975-1990 the number of timber companies operated in Papua reached 20 companies with 21 business units. Five years later (1990-1995) there was an increase of 77.78% (27 new units). That number kept on growing so that in 2000 Papua became the "forest business field" for 54 companies holding forest concession (HPH). According to the data from Forestry Office of Papua Province, in

2006 the number of companies reached 46 spreading throughout Papua Province (23 units) and West Papua Province (23 units). This number, however, declined up to 35 units in 2007; 15 of which were active, and the rest were stagnant.

Papuan forest area covers 21,901,450 ha production forest which has been managed intensively since 1970 by Forest Concession (HPH) holders. Based on the result of satellite image in 2004 the primary forest in the production forest area was only 65.22% or 14,284,153.05 ha (BPKH X, 2004). Thus, of the production forest area (21,901,450 ha), not all can be expected to produce logs.

The distribution of forest concession in Papua is mostly (57.41%) in Papua Province; while the one in West Papua reaches 42.59%. There are three administrative regencies that give the biggest contribution towards concession area coverage; namely, Sarmi Regency, Boven Digul Regency, and Bintuni Gulf Regency. This paper focuses on the forest concession in Sarmi Regency with a case study on the holder of the Concession for the Utilization of Timber Forest Products (IUPHHK); namely, PT. Bina Balantak Utama.

HPH PT. Bina Balantak Utama (BBU) is one of the companies belonging to Kayu Lapis Indonesia (KLI) Group. The working area of HPH PT. Bina Balantak Utama covers the forest group in Tor River and Apauwer River. Geographically, this forest group is located between 138°05' - 139°00' East Longitudinal and 01°30' - 02°30' South Latitude, and belongs to the management of both Forestry Office of Sarmi Regency and Forestry Office of Papuan Province.

Based on the map of satelite image made in 1999, the total area of IUPHHK working area was 325,300 ha, consisting of 215,249 ha forest area and 7,080 ha non forest area; 18,067 ha was covered by cloud, and 84,904 ha was a swamp area.

The following is the total area and the forest planning based on forest arrangement: 1) Production Forest (HP) covering 59,693 ha; 2) Permanent Production Forest (HPT) as much as 159,781 ha; 3) Conversion Forest amounting to 102,255 ha; and 4) Other Utilization Area (APL) which covers 3,571 ha. In order to understand the dynamic and arrangement of forest products in the concession of PT. Bina Balantak Utama (BBU) region, the observation was focused on both primary forest and logged over forests.

The observation blocks for the subject of discussion in this book lie on logged over forests 2001, cutting blocks 56 KK, and primary forests. In the logged over area, there were 6 observation blocks, containing Vegetation Permanent Plot (PUP) with a total area of 24 ha. The PUP location lies in the altitude of 35 m a.s.l and belongs to Maran village, the forest group of Tor River and Apauwer River.

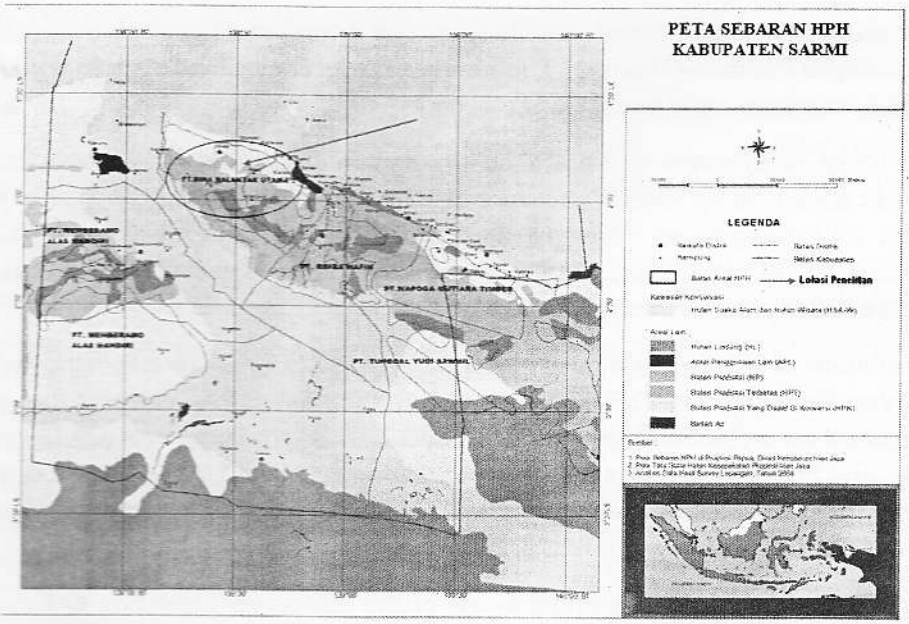


Figure 1. Production Forest of PT. BBU in Sarmi Regency

Biophysic of the Study Area

Soil Types and Field Configuration

The types of soil found in HPH PT. Bina Balantak Utama (BBU) concession are alluvial, rezina, cambisol, and podsolic. The situation of field of the whole area consists of: dry soil: 80,75%, swamp 6,25% and brackish 13%, with an altitude ranging from 0-600 m a.s.l. The area of the Vegetation Permanent Plot (PUP) belongs to a flat category.

Topography

Based on the slope area, most of the area in Sarmi Regency has an altitude level between 100 500 m above the sea level for Tor Atas District. Meanwhile, Sarmi, West Coast, East Coast, and some parts of Bonggo have altitudes less than 100 m above the sea. The slope ranges between 2% and 65%, consisting of 2% 8% in East Coast and West Coast. Tor Atas and some parts of Bonggo vary between < 2% and 8%.

The topography in BBU area is more dominant than the regions in the low land; covering area as much as 47.8%, flat 21.7%, wavy 17.2%, and rather steep areas 13.3%. This region relatively does not have very steep topography; as a result, the production cost is smaller.

The Types of Weather

According to the classification forwarded by Schmidt and Ferguson, this area belongs to the one in A weather type, with an average rainfall of more than 2.485 mm/year. The highest rainfall occurs in May, while the lowest is in September. Rainfall occurs continuously without dry months and the average of the rainfall is 5 days of rain per month.

Vegetations

Forests in HPH PT. Bina Balantak Utama working area belongs to the tropical rain forest. Based on the measurement of Permanent plot (PUP), this area is dominated by the types of dipterocarp, such as merbau (*Intsia bijuga*), matoa (*Pometia spp.*), kenari (*Canarium sp*), nyatoh (*Palaquium amboinense*), and resak (*Vatica papuana*). Meanwhile, the types of non dipterocarp and non commercial vegetation found in this area are (*Cananga odorata*), Dahu (*Dracontomelum edule*), medang (*Litsea sp.*), jambu-jambuan (*Eugenia spp.*), pala hutan (*Myristica spp.*), melinjo (*Gnentum gnemon*), and buah hitam (kecapi) (*Haplolobus*) with a relatively balance proportion.

Potency of Forest Resources in Sarmi Regency

Sarmi regency is one of the new regencies in Papua Province that has been developed since 2002 with a total area of approximately 8,948 km^2. Based on the Forest Area and Watershed Area Map, forests in Sarmi Regency are divided into 6 forest area functions as presented in Table 2.

Table 2. Forest Distribution According to Its Functions in Sarmi Regency

No	Forests	Total area (Ha)	(%)
1	Protection Forest	264,675.02	8.03
2	Natural Protection and Natural Conservation Area	1,296,782.40	39.37
3	Limited Production Forest	391,640.50	11.89
4	Permanent Production Forest	949,493.05	28.83
5	Conversion Production Forest	367,412.98	11.15
6	APL	24,003.40	0.73
	Total	3,294,007.36	100

Source: Forestry Office of Papua Province (2006)

The majority of Sarmi Regency is covered by forest vegetation with a total area of approximately 2,825,965 ha or about 92.5% of the total regency area. The condition of vegetation coverage is mostly dry land forests, 2,340,816 ha (76.6%), swamp forests, 466.479 ha (15.3%) and mangrove forest in the coastal area, which covered 18,699 ha (0.6%). Log cover areas (secondary forests) only cover 82,615 ha (2.7%). This leads to a conclusion that the forest area in Sarmi Regency is mainly primary forests. This kind of potency offers management opportunities for the regional economic growth. In line with the issue of regional autonomy, the local government of Sarmi regency accelerates the increase of regional incomes; one of which is from forestry sector. At the moment, there are 5 units forest management in the form of Concession for the Utilization of Timber Forest Products (IUPHHK) that utilizes forest resources in Sarmi Regency (Table 3).

Table 3. The existence of HPH/IUPHHK in Sarmi Regency in 2008

NAME of HPH/IUPHHK	SK HPH/IUPHHK		Total Area (Ha)	Note
	Number	Dates		
PT. Wapoga Mutiara Timber Unit II	774/Kpts-II/90	13 Dec 90	196.900	Active
PT. Bina Balantak Utama	40/Kpts-II/91	16 Jan 91	325.300	Active
PT. Mamberamo Alas Mandiri	1071/Kpts-II/92	09 Nov 92	677.310	Active
PT. Mondialindo Setya Pratama	13 Year 2002	21 Feb 02	94.500	Active
PT. Salaki Mandiri Sejahtera	15 Year 2002	21 Feb 02	80.500	Active
TOTAL			1.374.510	

Source: Forestry Office, Papua Province (2008)

Forest Ecosystems and Stand Dynamics

The type of forest ecosystem of Papuan forests is the one which is relatively complete, commencing with the formation of mangrove forests, swamp forests, low land forests, low land mountain forests, high land mountain forests to alpine forests (Petocz, 1989). The ecosystem in these forests is considered to be one of the natural resources which gives multiple benefits in the realization of development, not only from ecological point of view, but also from social, and economic ones. This fact was utterly advantages in supporting development and gives an essential contribution in producing income for the country. However, this role is now faced by unsustainable forest management since the forest condition has undergone changes. Forest areas, particularly the production natural forests, mostly come from logged over areas whose conditions continues to experience a degradation due to excessive logging, so that efforts to manage the sustainable forests are definitely required.

One of the major requirements to achieve sustainability in forest management units is the provision of long term forest management plans where product management becomes its major component. Yield arrangement through cutting allowance also plays a vital role in a sustainable forest management and therefore, has to be carried out in a specific way due to the fact that the condition and potency of forests vary from one area to another. Such a yield arrangement has to be determined both precisely and objectively through a good planning mechanism.

Meanwhile, it is widely known that the prescription of the planning key for forest is not long because cutting cycle, optimal cutting intensity, cutting diameter limit, and proportion of timber cut are also essential in preserving forests. The determination of such a prescription has to be based on several things; one of which is on the consideration of dynamic condition of structural stands. From the point of view of economic factor, structural stands can show the potency of minimum stands that has to be provided; while from the point of view of ecologic consideration, structural stands will reveal the picture on the ability for the stands to regenerate (Suhendang, 1993).

The dynamic structure of stands, then, is closely related to economic aspects in timber production activities since it has a correlation with the duration in which a capital will be invested in order to produce the timber (Davis *et al.*, 2001). Maximizing the discounted income is very important in achieving both cutting intensity condition and optimal cutting cycles. Indeed, this strategy requires a financial evaluation as its element to assess the financial performance of a company.

By relying solely on stand dynamic, nevertheless, a consideration is not adequate to explain forest ecosystems not only because forests contains complexities and uncertainty, but also due to the fact that they are dynamic and non linear. Accordingly, the measurement has to be integrated, taking into account other aspects like economic and social (Low *et al.*, 1999; Ness *et al.*, 2007). Such a complex character can be approached with a dynamic system approach by building models using a computer instrument towards a complex situation. Then, an experiment and a behaviour study are carried out towards the models at a certain period of time (Caulfield and Maj 2001 in Ness *et al.*, 2007).

Vanclay (1988) points out that several models are built to test the ecology succession upon different types of forests; however, such models are not able to be applied in yield arrangements. Likewise, the transition matrix approach developed by Usher in 1966 can only give a small contribution in order to understand growth processes in forest stands. With this kind of dynamic system model, it is expected that it would be able to determine the prescription of forest yield arrangement from production conservation and socio-economic aspects as well as its contribution given by yield arrangement method towards the income of not only society but also local government.

Forest Utilization in Papua

Forest resource utilization can not be separated from the government plan to increase local original income. This relation can be in the form of either synergic or asymmetric relation. In fact, excessive forest resource utilization fails the efforts to conserve forest resources a topic which then became the target of the conference in Rio De Jainero in 1992.

During 2000-2005, Indonesian forest area declined by almost 5.2%. Data showed that the speed of forest area decline in Sumatra Island reached 2% per year, in Java Island was 0.42% per year, in Kalimantan Island reached 0.94% per year. Likewise, the decline speed in Sulawesi Island was up to 1% per year, and in Papua, it reached 0.7% per year (Media Indonesia, 2007).

Up to present, forest management in Papua (Papua Province) has been run for approximately three decades and directed to the management of logged over area. In order to keep pace with economic growth rate, government has given forest concessions to approximately 54 companies to manage Papua Province forests which cover around 31 millions hectare. In line with the development of such forest utilization, however, both the government and society as the owner of forest resources, have not obtained any optimum benefit. In fact, the contribution given by forestry sector towards Papuan economy during 1993-2003 only reached 6.7% (Pawitno 2003).

The new paradigm in forest management is, therefore, expected to increase the income of the local government and the welfare of society by taking into account conservation management aspects. The control upon log production from forest area is an important part in realizing the efforts to reach sustainable products directly lead to the realization of forest business conservation. Theoretically, the production number of logs depends on forest condition and is determined based on *etat* cutting rules; accordingly, in a normal condition, log production is of a certain number which is relatively the same unless there is a sophisticated technology input. One of forest management forms is forest yield arrangement through the determination of annual allowable cut (AAC) established by the government. Forest yield arrangement has its short-term and long-term effects; in other words, AAC establishment bores ecological, economic and social consequences. At the moment, forest arrangement method used to determine annual cutting allowance (AAC) is general for any forest condition; thus, it is practiced in most HPH. In contrast, specific condition of each forest is not always the same in relation to its climatic and edaphic, so yield arrangement based on a specific site is definitely required.

One of the IUPHHK whose AAC is based on a conventional arrangement method is IUPHHK PT. Bina Balantak Utama (BBU) in Sarmi regency which manages 325,300 ha forest. However, the questions raised in such a case are: with the knowledge and silvicultural techniques, degradation of the current natural production forests, and changes in government's policies, will forest managed by IUPHHK through yield arrangement mechanism applied give sustainable products? Will the forest managed be able to give optimum contribution in supporting regional economy? And will it be feasible to be given to IUPHHK holders? If the answers are "no" an alternative to sustainable yield arrangement is absolutely needed. This can be carried out by conducting a study in order to know two important aspects in Papuan forest management: the first is an alternative for the yield arrangement from uneven aged forest based on the cutting intensity and a sustainable cutting cycle by using the dynamic approach, and the second is the interrelation between forest yield arrangement and the economic improvement of both society and region.

This study, therefore, is expected to be able to recommend a valuable input for the policy makers in establishing the strategies of production natural forest arrangement in a sustainable way. Furthermore, the alternatives of yield arrangement developed in this study are expected to be able to be used as techniques for forest utilization which is optimum and sustainable, so that finally, they can support the economic growth of the region.

Chapter 2

THE DYNAMICS OF FOREST

The History of the Growth and Product Model Development in the World

Both growth and stand product models have a long history. In the beginning of 1850 foresters from Middle Europe (French and Switzerland) had used a graphic method to make the model for the growth and production of forests including the stand table (Vokila, 1965 in Peng 2000). The most meritorious person in this case was Henry Biley, a forester from Switzerland who introduced the growth method through his writing entitled Me'thode du Contro'le (control or check method). He succeeded in developing an inventory system that could measure trees from the small, middle, to big sizes.

Furthermore, America started to make a stand table from 1920 to 1940 as a foundation in making assumptions to make curves. This stand table had a status quo until 1950s. Since 1970s, however, the influence of computer technology has significantly assisted to build the models for growth and stand product, particularly the stand for uneven age forests. Both of these models described forest dynamics such as the growth, the mortality, reproduction, as well as their relation with the stands at a certain time; therefore, they are used widely in forest management.

The elements of stand dynamics are required in forest management due to their abilities to update inventory data, predict the stand products, and explore management alternatives, and also silviculture choices so that they became useful information for decision makers (Burkhart, 1990; Vanclay 1994 in Peng 2000). In the future, the impact on the growth and product prediction with different scenarios will become keys to realize sustainable forest management (Kimmins 1997 in Peng 2000).

All models that have been developed are applied from the stand level to individual tree, and the purpose is that through these, processes from the stand product models to ecological ones in the forest can be reached.

In general, uneven aged forests have three major characters; namely, 1) maximum diameter, (2) density (usually the width of basal area), (3) ratio or Q factor, that is, the ratio of tree numbers in the closest diameter class (Murphy and Farrar 1982 in Peng 2000).

The metric growth model is used to observe the impact of both short-term and long-term impact on different kinds of cutting alternatives towards economic benefits and ecological diversity in mixed forests in Wisconsin, USA (Lu and Buongiorno 1993). The growth model developed here is the same as the one proposed by Buongiorno and Michie (1980); however, there some additions in grouping the kinds and sizes of the plants. Moreover, ingrowth plays its role as the function of diameter and the number of trees with the following equation:

$$I_H = 14{,}650 - 0{,}020G_H - 0.007G_L - 0{,}016G_N + 0.002N_H \quad (R^2 = 0{,}3\%)$$

$$I_L = 29{,}596 - 0{,}039\,G_H - 0.033\,G_L - 0{,}043\,G_N + 0.010\,N_H \quad (R^2 = 5{,}8\%)$$

$$I_N = 9{,}842 - 0{,}013\,G_H - 0{,}01O\,G_L - 0{,}043\,G_N + 0{,}012\,N_H \quad (R^3 = 4{,}2\%)$$

where I_H, I_L, and I_N are annual ingrowth rate (tree/ha) of trees with high value, low value, and non commercial, respectively; GH, GL, and GN are the total diameter (m/ha), and NH, NL and NN are the total number of trees (tree/ha).

In addition, Buongiorno *et al* (1995) carried out a study on the growth and mixed types of uneven aged forests in Jura France, as well as its implication on economic return and tree diversities. The equation for ingrowth, upgrowth, and mortality are based on the type grouping (Fir, Spruce, and Beach). Such a study was performed by using the following model:

$$I_{kt} = \sum_{i=1}^{m} d_{ik} \sum_{j=1}^{n} B_j\,(\mathrm{y}_{ijt} - \mathrm{h}_{ijk}) + e_k \sum_{j=1}^{n} (y_{kjt} - h_{kjt}) + C_k \quad (\mathrm{R}^2 = 37\text{-}47\%)$$

The Equation for ingrowth of each species is a function of tree number and reversed with basal area of each kind of tree. Meanwhile, the ingrowth equation is as follow:

$$I_{kt} = \sum_{i=1}^{m} d_{ik} \sum_{j=1}^{n} B_j\,(\mathrm{y}_{ijt} - \mathrm{h}_{ijk}) + e_k \sum_{j=1}^{n} (y_{kjt} - h_{kjt}) + C_k \quad (\mathrm{R}^2 = 37\text{-}47\%)$$

Where:

I_{kt} = *ingrowth* or number of k type of trees per unit area belongs to the smallest diameter class during a 5 year interval (tree/ha)

B = basal area average of the -j diameter class (m^2/ha)

$d_{ik}\,e_k$ = Parameter

Ck = A Constant which is expected not to be negative, meaning that ingrowth might happen, not depending on stand situation, can occur freely, and the form of its stand structure is in line with seedling spread around the stand.

Upgrowth (b_{ij}) is the function of stand basal area and tree diameter measurement which is formulated as follow:

$$b_{ij} = {}^{p}{}_{i} + q_i \sum_{i=1}^{m} \sum_{j=1}^{n} B\,(y_{ijt}\text{-}h_{ijk}) + si\,D_j \qquad (R^2 = 1{,}3\text{-}40\%)$$

where:

bij = upgrowth opportunity of -i type diameter to-j within 5 years

i = 1,......,*m*;*j* = 1 ......,n-1 b_{ij}=0(i = 1, 2, ..., m)

B = total of basal area of all kinds of trees from -i diameter class to -j (m^2/ha)

D_j = average of diameter in -*j* diameter class (cm)

Pi, qi, Si = parameter/regression cooeficient.

Mortality (mij) is the opportunity for a tree to die from the i tree and j diameter class experienced within 5 years, is formulated below:

$$m_{ij} = {}^{u}{}_{i} + v_i \sum_{i=1}^{m} \sum_{j=1}^{n} B\,(y_{ijt}\text{-}h_{ijk}) + wi\,D_j \quad (R^2 = 7\%)$$

where : *ui, vi,* wi = parameter/ regression coefficient

Kariuki *et al* (2006), built a growth quantitative model, recruitment and mortality in tropical rain forests in North-east South Wales Australia using multilevel non linear regression in various disturbance levels. The result of simulation using simile tools was a moderate product with an intensity of 47% basal area (BA), and needed 120 years to produce sustainable products without considering their integration with ecological aspects. The single tree selection (35% BA), however, produced a small gap in the canopy; as a result, recruitment became low, the growth of the stem increased, but it needed 180 years to revive such an area. In the areas with intensive exploitation (50% BA) as a result of high activity of logging, the area destroyed increased, and needed approximately 180 years to revive. The areas obtaining the impact of intensive logging (65-80% BA) reduced stem density, created a bigger gap on canopy, and gave big growth products and recruitment. Nevertheless, such a condition increased the period for reviving a 180-220 year decay. In addition, with the availability of simulation software, Stella Aswandi (2005), Septiana (2000), Bakri (2000), Cahyadi (2001), and Labetubun (2004) used this in order to simulate a dynamic model of stand structure. With such kind of system dynamic model, ingrowth, upgrowth, and mortality were made non linear towards stand basal area by using hypothesis data.

Models for an Optimal Natural Forest Management

Tropical forests are of many kinds; accordingly, it is difficult to define an optimal stand structure and, probably, it is more relevant with the study on harvest cycle length, minimum diameter for harvest (Vanclay 1995), and the number of trees harvested in each cycle (Mendoza and Setyarso 1986).

