TPTI Implementation by Inhutani I, Labanan: Options for Improving Sustainable Forest Management.

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Executive Summary

This report summarises the findings of the Silvicultural Consultant to the EU Berau Forest Management Project (BFMP) during activities based at the Labanan concession of PT Inhutani I, Kalimantan Timor, during November and December 1998. The consultant was required to report and make recommendations on:

- Silvicultural prescriptions and research requirements for the 1999-2000 annual work plan.
- Review the existing TPTI regulations as implemented by PT Inhutani I at Labanan.
- Review plans for training and trials for thinning treatments to be implemented from December 1998.
- Review options for the application of inventory and permanent sample plot data for yield regulation.

The report reviews each of the activities specified in the TPTI regulations, discussing how they are applied by Inhutani, and makes recommendations for monitoring by BFMP or Inhutani staff.

The recommendations in the report identify:
(1) Possible improvements to current working practice that are consistent with existing TPTI regulations;
(2) Suggested modifications to the TPTI regulations to improve sustainable forest management;
(3) A framework for a new silvicultural system suggested as an alternative to TPTI.

The review of TPTI implementation by Inhutani suggests that the following activities would benefit from additional research and development:

- ITSP, pre-logging inventory.
- Harvesting (logging) activities.
- Post-logging assessment (proposed new activity).
- ITT, post-logging inventory.
- Planting and rehabilitation.
- Liberation treatments.
- Thinning.

*ITSP (Section **3**)*
The pre-logging inventory needs to be promoted as a tool for the management of the forest estate to encourage improved data collection and processing. The ITSP needs to be linked to a topographic survey to unable the results to be used for planning of reduced impact logging. A prototype system implemented by BFMP and Inhutani in RKT 1998-99 has been a significant improvement on previous systems and has identified opportunities for further improvements. These include:

- Improved species identification by cruising teams
- Improved identification of "real" crop trees during the ITSP. This will require the production of specifications for crop trees by the production unit at Labanan.

*Harvesting activities (Section **5**).*
Harvesting should be considered to be the most important silvicultural treatment applied to the forest stand. Correct implementation of reduced impact logging techniques will lower cost, improve the regrowth of the forest and minimise environmental impacts associated with logging.

The principal activities for reduced impact logging have been identified as, planing, training and supervision or monitoring. The number of trees to be harvested should not exceed 8 stems ha^{-1}, but this limit is unlikely to affect production at Labanan, where current levels of extraction are almost half of this limit. Tree position and topographic maps from the ITSP should be used to plan skid-trials to be implemented in the field being initially cut by teams of labourers before logging commences.

Staff will require additional and ongoing training in implementation of RIL activities, specifically: planning and construction of skid trails, directional felling, extraction techniques and decommissioning of skid trails.

Improved supervision and monitoring in the field will be required to assess progress and achievements of objectives. A post-logging assessment of each petak should be carried out after logging has been completed. Successful implementation of RIL will require the development of an incentive system that would be linked to the post-logging assessment.

*Post logging assessment (Section **17.6**)*

A post-logging assessment is suggested as an important component of operational forest management assessing the performance of harvesting activities against the operational plan and a set of environmental standards.

An important indicator of reduced impact logging will be the assessment of the length, width and degree of soil disturbance associated with skid trails. Additional data should be collected to describe the quality of felling activities. Collection of data describing the outcomes of the logging operation will be enable the application of incentive systems for RIL activities.

*ITT Inventory of Residual Stand (post-logging inventory, Section **8**).*

It is suggested that the post-logging assessment could be combined with the improved ITSP to replace the requirement for the post-logging inventory (ITT).

*Planting and rehabilitation (Section **10**)*

Reduced impact logging techniques should significantly reduce the requirements for replanting and rehabilitation. Research is required to decide if enrichment planting is effective and to identify the best species for rehabilitation planting in open areas. Plans for trials to monitor the survival and growth of planted seedlings are discussed.

