Evaluation of Annual Allowable Cut (AAC) Determination of Teak Forest Plantations in Perum Perhutani, Indonesia

Rohman[1]*, Sofyan P. Warsito[1], Nunuk Supriyatno[1], Ris Hadi Purwanto[1], Catur Atmaji[2]

[1]Faculty of Forestry, Gadjah Mada University, Bulaksumur, Yogyakarta, Indonesia 55281
[2]Faculty of Mathematics and Natural Sciences, Gadjah Mada University, Bulaksumur, Yogyakarta, Indonesia 55281

Abstract

The degradation of teak forest plantations in Java that are managed by Perum Perhutani (PP) continues to happen, and this is caused by some risk factors such as illegal logging, grazing, forest fire, and encroachment. However, these risk factors have not been considered by PP notably in annual allowable cut (AAC) determination of yield regulation. Therefore, the AAC value could be overestimated. The research was aimed at evaluating the method of AAC determination and proposing an alternative method that considers the risk factors. This research was conducted with a series of data analysis approach from the data on five planning periods. The research result showed that forest damage occurs in varied situations. On average, the rate of deforestation accounted for 0.8% per annum. The calculation of AAC by considering the rate of damage risk in normal condition approximately made up 70.8%. Thus, compared to another method without considering damage risk rate, overestimation constituted 29.2%. In brief, this had an impact on the decline of timber stock.

Keywords: teak forest plantation, Perum Perhutani, casualty per cent, AAC

*Correspondence author, email: rohman_fkt@ugm.ac.id, tel.: +62-813-28122428

Introduction

The conception of the fully regulated forest, in the classical timber management, scheduling addressed the questions of how many areas and how much volume to cut. Over the years of forest history, several methods for determining the cut were developed in various parts of the world (Davis *et al*. 2001). These methods are formulated to achieve a harvest schedule that exhibits nondeclining yield or below long-term sustained yield capacity. Sustained yield in this context dealt with achieving a permanence of timber resources through limiting harvesting to a level that could be maintained over time.

Luckert and Williamson (2005) explain that sustained yield principles are not essential. Deten (2011) states that it is not possible for forest planning experts to adequately integrate the manifold and intangible relevant factors from nature (e.g. climate and its change, natural hazards, changing site factors) and society (e.g. global market development, social changes, rearrangements of the political environment) into forest management plans which sustainably shape forests. van Gardingen *et al*. (2006) recognizes that yield regulation should be adaptable to the different contexts (social, ecological, environmental, and economic) and the variety of objectives for forest management. However, Elbakidze *et al*. (2013) state that the concept of sustained yield in forestry only could disappear as a separate concept, and sustainable wood production will be just one criterion to be considered in Sustained Forest Management along with other criteria.

Regulation of the yield requires (a) a calculation of the amount of the yield should be, (b) an apportionment of that yield to thinnings and final fellings, and (c) the construction of a cutting plan which determines the identity of stands to be felled or thinned and the time of their felling or thinning (Recknagel 1917; Osmaston 1968). Seydack *et al*. (1995) add that forest sustainable regulation ensures how to determine the optimal residual growing stock. Warsito (2010) mentions that the activity of harvesting has the biggest impact on forest stand sustainability, so the forest management should be planned from harvesting regulation.

Teak forest in Java-Indonesia has been managed for more than 12 centuries, starting from the era of the Javanese Kingdoms, during the era of Dutch colonial, and until the present time under the management of Perum Perhutani (PP, a state-owned forest entreprise) (Simon 2010). Almost 61% of state forest areas in Java have been established as production forests (MoF 2008), approximately 60% of which are managed as teak plantations (Perhutani 2011).

Since the 60s, teak forests in Java that are managed by PP have been experiencing a stand quality decline (Simon 2001) due to the various of forest disturbances (i.e. illegal logging, forest fire, grazing, fuelwood collection, and encroachment). Forest disturbances, which accelerated during the period of economic crisis (1998−1999), have caused severe destruction that has drastically changed the age structure of teak plantations (Tiryana *et al*. 2011). In the last two decades, the forest area depletion characterized by the forest stand structure which is dominated by young stands (1−20

years), bare land, and other types of unproductive land. In 2011, the young stand of teak forests area accounted for 452,000 ha or 80% of the productive forests area (Perhutani 2011). A high rate of unplanned harvesting, especially to the remaining stands in illegal-logging areas brought unbalanced distribution of the teak growing stock and it gives a bad sign for unsustainable harvest in the future (Ichwandi *et al*. 2009). Although the effect of forest disturbances on teak plantation is obvious, the potential risk of stand destruction is still ignored in the current forest management planning, especially when PP determines the annual allowable cut (AAC) (Tiryana *et al*. 2011).