Lu and Buongiorno (1993) studied both the short term and the long term of cutting regime alternatives towards the revitalization of economy and ecological biodiversity in mixed forests in hardwoods forest, Wisconsin, USA. The result of this study is a simple guideline for cutting all kinds of trees whose diameter was the smallest (15 cm) every year. They show that the biodiversity is nearly 95% of the natural stands, and the land rent is approximately 70% of what could be reached.

Likewise, Buongiorno *et al* (1995) determines a variety of tree measurement and economic revitalization in the stands of uneven aged Northern hardwood forest, the USA. It was found that natural stands which are not disturbed are likely to reach the sustainability of the highest tree diversity. In general, the economic stand harvest policies gave an impact on the decline of diversity of tree measurement for approximately 10-20%, depending on the cutting cycle length.

Other studies on the trade-offs between income and the variety of dipterocarps mixed forest management were also carried out in the low land of Malaysia. Among the regimes studied, a good compromise between economy and diversity was to cut more trees with 30 cm and 40 cm in diameter for the types of both Dipterocarpaceae and Non-Dipterocarpaceae trees in every 10 years. Such a condition would guard several trees in all measurements and types. Moreover, the financial revitalization could be compared to other investments in Malaysia, and the highest result is under the present management regime; the diversity, however, is significantly higher (Ingram and Buongiorno 1996).

Other studies on an optimum harvest model in order to evaluate Indonesian Selective Cutting and Replanting System (TPTI) by using the linear program was also performed by Sianturi. A simulation was conducted towards 7 types of cutting rotation, 3 interest rates, 3 levels of stand damage and, 6 types of royalty system. The result is that an optimum cutting rotation is determined by not only the amount of interest rates but also the existence of stand damage level. The bigger the interest rates used, the shorter the cutting rotation is, so that it would give the highest forest products (Sianturi 1993).

Indeed, simulations give more flexibility in modeling (Buongiorno and Gilless 1987). A phenomenon is able to be presented through mathematical relations of a form that is easy to be applied upon the real system. Simulations are also used as the best and most useful tools in solving problems in forest management. Both output and application that can be produced from these kinds of models are, among others, stand dynamics, forest value, the best remaining stand number, the best cutting intensity, optimum combination and sensitivity analysis.

Simulation Models

A model is the real abstraction from the reality (Hannon and Ruth 1994; Grant *et al.* 1997; Banks *et al.* 1999), which comprises formal description of essential elements upon a particular problem (Grant *et al.* 1997).

Besides, a model is defined as a representative of a system in order to study the system. A model is crucial for taking into account all aspects being observed from a system that influence the system on investigation. These aspects represent the model of a system. Moreover, more detail models might allow one to draw a valid conclusion in order to explain a real system. The components of a system are elements (entities), attributes, and activities of a model.

The establishment of a model is able to help obtain the data from experiment and observation blocks. This can also help synthesize and deliver the existing knowledge as well as identify the gap of our understanding. Besides, modeling enables one to find the most efficient way to test experimental data, investigate their implication, and formulate the guidelines of optimum silviculture guidelines (Vanclay 2002).

Furthermore, a model is a form made to imitate a symptom or a process. Models are commonly taken from different kinds of assumptions related to the system operation. Such assumptions are then expressed in relations to mathematics, logic, and symbolic among the objects or entities from a system.

Models can be grouped into quality model, iconic model, and quantitative model. The lattest model is a kind of model formed of mathematics, statistics, or computers. A mathematic model is usually of two categories; they are static and dynamic models. A static model learns about static system behaviour (without including time element). The dynamic model, on the other hand, assists us to find out how a system changes in line with time. The growth, decay, and assimilation are the bases of the dynamic system pattern.

A simulation model can be used for the following: (1) to analyze the detail of certain policies, (2) to conduct a sensitivity analysis (3) to compare several policy alternatives (scenarios), and (4) to observe the behaviour between the price and the benefits (Eriyatno 1999).

The Challenges in Natural Forest Modeling

Compared to tree forests, natural forests have various difficulties in modeling since they have more variables and high complexity. This can be observed from the diversity of tree species, forest structure, changes due to succession, natural disturbance, and interaction dynamics among the stand elements (Turland, 2007). Apart from this, natural forest management experiences many obstacles due to the silviculture system applied, both regulation policies and economic situation of the government, and the influence of environmental and social problems.

A computer as a modeling tool can be used to maximize the volume of timber provision, log production levels, and species composition. Even more, in environmental conflict level, as well as social and political charges, computers are also required. Nevertheless, modeling in natural forests is admitted to be an extreme model science. According to Turland (2007), this is caused by several points; among others, data limitation in both composition and stand dynamics, length of the time period required to shift from one silviculture system or main natural disturbance, and the provision of fund for inventory, crown stratification, and classification of natural resources. The consequence is that complexity of resources leading to the difficulty in the prediction of growth and product models as well as product regulations.

Model in the field of forestry is an abstraction of the reality in the forest for research and management purposes. The major focus of the forestry modeling is to provide quantitative information in order to plan forest management and policy making.

Furthermore, the purposes of modeling in forestry field, in particular, are, among others (Turland, 2007):

- to *up date* forest inventory data
- to make an evaluation in order to obtain good silviculture system alternatives
- to predict both the growth and the products for a particular period of time
- to determine permanent period
- to make model of forest covered level to see the landscape, habitat and area usage changes in a certain place and at a certain time.

The models of stand dynamic and silviculture system in uneven aged mixed forest are relatively complex and can be given creation towards harvest period which are directed to the purposes to manage the forests and move obstacles to the more complex levels in order to plan forest management. Several points of the complexities of uneven aged mixed forest using computer model are carried out so as to initiate the following:

- The continuity of temporary changes towards the growth, mortality, and recruitment in forest stands
- Natural vegetation succession that occurs actively towards species composition and the changing stand structures
- Natural disaster (such as forest fire) that occurs in a varied way, from the minor to the major one on the intensity scale, frequency, as well as spatial patterns
- Forests which are permanently managed in a selective way in order to utilize both commercial and non commercial products towards irregularity of forest structure
- Effectiveness of silviculture system which is limited by both economic and policy (social and environmental) factors so that it reduces forest production capacity
- Complex dynamics from uneven aged forests determined by species composition, mixed species, in this case, its relativity abundance, and their tolerance to shade
- Spatial variation. In a short distance, there is likely a change on forest structure (particularly its species composition) in different areas, there can be seed randomization, natural plot disturbance patterns, and the history of silviculture system intervention
- Spatial obstacles in the sizes and period of harvest activities towards the distribution of permanent blocks, and obstacles in maintaining the entire blocks so that they are not disturbed, or the adjustment of habitat towards wild life

- Temporary timber flow and other financial obstacles towards choices in harvest period
- Various charges on sustainable forest management (social, economy, and environment).

The Approaches to Dynamic Systems

According to Eriyatno (1999) a system is relation association totality that has structures in positional as well as dimensional aspects, particularly the dimension of space and time.

A system can be imagined as a collection separated from interacted components. The elements of a system can be in the forms of objects, facts, methods, policies procedures, organizational parts, and others. The relation between systems may be in the form of transaction, interaction, interrelated correction, relation, and like. In a system there are transformation processes that process input to become output in line with the purpose to be reached.

Furthermore, Eriyatno (1999) points out that there are three thinking patterns that become the main guidelines for system experts in order to analyze problems. They are (1) cybernetic, that is, the orientation in goals, (2) holistic; namely the integrated point of view towards system's decision, and (3) effectiveness; namely, a principle that gives more focus on the yields that are operational and can be implemented rather than an in-depth theory to reach decision existention. Experts give problem limitation which should use a system approach in its study; namely, problems that meet the following characteristics: (1) complicated, (2) dynamic, and (3) probabilistic.

Furthermore, a dynamic system is a study on system changes according to time by taking into account the feedback factors (Purnomo 2004). A dynamic system is a method that can be used to understand a complex and complicated problem. The dynamic system model will involve many kinds of input, relation, and out put among parts of the system and model. Problems that will be made into the dynamic system have to have two major characters; namely, (1) characteristically dynamic, covering quantities that change according to time that can be described in the form of a changing graph based on the time (2) thought on a feedback since all systems basically have a feedback system. Forest ecosystem is a complex system which consists of many kinds of component interactions and is influenced by various factors; accordingly, a specific method; namely, system analysis, has to be applied. The essence of the system analysis does not lie on the group of quantitative techniques, rather, it focuses more on the strategy to solve problems which are difficult or can neither be solved by mathematics nor statistics, as presented in Figure 2.

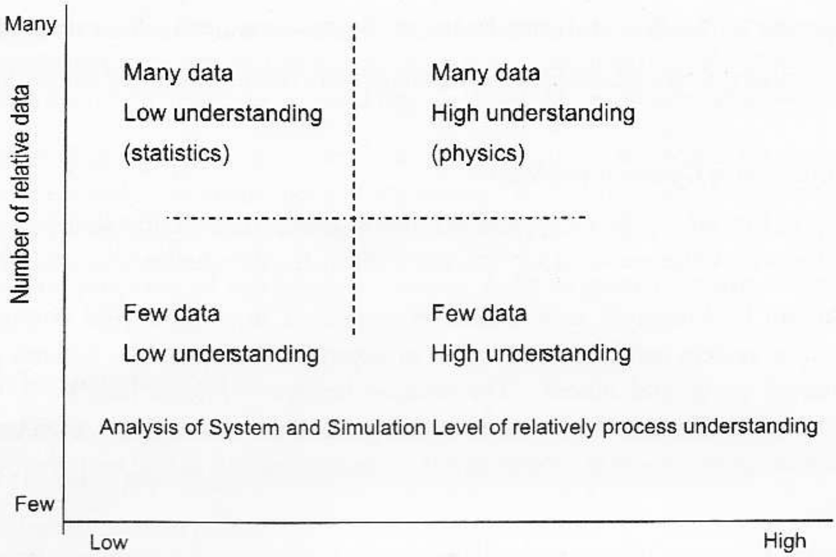


Figure 2. The comparison of Problem Solving (Grant *et al.* 1997)

Dynamic Models for Sustainable Forest Management

The objective of sustainable products, in the concession of both even aged and uneven aged forests is to reach a particular condition from a forest stand so that products can be obtained sustainably by arranging forest productivity, not only the growth but also product harvest. Forests that have multiple uses in terms of economy and ecology are, in fact, complex and dynamic ecosystems. Such forests are managed based on units which are in line with their management goal. Forest management as an ecosystem has to adjust with environment that surrounds it (adaptive); as a result, a specific prescription that offers optimum ecosystem dynamic balance will be obtained (Purnomo *et al.* 2003; Purnomo 2004). Accordingly, the division of forest management units has to be based on the characteristics of the surrounding area which has specific characteristics.

Furthermore, in every forest management unit, there are activities of planning, harvesting, and educating. The activity of product management planning such as the determination of optimum forest cutting prescription (cutting intensity and cutting cycle) is conducted based on the condition of the first stand, information on the fund, and the benefits as well as dynamic behaviour of stand structure. Moreover, the intensity and optimum cutting cycle have an implication towards the income of local government and indigenous society from a compensation based on price information and forest management benefit. The behaviour of stand structure dynamic is based on the information concerning growth and products obtained from vegetative permanent plot (PUP). The understanding towards stand structure cannot be separated from the information on the diversity of tree types in both PUP and primary forests.

In order to determine optimum cutting intensity (both cutting intensity and cutting cycle) a system dynamic model is developed; consisting of a model for stand structure dynamics, a model for economic revitalization, another model for product management, and a model for the indigenous people income. Meanwhile, the information on tree type diversity is information that supports stand structure dynamic model. A variety of simulation models related to both cutting intensity and cutting cycle are performed so as to determine the prescription of optimum product management viewed from the aspects of production sustainability and economy.

Finally, forests posses their own complexity and uncertainty; therefore, the utilization of timber forest product in a management unit cannot be conducted partially (separately), but rather, it has to be performed holistically. One of the approaches that is able to accommodate the complexity of forest management is the dynamic analysis approach (Grant *et al.* 1997). The system analysis as a holistic model is able to give impact scenarios on every policy alternative within a large spectrum so that the best alternative selection is easier to obtain (Purnomo *et al* 2003).

Chapter 3

FOREST YIELD ARRANGEMENTS

The Concept for Yield Arrangement in Forest Management

Stand products are the number of stand dimensions that can be harvested and yielded at a certain time, or the cumulative number up to certain time (Davis & Johnson 1987). The sustainability of stand products will be reached when the growth and the harvest occur in a balanced way. Product sustainability is used as a fundamental principle in harvesting and extremely depends on the yield arrangement system used. Yield arrangement is a method used to control the number, the types, and volume of logs, so that it can be used for the following harvesting (McLeish & Susanty 2000).

Yield arrangement gives an impact to the sustainability of forest resources with regard to ecology, economy, and social. In addition to that, product sustainability that has been applied in either tropical or subtropical forest leads the natural forest utilization to the long term one whenever applies consistently, and this will give an obvious impact towards environmental services (such as protection for water and soil planning) as well as their biological qualities (for instance, their biodiversity).

Harvesting sustainability means that the number and types of the same products (dimension, qualities, and types) can be taken continuously for a long period. This means that harvesting has to consider the sustainability of forest resources.

The above concept on product sustainability is in line with the concept of sustainable forest management, which is defined by ITTO (1998) as a process in managing forests in order to reach one or several goals which have been clearly determined involving the sustainability of products and other benefits desired without causing the decline on both forest productivity values and effects on physical and social environments in the future. There is another definition stating that product management is the determination on not only timber but also other products in the management planning prescription, including where, when, and how products should be extracted (FAO 1998). Both definitions definitely include the aspects of ecology, economy, and socio-culture in managing forests. The inclusion of social aspects in sustainable forest management means that humans are also taken into consideration as a part of a forest ecosystem.

Theoretically, product sustainability is not absolute. Indeed, there is relativity in it. The relativity is the measurement to declare the products, the width and volume of a timber, currency, or the number of trees. There is no guarantee that the use of one product measurement will give the same sustainability if measured with other measurements. If only there is the same sustainability level for all product measurements, this must be an outstanding event, and it is not a general natural phenomenon (Suhendang 1995).

Product Management Based on Simulation Model

Product management based on the simulation model cannot be separated from growth and product models. This simulation model is advantageous in explaining, understanding and predicting. Similarly, simulation model is useful for analyzing data and synthesis, communicating the existence knowledge, and identifying a gap in understanding (Vanclay 2002).

Furthermore, a simulation model can be applied on forests which are varied from one place to another due to forest ecosystem complexity, so that the assumption on stand homogeneity is not really important. This kind of model can also be used to test a variety of management regimes, where product realization depends on the accuracy and completeness of the model. Such models need knowledge on growth speed and stand dynamics (Alder 1999 *in* Krisnawaty 2001).

At this present time, several simulation software have been developed to predict either AAC or product management. Several studies on product management method for logged over areas on production natural forest in natural forests have been carried out based on the forest provision stand combination, increment stand volume and forest stand structure dynamic, as well as socio-economic condition of the surrounding people.

a. Dipterocarp Forest Growth Simulation Model (DIPSIM).

   DIPSIM (Dipterocarp Forest Growth Simulation Model) is a kind of computer software developed by Sustainable Forest Management Systems Programme (SFMP) through a cooperation between Indonesian Government (the Minister of Forestry and Plantation) and Germany *(Deutsche Gesellschaft fuer Technische Zusammenarbeit, GTZ)*. DIPSIM is a growth of individual tree developed from growth data and products through repeated measurement at PUP in East Kalimantan. DIPSIM is used to determined annual allowable cut (AAC) based on forest growth simulation, tree diameter, tree quality changes, mortality, recruitment and harvesting simulation (Kleine & Hinrich 1999 *in* Suhendang 2002).

b. Sustainable and Yield Management for Tropical Forests (SYMFOR).

   SYMFOR is a model of growth and yield used to measure and evaluate management system ecologically, and not a model of forest concession economically. SYMFOR model can be used to predict the growth of the tree, cutting yield, and the remaining stand in every period; thus it can determine optimum period for stand harvesting. One of the study cases in SYMFOR method experiment showed that Reduce Impact Logging (RIL) system 70 m^3/ha with a yield regulation in a sustainable form gave a better result compared to TPTI system and RIL 8 trees/ha based on the amount of production potency, particularly for areas with high potency (Susanty & Sarjono 2001).

c. Yield Simulation System (YSS)

YSS is computer software consisting of several program modules used to predict stand condition in the future through a simulation technique by using transition matrix. YSS was developed in 1999 by Rombouts.

d. Model Prototipe The Forest Land Oriented Resource Envisioning System (pFLORES)

The pFLORES model is a prototype FLORES model built by Muetzelfeldt in 1997. This pFLORES model used modeling software belongs to AME which basically explains sociological, ecological, and environmental interactions as well as factors which are related to area usage factors (Muetzelfeldt *et al.* 1997).

e. Model for The Forest Land Oriented Resource Envisioning System (FLORES)

FLORES is another model developed based on the FLORES prototype model during a workshop in Bukit Tinggi, West Sumatera, in 1999. Such a model was built for approximately three years based on the idea given by Vanclay in 1995 by using computer instrument. The materials presented in and sent to the workshop in Bukit Tinggi were compiled to be built as a FLORES model. This FLORES model uses Simile software as its tool in processing data. This model is developed in order to understand interactions between humans and natural resources in marginal forests in all developing countries, such as Indonesia, Zimbabwe and Cameroon (Muetzelfedt and Massheder 2003).

f. MYRLIN (Methods of Yield Regulations with Limited Information)

This method was built by Alder and his friends to predict the yield of stand growth in tropical rain forests. This method explains the patterns for tree diameter addition for the species of vegetative grown in a tropical rain forest that has significant similarities between one region and another based on general assumptions made in response to the growth yield. This model uses an equation to predict diameter addition, tree mortality, and other changes in the forest statistically (Alder 2002 *in* Vanclay 2003).

g. The Simile Visual Modeling Environment

Simile programming is a place that provides the ability and relative ease to build models and simulations on biological processes in forests, stand growth, marketing process, including humans and other systems in the forests (Vanclay 2003). In the beginning, Simile was previously known as AME (Agroforestry Modeling Environment) built by researchers from the University of Edinburgh, and for the last five years, it has focused more on forestry field. Other language programs the same as Simile are Vensim, Powersim and Stella. This study used the *stella* application research program 9.0.2

Stands and Stand Structures

Buongiorno and Gilless (1987) defined stand as a relatively small plot of area cut within a very short time, for instance, one year. A stand might cover the entire florest area or just a part of a vast forest area which is managed with a certain cutting cycle. A stand in a forest management perspective covers a forest area which geographically is centralized and has combination features and vegetation characteristics (type composition, growth pattern, and growth qualities), physical features (the form of the field), has a certain minimum coverage as required (Suhendang 1993).

The stand structure is both physical and temporary distribution of trees in a stand based on their types, vertical and horizontal distribution patterns, tree sizes or those belong to crown volume, leaf width index, stems, stem diameter, age of the trees or their combination (Oliver and Larson 1990).

Stand structure can be differentiated as vertical stand structure, horizontal stand structure, and spatial stand structure. According to Richard (1964), a vertical stand structure is a tree individual spread in various crown layers; whereas a horizontal stand structure is defined as the number of trees per width measurement in each diameter class (Meyer et *al.* 1961 in Davis *et al.* 2001). A spatial stand structure is related to the existence of trees in a certain growing space, determined by the surrounding environment, competition processes, the tree ability to grow and die, and the possibility of seeds to grow and improve the stand capacities. This study, however, will only focus on the horizontal stand structure.

In general, the horizontal stand structure of a natural forest follows negative exponential equation or referred to as *J*- (upside down J letter), but natural forest stand structure does not always follow this symbol (Meyer *et al.* 1961; Davis & Johnson 1987). The result of a study on the tropical rain forest in Imataca, found out that stand structure for all types of vegetations follow this *J*- symbol; however, when made for each type, their stand structure forms varied, according to their tolerance characteristic towards shade.

Due to economic factor consideration, a stand structure is able to show the minimum potency that has to be provided; while with the ecological consideration of stand structure, a picture on regeneration ability from related stand can be obtained (Suhendang 1993).

The stand structure in the form of curve which is closely similar to *J*- figure with the following model: $N = N_0e^{kD}$, has been found in studies on forest ecology. Suhendang (1985) in his study about the low land tropical rain natural forest in Bengkunat, Lampung, presented a stand structure form in the model of density function continuous random variable, based on gamma spread, lognormal, negative exponential and Weibull. Furthermore, it was revealed that the use of density function model to arrange stand structures is due to its significantly high reliability and easiness on its application. Based on the study of Suhendang (1995) in Riau Province, the stand structure model $N = N_0e^{-kD}$ can be accepted by all experiment plots, identified by the big determination coefficient obtained (R^2 was approximately between 73% and 89%).

Another stand structure model $N = N_0 e^{-kD}$ was also formed by Rosmantika (1997) on logged over natural forest in Stagen, Pulau Laut, South Kalimantan whose R^2 value obtained was between 66% and 99,3%.

Moreover, Krisnawati (2001) in her study in Central Kalimantan found out that a stand structure model $N = N_0 e^{-kD}$ which follow *J*- symbol could be accepted by all type groups in every experimental area; with its determination coefficient value as much as 87% to 98.8% for Dipterocarpaceae type group, and between 98.9% to 99.6% for Non Dipterocarpaceae type group, and from 98.6% to 99.9% for Non commercial type group, while for all other types the range was between 98.8% and 99.6%.

