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Reassessment of forest area and its scoring as a permanent production forest

T Sudarmadji* and W Hartati

Faculty of Forestry, Mulawarman University. Jl. Ki Hajar Dewantara, Samarinda, East Kalimantan, Indonesia

*Corresponding Author: triyonosudarmadji@gmail.com

Abstract. Along with the increasing demand for tropical timber, the need for wood raw materials is not enough just to rely on natural forests, and therefore in the early 1990s began to be developed timber estates concessions. The designation of forest areas can basically be altered using procedures established by the Ministry of and Forestry. PT Permata Borneo Abadi (PBA) as the holder of IUPHHK-HT covering 38.680 ha intends to propose changing of forest function from limited production forest (HPT) and convertible production forest (HPK) into permanent production forest (HP) to be developed as timber estates with fast growing species. Reassessment of forest function is intended to formulate official documents aimed to reevaluate IUPHHK-HT especially HPT and HPK. The assessment is based on established criteria and standard values (scores) covering topographic, soil and vegetation conditions as well as regional rainfall distribution. The assessment results indicate that there is an area with a slope of >40% of 840.18 ha with score >175 which must therefore as protected areas. The area of HPT that scored between 125-174 remains HPT is 12.287,77 ha. The area of HPT that scored <125 is 27.637.80 ha and therefore is possible to be converted into HP. The results can be used as an important basis for intensive forest management synergically with conservation efforts.

1. Introduction

Exploitation of natural forests outside Java and Madura is mandated by government act No. 5/67 regarding basic forestry provisions. However long time before that, the exploitation of natural forests in Kalimantan has been done traditionally by cutting down groups of floating commercial species, assembled in the river for further transported downstream to wood processing sites (wood industry). Over the time, selective logging techniques are then widely practiced with the involvement of more advanced technologies using various heavy equipments [1].

Along with the increasing demand for tropical timber in the world for various purposes including pulp and paper industries, the need for wood raw materials [1] is no longer deemed sufficient simply by relying on wood that grows naturally in natural forests. Thus, in the early 1990s a forest concession was developed that planted fast growing species to supply the timber industry and was known as timber estates or industrial plantation (HTI). Wood species such as *Acacia mangium*, *Eucalyptus sp* or *Gmelina arborea*, are widely cultivated by HTI concession holders (IUPHHK-HT).

In Indonesia, the boundaries between forest and non forest areas and between different forest areas of status and function have been set forth in the map of forest use agreement (TGHK) to determine the allocation of forest area and their functions [2, 3]. Designation of forest function principles can be changed and legally regulated in government regulations [4].

Reassessment of forest function was intended to provide complementary official document to the propose changes in the function of forest submitted to the Minister of Environment and Forestry as a determinant of national forest management policy [5]. The objective of this research was to re-assess and to find out wether there are any areas of HPT and/or HPK that might be functionally converted to HP using the criteria and scoring standards set up in the applicable government rules and regulations.

2. Method

2.1. Location and fieldworks

The study was conducted in the concession of IUPHHK-HT PT PBA, which is administratively located in East Kutai Regency, East Kalimantan Province covering 49.680 ha (figure 1). Fieldworks were conducted in 14 sample plots of field observations focused on forest stands, soil profile and soil sampling, and several weather station records in the area and its surroundings.