The risk of the forest damage must be integrated in long-term forest management. Integrating risk into long-term forest management means applying the entire risk management process to decisions made (Hanewinkel *et al*. 2011). Modeling the risk of forest damage has done to damage caused by natural hazards, for damage caused by illegal logging is relatively rare. Modeling of forest destruction (mainly due to illegal logging) in teak plantations have been done with survival analysis approach (Tiryana *et al*. 2011), but it has not been used for the determination of AAC. Another risk consideration focus on how to reduce the volume of harvested timber based on predicted risk (Leech 2002).

Currently, AAC in PP is determined by using Burn method, which estimates the growing stock volume at average cutting time (ACT) (Soeranggajiwa 1978). ACT is the time indicating a combination of weighted average age, determined based on forest inventory, and half of the rotation period. The method is regulated in the Director-General of Forestry Decree Number 143/KPTS/DJ/1974 (Ministry of Agriculture 1974), known as '74 Instruction. The regulation has been revised by the Ministry of Forestry Regulation Number P.60/Menhut-II/2011, but the determination of AAC remains using the same method as before (Perhutani 2013).

One outcome of forest inventory is the structure of age classes which describes the actual standing stock. Teak forest age classes in the PP has a 10-year interval, for example, age class I (AC_I) consists of stand aged between 1−10 years old, age class II (AC_{II}) aged 11−20 years old, and so on. A forest consisting of AC_I with an area L_I and the weighted average age of the U_I, AC_{II} with an area L_{II} and the weighted average age of U_{II}, and so on until the AC_n with an area L_n and the average age of the U_n, managed with rotation of R years, will have an ACT as explained in Equation *[1]*.

$$ACT = \frac{\sum_{i=I}^{n} Li.Ui}{\sum_{i=I}^{n} Li} + \frac{1}{2}R \qquad [1]$$

Estimation of the growing stock for AAC determination is calculated at the ACT (*not the actual age*) by using the Wolff von Wulfing (WvW) yield table of teak stands (Departemen Pertanian 1974). The estimated volume of AC_I calculated by the formula, $V_I = L_I \times V_{ACT}$, $V_{II} = L_{II} \times V_{ACT}$, and so on up to $V_n = L_n \times V_{ACT}$. V_{ACT}. V_{ACT} is the volume on the WvW table at the age of ACT multiplied by basal area density index (BDI). BDI is defined as a ratio between the current basal area (from the forest inventory) and the normal basal area (from the WvW table). The total volume of all the forest area is calculated by Equation *[2]* and the AAC determined by the Equation *[3]*.

$$Vtot = \sum_{i=I}^{n} Vi \qquad [2]$$

$$AAC = \frac{Vtot}{R} \qquad [3]$$

This approach is assumed that all stands are determined in the future (ACT) and the planner assumes there will be no risk or stand failure damaging the stand up to ACT or the rotation age. Hardjosoediro (1974) stated that the estimated volume at the end of the final cutting could be illustrated as an "imagined value". For instance, a stand aged 5 years old and will be cut at age 50 years old, will grow up for 45 years without any reducing areas. In fact, the forest stands are dynamic and most of them are vulnerable due to the various of disturbances (Rohman 2008).

To deal with this weakness, in 1865 Brandis considered the dynamic risk by implementing his method in natural teak forests in Pegu, Burma (Osmaston 1968). Since 1856, teak forests management in Burma adopted a selective cutting system known as Myanmar Selection System (MSS) (Mon *et al*. 2012). The method requires a knowledge of three attributes of the growing stock, one of this is the casualty per cent (CPC) of each size-class. CPC is defined as the percentage of the stand number of each class that fails to reach the diameter of exploitable size (Osmaston 1968). According to this method, trees with small diameters are exemplified as having a CPC of 75%, so that only 25% of the trees would be able to reach the exploitable size.