In this paper, both stand condition and stand structure were studied based on data and information on logged over natural forest stand and primary forest stand. Logged over natural forest stand was taken from Vegetation Permanent Plot (PUP) located in logged over blocks which were measured and observed for 5 years. Meanwhile, the primary forest stand data were obtained from a primary forest area which belongs to a concession area. The primary data gathered included: data on stand growth and primary forest stand structure. The stand growth data used were the results of PUP measurement at Annual Work Plan (RKT) Block 1999/2000 which was the location of logged over area two years ago. Of the total PUP area covering 24 hectare; it was only 12 hectare used, consisting of three PUP; namely, block 4, 5 and 6 which were not given any silviculture treatment. The total area of observation block was on each 100 m x 100 m (1 ha) block, comprising 100 observation plot, each of whose size was (flat distance) 10 m x 10 m. Geographically, PUP was located at $138^0 42'$ East longitude and $1^0 55'$ South Latitude.

Measurement was carried out from 2001 to 2005 and was repeated once a year. These data were presented in several Diameter class (Phn_D) according to the type group with an interval of 10 cm upward, the smallest diameter (Phn_D_{15}) sized 10-20 cm. The division according to the type group was conducted by grouping vegetation into dipterocarpaceae, non-dipterocarpaceae, and non-commercial types respectively. Such a division was based on the grouping performed by PT. BBU by taking into account that these type groups are the major commercial type groups on trade.

Other supporting data used were PUP report, data on Production Yield Report (LHP), weather data, Annual Work Plan (RKT) Book, Five Year Work Plan (RKL) Book, and Forest Concession Work Plan (RKPM), maps, both financial and TPTI reports, as well as other sources that support this research. The above data were taken from the observation on the Base Camp, and also information from interrelated institutions.

The components arranged stand structure dynamics consist of the number of trees within a variety of diameter class, and type group, by involving stand dynamic elements, such as ingrowth, upgrowth, and mortality. The stand structure general model can be approached with a negative exponential equation which were formulated as follow (Meyer 1961 in Davis *et al.* 2001) :

$$N = N_0 e^{-kd}$$

where:

N = Number of trees in every diameter class

No = Constant which shows stand density in the smallest diameter

e = Exponential (2.718)

k = Rate of tree number decline in each tree diameter increase

D = Centre of diameter class

Of all type compositions in the primary forest area, the non dipterocarpaceae type was of the biggest number in the research area, amounting to 39 types, followed by the non commercial types which reached 21 types, and finally dipterocarpaceae with 8 types. Some of them are: merbau (*Intsia bijuga*), matoa (*Pometia spp.*), kenari (*Canarium sp*), nyatoh (*Palaquium amboinense*), and resak (*Vatica papuana*), kenanga (*Cananga odorata*), Dahu (*Dracontomelum edule*), medang (*Litsea sp.*), and pala hutan (*Myristica spp.*) (HPH PT. BBU 2001). The types of trees observed not only in logged over area but also in primary forest are dominated by commercial tree types from Non Dipterocarpaceae group: namely, 57.35% in primary forests, and 68.08% in the logged over area. The non comercial types, on the other hand, were found in primary forests, as much as 30.88%, and 21.28% was found in the logged over area. The Dipterocarpaceae types were found approximately 11.76% and 10.63% in primary forests and logged over area, respectively.

In addition to the stand structure changes, stand dynamics showed stand behavior, regeneration ability, tree individual growth that supports the stand, particularly after the disturbance. The dynamic occurs in a stand every time period could be observed through three main variables; namely: ingrowth, upgrowth, and mortality. Ingrowth gave a material input in the form of the number of trees in the smallest diameter class, so that it could add the number of the trees in that diameter. Upgrowth, however, caused the exit of tree number in that particular diameter class, but give input on the number of the trees for the above diameter class. Finally, mortality caused the exit of material (number of the trees) in one diameter class so that it would decrease the number of trees in the diameter class. The process of material input (number of trees) among diameter classes might lead the stand to open.

The result of analysis towards the three observation blocks in the logged over area was that there were 47 tree types consisting of Dipterocarpaceae group (5 tree types), Non-Dipterocarpaceae (32 tree types), and non-commercial group (10 tree types).

It was predicted that in average, the entire primary forest structure produced an exponential model as follows: Y = 396.31 *exp* (-6.25), where $R^2 = 0.83$ and p =0.003. The result of stand prediction with this kind of model was considered to describe a climax condition that could be reached in this area or to show the average of primary forest in the beginning of forest management period. Meanwhile, for the logged over area, the following model was obtained: Y = 70.5 *exp*(-1.4) and p = 0,004 $R^2 = 0.82$. The prediction on the stands in both primary natural forest and logged over area was shown in Figure 3.

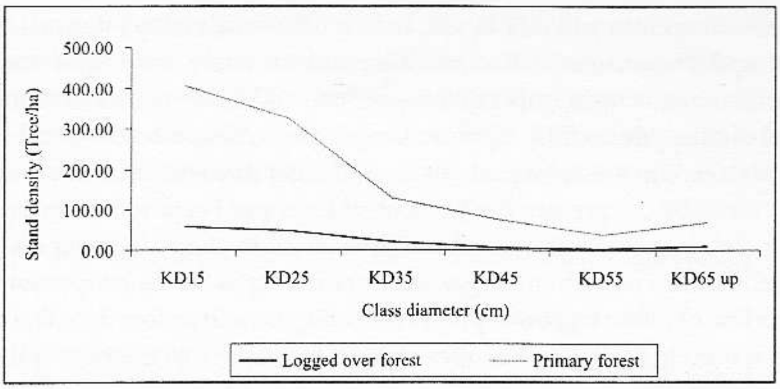


Figure 3. Forest stand structure in the research area

A Growth Model for Uneven Aged Forests

A growth model is a natural dynamic abstraction of one forest stand including growth, mortality, and other changes in the structure and composition of a stand. (Vanclay 1994). A growth model comprises a series of mathematic equation that can also be connected with a computer instrument in order to make a model.

The growth leads to the addition of dimension in one or more individuals in a forest stand at a certain period of time (for instance, volume growth $m^3ha^{-1}yr^{-1}$). The yield of a stand is the number of stand dimension that can be harvested and excreted at a certain time or in a cumulative way for a specific time (Davis and Johnson 1987). In an uneven aged stand, yield is a total production along certain period of time; while growth is the yield of production. Growth and yield, therefore, have a relation regarding mathematics: if yield is *y* then growth is its derivation; namely, *dy/dt*.

The empirical model is categorized into three groups: namely, individual tree models or single tree models, stand class models, and whole stand models (Davis *et al.* 2001; Vanclay 1995; and Turland 2007). The individual tree model uses an individual tree as its basis unit in arranging the model. The minimum input required in the application of such a model is the list of all tree types arranging the stand including the measurements on diameter, the height and form of crown. Other models also take into account the stand arrangement that include diameter size, the height and the form of crown, spatial position of every tree, the height of the tree and the class of the crown. The approach to the whole stand model describes the condition of the tree or forest stands by using a little parameter (Davis and Johnson 1987).

Vanclay (1995) pointed out that the approach to the whole stand model can be used to describe stand level parameters (directly per unit area), such as; provision stand (tree /ha), stand basic area (m^3/ha) and stand volume (m^3/ha). There are four key variables in modeling uneven aged forest; namely, stand growth rate, diameter spread in each stand, composition types, and the duration of cutting cycle (Leuschner 1990). The main problem arose in the prediction of tropical forest productivity (growth and products) through a growth model managed by selective cutting like TPTI, are, among others: mortality rate and ingrowth, type identification and the accuracy of re-measurement on every individual tree. In growth expresses the increase on the number of trees per hectare in the smallest diameter class for a certain period of time. Meanwhile, upgrowth expresses addition on the number of trees per hectare towards a certain diameter deriving from smaller diameter class at a certain period of time. Finally, mortality, expresses the number of trees per hectare died in every diameter class during a certain period. The number of trees fixed in every diameter class at a certain period of time is the accumulation of growth opportunity with the proportion of mortality and the proportion of either ingrowth proportion or upgrowth proportion. The most suitable approach often used in modeling the uneven aged forests at this moment is the stand class models (Vanclay 1995).

Ingrowth, upgrowth and mortality rates

The initial state variable in this stand structure is the number of trees in a diameter class (Phn_D_{15}), so that ingrowth is defined as the number of logs entering Phn_D_{15}. Ingrowth is expressed in a proportion, symbolized by inrate. Data available are in the forms of data of five year measurement, so that inrate used is the average of the five year measurement. Table 4 describes the result of calculation of each type group.

Table 4. Inrate of each type group

Type group	Inrate of five year measurement (%)				
	2001/2002	2002/2003	2003/2004	2004/2005	Average *Inrate*
Dipterocarp	0.2667	0.0278	0.1143	0.1667	0.1439
Non-Dipterocarp	0.0117	0.04938	0.05194	0.0694	0.1456
Non Commercial	0.0508	0.0167	0.0476	0.0045	0.0299

Source: IUPHHK PT. BBU (own processed)

Upgrowth is defined as the addition of tree number per hectare per year in a diameter class or certain growth phase derived from the smaller diameter class. The shift to the higher growth level means the decrease of density in the previous growth level. Upgrowth for dipterocarpaceae group went up from 25 cm (0.1038) diameter class, but then decreased to 55 cm or 0.0396 diameter class. Next, in non dipterocarpaceae group, there was an upgrowth increase from 15 cm (0.0723) diameter class to 45 cm (0.1033) diameter class, and also a decrease in 55 cm (0.0704) diameter class. On the contrary, the non commercial groups experienced an upgrowth increase from 15 cm (0.0592) diameter class to 0.0938 in 45 cm diameter class, but decreased in 55 cm (0.0500) diameter class. As a whole, the dipterocarpaceae group showed a bigger growth compared to both the non dipterocarp and non commercial groups because the upgrowth showed the growth capacity of a certain group which is in line with its increment behavior.

Compared to the result of study in PUP HPH PT. Sumalindo Lestari Jaya II of Sarmi Regency, there was the same growth behavior where in 20-29 cm diameter class the dipterocarp growth was 0.1528, but then declined to 0.0643 in 50-59 cm diameter class, then increased and became stable in 60 cm (0.0844) diameter class (Anonimous 2001). The calculation of the upgrowth rate in each diameter class according to its types is presented in Table 5.

Table 5. Upgrowth rates in IUPHHK PT. Bina Balantak Utama (BBU).

Upgrowth rates (diameter class)	Type Group (%)		
	Dipterocarp	Non-Dipterocarp	Non-Commercial
Phn_D15	0.0701	0.0723	0.0592
Phn_D25	0.1038	0.0906	0.0944
Phn_D35	0.0882	0.0767	0.0732
Phn_D45	0.0932	0.1033	0.0938
Phn_D55	0.0396	0.0704	0.0500

Source: IUPHHK PT. BBU (own processed)

The value of upgrowth was inversely proportional with the stand total block, so that the upgrowth rate would be lower if the stand total block was higher. This could be related to the increment, in which one of the affecting factors of it was a competition among individuals in the stand (Ong dan Kleine 1996).

Mortality is a death rate of the trees in the stand, which is generally expressed by percent per year. Natural mortality rate has a positive correlation with stand basal area, where a high density caused a high competition; therefore, there will also be a high natural mortality (Table 6)

Table 6. Mortality Rate in IUPHHK PT. Bina Balantak Utama (BBU).

Diameter Class (Phn_D)	Proportion of natural mortality in each Diameter Class (%)		
	Dipterocarp	Non-Dipterocarp	Non-Commercial
Phn_D15	0.0058	0.0320	0.0893
Phn_D25	0.1535	0.1768	0.0873
Phn_D35	0.6025	0.0864	0.1148
Phn_D45	0.1786	0.5542	0.2447
Phn_D55	0.1695	0.2737	0.1750
Phn_D65	0.0290	0.0893	0.0624

Source : IUPHHK PT. BBU (processed)

The highest mortality proportion for all dipterocarp type group occurred in 35 cm diameter class; while the one for both non dipterocarp and non commercial groups took place in 45 cm diameter class. Moreover, in 65 cm diameter class, there was a decline, but then it leveled out. In other words, the sizes of a diameter did not affect this mortality rate. This was in line with the view of Carey *et al.* (1987) referred in Favrichon (1998) that between the diameter and tree mortality in a mixed forest there was no significant correlation.

Annual Average Increment

Increment is a tree additional dimension both in vertical and horizontal ways. The result of the calculation on an average increment in a stand based on type groups in IUPHHK PT. BBU is presented in Table 7.

Table 7. Average stand increment of each type group

	Diameter Class (cm/year)						
Type Group	KD15	KD25	KD35	KD45	KD55	KD65	Average
Dipt	0.701	1.038	0.882	0.931	0.396	1.128	0.846
NonDip	0.723	0.906	0.767	1.033	0.704	0.685	0.803
Non-Kom	0.592	0.944	0.732	0.938	0.500	0.816	0.754
Average	0.672	0.963	0.794	0.967	0.448	0.876	0.801

Source: IUPHHK PT. BBU (own processed)

The average of dipterocarpaceae stand annual diameter increament is relatively the same as the one of the non dipterocarpaceae; namely, as much as 0.846 cm/year and 0.803 cm/year respectively. However, it differs with non-commercial annual increment which reached 0.754 cm/year. This diameter average is bigger than trees whose diameter are 40-50 cm (with average increment of 0.967 cm/year); while the increment of the dipterocarp type with 65 cm diameter can even reach 1.128 cm/year (Table 8). This clearly shows that the competition on a stand after cutting is dominated by big diameter trees, particularly those of the commercial types. If the determination of Annual Allowable Cut (AAC) is based on Table 8, it is likely that overestimation takes place *in* non dipterocarpaceae type group since the total average is bigger than cutting diameter increment (KD55 and KD65). As a result, increment calculation needs to be arranged based on cutting diameter limit (cycle cutting and rejuvenation).

Model Building and Forest Yield Arrangement

Based on quantitative data obtained from variables of the above tree growth, analysis and simulation were conducted. The stages were as follow: (Grant *et al.* 1997; Purnomo 2004):

1. Identification of Issue, Goals and Limitations

   This stage was aimed to identify all issues so that problems can be precisely seen. The next stage was determining the aims of modeling. Issue being discussed was then used to determine the aims of the modeling. The issue being focused on and the aim determined were expressed explicitly.

The next stage was to determine systemic components related to the way to achieve model intended. The relation of those components were identified and then presented in a box-arrow, and gave a definite limit towards parameter which would be used in the model.

2. The Formulation of Conceptual Model and Quantitative Model

   This stage is aimed, firstly, to build an understanding towards the system observed into a concept in order to obtain a thorough description on the model which is going to be made, and secondly, to form a quantitative model based on either the model concept which has been determined or mathematic equations. Based on the execution being carried out, a list shorter than a scenario which meets the aim of modeling is made.

3. Model Evaluation

   The aim of this stage is to discern model reliability in order to describe the real condition. The testing process was carried out by observing the logic of model and then comparing it with either the reality or any other reliable model, if it is available. In this study, comparison was conducted by testing Chi-Square (Walpole 1995) with the following formula:

$$\lambda^2_{calc} = \frac{(y_{actual} - y_{model})^2}{y_{model}}$$

With hypothesis H_o: $Y_{model} = Y_{actual}$

H_1 : $Y_{model} \neq Y_{actual}$

With a testing criteria: $^2_{calc} < ^2_{table}$: accepted the H_o

$\lambda^2_{calc} > \lambda^2_{table}$: rejected H_o

4. The use of Model

   The model formed is used to reach the aim of its formation. The activity was initiated by making a list of all scenarios which could likely be made based on the model being developed. All of these scenarios were then implemented, and their results were studied.

Identification of Issues, Aims and Limitations

Forest management in Papua Province has run for more than three decades, and at the moment, it is directed to the management of forests that are now logged over forests. Aiming to catch up with its economic growth rate, government has given forest concessions to approximately 54 companies to manage Papuan province forests, covering a total area of about 31 million hectare. However, until now, government as the owner of the resources and the local society living around the forest have not obtained optimum benefits.

The new policies on forest management are expected to be able to increase local government's income and the society's welfare without, obviously, ignoring sustainable management aspects. One of such aspects is the arrangement of forest yields through annual cutting allowance.

The yield management method that has been used to determine the annual cutting allowance is general for all forest conditions so that it is practiced in majority of forest concession. However, specific condition of each HPH is not always the same not only with regard to climatic but also edaphic aspects. Accordingly, there is a need to manage the yields (timber-in this case) in accordance with each forest site. In order to understand such specific conditions, this study limits its observation on IUPHHK PT. Bina Balantak Utama (BBU) in Sarmi Regency.

PT. BBU has performed timber forest yield utilization activities in the regional administration in Sarmi Regency for 17 years (3 five-year work planning, so called RKL), where RKL I and II are contributed to the development of Jayapura Regency an area which was previously the main regency for Sarmi. Since 2001, (RKL III) timber products have become a source of local income for Sarmi Regency.

The annual product allowance determined by the government has fluctuated according to the specific site. Such a situation was further described in the company's Annual Work Planning Proposal (URKT) determined to become an Annual Work Plan (RKT) as presented in Table 8.

Table 8. RKT Block area, Production Volume and log number during RKL II in IUPHHK PT. Bina Balantak Utama, Sarmi Regency, Papua

RKT	RKT Block Area (Ha)	Production Volume (m^3)	Log Number
2001	6,879	11,936.78	2,615
2002	6,789	13,169.24	2,352
2003	6,745	24,652.22	4,705
2004	4,100	22,705.57	1,579
2005	3,967	5,085.00	13,569
2006	6,998	122,857	30,260
2007	6,990	122,716	30,266
2008	6,840	120,083	29,577
2009	6,858	120,399	29,655
2010	6,922	121,523	29,932
Total	63,088	685,127	174,510
Average	6,309	68,513	17,451

Source : IUPHHK PT. BBU (2008)

In average, the exploited forest areas in each RKT covered the total area of 6,309 ha, with the annual production volume average of 68,513 m^3 or 10.86 m^3/ha (Table 8). Such a potency is considered low compared to the production log volume average of a number of HPH in Papua which reach 33.11 m^3/ha (Rachman 2003). Based on the satellite data made in 1999, forest total area of IUPHHK PT. BBU amounted to 215,249 hectares. When AAC was determined based on an etat's area with a cycle of 35 years (conventional cycle), the maximum area that had to be exploited in order to maintain the sustainability of a forest is 6,150 hectares per year. This means that there was a difference of about 159 hectare per year between the actual coverage area in average (Table 8) that had been exploited for 2 RKL and forest condition based on satellite data analysis. The implication was that at the end of the cycle, a company had to conduct moratorium so as to put stand condition closer to its initial condition. With a 35 year cutting cycle as written in TPTI system, the forest managed by IUPHHK PT. BBU still leave approximately 3 more RKL before coming to the second cutting cycle which was directed to the management of logged over areas.

Cutting intensity used during forest concession activities ranged between 60% and 100% depending on the topography condition in each cutting plot. In this study, however, 80% intensity was used.

System analysis model built was aimed to find an alternative for yield arrangement in uneven-aged forests based on cutting intensity and sustainable cutting cycle, and also the interrelation between forest yield arrangement method and the increase of both local government and society's economy. To achieve the above aim model was divided into 4 (four) sub models; namely, stand structure dynamic sub model, yield arrangement sub model, economic revitalization sub model, and indigenous people income sub model.

Limitation and definition of components in the system are as follow:

a. Cutting cycle is a time interval (in two years) between two consecutive cuttings at the same place within a polycyclic silviculture system.

b. Ingrowth is defined as the increase of addition towards the number of trees per hectare in the smallest diameter class at a certain period of time.

c. Upgrowth is the increase of tree number per hectare towards certain diameter class derived from the one below at a certain period of time.

d. Mortality is the number of tree per hectare died in each diameter class at a certain period of time.

e. The cutting effect is a kind of mortality or damage of a stand resulted from timber cutting activities.

f. Indigeneous people are people who traditionally rely on and have a closely relation in socio-cultural as well as religion with their local environment.

Formulation of Conceptual Model and Specification of Quantitative Model

The conceptual model developed here was described through a causal loop diagram. The number of trees in a stand was influenced by the number of ingrowth, upgrowth, and mortality of trees, cutting effects and illegal logging. Ingrowth gave an input on material (number of trees) in the smallest diameter class (Phn_D_{15}), so, it increased the number of trees in that class. The number of mortality, cutting effects, and illegal logging would lead to the decline of tree number in a stand in each diameter class. In this study, nevertheless, illegal logging was not referred to a forest disturbance form in model calculation; thus it was assumed that illegal logging did not take place. Furthermore, the number of upgrowth trees would result in an increase on the number of trees which belong to 25 cm to 65 diameter class. The relation between ingrowth and the tree number in a stand was a positive one, meaning that the bigger the ingrowth number, the bigger the number of trees in a stand. In contrast, the relation between tree number in a stand and mortality and cutting effect was negative. Therefore, the higher the mortality number and cutting effect would cause a significant decline of tree number in a stand. Cutting was carried out in nearly all diameter classes with different intensities based on the scenario being developed. Moreover, cutting was performed on ready-to cut trees (Phn_D55 and Phn_D65) in order to obtain production timber that would be sold by the company to give it an economic benefit. The number of the trees and their volumes have a positive correlation; therefore, the higher the number of trees, the bigger the volume was. In order to obtain commercial timber, the company conducted a harvesting activity with a certain amount of cost. Likewise, the price and volume showed a positive correlation; namely, the higher the prices, the higher the volume of timber produced. Each stand growth variable was calculated by using the following approaches:

a. Ingrowth

Ingrowth was defined as the increase of tree number per hectare in a small diameter for a certain period of time (in this study: 1 year). In arranging the *ingrowth* hypothesis model, *ingrowth* was expressed in the following formulation:

$$I_j = \frac{Xj}{\Delta T}$$

Then *ingrowth* can be described in the following proportion:

$$Inrate = \frac{I_j}{N_{jt}}$$

Where:

I_j = *ingrowth* of the i type tree (tree/ha)

Xj = tree number of -i type entered Phn_D_{15}

ΔT = measurement period interval (year)

Inrate = *ingrowth* of tree proportion

N_{jt} = number of ingrowth during measurement period

B. Upgrowth

Upgrowth was the increase tree number per hectar in a certain lower diameter class in a year. *Upgrowth* was predicted to be obtained from increment average for each diameter class. To obtain an annual average diameter increment, the following formula was used:

$$MAI = \frac{\Delta D}{\Delta t}$$

Where:

MAI = *Mean Annual Increament*
ΔD = diameter difference between measurement
Δt = measurement time period
W = class interval (10)

To predict the following behaviour in each diameter class, the formulation below was used:

$$Uprate = \frac{\text{Annual average increament (MAI)}}{\text{Class Interval (W)}}$$

C. Mortality

Mortality in this study referred to the number of plants per hectare died in each diameter class for a year. In this tree mortality hypothesis model, tree mortality was expressed in a proportion, with the following formula:

$$m^{(i)}{}_{j} = \frac{m^{(i)}{}_{jt}}{N^{(i)}{}_{jt}} \times 100\ \%$$

where:

$m^{(i)}{}_{j}$ = *mortality* rate of the -i tree type in a -j diameter class (%/year)
$m^{(i)}{}_{jt}$ = the number of trees died in the -i tree type -j diameter class in t year (tree/ha)
$N^{(i)}{}_{jt}$ = number of trees in i tree type in a -j diameter class in the -t year (trees/ha)

The number of trees in a stand also plays a role in calculating the stand biomass. This stand biomass is, indeed, essential for the carbon cycle in the forest, so it can be used to determine the carbon content. This variable was used to determine carbon trade mechanisms through the *Reduce Emission from Degradation and Deforestation* (REDD) scheme.