*Liberation treatments (Sections **7** & **12**)*

The review concluded that liberation treatments are likely to cause environmental damage through enhanced risk of erosion and loss of biodiversity. It is suggested that these activities should not be included in revised silvicultural specifications.

*Thinning (Section **13**)*

It is suggested that thinning should become an optional activity. Data from the STREK and Inhutani thinning trials should be analysed to quantify the benefits associated with thinning for the Labanan concession. Economic analysis of thinning suggests that it is difficult to justify when the costs are balanced against the projected yield increment when discounted over the length of the cutting cycle. The environmental impacts of thinning are also likely to be detrimental. These include loss of biodiversity, risk of erosion and poison leaching into the soil and ground water.

The plans for the training course in thinning at km 50 were discussed with Inhutani staff. A field visit to the proposed site found that this area had previously been very heavily logged and that the current forest structure was characterised by a open canopy and relatively few stems of commercial species. The site had steep topography that would make thinning difficult and it is likely that the site would be excluded from future logging because of the steep slopes. For these reasons, it was agreed that this location was not suitable. An alternative site at km 24 was also assessed. This site was logged as part of RKL 1 and is approximately 20 years after logging. The canopy was relatively closed and a higher proportion of commercial species make this site for suitable for a thinning treatment. It is suggested that the thinning training and trial should be implemented at km 24.

*Growth and Yield Prediction (Section **16**)*

It is suggested that PSP and inventory data should be used for statistical analysis and modelling to support management of the Labanan concession. The current BFMP inventory design was found to be inadequate for this activity, and alternative approaches are suggested.

*Research and Development (Section **17**)*
Research activities are suggested in support of the development of improved management procedures. These activities should be included into the 1999-2000 work programme.

*An Alternative Silvicultural System (Section **18**)*
The report concludes with an outline of one possible approach to the development of an alternative silvicultural system. The system emphases desired outcomes in terms of forest management objectives and environmental impact standards. This contrasts with the highly prescriptive activities in the TPTI system. The proposed framework provide technical guidelines on how the standards may be achieved.

1 Introduction

1.1.1 The TPTI (Tebang Pilih Tanam Indonesia) system or Indonesian Selective Cutting and Planting system is implemented through government regulations originally through the decree of the Directorate General of Forest Utilisation (Ditjen PH) through KPTS 564/KPTS/IV-BPHH/1989, and subsequently modified as number 151/KPTS/IV – BPHH/1993.

1.1.2 Technical aspects of the system are described in a technical annex or manual, *Pentunjuk Teknis Tebang Pilih Tanam Indonesia (TPTI) Pada Hutan Alam Daratan.*

1.1.3 The TPTI system is specified for a 35-year cutting cycle and the regulations list 12 activities that should be completed over a period from three years before harvesting through to the next cutting cycle. (Table 1).

1.1.4 The TPTI system is essentially prescriptive; that is, it specifies a sequence of activities that must be carried out by the forest managers. It has been criticised as being overly regulated and lacking in clear management targets or objectives. Most of the prescriptions do not include performance targets or objective measures that could be used to assess or improve forest management

	Aktivitas	Activity	Year
1	Penataan Area Kerja (PAK)	Working Area Organisation	Et-2
2	Inventarisasi Tegakan Sebulum Penebanan (ITSP)	Pre-logging inventory	Et-2
3	Pembukaan Wilayah Hutan	Infrastructure establishment	Et-1
4	Penebangan	Felling	Et
5	Perapilian	Re-establish petaks	Et+1
6	Inventarisasi Tegakan Tinggal (ITT)	Inventory of residual stand	Et+2
7	Pembebasan Tahap Pertama	First release treatment	Et+2
8	Pengadaan Bibit	Seedling procurement	Et+2
9	Pengayaan/Rehabilitasi	Planting and rehabilitation	Et+3
10	Pemeliharaan Tanaman Pengayaan/Rehabilitasi	Tending planted seedlings	Et+3,4,5
11	Pembebasan Tahap Kedua and Ketiga	Second and third release treatment	Et+4,6
12	Penjarangan Tegakan Tinggal	Thinning	Et+10,15,20

Table 1. Activities specified in the TPTI system (1993)

1.1.5 This report will review each of the activities specified for TPTI, discussing how they are applied by Inhutani, and make recommendations for monitoring by BFMP or Inhutani staff. The objective of this work will be to make recommendations for (1) improvements to current working practice that is consistent with existing TPTI regulations and (2) suggested modifications to the TPTI regulations.