The CPC is effectively used for the belief that not all of trees would be able to reach the exploitable size. This also happens in the teak plantations of PP that not all of the young stands can reach the age of final cutting. The research was aimed at evaluating the method of AAC determination and proposing the CPC as an alternative method that considers the risk factors.

Methods

This research was conducted in PP which manages almost all of the state forests (production forests and protected forests) in Java. The total of PP working area covers an area of approximately 2.4 million hectares which divided into 3 division, namely Central Java division (630,719 ha), East Java Division (1,136,479 ha), and West Java and Banten Division (659,007 ha) (Perhutani 2011). Each division is divided into Forest Management Unit (FMU) as the unit of management at site level. Central Java Disvision is a region of the earliest established the FMU, which began in 1898 (Simon 2010). Central Java Division divided into 20 FMU and as many as 14 FMU is managed with the main products of teak wood. Randublatung FMU is one of the FMU that produce teak which well-managed. This is indicated by obtaining a certificate of Sustainable Forest Management (SFM) with Forest Stewardship Council (FSC) standards in 2012.

The total area of Randublatung FMU is 32,464.1 ha, divided into 6 planning units called *Bagian Hutan* (BH) such

as BH Randublatung (5,110.1 ha), BH Doplang (5,801.5 ha), BH Bekutuk (4,818.5 ha), BH Ngliron (6,235.8 ha), BH Banyuurip (5,044,3 ha), and BH Banglean (4,889.0 ha). All of the forest areas in Randublatung FMU are managed for teak production. The AAC determination in PP was conducted in each BH, therefore, the research data was analyzed in every BH. The attached example of analysis process was from BH Banyuurip, whereas for the other BH in Randublatung FMU, only the result was presented.

Data collection and processing   The material of this research is the data of the forest area over planning periods. The data were taken from the forest inventory data, which came from the periodic forest inventories (10-year measurement cycle). The forest inventory data contained reliable information on teak stands in each sub-compartment, e.g. the size of stands (in hectares), stand variables (e.g. top height, basal areal density index, age), and a brief description of stand conditions (e.g. classification into productive or unproductive stands). The data used by PP to develop a 10-year working plan for teak plantations. The data over five planning periods comprising 1973−1982, 1983−1992, 1993−2002, 2003−2012, and 2013−2022 were used in this research. The data were analysed by the following steps:

1   Calculating the forest damage from age of t and $t+10$ years ($1 < t < 60$) for cycle of 60 years. This was analysed by implementing Equation [4] (Tiryana et al. 2011) :

$$d_i = r_{it}\, c_{(i+1)} \qquad [4]$$

where d_i is damaged stands between age t to $t+10$ years or demaged stands of (AC_i) in ha, r_{it} represents forest stand area at the age of i on t years, t is the beginning year of a planning period (for instance 1973−1983), and $c_{(i+1)}$ represent surviving stand (area of $AC_{(i+1)}$ at the year of $t+10$).

2   Calculating the percentage of forest damage rate (x_i) of AC_i to the area in the beginning of planning period. There

were two periods analysed, i.e. the period without the massive illegal logging (1973−1992) and the period of 1993−2012 with the massive illegal logging cases.

3   Calculating the CPC of the AC_i in order to reach the rotation age based on the forest damage rate in each age class. In brief,   if the damage rate of AC_i to $AC_{(i+1)}$ (expressed in $x_i\%$), the CPC $(Y\%)$ from AC_i to AC_n can be predicted with Equation [5] :

$$Y_{i\%} = 1 - \prod_{i=i}^{n+1}(1 - X_i\%) \qquad [5]$$

where n is AC_{VII} (rotation of 60 years).

4   Calculating AAC determination by involving the CPC value from point 3. In short, if there is AC_i with area of A_i ha, then the forest area that could be used in AAC determination $(A_i^{'})$ is:

$$A_i^{'} = A_i - A_i \cdot Y_i\% \qquad [6]$$

Results and Discussion

The dinamic of productive forest area The productive forest area in this paper has been explained by PP terminology (Ministry of Agriculture 1974) for AAC determination such as maturity (masak tebang or MT), low increment (miskin riap or MR), and age-class (AC). The definitions of those stand classes are based on the age as well as the basal area density index (BDI). AC_1 is a group of forests stand of 1−10 years old with BDI of ≥ 0.6. The width of the productive forest areas in Randublatung FMU undergo changes due to the increase of age. Overall, the productive forest area from period t to period $t+1$ undergoes a decreasing trend as shown in Table 1.