The big volume of timber produced offered double benefits; namely, benefits for not only the local government's economic growth but also for the interests of company itself and the society which possess customary right. Every volume of timber harvested by the company gave an impact on company's income and extra income for society possessing customary right. If the company conducted a moratorium, the society would lose their extra income (*trade off*). These societies could also use their possessive rights to cut timber in the concession area, in order for them to obtain their own income. The relation between those above components was a positive one, and tied up one another. The high level of the company's income expressed by the high level of trading would lead to the big income for both the local government and the society. The relations among all the above components which arranged the model were presented in Figure 4.

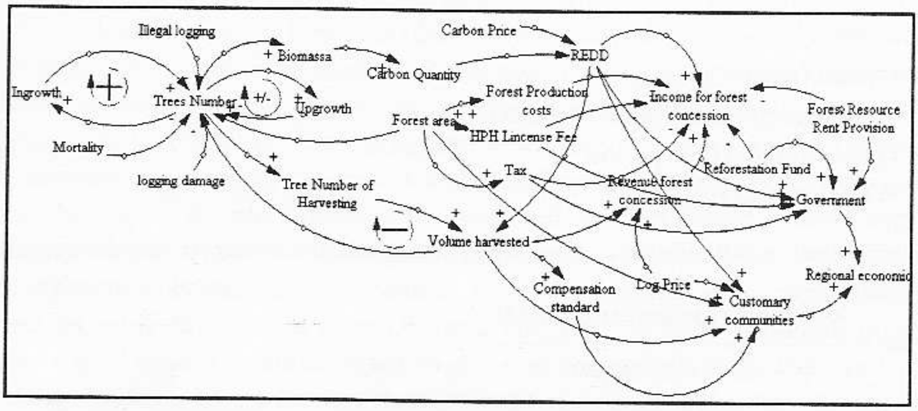


Figure 4. *Causal loop* diagram among the components in the model

Sub Model for Stand Structure Dynamics

In this sub model, the discussion would be focused on the development of stand structure dynamic model for three type groups; they are: dipterocarpaceae, non dipterocarpaceae, and non commercial. The stand dynamic model in this study used a number of trees from each type group and each diameter class as its *state variables*. The material flow in each model was assumed to be series flow. This means that each model would go through a certain diameter class in a sequence, so that there was no tree that passed more than one diameter class at the same time. This followed the TPTI assumption which stated that the annual average increment was 1 cm; whereas the class width for this stand dynamic model was as much as 10 cm. Besides, it was unlikely that a tree could pass two or three diameter class all at once in one year.

The material flow in this dynamic model was commenced from trees with the smallest diameter class (Phn_D_{15}). The general quantitative structure of this model was in the format of model structure based on time. The simulation measurement unit used was year.

The tree mortality in one diameter class was represented by flow mortality with two variable *auxiliaries;* namely, natural mortality (*morate*) and mortality due to a cutting (cutting effects). Mortality as a result of cutting would increase shortly after the cutting and decreased in the following years. Meanwhile, natural mortality was influenced by stand basal area where tree mortality increased in line with the density of the stand basal area. In 50-59 cm and 60 cm diameter classes or more, there were cutting activities, and these became factors for reducing the number of trees from their *state*. Since the cutting activities were only carried out when entering the cutting cycle, *state* year was required, and the amount of the cutting performed would be determined by cutting percentage.

The amount of *ingrowth* was expressed in the form of inrate of the number of trees belonging to the smallest diameter, and the amount of such an *inrate* was influenced by total basal areas (*BA*). *Ingrowth* inrate of one type would be higher in accordance with the bigger number of trees; the rate, however, would decrease with the increase of basal area.

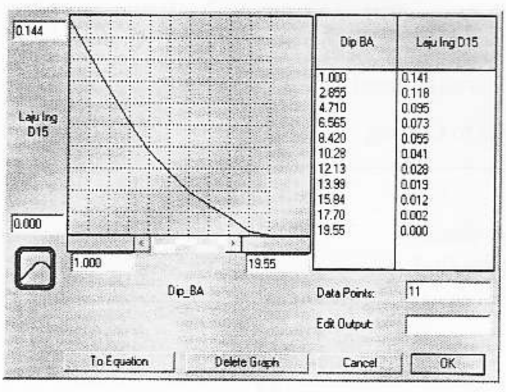
Like *ingrowth* and *upgrowth*, natural mortality rates also a function in stand basal area. This kind of mortality is a natural mortality rate of tree individual in one diameter class. Such a natural mortality had a positive correlation with the stand basal area so that the mortality of an individual tree would be higher when either the stand basal area or the stand density was bigger.

The amount of *ingrowth* and *upgrowth* was determined by their inrates. This could be expressed by using the following equations (Aswandi 2005):

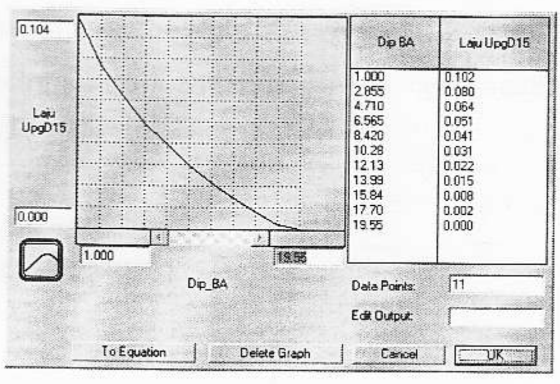
Inrate	= *f(BA)*
Ingrowth	= *inrate* * tree number in the smallest diameter class
uprate	= *f(BA)*
Upgrowth	= *Uprate* * Phn_Di
Morate	= *f(BA)*
Mort	= (Phn*Cutting effects)+ (Phn**morate*)

Where: *inrate* = *ingrowth* rate, upg rate = *upgrowth*, *phn_Di* rate = number of trees in -i diameter class, *BA* = stand basal area

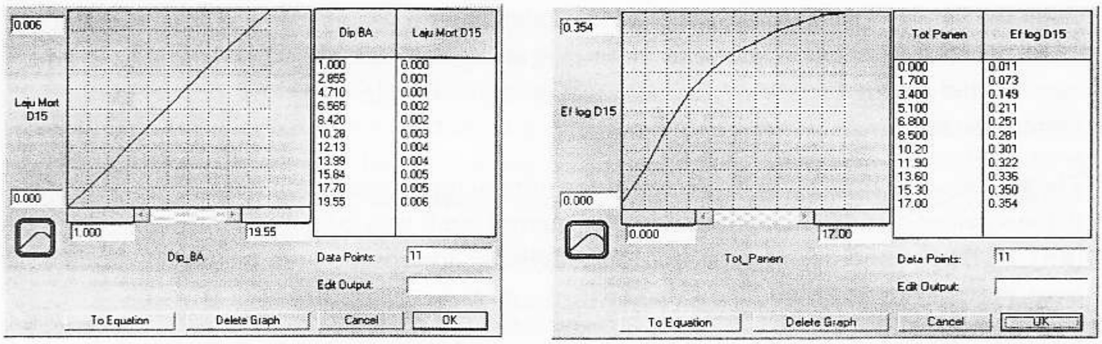
Based on the Elias' data (1998), as an illustration, there was a depiction on the relation between growth parameter rate and stand basal area (*BA*) of dipterocarpaceae type group shown in Figure 5.



(a)



(b)



(c) (d)

Figure 5. The relation between stand basal area (*BA*) and growyh parameter. The relation was to (a) ingrowth rate (*inrate*) of dipterocarpaceae type group, (b) upgrowth, (c) stand natural mortality, (d) cutting effect mortality

Mortality rate due to cutting effect was affected by the number of cutting intensity (N/Ha) and technology used in carrying out logging activities, where opportunities for died tree individual opportunity became higher when the cutting intensity was also high. With an assumption that the same harvesting system would increase similar damage, the data of cutting effects used in this study were taken from those in Elias (1998) research. This was caused by the limitation of researches focusing on this matter in their research location.

The relation between cutting effect stand mortality and cutting intensity can mathematically be formulated in the following equation:

Cutting effect = *f(Tot cutting)*

Mort = *cutting effect* *tree

where :

Ef cutting = mortality rate due to cutting,

Tot cutting = number of trees cut,

Mort = tree mortality due to cutting, and

tree = tree number in -i diameter class

Remaining stand damage based on cutting intensity is as follow:

Table 9. Remaining Stand Damage Due to Cutting

Permanent Plot	Cutting Intensity (tree/ha)	Tree Damage (tree/ha)	Cutting Effects (%)
1	2	58	9.39
2	6	146	21.13
3	17	259	35.43

Source: *Elias (1998)*

Stand mortality was still high within several years after cutting activities as a result of land closing changes and micro weather. During the cutting time, more stand mortality occurred more on trees with small diameter and declined on those with bigger diameter. Anonimous (1997) reported a research result that in Papua, damage level due to logging had led to the damage on remaining stand (nucleous trees) between 5-40%, pole and sapling between 10-33%, and seedling between 3-17%.

Forest stand dynamic sub model can give description on cutting carried out each year or every cutting cycle based on both cutting intensity and cutting interval that have been determined. Cutting was conducted on dipterocarp and non dipterocarp trees when they reached 55 cm and 65 cm diameter classes. In order to observe cutting effects performed by local people towards stand structure, cutting was conducted in 45 cm diameter class with lower intensity but relatively high cutting frequency. The relation among each component of dipterocarp stand and the non commercial one as well as a variety of their dynamic elements is presented in Figure 6, 7, and 9

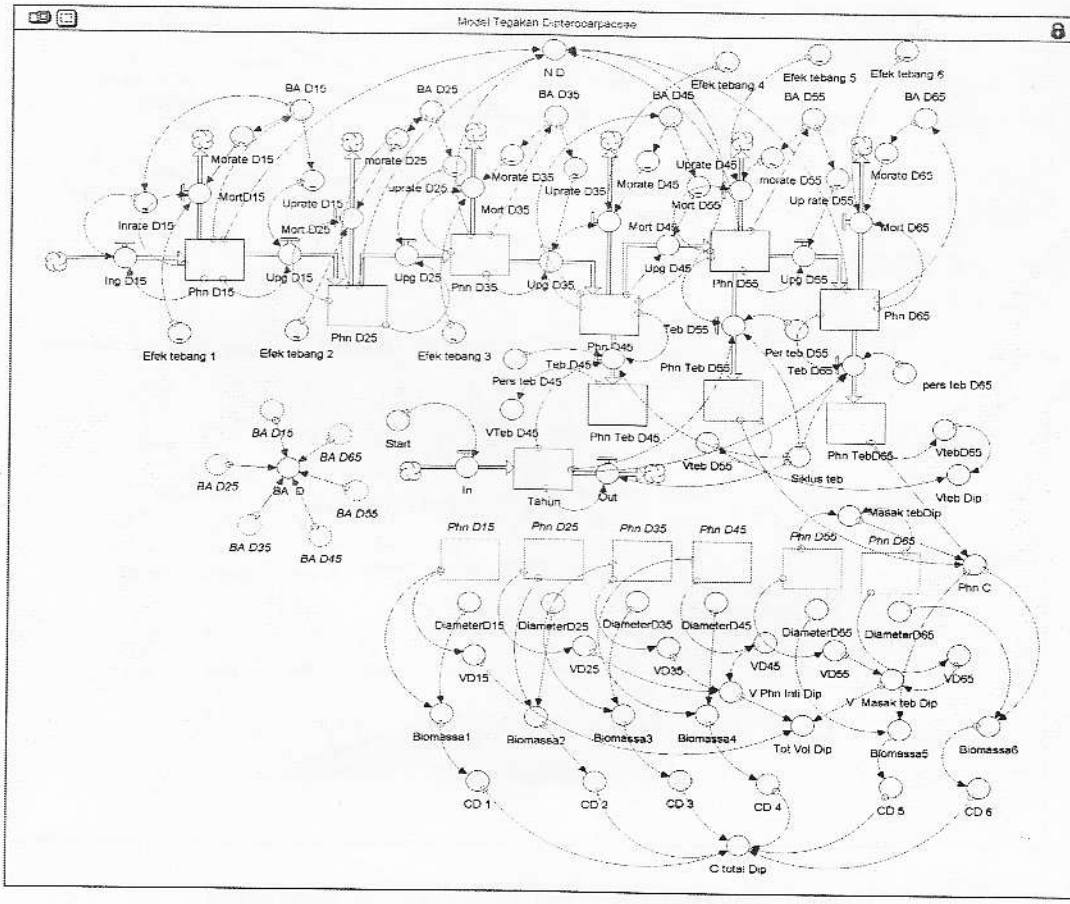


Figure 6. Representation of dipterocarpaceae stand dynamic model

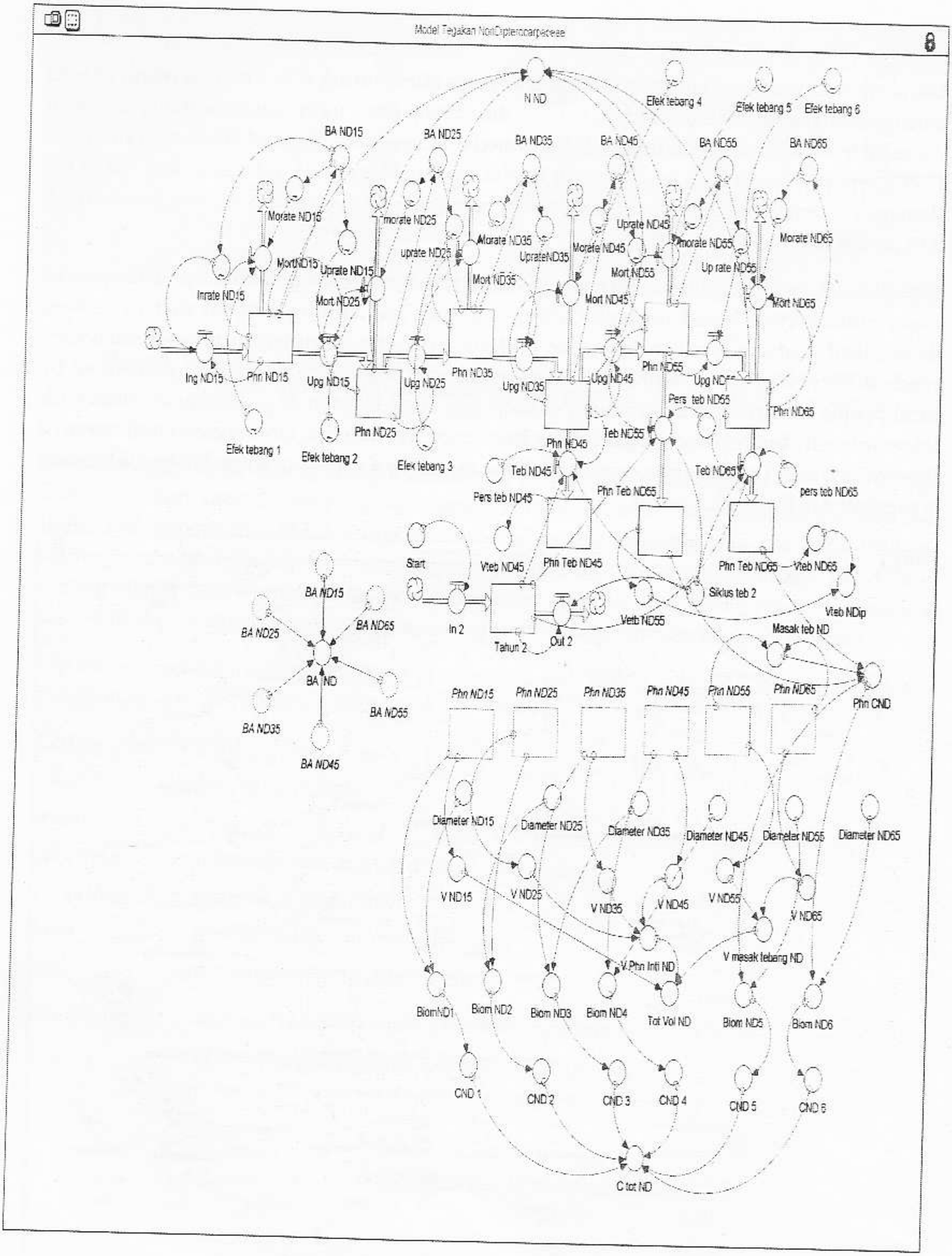


Figure 7. Representation of non dipterocarpaceae stand model

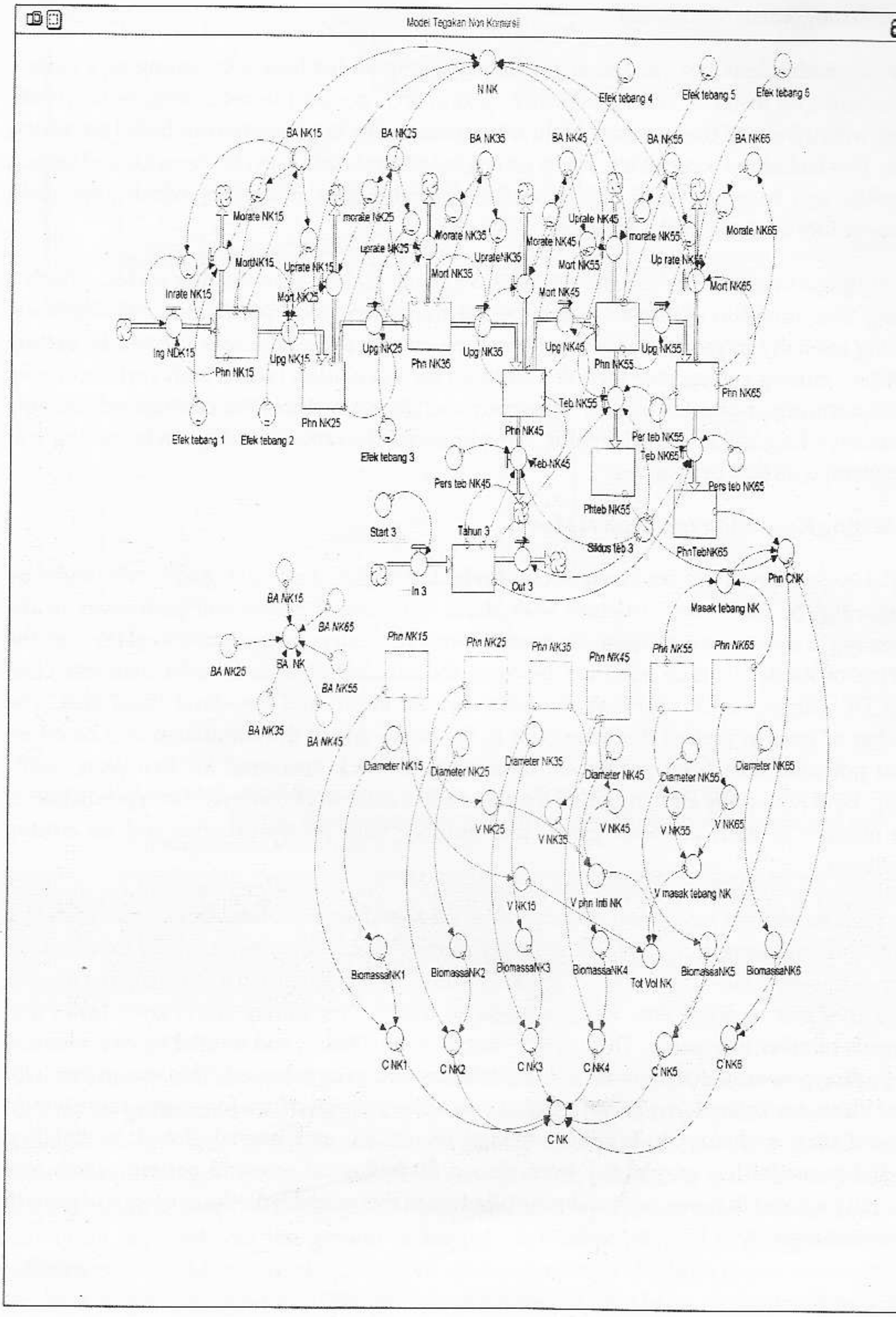


Figure 8. Representation of non commercial stand dynamic model

Yield Arrangement Sub Model

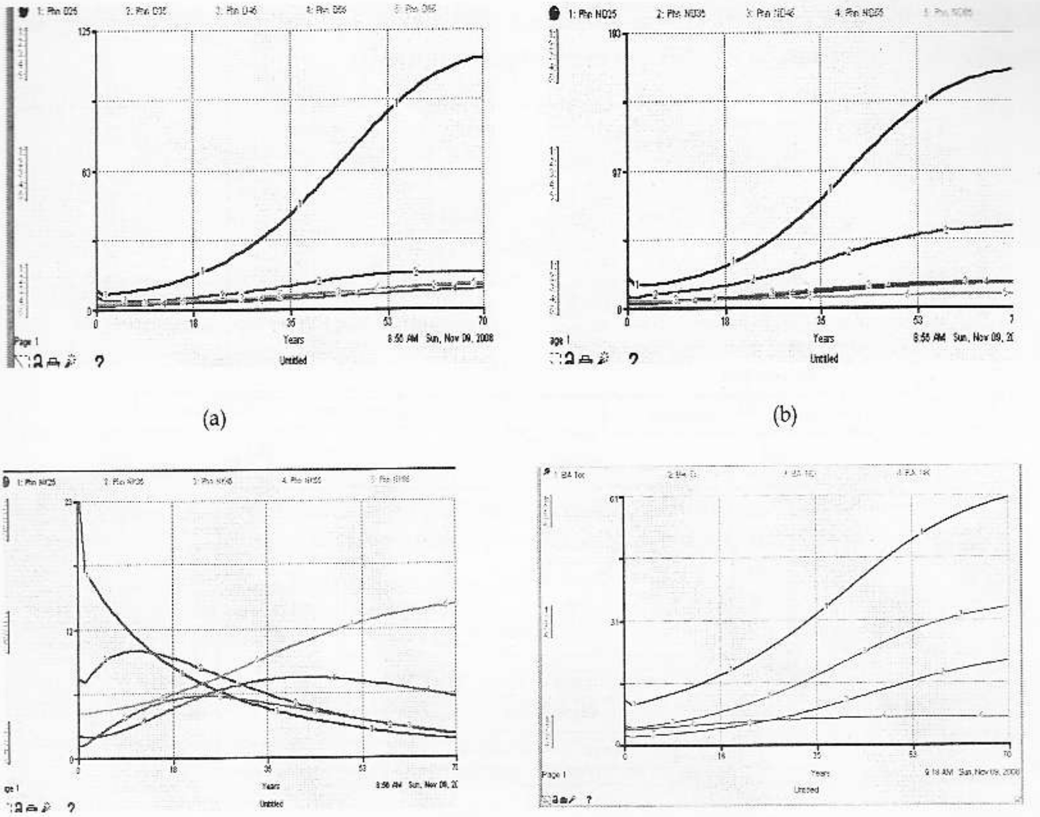
This sub model describes yield arrangement choices in timber forests by arranging a variety of *auxiliaries,* for instance, cutting intensity, cutting cycle period, diameter limit, cutting itself, in line with the aim of the analysis. Yield arrangement type used was the one based on cutting cycle. This technique was carried out by arranging several cutting cycle scenarios and certain intensity, and based on such cutting cycles, several cutting intensities which gave yield sustainability in a long term were chosen.