2 Penataan Areal Kerja (PAK), Working Area Organisation (Et-3)

2.1 Overview

2.1.1 The working area organisation activity is designed to prepare an annual operating plan for an area of forest. The main components include the planning, marking and mapping of boundaries for the annual block and felling sub-blocks.

2.2 Implementation

2.2.1 Inhutani implements the working area organisation in preparation for their application for the annual operating plan. The work is carried out by their planning department.

2.3 Recommendations

2.3.1 There is no current need to modify these activities.

3 Inventarisasi Tegakan Sebelum Penebangan (ITSP), Pre-logging Inventory (Et-2)

3.1 Overview

3.1.1 The pre-logging inventory is a 100 % survey to identify the number and species of crop trees (commercial species above the cutting diameter limit), protected species and potential crop trees (pohon inti, commercial species of diameter 20 cm up to the cutting diameter limit). The inventory of crop trees aims to determine the annual production (annual allowable cut) for the felling block and is an important step for the concession to gain an annual operating permit or RKT. During the field survey, all crop trees should be marked with a red label, whilst potential crop trees and protected species should be marked with a yellow label.

3.1.2 The ITSP produces a summary table of the inventory results and a tree position map. The total volume of timber is multiplied by a factor of 0.56 representing safety and utilisation factors to obtain the annual allowable cut. The map is meant to be used in planning of logging and post-logging activities. The maps do not include topographic information.

3.2 Implementation

3.2.1 Inhutani implement their ITSP within existing regulations and their performance appears to be better than most logging concessions. The ITSP is conducted by the planning unit with the main objective of obtaining the annual operating plan or RKT. The tree position maps appear to be largely unused for planning or implementation of the logging operation. There is poor communication between the planning and logging units (Matikainen, Herika & Muntoko, 1998).

3.2.2 The following issues have been identified during field checks of the standard ITSP in Labanan.

- Poor species identification. This means that trees may be harvested even if they do not have a red tag, and that many tagged trees are not suitable.
- Tree positions and maps may be highly inaccurate.
- Lack of information about the quality of crop trees.
- Data and maps are not used for planning or implementation of logging activities.

Only around 30 % of the crop trees identified by the ITSP are actually harvested. This is considerably lower than the annual allowable cut calculated from the ITSP. Final selection of harvested trees is made by the chainsaw operator who usually does not use the ITSP results. Data from the 1997/98 RKT (Matikainen, Herika & Muntoko, 1998) showed that 28 % of the crop trees were harvested. Of the trees not selected, the main reason was small size (44 %) followed by defect (29 %), species identification (8 %) and topography (6 %). Of those trees not harvested, only 6 % should have been harvested. These results clearly illustrate the need to improve the selection of crop trees by the planning team during the ITSP.

3.2.3 BFMP and Inhutani intended to implement a combined ITSP and topographic survey for the entire 1999/2000 RKT (11 Petaks, approximately 1000 ha). Analysis of these data have illustrated major difficulties. This activity was completed early in the project and appears to have suffered from insufficient training, field supervision and feedback. The field teams did not realise the objectives of the activity and requirement for accurate data. This is illustrated by a misunderstanding that resulted in topographic information only being recorded in recording units (20*20m) if crop trees were present. The existing data cannot be used to produce combined topographic and tree position maps for the RKT, and these are required for planning

reduced impact logging activities for in the 1999/2000 RKT. Inhutani are committed to revising the surveys, a decision is needed on the extent of this activity.