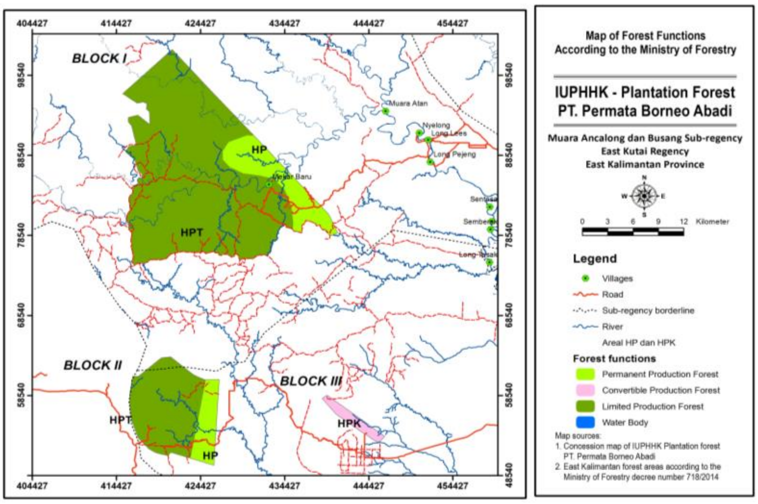

Figure 1. Map of forest functions of IUPHHK-HT PT PBA concession

2.2 Procedures

The initial environmental condition of IUPHHK-HT PT PBA was studied in the documents of forest product utilization work plan and environmental impact assessment. Basic data of lanslope, rainfall depth and rainfall intensity, soil type and other supporting data were used for assessing forest area function determination. Furthermore, the determination of proportional weight and scores were set up to obtain total scores in each observed location to find out proper recommendations for areas that are technically possible to be functionally changed from HPT and/or HPK into HP [6-8].

2.3. Analysis

Data analysis was conducted by applying the assessment criteria that HPT is a region with total score of slope, soil type, rainfall intensity of 125-174, HP designation area has the largest number of scores 124, whereas HPK is determined by criteria that the largest number of scores is 124 and/or an area if converted is still capable of maintaining environmental carrying capacity. The determination of each score follows technical guidance in the decree of Minister of Agriculture No. 837/Kpts/Um/11/80 on criteria and procedures for the establishment of protection forest [6] and No. 683/Kpts/Um/8/81 [7] on the criteria and procedure of production forest determination (table 1). All of environmental factors were analyzed to obtain units of land with unique values which are a combination of the three environmental factors [9]. The sum of these unique values generates a total score that gives direction to whether an area will be designated as HPT, HL or HP. The analysis of land cover and land system was done to justify forest function change.

Table 1. Scores of landslope, soils, and rainfall for reassessment forest functions

Class	Landslope			Soils			Rainfall		
	Description	**Slope (%)**	**Score**	**Erodibiliy**	**Type**	**Score**	**Description**	**Intensity (mm/day)**	**Score**
1.	Gentle	0 – 8	20	Low	Alluvial, Gley soil , Planosol, Grey hidromorf, Laterit	15	Low	< 13.6	10
2.	Moderate	8 – 15	40	Moderate	Latosol	30	Moderate	13.6 – 20.7	20
3.	Moderately steep	15 – 25	60	High	Cambisol, Mediteran, Brown Forest (*Inceptisol*), Non Calcic Brown (*Inceptisol*)	45	High	20.7 – 27.7	30
4.	Steep	25 – 40	80	Very High	Vertisol, Andosol (Andisol), Grumusol (*Molisol*), Laterit (*Oxisol*), Podzol (Spodosol), Podozolic (*Ultisol*)	60	Very high	27.7 – 34.8	40
5.	Extremely steep	> 40	100	Extremely High	Litosol, Organosol, Rendzina, Regosol	75	Extremely high	> 34.8	50

The classification of slopes is made to determine the condition of area associated with the potential erosion-sedimentation and conservation efforts. Soil observations were carried out in the soil profile on each land cover to determine soil characteristics for scoring soils. Subsequently, monthly ranfall and rain days were used to determine the rainfall intensity and its occurence probability events as the basis for determining proportional rainfall scores.

3. Results and Discussion

3.1. Climate condition

The average monthly air temperature ranges from 26.8 – 27.5ºC, with the highest air temperature occurring in April and the lowest in July. Relative humidity is 71.3 – 82.2% with an average of 79.0%. Average duration of solar radiation intensity is 43.7% with a range of 33.7 – 50.9%. Mean annual rainfall is 1.707 mm varies relatively small or evenly throughout the year. Highest rainfall occurs in January - March and December and the lowest at September with monthly rainfall days between 11 - 17 days. Based on the Schmidt and Ferguson Climatic Classification System (1951), the study location is generally under influence of B climatic type which means having significant low rainfall periods of rainfall (table 2).