The cutting cycles tested were the 30 years, 35 years, and 40 years cutting cycles. Such a testing was aimed to obtain economic period that maintained production sustainability. Cutting intensity in yield arrangement based on cutting cycle type was affected by *driving variables,* cutting cycles, *state variables,* cutting year calculation (year), with various *driving variables* cutting proportion in each type group and diameter class. The cutting cycle became a constant which has a particular value. If the time was the same as cutting cycle, cutting was carried out with 80% proportion.

Evaluating Reliability and Logical Model

Model evaluation in this study was only conducted on forest stand dynamic sub model by comparing the real stand structure with stand structure of simulation performed in the beginning of measurement. Simulation result forest stand structure was obtained through the making of model relation equation between the number of trees in each diameter class (Phn_D) with *ingrowth, upgrowth, mortality,* cutting effect, and the stand basal area. The number of trees in each of diameter class in the beginning of the simulation was based on stand potential data from permanent measurement block measured for five years (2001-2005). Both Reliability and Logical of the stand sub model were observed from prediction of tree number in each diameter class tree number with no disturbance and no cutting conditions.

The basal block area influenced the growth of the tree diameter; thus, there was a diameter increase up to certain conditions in the early years after cutting, then it would experience a stagnant closer to climax conditions (primary stand). This was caused by the fact that in early years after cutting there was an open space so that the remaining stand grew faster and *ingrowth* number increased. Then, space started to be filled in and limited by environment supporting power so that *ingrowth* and *mortality* tended to be balanced. This was in line with what Volin dan Buongiorno (1996) pointed out: when projected for a long term, there would be oscillation and amplitude which tended to decline and moved closed to stability. Reliability model has graphically been shown by biological growing pattern which was sigmoid (logistic) that was expected to be filled up in this model with the existence of growth maximum capacity.



(a) (b) (c) (d)

Figure 9. Long term stand dynamic projection with 20 cm diameter (a) dipterocarpaceae stand structure, (b) non dipterocarpaceae stand structure, (c) non commercial stand structure, (d) stand basal area for all type groups

Notes: PhnD25 (diterocarp tree number of 25 diameter class), PhnD35 (dipterocarp tree number of 33 diameter class), PhnD45 (dipterocarp tree number of 45 diameter class), PhnD55(dipterocarp tree number of 55 diameter class), PhnD65 (dipterocarp tree number of 65 and up diameter class), BAtot (total basal area), BAD (dipterocarp total basal area). BA ND (non dipterocarp total basal area), BA NK (non commercial total basal area)

In a 70-year simulation, both dipterocarpaceae and non dipterocapaceae types experienced a decline on growth rate in about years 47th 48th, and then started to reach a relatively stable state (*steady state*) with 20 cm diameter stand density amounting to 145 - 257 tree/ha. With the non commercial type, the growth rate was slow down in year 2, and was relatively stable in the beginning of year 17 with 20 cm diameter stand density as many as 17 32 trees/ha. Such a condition depicted that the growth of logged over stand allowed to grow without any disturbance, would regenerate to reach its climax condition although it was not exactly the same as its primary condition. The growth of a constant total basal area gave an indication that stand structure composition did not undergo any changing in line with time dynamics.

Reliability model's evaluation was validated empirically by comparing model hypothesis results with actual data in PT. BBU, as presented in Figure 10.

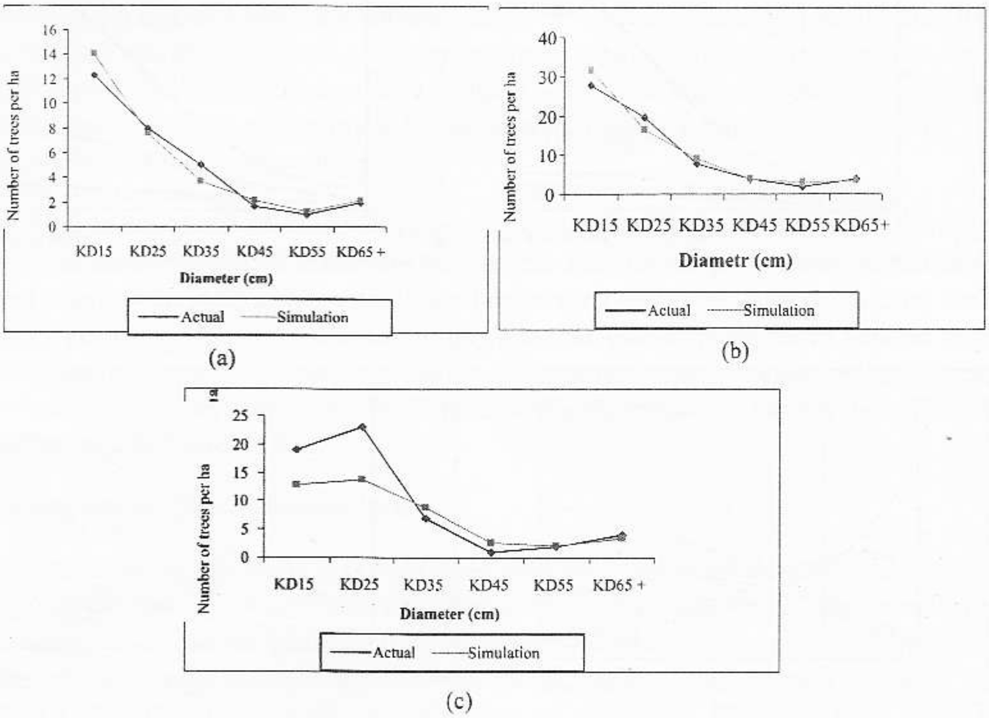


Figure 10. Comparation stand structure as the observation result after a 5-year simulation according to type groups: (a) Dipterocarpaceae, (b) Non dipterocarpaceae, and (c) Non commercial

In general, the result of hypothesis (simulation) was not significantly different from the one in the field observation (actual). This is proven with statistic test *chi square* which showed that simulation result of stand structure dynamic model in year 5 was not significantly different from the actual condition in 95% of confidence interval.

The *chi square* statistic test produced χ^2 value (calculate) amounting to 12.98, much lower when compared to χ^2 value in the table; namely, 27.59 at df (degree of freedom) 17 and confidence level of 5%. This proved that the use of stand structure dynamic simulation model was relatively reliable as it was close to the actual conditions.

The Use of the Model

The model made was used to make forest yield arrangement scenarios. Scenario 1 was a *base line* or basic simulation.

Scenario No intervention

Stand simulation with no intervention is meant to obtain information on stand productivity level by assuming that there was no treatment and disturbance on stand. Simulation result for 70 years of model simulation was shown in the following Table 11 and Figure 11

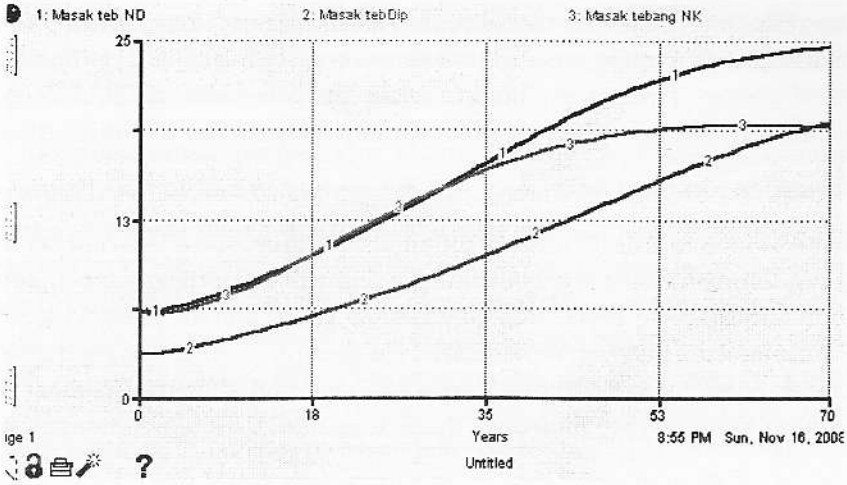


Figure 11. Simulation result for 70 years of cutting mature condition on Dipterocarpaceae, non dipterocarpaceae, and non commercial

Notes : 1 = Cutting maturity of Non-Dipterocarpaceae
2 = Cutting maturity of Dipeterocarpaceae
3 = Cutting maturity of Non-Commercial Trees

Table 10. Number of Cutting Mature Trees Based on The Result of No Cutting Simulation

Years	Cutting maturity (N/Ha)			
	Dipterocarpaceae	Non dipterocarpaceae	Non Commercial	Total
0	3	6	6	15
5	3	7	6	16
10	4	8	7	19
20	6	11	10	27
25	7	13	12	32
30	8	14	14	37
35	10	16	15	41
40	11	18	17	46
70	19	25	18	62

Table 10 showed that the number of cutting mature trees was as many as 62 trees / ha deriving from dipterocarp group (19 trees/ha), non dipterocarp (25 trees/ha), as well as non commercial (18 trees/ha). Distribution of commercial cutting mature tree type reached 70.79%, and the remaining (29.03%) consisted of non commertial trees.

This condition was expected to be reached at the next cutting cycle after certain treatments. Cutting mature trees were defined as trees with more than 50 cm in diameter, and were divided into 55 cm and 65 cm diameter classes. Diameter class division was carried out due to product diversification. Based on the table, it could be viewed that the number of cutting mature trees before the cutting (year 0) was as many as 15 trees/ha. This number was the same as stand average potency per hectare under the concession of HPH PT. Sumalindo Lestari Jaya; namely, 14.9 trees/hectare with volume average of 54.7 m^3/ha (Rachman 2003).

Scenario Changing Cutting Cycle

This scenario was built in order to observe different cutting cycle towards number of trees cut, and its role in giving contribution to both local government and indigenous people's incomes. The length of cutting cycle tested was 30 years, 35 years, and 40 years with 80% cutting intensity for dipterocarp and non dipterocarp type groups. Cutting was conducted towards all commercial types; namely, dipterocarpaceae and non dipterocarpaceae types with diameter of 50 cm or more. The following is the picture on scenario simulation results.

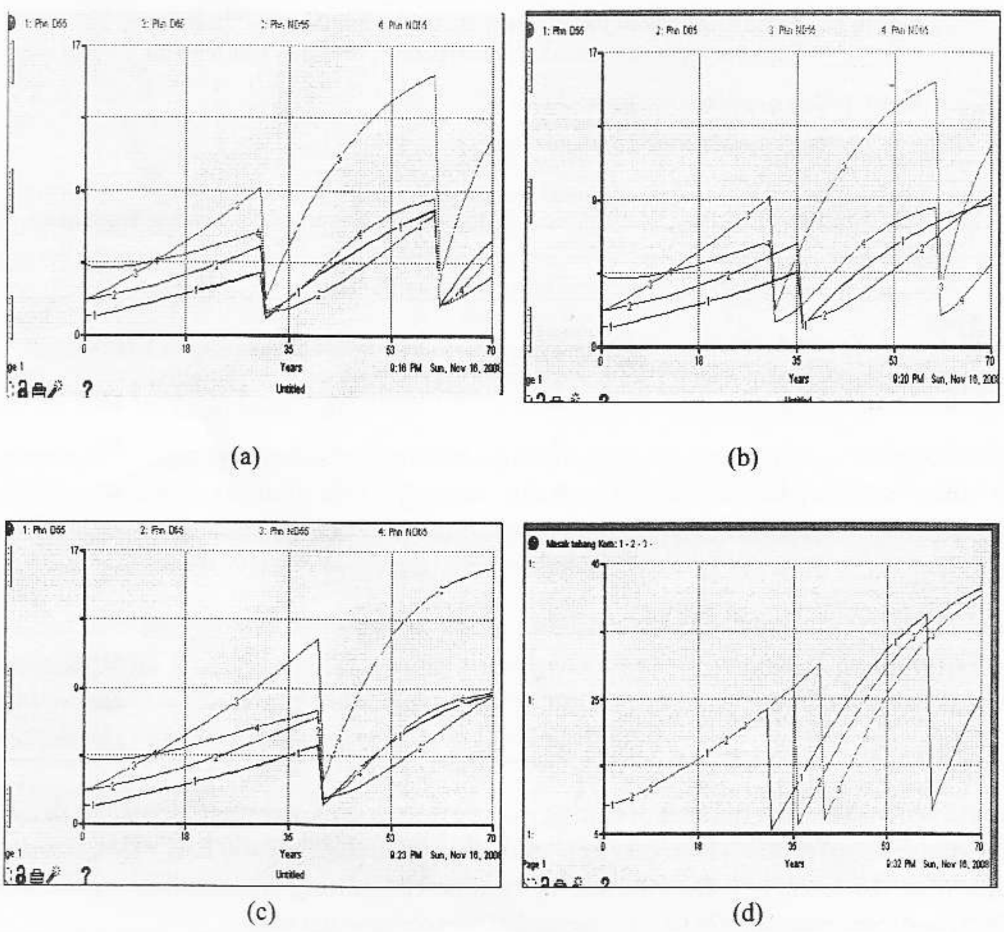


Figure 12. Cutting mature tree projection within (a), 30 year cycle (b), 35 year cycle (c), 40 year cycle, (d) all cycles

Projection on mature cutting tree number average was observed to be relatively stable in both type groups. This gave indication that interval span between cutting were able to restore stand condition and provide sustainable yields.

However, dipterocarpaceae group in Phn_D_{65} in all cutting cycles gave different responses in accordance with the decline of cutting number occurrences. In such a situation, stands experienced a slow restorement due to cutting intensity performed, particularly with *Intsia bijuga* (merbau) type. The reason was that the timber type become the major target in logging activities in Papua and dominated primary forest stand structure which amounted to 40.72%. Based on the production yield report, it was found that merbau tree number cut at each RKT by IUPHHK PT. BBU reached 60%. Furthermore, this was influenced by a higher cutting intensity; that is, 80% in each type. This meant that before cutting, there were selections towards both types and diameter measurement based on TPTI regulations; namely, more than 50 cm, accordingly, it was noticed that trees with more than 50 cm diameter classes experienced slow reforestation.

When sustainable measurement was viewed from physical measurement regarding volume and the number of cutting on mature trees, cutting with cutting cycle system in all prescriptions met yield sustainable principles. This is in line with the value of yield sustainable coefficient (*kkh*) that was, in fact, the comparison between volume number per cutting and previous cutting cycle as presented in Table 11. When the AAC in the *t* cutting rotation was expressed by AAC_t and AAC as well as in the next cutting cycle as AAC_{t+1} yield sustainability would be able to reach when $q_t \geq 1$.

Table 11. Prescription on cutting intensity, the number of trees cut, volume and yield coefficient sustainability in yield arrangement simulation

No	Prescription	Cutting cycle	Cutting number (N/Ha)	Cutting Volume (m^3/ha)	Yield sustainable coefficient
1	80% intensity of both 50 cm up and 60 cm up diameters. (30 years cutting)	I II	23.15 38.35	43.39 111.48	2.57
2	80% intensity of both 50 cm up and 60 cm up diameters. (35 years cutting)	I II	26.48 41.44	49.49 124.85	2.53
3	80% intensity of both 50 cm up and 60 cm up diameters. (40 years cutting)	I II	29.90 44.33	55.51 135.69	2.44

The volume yielded was based on a very sensitive simulation towards *ingrowth*, *upgrowth* and mortality factors since simulation depends significantly on input data used. These data had to represent particular area conditions (Susanty and Sardjono 2001), so that there was difference in volume per hectare between simulation result and production report data (Table 9).

Based on the simulation result, volume average on commercial type cutting in the first cutting cycle ranged between 43 and 55 m^3/ha. This result was much bigger than average potency of 19 HPH in Papua which generally ranges between 11-55 m^3/ha (Rachman 2003), but relatively the same as the potency of HPH PT. Sumalindo Lestari Jaya II; namely, 54.7 m^3/ha which is also located in Sarmi Region. Nevertheless, when compared to potency in other regions such as Kalimantan with its highest potency average of 84 m^3/ha (commercial) and 90 m^3/ha (all types), Sumatera whose potency was 64 m^3/ha (commercial) and 79 m^3/ha (all types), as well as Sulawesi for commercial and all types with its potency of 44 m^3/ha, the potency resulted from simulation was extremely lower. Besides its low potency, it was found that the majority of timber comprised the types which have not been known in the markets (not commercial yet).

Chapter 4

ECONOMIC VALUE OF PAPUAN FOREST

Types of Regional Income from Forestry Sectors

Regional income in Indonesia is derived from: Regional Original Income (PAD), Development Balance Fund, Regional Loan, Other Regional Resource Managements, Grants, Emergency Fund, and the like. It could be concluded that a high Regional Original Income does not always mean that society's income in that region is also high. Nevertheless, the high amount of Regional Original Income can become a crucial source for local government in developing its region including increasing its people income (Rustiadi *et al.* 2005).

It is widely known that Regional Original Income is rarely used by a region, or even a country, as a measurement of regional productivity. In general, what is generally used as a regional development measurement is Gross Domestic Regional Product (GDRP), because such a measurement is the most operational one and is accepted universally by all over the countries. The amount of this GDRP in a region will finally become a potency to be the regional income. GDRP is, in fact, the total value of both goods and services produced in one region, whose intermediate-price was removed at a certain period of time.

Operationally forest concession activities or forest utilization was managed in the Forestry Law No 41/1999 and Government Regulation (PP) No 6/2007 jo PP 3/2008 on Forest Arrangement and Forest Utilization Planning. Based on the regulations, there are 6 types of forestry tariffs:

a. Forest Utilization License Fee (IIUPH)

b. Reforestation Fund (DR)

c. Forest Resource Provision (PSDH)

d. Performance Guarantee Fund (DJK)

e. Investment Fund for Research and Development, Education and Training, as well as Forestry Extension

f. Forest Sustainability Investment Fund (DIPH)

Up to these days, however, there are only three of the above contributions have been executed due to the guidelines availability; IHPH/IIUPH (forest concession's fee / license fee), DR (reforestation fund) and PSDH/IHH (forest resource provision/tax). Whereas the ones for DJK (performance guarantee fund), DIPH (Forest Sustainability Investment Fund), and Investment Fund for Research and Development, Education and Training, as well as Forestry Exhibition have not been accommodated into any regulations.