3.2.4 The ITSP is perceived by most forest managers as a prescribed activity under the TPTI system that is required in order to obtain a permit to log (RKT). They do not consider the inventory to be a management tool, and for this reason, there is little effort to encourage data quality or accuracy.

3.3 RKT 98/99

3.3.1 The BFMP project implemented a topographic survey for two petaks (200 ha) for the 1998/99 RKT. This was designed to overlay the existing ITSP and was used for planning of reduced impact logging trials. The results were disappointing in that results from one Petak (43) could not be used for map production, as there was little correspondence between the ITSP and topographic survey. The maps produced for Petak 43 were adequate and used for planning of harvesting.

3.3.2 Data from the ITSP for petaks 43 and 44 have been used to examine how such data could be used to improve planning for harvesting. Previous studies have shown a very low level of correspondence between crops trees identified during the ITSP and those actually harvested. Inhutani harvest approximately 40 % of the total. The major reasons for this difference are:

- Diameters between 50 and 60 cm are often considered uneconomic to harvest.
- Many of the minor commercial species are not currently harvested.
- Poor species identification
- Defect or bad form of planned harvest trees.

3.3.3 A field survey was conducted by BFMP and Inhutani staff in an attempt to identify the "real" crop trees before logging. These trees were marked and recorded in the database. It is intended that this information will be compared against a record of the trees that were actually logged. This activity was made difficult by the lack of a definition of desirable characteristics for harvestable trees. The production unit of Inhutani I should now be assisted to produce such a specification for use in future ITSP surveys.

3.3.4 The ITSP only records data for commercial and protected species. A summary of the data for Petaks 43 and 44 is shown as Table 2. These results show a total basal area of 8.3 and 7.2 m^2 ha^{-1} for all trees with diameters exceeding 20 cm. For comparison STREK plot 4 in RKL4 (control treatment) has a total basal area of 25.3 m^2 ha^{-1} from 200 stems ha^{-1} exceeding the 20 cm diameter limit. The ITSP is thus probably only represents around 30 % of the total basal area of the stand, and as such should not be used to determine silvicultural treatments. In a previous study, it was also noted that there may be large discrepancies between data from the ITSP and more precise measurements on harvested trees (Matikainen, Herika & Muntoko, 1998).

Selection	Petak 43			Petak 44		
	Stems (ha^{-1})	BA (m^2 ha^{-1})	Vol. (m^3 ha^{-1})	Stems (ha^{-1})	BA (m^2 ha^{-1})	Vol. (m^3 ha^{-1})
All ITSP Data	38.1	8.3	103.5	32.1	7.2	92.8
Commercial > 50 cm	11.8	4.7	62.4	10.6	3.8	56.4
Meranti group > 50 cm	10.7	4.3	57.3	9.8	2.9	53.0
Meranti group > 60 cm	6.0	3.2	43.7	6.3	4.0	42.3

Table 2. Summary of data obtained from ITSP survey of petaks 43 and 44 in RKL 1998/99. Data are presented for the whole dataset, followed by a subset showing all commercial stems with DBH greater than 50 cm, and then the Meranti group only at diameters of 50 and 60 cm.

3.3.5 Analysis of the results from the improved ITSP suggests that field crews will need additional training in the implementation of the survey. This training should emphasise the importance of data quality. The quality of the data from petaks 43 and 44 in RKT 1998/99 should be further assessed by comparing trees that were actually logged against those identified as "real" crop trees during the ITSP.