As mentioned above, in this paper the calculation process just described for BH Banyuurip.   The dynamic   of productive forest area in BH Banyuurip are presented in Table 2. As in FMU level, BH Banyuurip also experienced the productive forest area decline from one period to another

Table 1 The productive forest area in Randublatung FMU during 5 planning periods

Stand-age classes	Productive forest area at the begining of planning period (ha)				
	1973−1982	1983−1992	1993−2002	2003−2012	2013−2022
- AC_I	5,269	4,412	3,962	7,369	9,352
- AC_{II}	5,197	5,038	4,452	3,611	4,247
- AC_{III}	2,846	4,867	4,484	2,458	2,736
- AC_{IV}	2,776	2,732	4,611	1,983	1,724
- AC_V	3,280	2,141	2,353	2,162	1,043
- AC_{VI}	2,371	2,985	2,071	956	1,635
- AC_{VII}	1,972	2,152	2,697	1,181	796
- AC_{VIII}	915	1,736	1,893	1,189	663
- AC_{IX}	478	827	424	186	-
- AC_X	14	386	-	17	-
- AC_{XI}	44	-	-	-	-
- MT	-	604	301	7	51
- MR	4,848	1,763	1,410	1,061	640
Total	30,010	29,641	28,658	22,179	22,887

period. For instance, the area of AC_I at the beginning of the planning period of 1973−1982 with 702.9 ha had been decreased to 666.8 ha at the beginning of the planning period of 1983−1992, and change to 537.0 ha at the beginning of the planning period of 1993−2002.

The rate of forest damage The rate of forest damage depicted the alteration from productive forest areas to unproductive forest areas during certain periods. Based on periodic forest inventory data (see Table 2), there are some stand-age classes which have area increase compared to the previous period. In the AC_I for period of 1983−1992 has significant rise from 629.1 ha to 672.2 ha in the next period. This was due to the unproductive forest areas had been changed to the productive forest areas with in 10 years. However, these cases should be ignored, then the areas were considered have the same width as the previous period. Similarly, the depletion in productive forest area over of AC_{VII} does not count as damage because the rotation of Randublatung FMU is 60 years, so that the depletion of productive forest area is likely to be caused by logging activities of PP. Unfortunately, comprehensive historical data on forest disturbances are not available, making it difficult to quantify and compare the amount and intensity of its disturbance agent (i.e. illegal logging, forest fire, grazing, fuelwood collection, and encroachment) for each period. However, for teak forests, generally the agent of disturbance for AC_I are forest fire, grazing, and encroachment, while for another AC mostly caused by illegal logging.

By implementing Equation *[4]* and calculating in step (2), the rate of forest damage can be seen in Table 3. On average, the rate of forest damage in the period of 1973−1992 could not show a certain pattern. In general, the average of damage rate in BH Banyuurip in the period of 1973−1992 accounted for 10.7% annually. The highest damage rate in the period was in AC_{IV} which made up 30.4%. Further, in the period of 1993−2012, when the illegal logging massively occurred, the forest damage experienced a significant increase in every AC with an average rate of 2.1% per annum.

In the FMU level, the damage rate for the period of 1973−1992 constituted 8.2% in average per period or 0.8% per year, as well as in the period of 1993−2012 the trend had increased approximately 3.7% per year. By comparing it to Kebonharjo FMU (Tiryana *et al.* 2011), the damage rate

Table 2 The productive forest area in BH Banyuurip during 5 planning periods

Stand-age classes	Productive forest area at the beginning of planning period (ha)				
	1973−1982	1983−1992	1993−2002	2003−2012	2013−2022
AC_I	702.9	629.1	836.7	854.6	1,078.0
AC_{II}	821.8	666.8	672.2	763.2	585.1
AC_{III}	578.9	712.9	537.0	485.7	577.7
AC_{IV}	360.5	582.0	849.0	408.1	387.3
AC_V	571.0	227.4	441.0	631.7	287.0
AC_{VI}	283.0	526.4	289.9	217.9	562.8
AC_{VII}	656.0	261.5	452.0	184.5	216.3
AC_{VIII}	157.1	383.6	208.6	322.7	85.2
AC_{IX}	-	97.3	22.2	-	-
MT	-	-	80.4	-	1.2
MR	496.3	572.4	260.3	103.6	77.3
Total	4,627.5	4,659.3	4,649.3	3,972.0	3,857.9