Table 2. Average values of climate elements at study sites (1986 - 2014)

Climate elements	Monthly average											
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Temperature (ºC)	27.1	27.0	27.4	27.5	27.4	27.1	26.8	26.9	27.1	27.2	27.3	27.3
Humidity (%)	80.2	81.0	81,2	79.9	79.2	80.2	80.3	75.6	77.4	71.3	80.9	82.2
Sunshine (%)	29.7	33.7	34.3	47.8	39.2	42.2	51.9	59.8	44.3	50.9	45.8	45.0
Rainfall (mm)	185	158	200	174	165	131	117	96	90	128	170	185
Rainfall (Days)	13	11	13	12	13	12	12	10	10	11	13	13

Sources: Weather Station: Kecamatan Sangkulirang (2003 - 2014), PT Indominco Mandiri (2003 - 2012), BWS-III Sangatta (1986 - 2010), UPTD Dinas Pertanian (2002 - 2011), BWS-III Muara Ancalong (1981 - 2008).

3.2. Geology and physiography

The area consists of 7 land systems composed of sedimentary rock types that old age as formed in the Neogen era. Old sedimentary rocks would form soil with low fertility, predominantly dominated by soft and coarse textured sedimentary rock types. Physiographic conditions vary from plain to hilly and most are flat (60.1%), and are in the range of 34 - 644 m above sea level (asl).

3.3. Soils characteristic

The study area is composed of four land associations namely ultisols - inceptisols, inceptisols - ultisols - oxisols, inceptisols - entisols, and inceptisols - ultisols - molisols. The association of ultisols - inceptisols occupies about 71.61% of the area (29.194,39 ha) while inceptisols - ultisols - oxisols assosiation occupies 12.41% (5.060,50 ha), and the rest of 7.73% (3.151,71 ha) and 8.24% (3.359,15 ha) are the territories of inceptisols - entisols association and inceptisols - ultisols - molisols. Each land association of more than 70% of its territory is in a flat to steep area except the territory of inceptisols - ultisols - molisols asssociation which mostly extends from a moderate to steep slope [10].

3.4. Vegetation cover

PT PBA forest concession is currently dominated by pioneer vegetation types such as Jabon (*Antocephalus cadamba*), Mahang (*Macaranga sp*.) and group of ferns. Originally, the area was covered by a type of lowland tropical rainforest rich in species from the Dipterocarp family with very high standing stock potential. However, the high standing stock potential triggers the setting of high production targets. Therefore, intensive timber extraction from natural forests causes the productivity of forests in East Kalimantan dramatically decline. Record of two major forest fire incidents in 1982/83 and 1997/1998 helped speed up the process of losing forest resources so it is no longer economical to cultivate in the second rotation. Excessive forest exploitation transforms primary forest cover into secondary forest with 50% or more damage [11]. Deforestation greater than that number due to various factors resulted in poorer land cover classes [12, 13]. The land cover map confirms that the shrubs as the dominant land cover class in the PT PBA work area (figure 2).

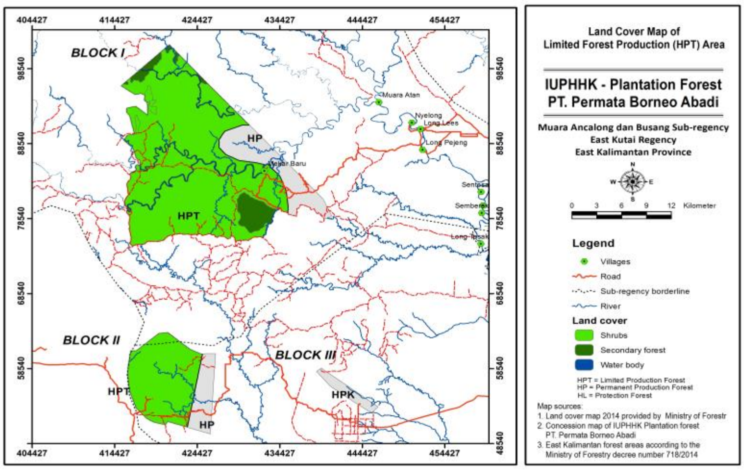

Figure 2. Vegetation map of forest concession of PT PBA

3.5. Forest function assessments

Study of changes in the function of forest area from HPT and/or HPK to HP reffers to the analysis of representative environmental factors i.e. landslope, soil type and rainfall intensity; which are considered to be represent the endogenous and exogenous energies that play a role in the formation of nature in which humans and other biological creatures [14-17]. Determination of sample plot location is based on land cover conditions, slope class, soil type and rainfall. A total of 14 sample plots were made in the field to represent some of the physical characters of the land. Thirteen sample plots measuring 50 x 50 m (0.25 hectares) and one plot measuring 30m x 60m (0,18 ha).