3.4 Recommendations

3.4.1 The pre-logging inventory needs to be promoted as an important tool for management of the forest estate to encourage improved data collection and processing. This requires significant improvements in communication between planning and logging or production units within the concession. **(3.2.4)**

3.4.2 The techniques used for mapping of tree position and topography must be improved to provide information that is more accurate for planning of harvesting. **(3.2.2)**

3.4.3 The number of incorrectly labelled crop trees should be reduced through additional training in species identification for field cruising crews. **(3.2.2)**

3.4.4 The production unit of Inhutani I should produce a clear specification of the desirable characteristics of trees to be harvested to be used by the planning unit in the production of the ITSP. **(3.3.3)**

3.4.5 The pre-logging survey should record additional information describing the condition of crop trees. Those with bad form or other characteristics preventing logging should be identified allowing the identification of actual crop trees to be more accurate for planning of harvesting activities. **(3.3.3)**

3.4.6 Field crews will require training in all aspects of improved inventory implementation. This must be combined with improvements in field supervision and monitoring of data quality. **(3.3.5)**

3.4.7 Data should be collected describing the characteristics of the trees actually harvested in petaks 43 and 44 of RKT 1998/99. This information should be compared with data from the ITSP and the subsequent survey of "real" crop trees. **(3.3.5)**

4 Pembukaan Wilayah Hutan (PWH), Infrastructure Establishment (Et-1)

4.1 Overview

4.1.1 The establishment of infrastructure is meant to support the harvesting and subsequent activities for each annual working block. The work includes land surveying, mapping and construction of bridges, log yards and the main road network. The TPTI technical manual includes detailed information about standards of planning and construction. This is consistent with international concepts of best harvesting practice and reduced impact logging techniques (Dykstra & Heinrich, 1996; Sist, Dykstra & Fimbel, 1998).

4.2 Implementation

4.2.1 The road network constructed for the 1998/99 RKT would not meet international standards for good forestry practice. The roads have excessive grades that in most cases could have been avoided through better planning. There is evidence of excessive soil erosion and poor drainage.

4.3 Recommendations

4.3.1 Inhutani requires assistance to improve the planning and establishment of infrastructure such as their road network to meet Indonesian and international standards for good harvesting practice. **(4.2.1)**

5 Penebangan, Felling (Harvesting) (Et)

5.1 Overview

5.1.1 The harvesting guidelines for TPTI are consistent with good forestry practice in terms of both safety and environmental standards. The guidelines cover aspects including felling technique and direction, crosscutting and skidding. There is however little evidence that these guidelines are correctly implemented by most HPH in Indonesia.

5.1.2 One weakness of current guidelines is the absence of planning for reduced impact logging, in particular planned skid trails.

5.1.3 A second weakness is that the current regulations do not include any firm environmental standards that could be used to monitor the impact or success of harvesting.

5.1.4 Many silvicultural systems outside Indonesia stress the importance of correct harvesting technique as the most important silvicultural treatment that is applied to the stand. This concept has not yet been applied in Indonesia. TPTI, instead concentrates on post-logging activities to rehabilitate the stand and promote growth.

5.2 Implementation

5.2.1 Harvesting practice by Inhutani I in their Labanan concession compares favourably with most concessions in Indonesia, but their performance cannot be considered to meet standards for good harvesting practice. The distribution of felled trees is often patchy leading to very significant disturbance in areas of high crop tree density. Skid trails are not planned, and felling techniques are dangerous and inefficient leading to significant wastage in the forest. There is a high degree of disturbance to the soil and residual stand associated with the construction of skid trails, which are often of excessive width.

5.2.2 Field teams do not appear to use data or maps from the pre-logging ITSP during harvesting. The final selection of trees is made by chainsaw operators who often ignore the labels assigned during the inventory. There are a number of reasons for this. Chainsaw operators are often better at identifying crop tree species than the cruising teams. Hence, they may occasionally harvest trees marked as protected species that have been misidentified. A good example would be a Red Meranti that had incorrectly been identified as Tengkawan (a protected species). Incorrect diameter measurements during the ITSP, may mean that trees marked as Pohon Inti (dbh < 50 cm) may be suitable for harvest and felled by chainsaw operators. These problems illustrate the important of improving the quality of data collected during the ITSP.