Table 3 The rate of forest damage in each period of BH Banyuurip

AC_i to $AC_{(i+1)}$	Forest damage rate in BH Banyuurip per period (%)					
	1973−1982	1983−1992	1993−2002	2003−2012	Average 73−92	Average 93−12
AC_{I-II}	5.1	-	8.8	31.5	2.6	20.2
AC_{II-III}	13.3	19.5	22.8	24.3	16.4	23.6
AC_{III-IV}	-	-	24.0	20.3	-	22.1
AC_{IV-V}	36.9	23.8	11.4	29.7	30.4	20.5
AC_{V-VI}	7.8	-	50.6	10.9	3.9	30.7
AC_{VI-VII}	7.6	14.1	18.9	0.7	10.9	9.8
Average	11.8	9.6	22.7	19.6	10.7	21.2

accounted for 2% for the period before the massive illegal logging cases and rose to 3.5% per year after the massive illegal logging cases. Those showed that the damage rates in both Randublatung FMU and Kebonharjo FMU were similar. FMU of Kebonharjo is an example of FMU in Central Java Division has obtained the certificate of SFM as Randublatung FMU. It shows that the forest damage has occurred in FMU which had been well-managed. Those rates were still above the maximum damage rate decided by PP for Randublatung FMU which made up 1% for improved condition (the same condition as the condition before the massive illegal logging cases) and 1.75% for pessimistic condition (Perhutani 2009).

The risk of forest damage over the cycle Based on the rate of forest damage as depicted in Table 4, by implementing Equation *[5]* the CPC could be obtained as is showed in Table 5. In 1973−1992, the CPC of AC_I accounted for 51.4%. The value showed that the productive forest area in AC_I was predicted to be damaged at 51.4% to reach the age of final cutting. AC_I has the greatest value of the CPC as an accumulation of damage from the AC_I, AC_{II}, and so on until the rotation age.

By implementing the similar procedure, there would be a CPC value for all BH in Randublatung FMU as mentioned in Table 6 for the periods of 1973−1992 (A) and 1993−2013 (B). The varied value of CPC showed the differences of the

rate of forest damage in each BH. As showen in Table 6, the risk of forest damage in Randublatung FMU underwent significant changes before and after the massive illegal logging cases. Before the event of the cases, BH Randublatung had the smallest damage rate, then increase a sharply after the case occured. Generally, BH Banglean and BH Banyuurip haved low damage rate, while BH Doplang underwent the most serious damage both before and after the cases.

Overall, when the condition improved as before the massive illegal logging, the CPC in AC_I accounted for 46.4% which mean 53.6% of AC_I was predicted to survive until the age of final cutting. This result had the same value as that of the survival analysis approach (Tiryana *et al*. 2011) for Kebonharjo FMU which mentioned that the survival probability before 1997 (before the massive illegal logging cases) made up 55% for cycle of 60 years. On the other hand, if the damaged condition continued to happen as in the condition in the 1993−2013, there would be only about 11.5% of AC_I that was predicted to survive until the end of rotation. The better condition as targeted by PP was that with only 1% of forest damage on average per year, it would result in a CPC as well as that was more or less like the condition before the period of 1993−2002.

AAC determination using the casualty per cent The CPC is used for area width correction in AAC calculation in PP.

Table 4 Forest damage rates in each period in Randublatung FMU

AC_i to $AC_{(i+1)}$	Forest damage rate in each period (%)					
	1973−1982	1983−1992	1993−2002	2003−2012	Average 73−92	Average 93−12
AC_{I-II}	4.4	0.0	8.9	42.4	2.2	25.6
AC_{II-III}	6.4	11.0	44.3	24.2	8.7	34.3
AC_{III-IV}	4.0	5.3	55.8	29.9	4.6	42.8
AC_{IV-V}	22.9	13.9	53.1	47.4	18.4	50.3
AC_{V-VI}	9.0	3.2	59.4	24.4	6.1	41.9
AC_{VI-VII}	9.2	9.6	43.0	16.8	9.4	29.9
Average	9.3	7.2	44.1	30.8	8.2	37.5