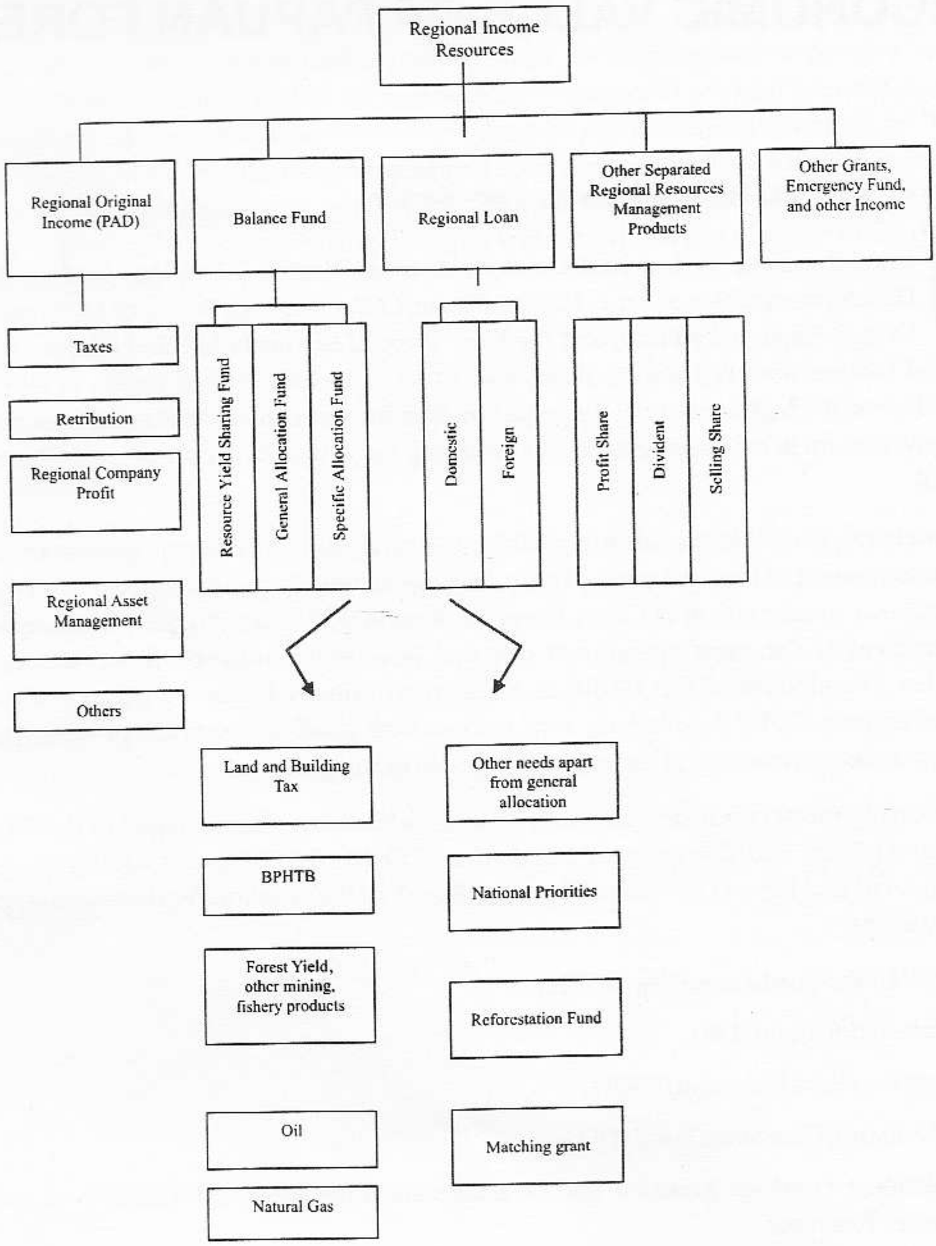


Figure 13. Sources of Regional Income Based on Law 33/2004

Forest Concession Fee (IHPH/IUPHH)

Forest Concession Fee (*license fee*) is a fee that has to be paid by forest concession holders. This kind of fee needs to be paid once in a year, at the time of concession determination. The basic law for such a fee is PP Number 22 Year 1967 and its changing in PP Number 21 Year 1980.

In addition, this type of fee is written in a number of Minister Decrees; they are: the Decree of Minister of Agriculture Number 415/Kpts/um/7/1979, the decree of Minister of Forestry, Number 479/Kpts-II/1992, and the Decree of Director General of Forest Utilization Number 403/KPts/IV-TPHH/1989, and Forestry law number 41/1999.

Forest Resource Provision (PSDH)

PSDH is a value of forest yield which becomes the share for the government as the resource owner. This value is determined by the selling price and the amount or volume of forest products sold. PSDH fee is determined based on the Circular Letter of Director General of Forest Utilization Number 02/VI-BIKPHH/2005, the determination of PSDH basic price was based on the Decree of the Minister of Industry and Trade Number 436/MPP/Kep/7/2004; while PSDH tariff was based on Government Rules (PP) Number 74 year 1999. Technical guidelines on imposing, collecting, paying, and depositing PSDH are arranged by the decree of Minister of Forestry Number 124/Kpts-II/2003.

Reforestation Fund (DR)

This type of contribution was first put into effect in 1980 referring to Reforestation Guarantee Contribution (DJR). This kind of contribution is imposed on every m^3 of timber taken from HPH/IUPHHK as Reforestation Guarantee Fund. In 1989 such a contribution was called Reforestation Fund (DR), with a rule that HPH/IUPHHK has to conduct planting and growing in the HPH/IUPHHK area, and pays a DR. This fund is also identical with Performance Guarantee Fund (DJK), Forest Sustainability Investment Fund (DIPH) (IPB, 2003). Reforestation Fund is based on Government Regulation Number 35 Year 2002 as fund for forest reforestation and rehabilitation and their other supporting contribution taken from forest concession holders of both forest products and natural forests in the form of timber.

The determination of DR tariff is based on PP Number 29 Year 1999; while its technical guidelines on imposing, collecting, paying and depositing of this DR is arranged according to the decree of the Minister of Forestry, Number 128/Kpts-II/2003.

Land and Building Tax (PBB)

A tax is a kind of contribution that has to be paid by all citizens to be deposited to the state based on the law, with no direct service in return, and this can be used to and directed to pay general expenses (Mardiasmo, 2006). The Land and Building Tax is a tax imposed on the land and the building.

Forest concession area is one of tax obligation objects where its PBB has to be paid depending on the total area of the land and building exist. If within the area there is an unproductive area, the concession holders can ask for reduction of payment. The basic law of PBB determination was formerly Law No. 12 year 1985 which was then changed with Law No. 12 year 1994.

Both the amount and type of such a tax has an implication on forest sustainability. Besides taxes form the Central Government, there are various kinds of local taxes regarding both the amount and types in line with the decentralization of forests. This means that the burden of a businessman is becoming bigger; and as a result, some of them maintain business feasibility in different kinds of ways including illegal *logging*.

Forestry Sector Contribution on Regional Economy

Since the beginning of its development economic activities in Sarmi Regency is still dominated by investment in the area of exploiting natural resources in regard with forestry, agriculture, animal husbandry, and the latest activity which has been developed since 2007, mining, due to the activity of iron sand mining. There are 5 forest management units in the forms of logging license (IUPHHK) apart from other legal license (ISL) and IPK (forest utilization license) operating in Sarmi region, one of which is IUPHHK PT. Bina Balantak Utama.

The impact on this IUPHHK BBU existence in supporting the economy of Sarmi regency has just been experienced for approximately 6 years (2002-2008), as since 1991 until 2001 timber yield harvest in Sarmi forests was the only income source for Jayapura Regency Government, which previously was the main regency for Sarmi Regency. With a timber potency average harvest which reached up to 68,512.68 m^3 annually and selling price average as much as Rp 600,000, the direct benefit derived from this timber amounted to Rp 41,107,608,000 per year.

The existence of a forest concession in Sarmi Regency will give an added value for production factors, institutions, and other economic sectors so that it affects its regional development. The direct utilization value of forest resources by companies (5 HPH units) derived from timber forests within 3 years (2005-2007), and when the average selling price applied was Rp 600.000/m^3, the total amount obtained was Rp 153,276,000,000 (Rp 153 billions). Such a value appeared to be relatively high, but when it was distributed to *stakeholders* and the society as the owners of customary right as well as the government as the owner of resources, the amount was not much.

Economic Condition of Sarmi Regency

The economic growth in a region can be viewed from the growth rate of its Gross Domestic Regional Product (GDRP). Good and service value produced in a region and removed from its intermediate *cost*- elements is called Gross Domestic Regional Product (GDRP). Such a PDRB obtained from one region will finally be potential to become a regional income.

According to GDRP classification used by the centre statistical for board of Indonesia, forestry sector belongs to one of the agricultural sub-sectors. Based on Table 12, it was found that forestry sub-sector contribution for GDRP formation in Sarmi Regency increased from Rp 16.57 billions in 2001 to Rp 55.9 billions in 2006 an increase by approximately 70.37% per year during 6 years, or an average of 31.53% per year. This indicates that Sarmi Regency is, indeed, a region whose activities are based on forest resources.

Table 12. Relative Contribution of Forestry Sector towards GDRP of Sarmi Regency based on 2000 constant prices during 2001-2006 (%)

No	Sector	2001 Share (%)	2002 Share (%)	2003 Share (%)	2004 Share (%)	2005 Share (%)	2006 Share (%)
1	Agriculture						
	1.1. Food Crops	13.48	14.6	14.01	13.86	13.39	12.76
	1.2. Commercial Plantation	4.20	5.2	4.95	4.80	4.67	4.58
	1.3. Animal Husbandry and its products	0.89	0.76	0.72	0.68	0.64	0.61
	1.4. Forestry	26.88	33.10	32.71	31.56	29.89	28.09
	1.5. Fishery	10.20	11.30	11.55	12.13	12.48	12.15
2	Mining and Excravation	1.33	1.65	1.57	1.53	1.50	1.46
3	Processing Industry	3.87	3.89	3.66	3.50	3.36	3.19
4	Electricity and Clean Water	0.16	0.15	0.16	0.17	0.17	0.17
5	Building	4.99	5.37	5.32	5.26	7.37	9.02
6	Trade, Hotel and Restaurants	9.48	10.65	10.20	9.85	9.56	9.18
7	Transportation and Communication	6.20	7.69	8.27	8.61	8.83	9.22
8	Finance, Renting and Company Services	1.85	2.44	2.38	2.43	2.43	3.80
9	Other Services -	16.46	3.42	4.50	5.64	5.68	5.77
	Total	100.00	100.00	100.00	100.00	100.00	100.00

Source: BPS and BP3D of Sarmi Regency 2007 (own processed)

Financial and Economic Analysis

The purpose of a business analysis is to improve investment assessment due to resource limitation; therefore, there is a need to carry out a selection towards various business types. Mistakes in conducting such an assessment can lead to the damage of rare resources; thus, before performed, experiment assessment needs to be conducted in order to know the results and possibility to choose other alternatives by calculating the prices and benefit expected from each business (Kadariah 1986).

Both financial and economic analyses are two alternatives that can be used to evaluate businesses. Financial analysis or private analysis is directed to calculate the benefits and business prices from the point of view of individuals or private companies as the parties that have interest in the project. Economic or social analyses, on the other hand, are proposed to resources as an effect of management limitation and policies; (3) diameter distribution regulation to maximize production, and (4) production plan with regard to target achievement (Buongiorno and Gilless 1987).

Forest management plan needs financial analysis as a tool to assess company's financial performance. Several financial criteria mainly used in this case are: (1) Net Present Value (NPV), (2) Land Expectation Value (LEV), (3) Internal Rate of Return (IRR), (4) Benefit Cost Ratio (BCR) and (5) Forest Value (FV) (Zobrist, *et al.* 2006).

Net Present Value Approach

Market economy has a principle to maximize present value; therefore, it tends to give attention to land use determination. Land use activities tend to be directed to improve NPV. One of the criterion forms to maximize the present value in determining its rotation is known as NPV or discounted cash flow.

According to Klemperer (1996), an understanding of NPV approach can be referred to the willingness of the investors to pay for an asset based on benefit assumption, cost and interest rate wanted, so that it can become an advantageous tool to assess forest land.

Davis *et al* (2001) states that assumption used in calculation analysis from forest land rental for timber production are, among others: (a) including all relevant money management costs, administration fee, and taxes (b) becoming average reference of interest rate which precisely reflects contexts and hopes from land owner, and (c) determining land management guidelines for the future, and the same guidelines will be used for each timber production cycle in the future.

Costs and benefits of NPV are assumed to be based on the *cash flow* of an addition by using present real prices, before and after the tax. In terms of sustainability towards rotation and maximum products, maximizing NPV is significantly required through supervision. The reason for this is that NPV maximum period is usually smaller compared to mean annual increment, but bigger when compared to periodic annual increment. The Net Present Value (NPV) is calculated by using the following formula:.

$$NPV = \sum_{t=0}^{r} \frac{y_t}{(1+i)^t} - \sum_{t=0}^{r} \frac{C_t}{(1+i)^t}$$

Where :

NPV = Net Present Value (Rp/ha)
Yt = income in year -t (Rp/ha)
Ct = expenses in year -t (Rp/ha)
R = cutting cycle
t = activity years
I = interest rate in decimal

calculate projects' benefit and prices from the point of view of local government or society as a whole or as a party which is interested in the business (McLeish, *et al.* 2002). Gittinger (1986), points out that basically, calculation in financial and economic can be grouped into 4 (four); they are:

1. Prices

   In financial analysis, the price used is market price. Such a price has included taxes and subsidy; nevertheless, in economic analysis, the price used is a price which precisely reflects social economic values. Price that has been adjusted is referred to as shadow price or accounting price that forms opportunity cost.

2. Taxes and Subsidy

   In economic analysis, taxes and subsidy are used as transfer payment. Income is resulted from a business including taxes that have to be paid during production process and sale taxes paid by the buyers when buying business products. These taxes are parts of the entirely business benefits. On the other hand, subsidy from the government is society's costs because subsidy becomes expenses of resources; thus, an economy has to have expenses in order to make a project run. In this financial analysis, taxes are considered as prices, and subsidy is considered to be yield (*return*).

3. Interest

   Interest toward capital in economic is neither separated nor reduced from gross products (*gross return*) since capital is one part of the gross (*total return*) towards capital available for society as a whole and as an entire product. An interest is a matter that is assumed in economic analysis. In a financial analysis, an interest is differentiated into two; the first is an interest paid to other people, and the other one is interest upon individual's capital. The one paid to people that loan their money for business activity is considered as a price; whereas the one upon individual's capital is not considered as a price as it is a part of financial *return* accepted.

4. Benefits and Business Costs

   In relation to business, anything that adds either national income or consumption goods in both direct and indirect ways is grouped into business benefits. In contrast, anything that is related to the reduction of consumption goods either in a direct or indirect ways belongs to project costs.

Land Value Assumption

Natural resources, including forest land, potentially possess usage alternatives or what is called *opportunity cost* principle; accordingly, in maximizing calculation, the need for land value or forest land must be included. In financial point of view, this kind of decision needs to consider the following points: (1) harvesting time: regarding the volume produced, both forest structure and timber output pattern from time to time; (2) value assumption of forest

Land Expectation Value Approach

Land expectation value is a description on the amount that has to be paid by buyers for the land used as an investment for forestry activities (Davis *et al.* 2001). Such land value is the same as the amount of cash within certain interest rate which will then lead to the same net income from the land annually.

Land Expectation Value (LEV) is also called Faustmann formula. Moreover, LEV is a special case from NPV where (1) land is removed from cash flow in relation with its calculation as the rest (2) investment is commenced within an empty land, with no stand (3) there is specific land where there is always the same stand (4) the *cash flow* of such a stand is definitely the same. For natural forests, the land expectation value is called forest value. Land Expectation Value (LEV) is approached with the following equation:

$$LEV = \frac{\sum_{t=0}^{r} Y_t (1+i)^{r-t} - \sum_{t=0}^{r} C_t (1+i)^{r-t}}{(1+i)^r - 1} - e/i$$

where:

LEV = land expectation value (Rp/ha)

Yt = Income in year -t (Rp/ha)

C_t = Expenses in year -t (Rp/ha)

r = Cutting cycle (year)

t = Years of activity (year)

e = Annual fee (administration and general affairs, forest protection, PBB, forest village education, and shrinkage)

i = interest rate in decimal figures

Internal Rate of Return (IRR)

Internal Rate of Return (IRR) is the same as the *Rate of Return*, or efficiency rate upon a net investment. IRR is an interest rate that makes a project returns all its investment as long as the business period. A business can be carried out when its IRR is bigger than or the same as the existing interest rate (*discount factor*); but when the reverse situation occurs, that business will be rejected (not feasible). In addition, an IRR is a discounted value that makes an NPV of a business activity equals to zero. Thus, an IRR is a maximum interest rate paid by the business activity for the resources used. This Internal Rate of Return (IRR) is formulated as follow:

$$IRR = i_1 + \frac{NPV_1}{NPV_1 - NPV_2} (i_2 - i_1)$$

where: i_1 = is a *discount rate* that produces NPV_1

i_2 = is a *discount rate* that produces NPV_2

Benefit Cost Ratio (BCR)

Benefit Cost Ratio (BCR) is a comparison between income and discounted fee. A business which has a BCR bigger than one is considered to be feasible, but when the reverse situation takes place, then this business is considered to be unfeasible.

$$BCR = \sum_{t=0}^{r} \frac{Yt}{(1+i)^t} : \sum_{t=0}^{r} \frac{Ct}{(1+i)^t}$$

where:

BCR = Benefit Cost Ratio

Yt = income in year -l (Rp/ha)

Ct = expenses in year-t (Rp/ha)

r = cutting cycle

t = years of activity

I = interest rate in decimal

Both IRR and BCR values determine efficiency levels of a business in using its resources - whether or not it is efficient. Meanwhile, an NPV is an absolute measurement determined by business period, which means that in general, NPV will be bigger in accordance with the length of the business period. When there is a certain amount of capital or fund at a certain interest rate, a project with the biggest NPV, BCR and IRR values will be chosen. In order to describe a forest economic potency, an economic revitalization model is established, consisting of two sub models; namely, production cost sub model, and economic revitalization sub model. This kind of method is, in fact, another form of economic analysis method which is generally performed mathematically in the forms of NPV, BCR, IRR and LEV (Zobritst *et al.* 2006; Davis *et al.* 2001; Lin *et al.* 1996).

Economic Revitalization Sub-Model

The components of economic revitalization model comprise benefits and costs. Benefits that derive from a company's total income come from the results of timber utilization (timber price changes x cutting volume). The costs, however, cover forest planning, harvesting, forest education, and other expenses for the government.

The economic revitalization model is another form of economic analysis method which is normally used mathematically to calculate the land expectation value (LEV), Net Present Value (NPV), Benefit Cost Ratio (BCR), and the Internal Rate of Return (IRR). The elements of each economic criterion is influenced by two auxiliary variables in the forms of company's income and total costs, and driving variables which are, in fact, interest rate, discount factor and compounding factors.

The benefits derived from company's total income comes from the obtained yield of dipterocarpaceae (D fluctuate prices x dipterocarpaceae volume), and non dipterocarpaceae

(ND fluctuate prices x non dipterocarpaceae volume). *Costs,* on the other hand, consist of forest planning costs (PAK, ITSP, PWH), forest harvesting costs, (timber cutting, log yard, skidding), Silvicultural activity (tidying, post-logging inventory, enrichment planting, maintaining the enriching plants, seed provision), annual fee (administration and general affairs, marketing fee, road maintenance and making, mess inventory, Community Development, forest and river protection, shrinkage) and other state obligation (PSDH, DR, IIUPHHK), PBB and PPh (Figure 14).

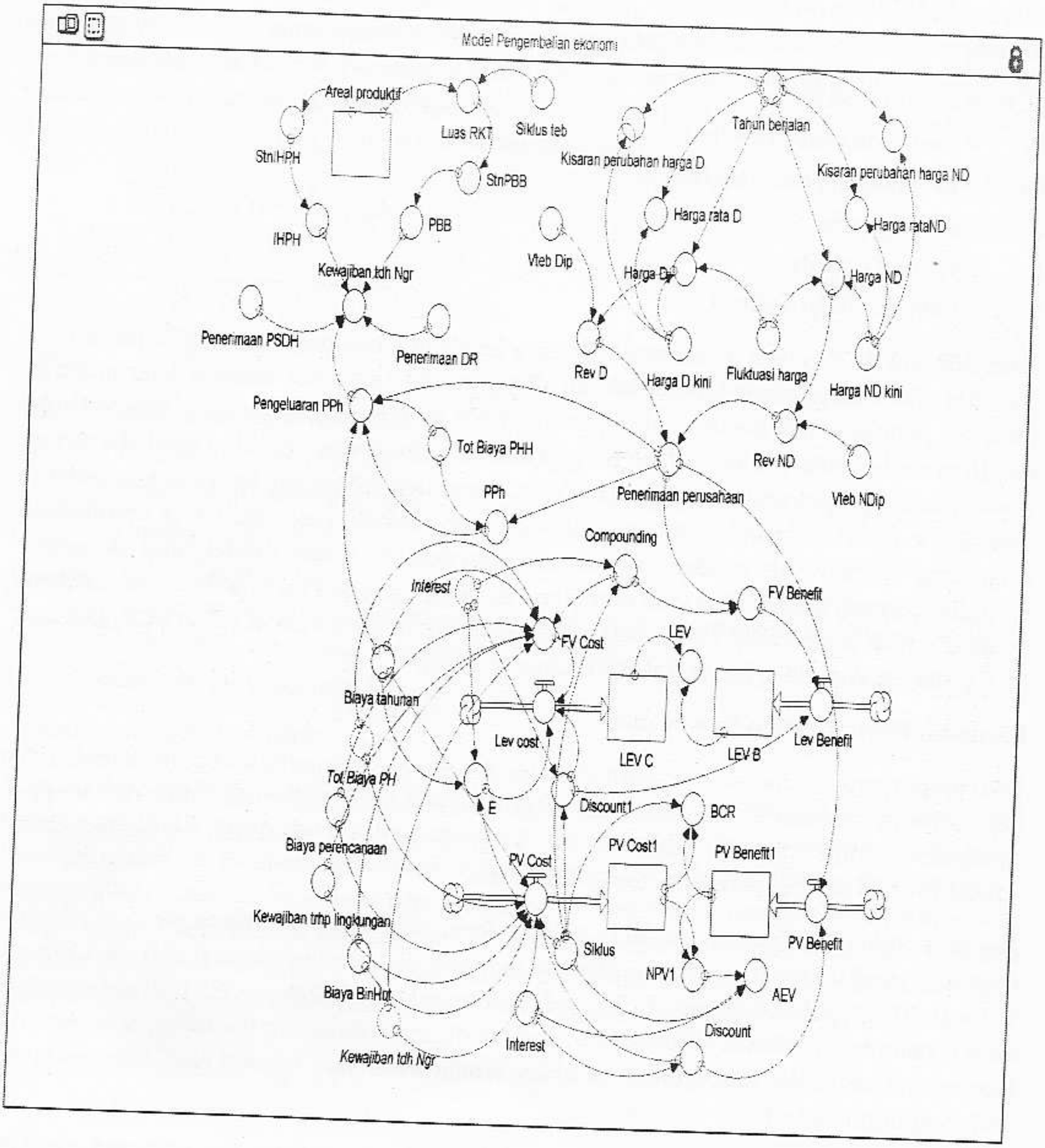


Figure 14. A Representation on economic revitalization model

Timber production costs are affected by the number of timber production being harvested (*production volume of trees*), production costs per hectare and the total area being harvested (total of RKT).