The class of land slopes is considered to be a major limiting factor in the process of forest area convertion [15, 17] due to its great potential to negatively impact upon the existence of living things when there was a change over it as a result of development activities [18-20]. The situation with very limited technology and access to forests, not all places can be visited to validate the accuracy of the topographical map created. This situation leads to a mismatch between the direction map function with real conditions in the fields. Even flat areas are classified as limited production forest areas (HPTs) that should be designated for special areas [21] with slopes of more than 40% or altitudes of more than 2.000 m above sea level. Similarly, vice versa in the field precisely into the area of HP.

The slope classes used in this study were obtained from the interpretation of SRTM (Shuttle Radar Topography Mission) images with spatial resolution of 30m x 30m. Currently SRTM is the only available global level elevation image even for free with high enough spatial resolution. Figure 3 is a visualization of the digital eleveation model of the SRTM image, while figure 4 is a class of PT PBA concession slope that has been derived from the SRTM digital elevation data.

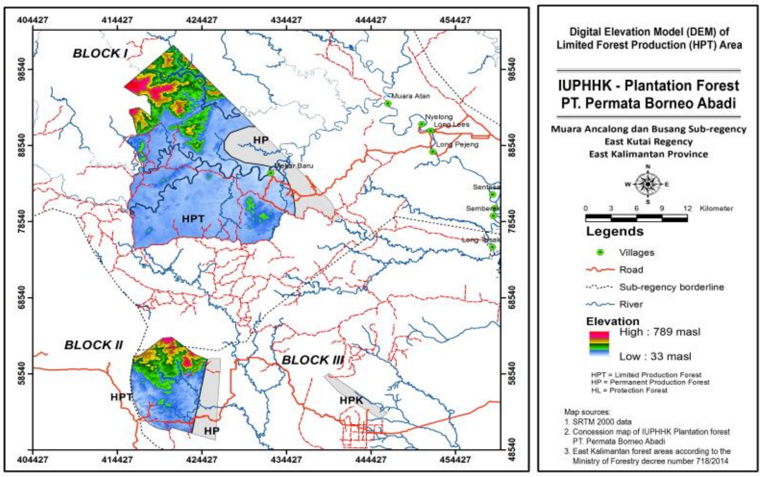

Figure 3. Map of digital elevation model of PT PBA forest concession

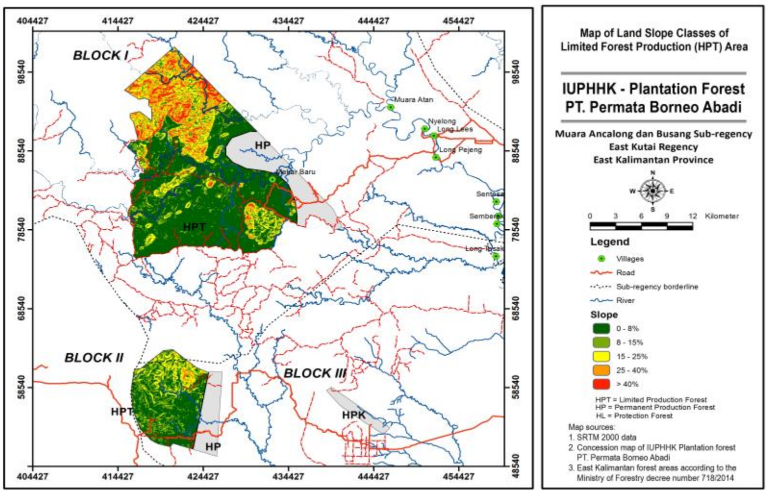

Figure 4. Map of land slope classes of PT PBA forest concession

Soil characteristic at the study site indicates the association of ultisols - inceptisols (candiudults, paleudults, dystropepts or podzolic candic, podzolic chromic, cambisol district), inceptisols - ultisols - oxisols (dystropepts, paleudults, candiudoxs or cambisol district, podzolic chromic, oxisol haplic), Association of inceptisols - entisols (tropaquepts, fluvaquents, dystropepts or district gleisols, alluvial gleics, district cambisol) and inceptisols - ultisols - molisols (dystropepts, paleudults, palehumults, argiudols - district cambisol, chromic podzolic, umbric latosol, mediterran).