5.2.3 A significant proportion of the trees marked as crop trees may be left (may exceed 70 %) for a variety of reasons. Data collected for compartment 17 (RKT 1998/98) shows why crop trees were left by chainsaw operators (Matikainen, Herika & Muntoko, 1998). The majority of trees (44 %) were left because of small size. This was mainly because trees between 50 and 50 cm DBH are currently considered to be of marginal commercial value, but a second reason would be if the ITSP diameter estimate was too large. Bad stem form or defect resulted in another 29 % of the stems rejected. Incorrect species identification accounted for 8 % and topography 6 %. Only 6 % of the trees rejected by the chainsaw operators should have been harvested.

5.2.4 The production unit appears to emphasise those activities directly leading to extraction of commercial logs. Therefore, there is little concern about the environmental impact of the

logging operation and its effect on the residual stand. This situation can only be improved through the establishment of clear guidelines and environmental standards for the logging operation and implementation of a post-logging assessment immediately after logging.

5.2.5 The BFMP have commenced training with Inhutani I in order to progressively implement reduced impact logging techniques within the concession, but to date only one Petak (100 ha) has been completed. Examination of this trial showed some considerable improvement over standard practice, but also illustrated some significant issues relating to implementation of RIL planning in the field. Most of these issues can be resolved through training in felling techniques and improved accuracy of the pre-logging inventory and survey.

5.2.6 Inhutani I plan to implement reduced impact techniques for the entire 1999/2000 RKT, but this is likely to be difficult to implement, because of the training requirements and lack of adequate topographic and tree position maps for the area.

5.3 Selection of trees for logging

5.3.1 In order to achieve the benefits of RIL techniques there should be a limit on the maximum number of harvested trees. A number of studies have suggested that a maximum limit of eight trees per hectare is appropriate for lowland and hill dipterocarp forests in Indonesia (Bertault & Sist, 1997; van Gardingen *et al.*, 1998; Sist, Dykstra & Fimbel, 1998). These authors also suggest raising the diameter limit to 60 cm when there are sufficient stems available in the stand.

5.3.2 Data from the ITSP in RKL 1998/99 (Petaks 43 and 44) have been used to analyse the likely effect of this change in policy on normal logging operations in the Labanan concession. Inhutani currently mainly harvests trees from the Meranti group with diameters exceeding 60 cm. This specification was used to predict the number of trees likely to be harvested, giving values of 6.0 and 6.3 trees ha^{-1} for petaks 43 and 44 respectively (Table 2). It is unlikely that there will be significant production losses associated with limiting the number of stems to 8 per hectare.

5.3.3 The proposed limit on the number of stems to be harvested needs to be checked against data on the number of trees actually harvested and their spatial distribution. Data for compartment 17 (RKL 1997/98) showed that whilst 15.8 crop trees per hectare were identified during the ITSP only 4.4 ha^{-1} were harvested. This is well below the suggested limit of 8 trees ha^{-1}. Preliminary results for RKT 1998/99 suggest that the suggested limit was not exceeded on a petak basis (100 ha). There has been no analysis of variation in the density of the number of harvested stems at for areas of less than 100 ha. This analysis should be undertaken for using information from the trials in RKT 1998-99.

5.4 Improving current practice

5.4.1 There are three key components required to improve current harvesting practice:

- Planning
- Training
- Supervision and monitoring

5.4.2 Planning activities will involve using improved ITSP results and topographic data to produce tree position maps that can be used to plan harvesting. These maps should then be used for skid trail planning by the skidding supervisor. Trees to be harvested should be determined from the "real" crops trees identified in the inventory and limited to no more than eight trees per hectare.

5.4.3 The planned skid trials should be marked in the field and then cut by a team of labourers before tractors are used to complete construction. The estimated savings in expenditure on tractor time and maintenance should exceed additional staff costs. Previous work by BFMP (Unto) estimated a cost saving of 18-20 %.

5.4.4 Previous studies at the Inhutani Labanan concession have concluded that there may be significant wastage of potentially commercial timber resulting from bad felling techniques and inefficient utilisation {Matikainen, Herika, et al. 1998 ID: 6480}{Bertault & Kadir 1998 ID: 6486}

5.4.5 There needs to be improved supervision of harvesting activities in the field, and this should be linked to an assessment of the performance of the harvesting team immediately after logging has been completed **(5.5)**.