Table 5 The Casualty Per Cent of each age-class in BH Banyuurip

The rate of forest damage from AC_i to $AC_{(i+1)}$ (%)			Casualty per cent AC_i to AC_{VII} (cycle of 60 years)(%)		
AC_i to $AC_{(i+1)}$	Average 73−92	Average 93−12	AC_i to AC_{VII}	Average 73−92	Average 93−12
AC_{I-II}	2.2	25.6	AC_{I-VII}	51.4	76.4
AC_{II-III}	8.7	34.3	AC_{II-VII}	50.1	70.4
AC_{III-IV}	4.6	42.8	$AC_{III-VII}$	40.4	61.3
AC_{IV-V}	18.4	50.3	AC_{IV-VII}	40.4	50.4
AC_{V-VI}	6.1	41.9	AC_{V-VII}	14.4	37.5
AC_{VI-VII}	9.4	29.9	AC_{VI-VII}	10.9	9.8

Note: The calculation of the CPC to the AC_{VII} as a limit that the stand can be harvested when it is fulfilled 60 years.

Table 6 The casualty per cent of each BH in Randublatung FMU

$AC i$ to AC_{VII}	Casualty per cent ACi to AC_{VII} (cycle of 60 years) per BH (%)													
	Banyuurip		Randublatung		Ngliron		Doplang		Bekutuk		Banglean		FMU	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
AC_{I-VII}	51.4	76.4	23.4	99.6	42.2	92.4	76.3	99.7	38.7	97.2	40.5	76.8	46.4	88.5
AC_{II-VII}	50.1	70.4	22.2	99.5	39.5	91.1	73.7	99.5	38.5	96.1	40.5	70.6	44.6	86.1
$AC_{III-VII}$	40.4	61.3	14.6	99.0	34.1	87.8	69.2	98.8	35.6	94.5	40.2	63.3	39.7	82.4
AC_{IV-VII}	40.4	50.4	14.4	98.2	29.6	81.3	55.4	94.3	33.2	89.5	38.4	45.5	35.0	75.2
AC_{V-VII}	14.4	37.5	6.6	94.5	20.3	59.6	35.7	79.7	20.1	67.7	22.3	22.8	20.6	58.4
AC_{VI-VII}	10.9	9.8	6.6	80.6	1.7	25.9	28.1	60.4	14.6	31.9	9.7	4.3	11.9	35.2

Note: A = average of period 1973−1992. B = average of period 1993−2012

Table 7 The AAC determination by considering casualty per cent in BH Banyuurip

AC	'74 Instruction **			Casualty per cent	
	Initial of areas (ha)	Volume at ACT (m³)	Casualty per cent	Corrected areas (ha)	Volume at the rotation age (m³)
1	2	3	4	5	6
MR	104	6,630	0%	104	6,630
AC_{VIII}	323	47,760	0%	323	47,760
AC_{VII}	185	25,830	0%	185	25,830
AC_{VI}	218	23,751	10.9%	194	21,162
AC_{V}	632	72,014	14.4%	541	61,644
AC_{IV}	408	59,583	40.4%	243	35,511
AC_{III}	486	57,313	40.4%	289	34,159
AC_{II}	763	94,637	50.1%	381	47,224
AC_{I}	855	107,680	51.4%	415	52,332
Total	3.972	495,198		2,675	332,253
AAC	66.2 ha yr^{-1}	8,253 m³ yr^{-1}		44.6 ha yr^{-1}	5.538 m³ yr^{-1}

** Source: Working Plan of Randublatung FMU, planning period of 2003−2012

The '74 Instruction assumed that all of timber stands as the result of forest inventory would survive until the age of final cutting. The CPC evaluated this area with different perception. Thus, there were some part of the productive forest areas that would be decreased until the age of final cutting. Table 7 shows the comparison of the results of '74 instruction calculation and the CPC method.