Based on the soil classification results from the representative profile of ultisols - inceptisols association either on the slope class 0 - 8% or 8 - 15% there are 2 (two) soil types namely inceptisols and ultisols. The score for the cambisol soil type (inceptisols) is 45 whereas for podsolic (ultisols), but for location with a complex soil type, the class is the same as the class of soil type whose sensitivity to class erosion is determined by the soil class with highest erosion sensitivity i.e. podzolic with a score of 60. Details of the scores from each land association with various slope classes at the study sites based on the classification of the representative land profiles can be seen in table 3.

Table 3. Scoring result of soil factor based on soil profile calssification

No	Soil association	Slope class (%)	Representative soil profile and type	Soil classes	Score
01.	Ultisols - Inceptisols (Candiudults, Paleudults, Dystropepts - Podzolic candic, Podzolic chromic, Cambisol distric)	0 – 8	PBA-01 (Podzolic) PBA-03 (Podzolic) PBA-05 (Podzolic) PBA-06 (Cambisol) PBA-11 (Podzolic)	3,4	60
		8 – 15	PBA-02 (Podzolic) PBA-07 (Cambisol) PBA-12 (Cambisol)	3,4	60
02.	Inceptisols - Ultisols - Oxisols (Dystropepts, Paleudults, Candiudoxs - Cambisol distric, Podzolic chromic, Oxisol haplic)	8 – 15	PBA-04 (Latosol)	2	30
03.	Inceptisols - Entisols (Tropaquepts, Fluvaquents, Dystropepts-Gleisol distric, Alluvial gleic, Cambisol district)	0 – 8	PBA-09 (Podzolic) PBA-13 (Podzolic)	4	60
		8 – 15	PBA-10 (Podzolic) PBA-14 (Podzolic)	4	60
		15 – 25	PBA-08 (Litosol)	5	75

Rainfall intensity is estimated by using rain and rain distribution both monthly and yearly. Based on the result of map study and orientation and field observation, the data collection is done at 5 (five) observation locations. Data on the distribution of rainfall depth and rainy days are used to describe the rainfall intensity characteristics. The monthly average within 13 years (2002 - 2014) is presented in figure 5. Average annual rainfall ranges from 1,309 - 2,355 mm and monthly rain huge between 103 - 212 mm. The highest rainfall possibility occurs in December while the lowest is in August. In general, rainfall is relatively low - below the average of some other parts of East Kalimantan, but the trend is relatively similar that it has 2 (two) peaks (March and December) based on polynomial trend - order 3 with R2 = 0.9382 (r = 0.97). The number of annual rainfall days ranges from 92 - 157 and monthly between 6 - 14 days, the largest in December while the smallest is in August.