5.4.6 These activities represent a significant change in the way that harvesting is implemented by Inhutani. Inhutani staff will require training in all aspects of RIL implementation and monitoring.

5.5 Monitoring success

5.5.1 One of the criticisms of the TPTI system is that the regulations focus on prescribed treatments rather than assessing outcomes. Implementation of an assessment of the impact of logging on the forest stand would be an important step towards developing an outcome-based management system. This approach would set minimum standards to be achieved for sustainable management of the forest.

5.5.2 BFMP and Inhutani I should work together to develop environmental standards for the condition of the forest stand following logging. These should be consistent with proposed standards for certification or eco-labelling. Examples would include maximum skid-trail length and area, density of harvested stems and maximum canopy opening.

5.5.3 A post-logging assessment should be implemented in each petak after logging is completed. This activity should be completed no more than one month after logging and used to assess the performance of field teams. The assessment will quantify wastage and should be used to improve the efficiency of the logging operation. The results of the assessment should be compared with the environmental standards and could be used to develop and implement a system of incentives payments for successful implementation of reduced impact logging techniques.

5.6 Recommendations

5.6.1 The harvesting operation should be stressed as the most important aspect of silvicultural management of dipterocarp forest in Indonesia. **(5.1.4)**

5.6.2 The number of trees harvested should not exceed eight trees per hectare. The calculation must be of net harvested area, excluding areas of excessive slope or riparian buffer zones. The largest harvestable trees should be selected. **(5.3.1)**

5.6.3 The diameter cutting limit for production forest should be increased to 60 cm in areas where the minimum of eight stems can be harvested. If eight stems per hectare cannot be achieved, the limit should remain at 50 cm. **(5.3.1)**

5.6.4 Topographic and tree position maps should be used to plan and implement harvesting techniques. **(5.4.2)**

5.6.5 Planned skid trails should be marked in the field, and then cut by a team of labourers before tractors are used to complete construction. **(5.4.3)**

5.6.6 Inhutani staff require training in all aspects of RIL techniques and more effective field supervision of activities. **(5.4.6)**

5.6.7 Environmental standards should be developed for the condition of the forest stand following logging. These should be consistent with proposed standards for certification or eco-labelling. **(5.5.2)**

5.6.8 The amount of wastage needs to be monitored and reduced through training in felling techniques and effective supervision and monitoring. **(5.5.3)**

5.6.9 A post-logging assessment should be implemented in each petak within one month after logging is completed. **(5.5.3)**

5.6.10 Inhutani should implement an incentive system for felling and skidding crews that could be linked to the post-logging assessment of RIL implementation. **(5.5.3)**

6 Perapilian, Re-establish petaks (Et+1)

6.1 Overview

6.1.1 The main objectives of re-establishing petaks are to mark the boundaries of the petaks, re-establish, survey lines and prepare for subsequent post-logging activities.

6.2 Implementation

6.2.1 Inhutani completes this activity as specified by the TPTI manual. It is one of the least expensive activities and is considered useful in preparing for subsequent treatments.

7 Pembebasan Tahap Pertama, First liberation treatment (Et+2)

7.1 Overview

7.1.1 Liberation is considered an activity to tend the residual stand with the objectives of (1) releasing the commercial regeneration from interfering vegetation and (2) facilitating the post-logging inventory (ITT) and replanting. In practice the liberation treatment involves cutting of the understorey vegetation, mainly shrubs and seedlings of non-commercial species.

7.2 Implementation

7.2.1 Inhutani completes the liberation treatment in most areas of the concession. It is usually not completed according to the specification for release of commercial species, rather it emphasises the post-logging inventory.

7.2.2 Inhutani staff stated that there was no benefit of this treatment for the replanting activity as the understorey would regrow before planting occurs in the following year.