Furthermore, costs are variables that significantly affect the amount of income. In this model, cost components become one of the essential considerations in product arrangement. This model also tries to describe a phenomenon on both increase and fluctuation of timber prices which are difficult to be predicted (*uncertainty*).

If it is predicted that every year there is a timber price increase in a linear way with an increase gradient average of 10%, then the timber costs will fluctuate between 5% and 15%. Based on the above assumption, costs can be expressed as the following formula:

$$X_t = X_0 \pm \Delta X$$

where: X_t = timber price in year -t, X_0 = timber price at present, ΔX = price change ranges

Furthermore, the cost changes are not the same from year to year, since its values are influenced by cost fluctuation and the running year. Such cost ranges are expressed in the following formula:

$$\Delta X = \text{Cost fluctuation} * X_0 \cdot t$$

$$= (5\%-15\%)/2 * X_0 \cdot t$$

where : X_0 = timber price at present, ΔX = price change ranges,

t = time period of calculation

In order to predict the prices in the following years, it is assumed that those prices raise in a linear way by a proportion increase as much as 10%. Based on the above formula, the average price of annual price change is described as a linear function with a gradient of curve increase as much as 10%. The average price, then, can be formulated as follow:

$$Y = f(X_0, t)$$

$$Y = X_0 + 0.1 * t$$

where: y = average price, X_0 = present timber price,

t = difference of calculation year

In this model there is no validation - exactly like forest dynamic model because the functional relations among their components take place in a simple mathematic way; however, there will be a sensitivity test to observe other alternatives that can be obtained. The amount of costs is, in fact, the report from IUPHHK PT. Bina Balantak Utama financial data in 2006 out of an area covering 6,840 ha.

The sensitivity model is carried out towards the economic revitalization values; namely, Net Present Value (NPV), Land Expectation Value (LEV), Benefit Cost Ratio (BCR) and Internal Rate of Return (IRR) as well as a compensation income when the interest rate parameter, timber prices, and compensation standards are changed. This evaluation is carried out by changing the interest rates as much as 9%, 14%, 19%, and 24%. Meanwhile, the determination of the IRR is by trial and error method to make the amount of NPV zero. Moreover, in auxiliary variable compensation income is carried out by imposing a changing on the amount of compensation standard.

Change of Price

The fluctuation of the timber price has given a direct effect on the economy return situation, so it is necessary to carry out sensitivity test to see the possibilities that might happen if the price changes. The results of results of simulations of revitalization on various price changes are presented in Table 13.

Table 13. Results of simulations of revitalization on various price changes

Logging Cycle	Criteria	Change of price (Rp x 1000)			
		-10%	0%	10%	20%
30	NPV (Rp/ha/yr)	2,959.50	32,097.48	61,235.46	90,373.45
	LEV (Rp/ha/yr)	27,867.26	56,322.45	84,777.64	113,232.83
	BCR	1.33	1.47	1.62	1.76
	IRR (%)	16	19	23	28
35	NPV (Rp/ha/yr)	24,768	58,311.38	91,854.75	125,398.13
	LEV (Rp/ha/yr)	57,064.86	90,171.93	123,279.00	156,386.00
	BCR	1.23	1.36	1.50	1.63
	IRR (%)	16	19	23	28
40	NPV (Rp/ha/yr)	6,199	33,714	61,232	88,748
	LEV (Rp/ha/yr)	88,861.69	126,622.34	164,382.99	202,143.64
	BCR	1.28	1.48	1,56	1,70
	IRR (%)	16	19	23	28

Based on the results of simulations on NPV and LEV, the 30-year logging cycle gives positive results when the price decreases 10% and when the price is 0% (present condition). Even if the price is increased to the level of 10% and 20% the NPV still gives positive response.

Furthermore, the NPV and LEV give positive results and the ratio of cost benefit is bigger than 1 at the logging cycles 30, 35 and 40 years. This means that each prescription of logging has met the criteria of economic feasibility. The criteria of NPV and LEV have given a positive correlation with the logging cycle, which can be seen from the increase of the NPV and LEV values in each logging cycle increase. When the price of timber decreases the value of land and the NPV also decreases, so it can reduce incentive for carrying out sustainable forest management, and the other way round (Darusman 2002).

Usually the rise and fall of the timber price in each logging cycle will affect the NPV as much as Rp 3.765.000 per hectare per year and the land value (LEV) as much as Rp 17.507.000 per hectare per year. The illustration of the correlation between logging cycle, price change and LEV is presented in Figure 15.

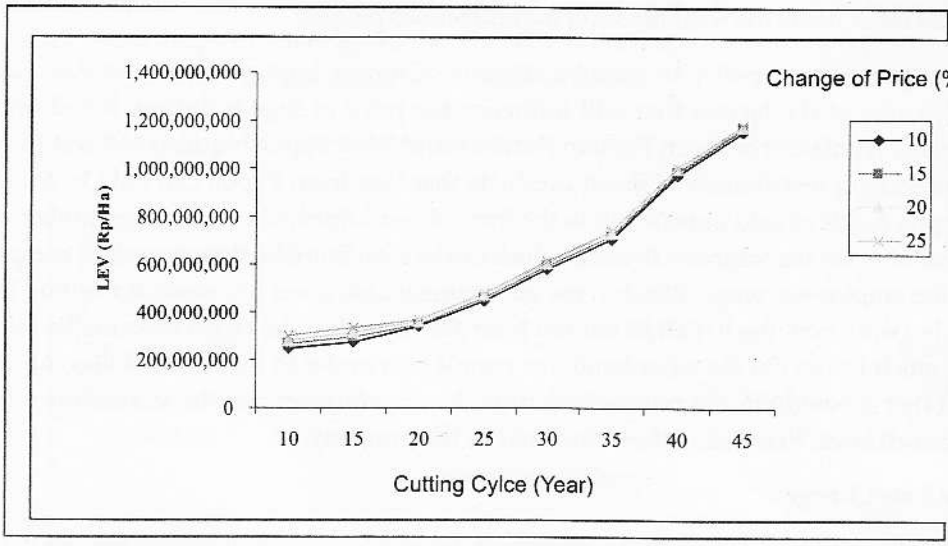


Figure 15. The LEV in various logging cycles and prices

The change of the timber price will affect the change of prescription of permanent logging choices. Based on the demand theory, this condition shows that market demand for logs has increased. This is supported by the fact that in 2001 the production of timber logs in Sarmi Regency had increased, but gradually it started to decrease in 2004 and 2005, and then increased again in 2006-2007 (Figure 16).

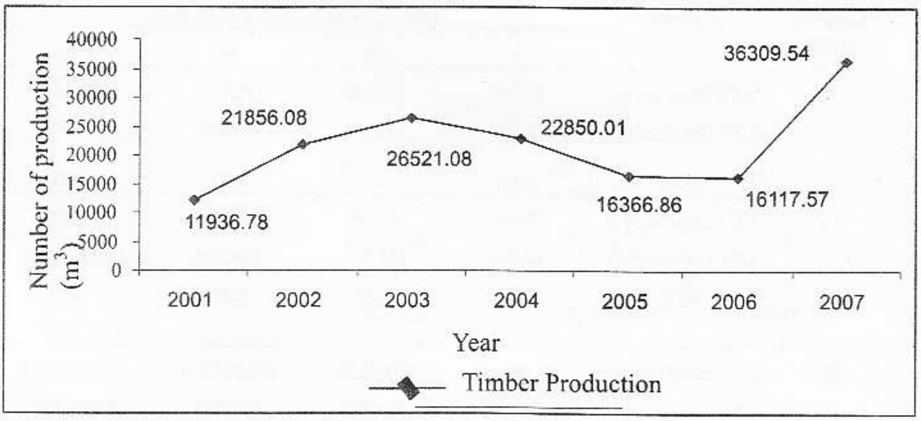


Figure 16. Production of timber logs of IUPHHK PT. BBU in 2001-2007

The decline of production in 2004-2005 was due to the Local Community Cooperative (Kopermas) activities that got Timber Utilization License for (IPKMA). The Kopermas activities to enter the concession area have made the company cooperate with the people to log the timbers in the concession area. The IUPHHK involvement by working together with the people is to get profit as well as to protect the timbers in the concession area from free riders that make use of the weaknesses of the indigenous people.

The local government policy to prohibit the sale of timber logs out of Papua (*Log Export Banned*) is one of the factors that will influence the price of logs in future. Based on the coordinated regulation between Papuan Province and West Papua Number 163 and 16 year 2007, concerning distribution of forest products that logs from Papua can only be sold for local Papua needs or sold outside but in the form of semi-finished or processed timber. The policy has affected the company finance, which can be seen from the slowness of the company to pay the employees' wage. Besides, the government also gives 5% quota for selling local timber, but until now the IUPHHK has not been able to realize the target because the selling price is much lower. On the other hand, the people also prefer to make use of illegal timber product that is bought by the rent seekers from the *ulayat*-owner people because the selling price is much lower than that of the timber sold by the company.

Interest Rate Change

The utilization of forest resources is a process of decision making that is inter-temporal. One way to carry out this is through a discounting process by determining an appropriate discount rate, and then based on this , a sensitivity analysis is carried out toward the interest rate change to determine the prescription of optimal logging. The results of simulation show that the NPV, the LEV and the BCR have given positive results. The interest rate change has reduced the NPV at the average of Rp 63,174,467 per hectare per year and the average of LEV as much as Rp 19,912,487 per hectare per year.

Table 14. Interest rate change toward the NPV, LEV, and BCR

Logging cycles	Criteria	Interest rate change (%) (X 1000)			
		9	14	19	24
30	NPV (Rp/ha/yr)	32,097	33,834	(18,825)	(25,195)
	LEV (Rp/ha/yr)	16,638	78,869	113,225	135,991
	BCR	1.47	1.20	1.02	0.91
35	NPV (Rp/ha/yr)	58,311	5,490	(15,165)	(23,654)
	LEV (Rp/ha/yr)	44,732	111,531	150,798	176,606
	BCR	1.60	1.24	1.04	0.92
40	NPV (Rp/ha/yr)	84,400.45	13,835.14	(12,113.20)	(22,423.52)
	LEV (Rp/ha/yr)	75,639	149,355	191,510	218,749
	BCR	1.71	1.28	1.05	0.92

When the BCR is bigger than 1, it shows that the cost affectivity in which each investment is Rp 1,000 will give average benefit of Rp 1,710. On the other hand, the IRR 17% shows that the return that will be attained will be higher than the *Social Opportunity Cost Capital* (fixed interest rate 9%), so although the bank interest rate reaches 17%, forest utilization by concession holders is still feasible to carry out. An illustration that shows the difference of interest rate values that can produce NPV as much as nil on the 35-year cycle is presented in Figure 17 From the picture we can see that the NPV is declining continuously in line with the increase of the interest rate (Buongiorno and Gilless 2003).

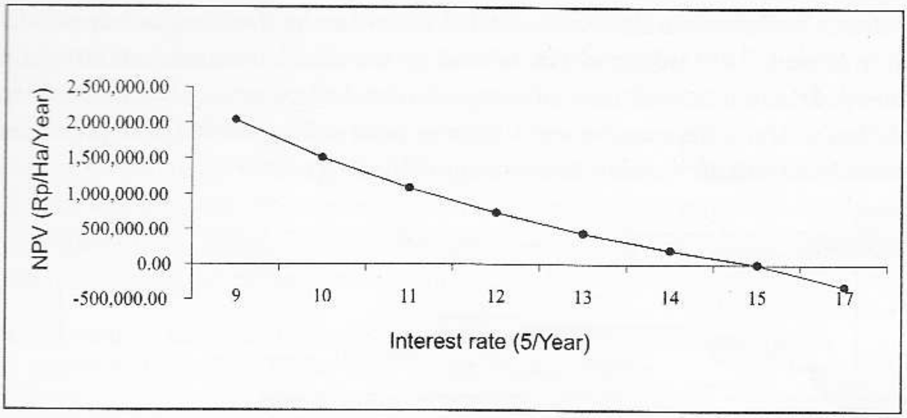


Figure 17. NPV on the interest rate at 35-year logging cycle

Based on the results of simulation at 30, 35, and 40 year cycles every logging interval rise will increase the revitalization value at the average of Rp 1,871,969 per hectare per year for the NPV and the LEV of Rp 1,679,922 per hectare per year. The amount of LEV shows the quality of land and the value of stand on the land.

Table 15. Results of simulation of the NPV, LEV, BCR, and IRR on the various prescriptions of logging with 9% interest rate

Note	Logging cycle (year)		
	30	35	40
NPV (Rp/ha/yr)	3,533,084	1,661,116	736,371
LEV (Rp/ha/yr)	3,021,820	1,350,898	554,595
BCR	1.47	1.60	1.71
IRR (%)	14%	15%	17%

The simulation also shows that the IRR will increase in line with the increase of logging cycle (Hanon and Ruth 1997). This means that at 30, 35, and 40 year cycles the increase of interest rate from 9% to 17% will still give a reasonable profit to IUPHHK when maintaining timber business from the natural forest in Sarmi Regency. The value of forest utilization owned by the company that is reflected from the economic criteria (NPV, LEV, BCR, IRR) is much higher compared to the income of the indigenous people.

Sub Model of the Indigenous people Income

This sub model explains the benefit obtained by indigenous people as a compensation of forest resource utilization in their area, carried out either by the company or non-company (private or group). This sub model is related to the stand dynamic model and product arrangement. The auxiliary variable of compensation and income of the timber owners are accúmulation of the difference between income from selling timber and processing costs (investment, transport, processing, and average of loading cost).

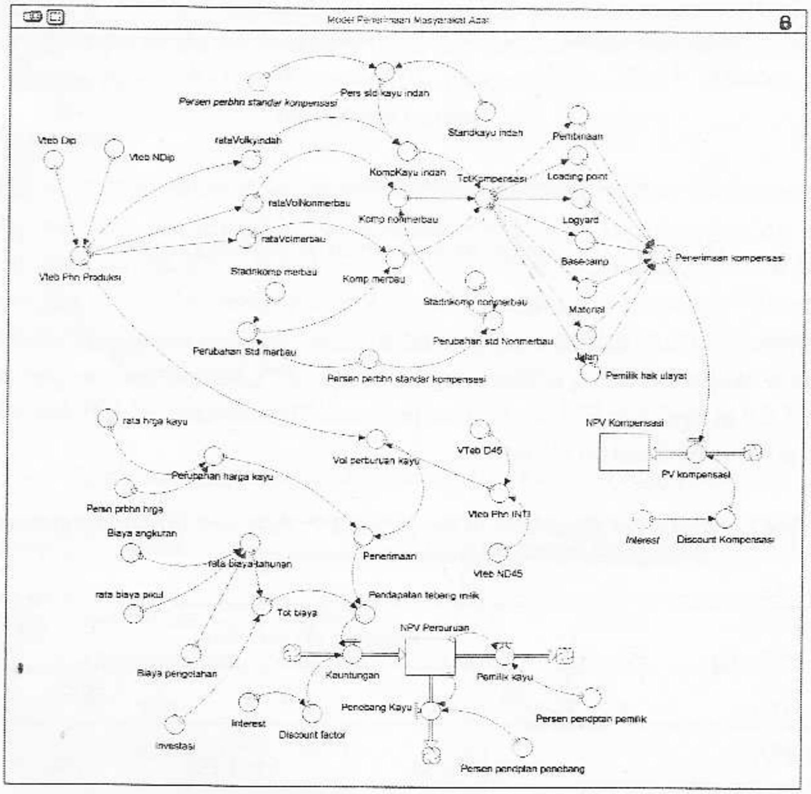


Figure 18. Representation of model of the indigenous people income

The compensation income is the total number of people's income every time the company pays, which is influenced by auxiliary variable, namely product volume, average of product volume per timber type (instia spp., non instia spp. and fancy woods), as well as compensation standard of each type.

The auxiliary variable of the timber owner is influenced by product volume, price of local timber, and total cost. The income of the timber owner is the income that is obtained from selling the timber that has been cut from the location claimed to be owned by indigenous people, the distribution of which is for the timber owner and the wood cutters 20% and 80% respectively. The indigenous people are parts of a forest ecosystem that have the right to get economical benefit from the custom forest that is managed by a company under their custom regulation. Due to the issue pertaining decentralization and regional autonomy the Papuan government has issued three governor decrees related to compensation payment standard to the indigenous people. The last decree that has been issued is Governor Decree Number 184/2004 in order to revise the previous decree, that is, Decree Number 50/2001 with the increase of 50% for *instia* timber and fancy woods. The change of compensation payment standard that is included in both decrees is presented in Table 16. The people only get compensation as an addition to their income outside their farming business. Compensation cost is a replacement cost of the decrease of the forest quality and the lost of access to the forest due to forest exploitation. The amount of the compensation payment depends on the compensation standard determined by the government and the volume of timber that is noted in the product report of the company (LHP).

Table 16. The value of the change of compensation standard to the indigenous people according to the Papuan Governor Decree No 50 and 184

Governor Decree No 50, 2001		Governor Decree No 184, 2004	
Types of Timber	Compensation (Rp/m^3)	Types of timber	Compensation (Rp/m3)
Instia spp.	25 000	Instia spp.	50 000
Non Instia spp.	10 000	Non Instia spp.	10 000
Fancy woods	50 000	Fancy woods	100 000
Mangrove timber	1 000	Mangrove timber	3 000

Source: Government of Sarmi Regency (2008)

The decrees are described further by the government of Sarmi Regency by issuing the Regulation of Sarmi Regency Head Number. 40/2007 with the following distribution: 65% is owned by *ulayat* right or logging block owner, Logyard (8%), coaching 7% and the rest is each 5% for road, base camp, and loading point. Previously with the same decree, the *ulayat* right or logging block owner obtained 70%, material for road surfacing 7%, road 7%, base camp 7%, log yard 7% and custom 2%. This compensation standard change will certainly affect the income of the indigenous people.

Compensation Standard Change on the Indigenous People

The results of sensitivity analyses on the change of the variable of compensation standard obtained by customary people (Picture 20) shows that every time there is a change on the compensation standard the average income of the people increases as much as Rp 298,442 per cubic meter. The increase of compensation income is very much influenced by the structure of stands in each logging cycle. This shows that the availability of forest resources very much determines the level of the people's compensation.

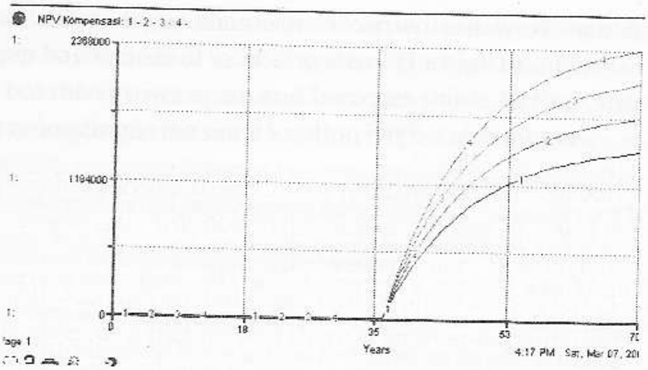


Figure 19. Compensation income at condition of compensation standard change, namely 0% (1), 20%(2), 40(%) and 60%

This condition is very different from the compensation received by timber owners involved in the timber hunting activity, in which the timber owners that receive compensation from the woodcutters (wood hunters) get relatively bigger amount of cash money. In the meantime the compensation income from IUPHHK is of incidental nature because it depends on the activities of the company production. Nevertheless, viewed from the continuity, the company compensation income can give trade off that keeps on increasing from time to time in line with logging cycles and management treatment being carried out, while the income of the timber owners will keep decreasing because of the absence of management and free rider activities. This condition is clearly presented in the timber hunting scenario.

Projection of compensation income of both the indigenous people and the local government at various logging cycles is presented in Table 17.

Table 17. Projection of the income of the government and the indigenous people at various logging cycles

Logging cycle (year)	Period	Income of indigenous people (Rp/year)	Income of the local government *(Rp/year)
30	1	603,576,024	1,976,001,837
	2	1.550,796,125	4,830,326,398
35	1	504,747,118	2,296,209,476
	2	1,276,080,751	5,805,181,655
40	1	434,359,863	2,745,804,392
	2	1,061,790,466	7,054,924,392

Note * without discounted factor

The income of the indigenous people and the local government is in line with the logging cycles, in which every logging cycle rise will give impact on the rise of compensation income and regional income. Every time there is a logging cycle rise the income of the indigenous people and the local government increases about 16.3%. This shows that economically the 40-year logging cycle can give more benefit to the indigenous people and the local government.

The compensation received by the indigenous people is only tentative, depending on the company production activities. Distribution of the indigenous people income is bigger than the timber owners' (65%), whereas the rest is distributed to the *ulayat* right owners for loading point, road, log yard, base camp, material, and coaching. In one year the average payment is two times, with various amount, depending on the volume of timber owned by each person. If the income (Table 18) is distributed to every member of the people the value is very small. The low compensation income of these people is assumed to be one of the factors that triggers timber hunting activities working together with the rent seeking that make use of the local timber owners's weakness to buy timber with a low price. As a result, the concession area belonging to IUPHHK PT.BBU can be freely entered by free riders coming from various groups and strata of people.

Scenario Timber Hunting

This scenario describes the condition of timber hunting after IUPHHK activities, namely, in the post-logging area, and the amount of income received by the *ulayat* right owners from the logging activities carried out in the forest that is claimed to belong to indigenous people. In this scenario, logging is carried out without considering the logging cycle, but according to the needs with high frequency and intensity of logging is 40% without management consideration, such as period of logging (logging cycle) and diameter limit.