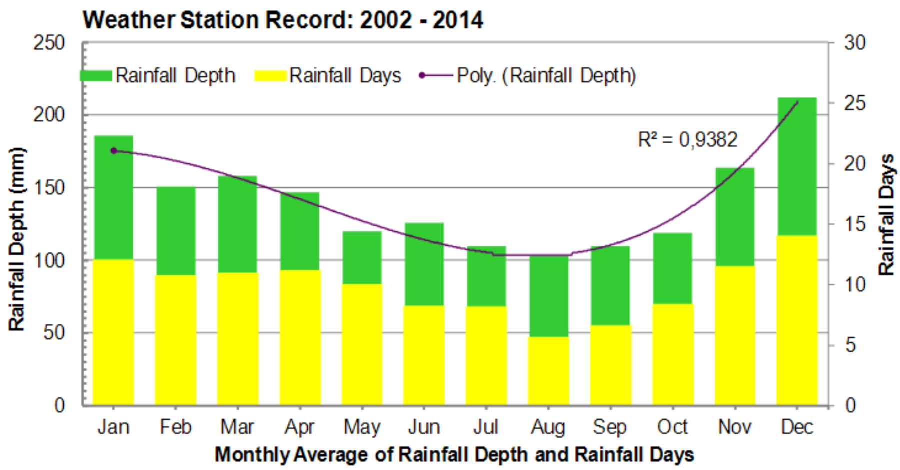

Figure 5. Distribution of rainfall depth and rainfall days at study sites

Average rainfall intensity per day (HH) in the four rainfall observation locations is presented in figure 6. The mean rainfall intensity for each location is between 5.0 - 18.5 mm/HH, 6.6 - 17.2 mm/ HH, 4.5 - 15.3 mm/HH, 7.2 – 14.9 mm/HH, and 17.4 - 39.7 mm/HH. The four locations have a magnitude of 6.7 - 19.8 mm/HH. This means that the range is Very Low (<13.6 mm/HH) to Medium (20.7 - 27.7 mm/HH). Although the above monthly rainfall intensity range is between Very Low to Medium, it is important to detect in more detail whether there are other high rainfall intensities of High and Very High [22].

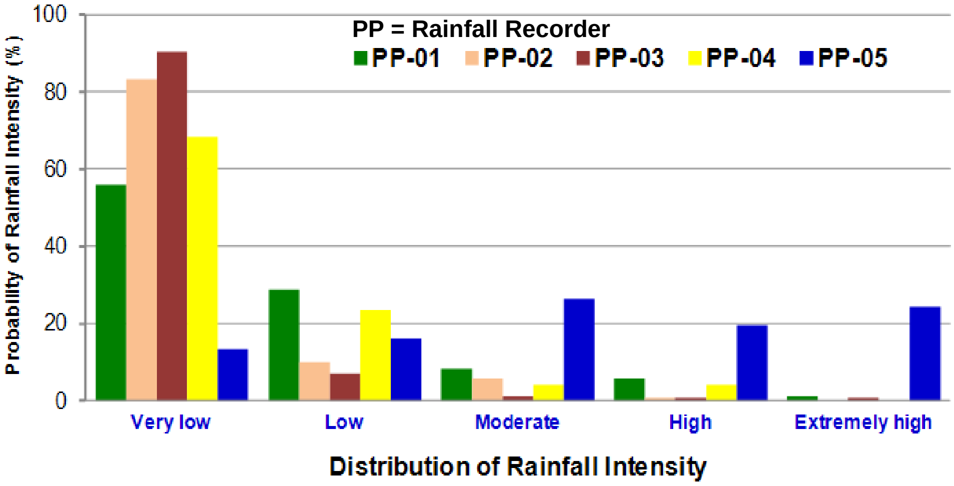

Figure 6. Distrution of monthly avarage rainfall intensity per-day occurences

Most of the possibilty of rainfall intensity are at very Low and Low prices. Decree of Minister of Agriculture No. 837/Kpts/Um/11/1980 stipulates that rainfall intensity is divided into Very Low (<13.6 mm/HH), Low (13.6 - 20.7 mm/HH), Medium (20.7 - 27.7 mm/HH, High (27.7 - 34.8 mm/ HH), and Very High (> 34.8 mm/HH) , and then multiplied by the value of the scales according to the relative magnitude of the impact of the erosion event. The proportional scale value of rain intensity is 10 (ten). Given that the dynamics of rain and rainfall days of the year can not always be accurately predicted, the determination of rainfall intensity score is calculated by counting all of rainfall occurrences. Weighted score of rainfall intensity possibility for each location was multiplied by the scale of the rainfall intensity for each class (Very Low, Low, Medium, High, Very High) is 6.2, 3.3, 2.4, 2.8 , and 3.5 respectively. Thus, the total rainfall intensity score for the entire study area is 18.1.

The process of overlapping was done on each classified data except the rainfall intensity, in the form of slope and land cover maps of which each class get a weighting value. Land slope was divided into five classes of slopes (0-8%, 8-15%, 15-25%, 25-40% and >40%) superimposing to the soil type associations present in the PT PBA concession ie associations of Ultisols - Inceptisols, Inceptisols - Ultisols - Oxisols, Inceptisols - Entisols, and Inceptisols - Ultisols - Molisols. The superimposing process produced unique land units as a combination of the above three factors. These land units ware then given a new score to deteremine appropriate forest functions. In overall the superimposing process of the three data produced 261 units of land units (figure 7).