AAC value by considering CPC in BH Banyuurip accounted for 5,538 m³/year or 67% of ACC without CPC which made up 8,253 m³ year^{-1}. It could be assumed that there was overestimation of 33% caused by forest damage. However, if the AAC of 8,253 m³ year^{-1} or 82,530 m³ for 10 years should be applied, then on the first 10 years the class MR, AC_{VIII}, AC_{VII}, and a half of AC_{IV} could be harvested (see column 3 in Table 7). In the next 10 years, only a half of AC_{VI} could be harvested. Thus, there would be a chance to harvest below the cycle or the standard of cycle should be

downgraded. Overall, in Randublatung FMU, with the optimistic condition, the result of AAC determination with CPC was 70.8% when compared to '74 instruction. The more detailed results of the AAC in each BH are depicted in Table 8.

In many cases, teak forests in Java experience many risks that damage their stand attributes even though the forest areas are in secure condition (less conflict). The damage of forest due to the various disturbances in Randublatung FMU, for example, on average is 0.8% per year, in Purwodadi FMU is 2% per year (Rohman 2008), and in Kebonharjo FMU is 2% per year (Tiryana et al. 2011). PP also recognizes this by setting the number of damage about 1% per year for such conditions before the massive illegal logging case (Perhutani 2009). Although this risk continues to occur and degrades the stand quality and productive areas, the planner has never considered this risk in determining AAC. Revised

Table 8 The comparison of AAC of Instruction '74 and AAC of casualty per cent

BH	AAC					
	'74 Instruction **		Casualty per cent		The comparison (%)	
	Area (ha yr^{-1})	Volume (m^3 yr^{-1})	Area (ha yr^{-1})	Volume (m^3 yr^{-1})	(4:2)	(5:3)
1	2	3	4	5	6	7
Banyuurip	66.20	8,253	44.58	5,538	67.3	66.4
Randublatung	63.03	6,282	50.96	5,203	80.9	82.8
Ngliron	73.43	10,143	53.23	7,558	72.5	74.5
Doplang	52.74	4,475	21.58	1,980	40.9	44.2
Bekutuk	54.50	6,810	38.40	4,793	70.5	70.4
Banglean	59.76	8,645	44.90	6,578	75.1	76.1
Total FMU	369.66	44,691	253.65	31,650	68.6	70.8

** Source: Working Plan of Randublatung FMU, Planning Period of 2003−2012

'74 Instruction with Regulation Number P.60 in 2011 and Regulation No P.01/VI-BUHT/2012 does not change the method of AAC determination (Perhutani 2013).

The increase in population led to increasing pressure on forests and the pressure of population is likely a major driver of forest degradation (Widiaryanto 2012). During this time, various efforts to control forest damage has been done by PP with various programs of social approaches, but it does not achieve the results as expected (Setiahadi 2012). Thus the risk of forest damage is a necessity to be integrated in forest planning including the determination of the AAC.

The overestimates of AAC determination by 29% can be interpreted that the PP planned to harvest by 29% exceeding its increment. That is not true because the increment of 29% is to swap loss due to the forest destruction. At short impact, the CPC method may reduce the AAC. In the case of Randublatung FMU, the AAC determined using the CPC method results in approximately 29% smaller than the Burn method. It will impact on the company's revenue from the sale of timber, which currently contributes 55% to Perhutani's revenue from domestic sales (Perhutani 2011). However, in the longer time, the inclusion of this method will improve the standing stock of forest, and regulate yield more sustainably.

To implement the method of determining the AAC that considers the risk of forest damage with CPC approach, it is likely that PP could revise the Regulation of Director General of Forestry Utilization Number P.01/VI-BUHT/2012 on Technical Guidelines for Preparation of Working Plan of PP especially on AAC Determination chapter. Such changes must be followed by the preparation of software of the data processing system that has been made based on the '74 Instruction.

Conclusion

Teak plantations owned by PP, in various situations-including in secure condition, would have the risk of forest damage which could lead to the unproductive condition. The conventional AAC determination in PP has not considered the risks. Those methods should be evaluated by considering the risk of forest damage, so the overestimated of AAC value could be avoided. The rate of teak forest damage in PP with secure condition in the period of 1973−1992 accounted for approximately 0.8% per annum while after the period of 1993 it tended to rise up to 3.7% per annum. In an improved condition scenario, the result of AAC determination by considering the casualty per cent made up 70.8% compared to the result witout a casualty per cent. It could be said that there would be a overestimated condition of 29.2%. In brief, the overestimated value had an impact on the growing stock decline.

Acknowledgments

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