Timber hunting has utilized the area belonging to community, and most of it overlaps with concession areas, so there is a paralel utilization on timber resources. This fact illustrates a forest as a common pool resource that has a nature of substracability and rivalness (Ostrom 1990). It has become a general phenomenon in Papua whose most forest is claimed as a communal property. If the property right is not carried out, which means there is no regulation about who can utilize the resources and how they are used, the forest is in the situation of open access regime. The people's practice of timber hunting is carried out in two forms, namely, waiting for the stands left after the company activities and cuting at the same time as the IUPHHK activities. Some causes of these activities are demand for cash money, the right of indigenous people, unemployment in the villages, and consumptive lifestyle. Logging projection per hectare of dipterocarpaceae trees without product arrangement for 70 years can be seen in Figure 20.

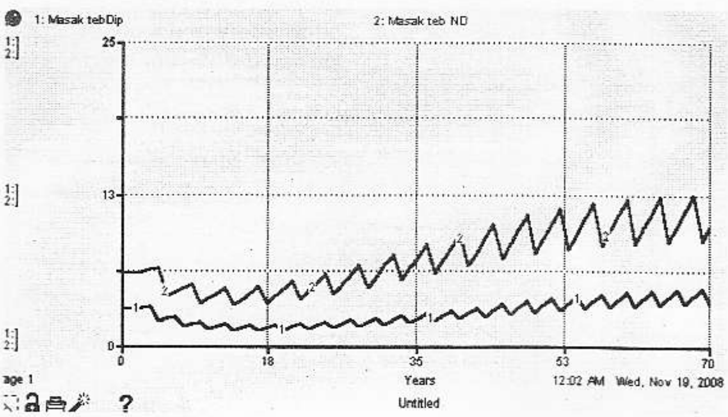


Figure 20.
Projection of diterocarpaceae trees of timber hunting scenario

Note (Figure 20)
1 : cutting maturity of Dipterocarp
2 : cutting maturity of Non-Dipterocarp

Cutting the trees of above 40-cm diameter is carried out with high frequency and low intensity (1-3 trees per ha) compared to TPTI system. The high frequency of logging has made the stand collapse, but then grows again and becomes stable. In this case, the period of time needed to carry out re-logging in the same location has become longer.

Economically, the people's income from timber hunting activities in early years shows a big income value. This income is distributed to the timber owners 20% and the woodcutters 80%. Although the condition of stands still produce trees of more than 40 cm high (main trees) in the long term they will decrease so that there will be short stands left (1%) compared to the early condition. This gives us a picture that there is an over-exploitation because of "double AAC". The high number and volume of trees in early years are caused by the rest of stands that is not harvested in the previous logging. However, after logging is carried out to the main trees, the number of trees in the stands decrease, so that it is not appropriate to cut them in the next cycle.

Timber hunting activity by indigenous people is carried out as follows: they show several types of timber in the area claimed to belong to the ulayat right to be cut by the producers (those that have money and tools), and after the timbers are sold they divide the money, in which the timber owners get 20% and the producers (woodcutters) get 80%. If the price of the processed timber in Sarmi Regency ranges around Rp 1,300,000 to Rp 1,500,000 per cubic meter and the total cost for processing and selling is Rp 337,500, the woodcutters (wood hunters) will get a very big profit. In the same way, the timber owners will also get a very big profit; however, this condition will not last long because the timber resources have decreased in a very big number and even over resilient limit (Figure 21).

The income of the woodcutters and the timber owners will decrease drastically because of the logging activity that is carried out intensively during a short period time. As a result, the timber owners' income will decrease and, one day, it will be undoubtedly finished. Meantime, the woodcutters, although their income decreases, they still can make use of the timber resource in other areas (rent seeking) because they have been able to dominate the production factors.

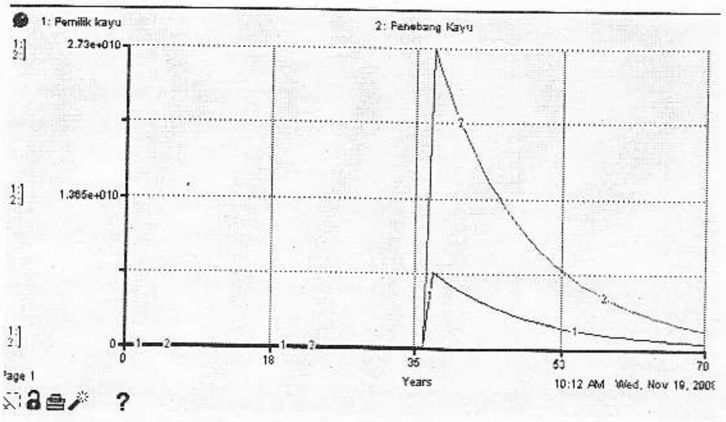


Figure 21. Condition of the income of the ulayat right community and woodcutters during the 35-year logging cycle

Note (Figure 21) =
1 : timber owner,
2 : timber cutter

Carbon Trading in the Production Natural Forest

The economic value of the forest resources is not timbers only. Nowadays, there is also a carbon trading scheme that can become one of the promising income sources for the people and the government.

Carbon sink is a term that is often used in the climate change field. This term is related to the function of forest as a sink and a reservoir of carbon. Carbon emission is generally produced from fossil fuel-burning activities from industrial, transportation and household sectors (Rusmantoro 2006). Carbon emission trading can give positive NPV earlier in the rotation compared to that produced at forest management as a timber producer, which certainly can replace the financial break-even point and in general can increase the value of Internal Rate of Return (IRR). Forest management might choose to take care of the stands in order to purely absorb carbon or to combine timber and carbon production (Harrison *et al.* 2000).

Papua is a land area that maintains its primary forest. It is assumed that there are 14,284,153.05 ha of primary forest in the production forest. This number does not include conservation forest and protected forest. This natural forest is the biggest carbon depositor compared to agricultural land-use system, because of the high diversity of trees, the amount of manure and low plants growing on the soil surface. Through the photosynthesis process, plants absorb CO_2 from the air which is then changed into carbohydrate, distributed and stored throughout the plants. The carbon maintaining process in the plants is called C-Sequestration. Therefore, calculating the amount of carbon kept in the plants (biomass) in a land can illustrate the amount of CO_2 in the atmosphere that is absorbed by plants. On the other hand, calculating carbon that is still kept in living plants that have decayed (necromass[2]) indirectly describes the CO2 that is not released to the atmosphere through the burning process.

Biomass

Biomass is the weight of living plants that occur above or under an area of soil surface at one point at a certain time (Catur 2002). This biomass assumption is needed, especially in tropical forest areas because they have big influence on the carbon cycle. If we look at the forest management point of view, forest biomass is very important because all forest management operations are very much influenced by the forest potential through biomass determination. These forests have big potential in reducing the CO_2 content through conservation and forest stand management. Moreover, biomass can give information about nutrition and carbon content of one stand as a whole.

[2]*Necromass*: mass of the part of the tree that is mortal whether it is still upright on the land (stem or tree stump), or lying on the land, tree stumps or twigs and fallen leaves (manure) that are not yet decayed.

Scenario: Reduce (Emission from Deforestation and Degradation (REDD)

REDD is a mechanism that gives incentive to forest-owner countries to maintain their forests from deforestation and degradation. Forest degradation is the main source of green house emission. In Indonesia forest areas have decreased up to 5% every year due to degradation (Marklund and Schoene 2006 referred to Mudiyarso *et al*. 2008). Degradation in tropical areas generally happens due to activities such as logging, forest fires in a large scale, wood and non-wood product taking, charcoal product, grazing, and shifting agriculture (GOFC-GOLD 2008). IPPC (2003) mentioned five carbon pools that are used to monitor deforestation and degradation, namely upper biomass, lower biomass, manure, dead wood, and carbon derived from soil.

Papua Province dedicates half of its production forest for reducing carbon emission or Reduce(?) emission from Deforestation and Degradation in Developing Country. A quarter of the Papuan conversion forest areas are dedicated to Clean Development Mechanism (CDM).

The Papuan government commitment to Climate Change Convention in Bali in 2007 to provide 15% (3,285,217 ha) of the total production forest area for carbon trading is a strategic effort politically; however, economically and socially this has not given a sound guarantee. Every 1 million ha conversion production forest that has been decided to be kept as an real forest and is involved in the carbon trading through avoided deforestation approach, can produce cashflow no less than Rp 3 quintillion (Suebu 2007). If this income is given to more or less 2 million Papuan people, every person will get cash as much as Rp 1,500,000,- or Rp 375,000,- for an area of 15% of the Papua forest.

Sub model REDD is made to analyze the financial condition of forest management by IUPHHK PT. BBU if it is changed for carbon absorption. The REDD income is the difference of carbon income and the REDD expense. The REDD income comes from giving service to absorb carbon in one ton (ton C) per hectare.

The price of carbon in carbon trading varies a lot. In the early trading system and carbon changing, the credit value of carbon emission reduction ranges between *US$* 2,5 to *US$* 12 (Niles *et al*. 2002, Rochmayanto, 2009). The value applied in this research is *US$* 5, and the exchange rate of Rupiah (IDR) is assumed to be Rp 9,500.

The REDD expense is the cost spent in the REDD scheme, namely: transaction cost. This transaction cost refers as the cost that is spent from the process to get Certified Emission Reductions-CERs to the process of finding an institution or country that will cooperate to buy and sell this certification. The amount of the transaction cost per ton carbon (ton C) in some projects is described in the transaction costs of forest carbon projects ranging between US$ 0.57 and US$ 2.96 (Milne 2002). In this research the transaction cost used is US$ 3/ton C or Rp 27,500/ton C.

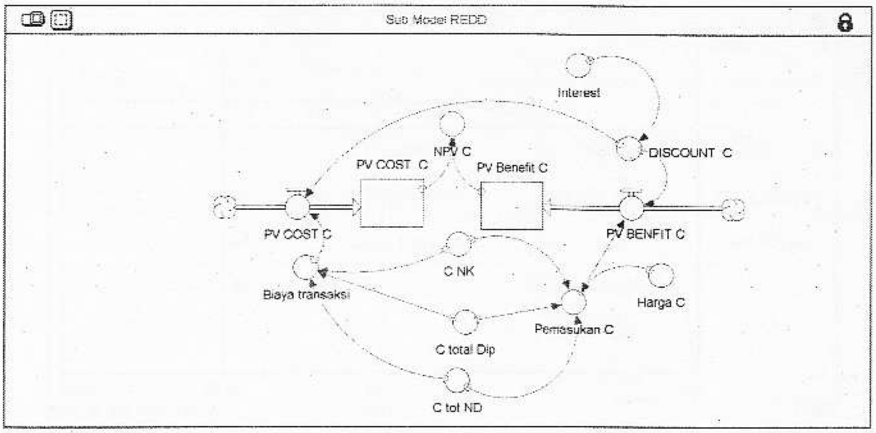


Figure 22. Representation of Model REDD

Based on the *stockdifference* method then estimation on the carbon stock change is carried out in the first and the last period. Data of carbon stock in the first period is estimated based on primary forest data, whereas carbon stock in the last period is estimated based on Permanent Measuring Plot (PMP). The difference between the number of carbon produced at base line condition and the number of carbon after reducing the logging percentage from 80% to 20% is the number of carbon that can be included in the REDD scheme.

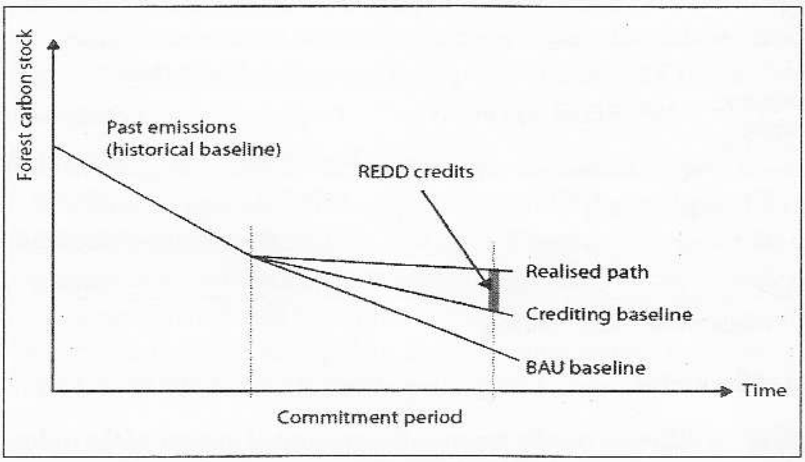


Figure 23. BAU and Baseline credit (Adapted from Angelsen 2008)

Sub model REDD is a sub model developed in order to compare the scenario of logging cycle with its implementation by the indigenous people, so that the payment scheme can be accepted by the people and the government. Simulation is carried out with logging as much as 20%, while the rest (80%) is reserved for carbon absorber.

With the Papuan government policy that provides 15% forest area for carbon absorption, it is expected that it can give a meaningful contribution to improving the income because of the mechanism of carbon trading being issued. Projection of the REDD income when the forest is left alone without logging for each cycle with 20% intensity is presented in Figure 24.

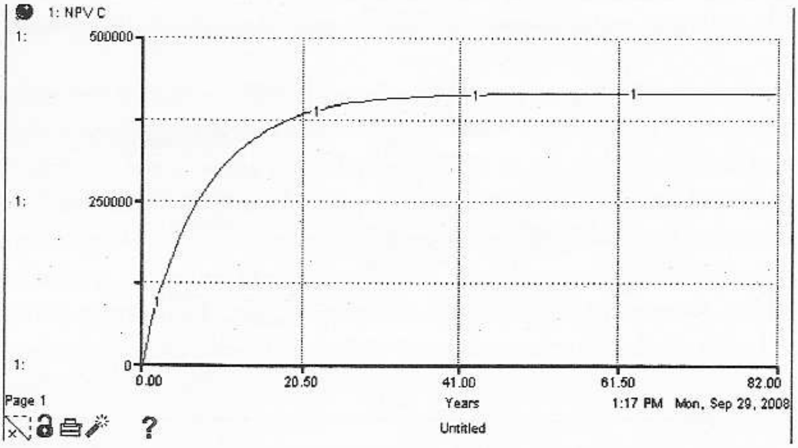


Figure 24. Projection of REDD income

Projection the REDD income is distributed to the central government (30%) for empowerment activity and to the indigenous people (70%) for their trade off the *ulayat* right owners (Table 18).

Table 18. Projection of REDD income distribution to the indigenous people and the government

Logging cycles	NPV REDD (Rp/ton C)	Distribution	
		People * Rp/ton C)	Government * (Rp/ton C)
30	1,963,300	1,374,310	588,990
35	1,684,622	1,179,235	505,386
40	1,475,042	1,032,529	442,513

Notes: * People 70% and Government 30%

Comparison of Scenarios

Each scenario gives different results towards the amount of income of the indigenous people and the local government in the IUPHHK PT. BBU area, whether it is seen from the point of view of the company NPV, the people's income or the government's income. The 30-year logging cycle scenario gives the highest NPV (Table 19). This shows that the logging cycle scenario is still the best choice in utilizing forest resources for the time being. The scenario that produces the lowest NPV is carbon trading business through forest degradation reduction mechanism. The low income obtained through this REDD scenario is because the cost that must be spent for this business is higher than the income from giving service to reduce carbon emission. The price of carbon considered reasonable in this research is US$ 2.5 per ton C; thus, if it is less, the NPV produced will become negative and the B/C ratio will be less than 1, so that it is not feasible.

Table 19. Comparison of Scenarios

Scenario	Logging period (yr)	Company NPV (Rp/yr)	Income of Indigenous People (Rp/yr)	Income of the Local Government (Rp/yr)**
Logging cycle	30	24,134,496,804	603,576,024	2,745,811,110
	35	11,347,083,396	504,747,118	2,296,209,476
	40	5,030,150,301	434,359,863	1,976,001,837
Timber hunting	30	-	142,372,886	-
	35	-	83,378,424	-
	40	-	51,588,040	-
REDD (Rp/ton C)	30	120,742,950	84,520,065	36,222,885
	35	103,604,130	72,522,891	31,081,239
	40	90,715,165	63,500,615	27,214,549

Notes : *Assumption of indigenous people 70% and government 30% from NPV; **without discount factor

Contribution towards regional economy

Contribution towards the regional income refers to the amount of contribution to the government, in which 20% is for the central government and 80% is for both the local government and trade off for indigenous people. The contribution is compared based on actual data and simulation results of the profit-sharing of natural resources. The result of the simulation is the value of income that comes from profit-sharing 32% that becomes the right of the producer region.

The contribution that is given based on the logging cycle scenario is very small, only 0.56% for the regional government income (Table 20). The income comes from Forest Resource Provision (PSDH), Reforestation Fund (DR), and taxes. There is a chance for the contribution to increase because it does not include those coming from sub-sector industry of primary forest product processing which will later be opened by every IUPHHK holder in Papua. This is related to the Papuan government policy that prohibits selling logs out of Papua and requires each HPH/IUPHHK holder to build a primary industry.

Table 20. Contribution of forestry sector income from PT.BBU towards the average income of the local government of Sarmi Regency based on the logging cycle scenario

Income of the Local Government of Sarmi Regency			
Year	Regional income (Actual) (Rp/yr)	Income of Forestry sector from PT.BBU (Simulation) (Rp/yr)	Contribution towards Regional Income average (%)
2005	354,876,971,000	2,745,811,110 (1)	0.66
2006	363,489,990,000	2,296,209,476 (2)	0.55
2007	528,804,000,000	1,976,001,837(3)	0.48
Average	415,723,653,667	2,339,343,560	0.56

Note : (1)= income at 30-year, (2) 35-year, (3) 40-year logging cycles

Table 21. Contribution of forestry sector income from PT.BBU towards the averag income of the local government of Sarmi Regency based on REDD scenario

Year	Income of the Local Government of Sarmi Regency		
	Regional income (Actual) (Rp/yr)	REDD income (Simulation) (Rp/ton C)	Contribution towards Regional Income average (%)
2005	354,876,971,000	36,222,885 (1)	0.009
2006	363,489,990,000	31,081,239 (2)	0.007
2007	528,804,000,000	27,214,549 (3)	0.007
Average	415,723,653,667	31,506,224	0.008

Note : (1)= income at 30-year, (2) 35-year, (3) 40-year logging cycles

On the other hand, if the government and the people are involved in the carbon trading scheme through the REDD, the contribution that will be given to the local government of Sarmi Regency is only 0.0008% (Table 21). Although the contribution given is relatively small, the scheme offered is worth considering. This is because this scheme contains high values about forest natural resources conservation.

Contribution of profit arrangement can accommodate not only the government income, but also the indigenous people's income, which is simulated in this research. The results of the simulation show the improvement of the amount of compensation income at each logging cycle with the average contribution of 47.91% (Table 22).

Table 22. Contribution of compensation income of the indigenous people based on the simulation results and actual situation

Compensation income of the people			
Year	Income from PT. BBU (Actual) (Rp/yr)	Compensation income of the people * (Simulation) (Rp/yr)	Average contribution (%)
2008	1,900,000,000**	8,129,890,723 (1)	76.63
		4,227,616,792 (2)	55.06
		2,159,944,992 (3)	12.03
Average	1,900,000,000		47.91

Note: *Discount factor 9%, (1)= income at 30-year, (2) 35-year, (3) 40-year logging cycles,
** Compensation payment to Western Coast District People in 2008

Although the amount of compensation that they receive is quite big, the value is actually relatively small after it is distributed to the people/each household in the area, that is Rp 617,848/family/year or Rp 51,457/family/month.

Chapter 5

POLICY IMPLICATION AND RECOMMENDATION

The choice of logging cycle is closely related to the contribution towards the people's trade off from the compensation of the *ulayat* right and the local government income. It is true that the people and the government obtain additional value from timber utilization activities, but for the company this becomes a burden, so that it affects the company financial performance. Choosing an optimal logging cycle could become an economical instrument; therefore, the forest concession holder will become motivated to manage the forest in the concession area professionally and efficiently.

Contribution using the profit sharing methods towards the local economy, when it is seen from the forestry sector income from PT. BBU, is relatively small; however, there is a great chance of increase because there are still other income resources in the forestry sector that have not been identified in this research, mainly indirect economic values from environmental services. Simulation also gives alternative scenario of timber hunting that is carried out by the *ulayat* right people and the woodcutters, which gives an implication towards forest ecosystem conservation. The profit obtained by the timber owners is high, but forest resources are not conserved. At the next logging cycle, forest concession holder will not carry out logging in the same area because there has been a "double AAC". This affects the sustainability of forest concession business. This condition can be used as a consideration by the government to encourage forest management by involving the indigenous people, for example by community logging or REDD, which nowadays becomes a part of new policy of forest management in Papua.

The new policy of Papuan forest management has appointed REDD and community logging as the part of forest management options, which is expected to be able to encourage regional economic growth through improving the indigenous people's income and the local government income. However, simulation shows that the REDD mechanism can give trade off to both regional and people income. The loss of income could be avoided, if the REDD scheme is combined with environmentally-friendly conventional logging activities. To understand the real implication of REDD scheme, it needs further and in-depth research, especially about the payment assurance and base line condition for Papuan area.

As a whole from the established simulation, the rights of the indigenous people towards compensation of forest resources can be accommodated, although it is still relatively small compared to the value that is supposed to be received. There are some lessons learned obtained from existing management and proposed scenarios for Papua forest. They are:

- Structure of stands from logged over areas in the concession area makes it possible to manage the next logging cycle.
- Logging cycle is correlated negatively with the amount of income of the government and the people.
- Economically the 30-year, 35-year, and 40-year logging cycle scenarios give reasonable results to forest management in Papua.
- The best profit-sharing scenario is 30-year logging cycle with average contribution for the local government 0.56% of the total regional income and for indigenous people compensation 47.91% of the total expected income. This result is very sensitive towards ingrowth, upgrowth, and mortality of forest stands, so that it cannot be generalized to other forest locations.
- Economically timber hunting scenario gives high extra income, but the implication is deforestation.
- Carbon trading scenario gives a relatively small income to the people compared to the conventional management activities.

To avoid timber hunting activities the government needs to consider forest management by involving the indigenous people. This study recommends to carry out some further important research to give more comprehensive information in formulating future policies on community forest management in Papua, that are: analyses of indigenous people forest management institution, the effects of logging cycles towards ecological aspects, distribution of profit from compensation, and the effects of fees towards profit-sharing carried out by the company.

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