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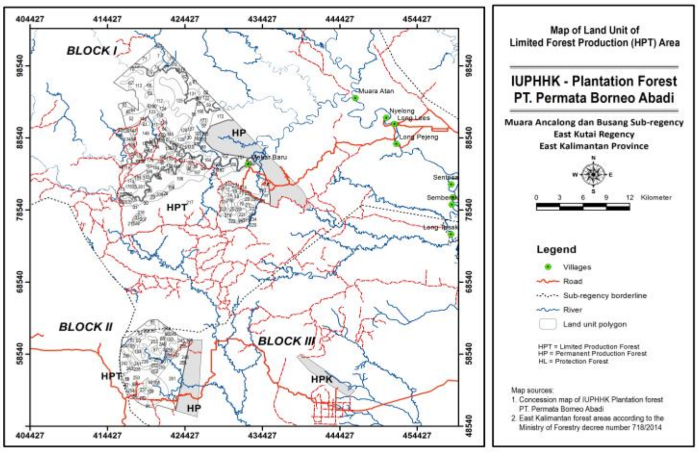

Figure 7. Land units distribution based on landslope, soil type and rainfall intensities

Each land unit has a unique identity and scores of three environmental used data. Referring to Minister of Forestry regulation No. P.34/Menhut-II/2010 on Forest Area Function Change Procedures, the function HP was determined with score below 125 while the score between 125-174 become HPT function. Score quantities greater than or equal to 175 were designated as protected forest areas. For this forest function assessment, table 4 displays the data attributes each score of land 261 land units generated from the analysis of superimpose based on standard values of forest functions regulated in Minister of Forestry regulation No. P.34/Menhut-II/2010 on the procedures for change forest function. An area of 70.53% or approximately 28,753.30 ha of total HPT area in PT PBA concession could be converted into HP. Further, n area of 840.18 ha (2.06%) should be a protected area because it has a very steep slope (>40%), and the remainder is reserved for HPT function (Figure 8).

Table 4. Forest function based on re-scoring results for effective and efficient forest management

Total score criteria	Forest function based on MoF decree P.34/Menhut-II/2010	Area	
		(Ha)	(%)
<125	Permanent Production Forest (HP)	27.637,80	67,80
125-174	Limited Production Fortest (HPT)	12.287,77	30,14
≥175	Protection Forest	840,18	2,06
	Total	40.765,75	100,00

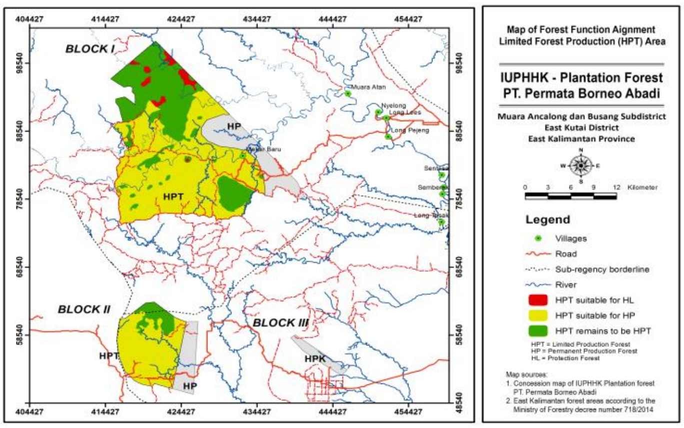

Figure 8. Map of forest function for effective and efficient forest management

Reassessment of forest function provides important direction for the function of forest areas but still need to be harmonized for the benefit of effective, efficient and compact forest management. The result of reassessment shows significant changing of forest function. From earlier designationof IUPPHHK-HT function covering 49,000 ha, the area of HPT would decrease enough from 40,765,75 ha to 12,287.77 ha. Conversely, the area of permanent production forest (HP) would increase from 7,336.25 ha to 34,974.05 ha. Consequently, HP's previously small areas would be dominant i.e. 71.37% of the total area of the previous designation forest function.

4. Conclusion

In conclusion, the area of HPT in the PT PBA concession is a region with a slope of > 40% (840.18 Ha) must therefore serve as a protected area. The area of HPT which scores between 125-174 and therefore remains HPT is 12.287,77 Ha. The HPT area that scored a new <125 score is 27,637.80 Ha and therefore allows to be converted to HP. Based on these conclusions, PT PBA may use the results of this study as the basis for full forest management in its concessions including conservation efforts while referring the laws and regulations governing the designation of protected areas and conservation.

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