7.2.3 The environmental costs of this treatment have not been assessed. Additional clearance of non-commercial species will lead to loss of biodiversity. There is also a high number of commercial species damaged during the activity, through either poor identification, or work practice. There is a high risk of additional soil erosion in areas of steep terrain or heavily logged forest.

7.2.4 This treatment is not effective in promoting regrowth of the forest stand, as the understorey is not thought to significantly reduce the growth of the stand.

7.3 Recommendations

7.3.1 The first liberation treatment should not be included as an activity in new silvicultural guidelines. **(7.2.4)**

8 Inventarisasi Tegakan Tinggal (ITT), Inventory of residual stand (Et+2)

8.1 Overview

8.1.1 The inventory of the residual stand aims to quantify the regeneration of commercial species in a range of size classes. This information is intended for use in identifying areas requiring different types of post-logging silvicultural treatments, for example enrichment planting. The inventory and resulting map are considered important tools in management of each petak.

8.2 Implementation

8.2.1 Inhutani complete an ITT for each harvested petak. Data are summarised by map and tables identifying areas requiring enrichment planting.

8.2.2 In practice, little use is made of the information from the ITT. Enrichment and rehabilitation planting are confined to skid trails and along major roads. There is no additional planting in other areas. Staff commented that this was often not necessary because, there was usually adequate natural regeneration by three years after logging except on badly damaged skid trails.

8.2.3 The ITT is considered as being an important tool in planning other post-logging silvicultural treatments. It is likely that the requirements for the ITT will change if these treatments are modified. Inhutani staff suggested that more effective use could be made of the ITSP in conjunction with effective assessment of logging impacts as an alternative to the ITT

8.3 Recommendations

8.3.1 The effectiveness of the post-logging inventory needs to be assessed and reviewed in conjunction with other post-logging activities. This should be done by comparing the application and value of the ITT results with alternatives based on an improved ITSP and post-logging assessment **(8.2.3, 17.6)**

8.3.2 An approach combining more effective pre-logging inventory (ITSP) with a post-logging assessment immediately after harvesting should be investigated as an alternative to the ITT to identify areas requiring planting or rehabilitation. **(8.2.3**)

9 Pengadaan Bibit, Seedling procurement (Et+2)

9.1 Overview

9.1.1 Seedling procurement aims to produce sufficient seedlings required for enrichment and rehabilitation planting in year Et+3. Seedlings are obtained from three sources, wildings collected from the forest, seedlings germinated from seed collected in the forest or from seed orchards, and lastly from rooted cuttings.

9.2 Implementation

9.2.1 Inhutani aims to produce approximately 130,000 seedlings per year. The majority of these come from wildings collected from the forest. The production of seedlings from cuttings has been slow. Most seedlings are from commercial dipterocarp species.

9.2.2 Inhutani are often presented with a surplus of seedlings as they find that areas identified requiring planting by the ITT (Et+2) have regained adequate regeneration by Et+3.

9.3 Recommendations

9.3.1 The requirements and specifications for seedling procurement should be reviewed in conjunction with those for replanting.

10 Pengayaan/Rehabilitasi, Planting and rehabilitation (Et+3)

10.1 Overview

10.1.1 Enrichment planting is carried out in areas where there is inadequate regeneration following logging. Rehabilitation planting is done on open areas such as along the edge of roads, on skid trails and log yards. Areas for replanting are identified by the post-logging inventory (ITT) map.

10.1.2 The TPTI guidelines state that enrichment planting should use commercial species, with light demanding species being selected for open areas.

10.2 Implementation

10.2.1 Inhutani routinely replant a proportion of each year's RKT. They estimate that the area planted currently represents 15 % of each RKT or approximately 150 ha annum^{-1}.

10.2.2 The areas selected for planting include roadsides (rehabilitation) and a zone of 200 m adjacent to the road (enrichment planting), skid trails landings and log yards. They do not use the ITT map to identify areas for additional enrichment planting.

10.2.3 Inhutani staff commented that they consider that replanting activities are unnecessary when harvesting activities have been well implemented.

10.2.4 It has been noted that planting with dipterocarp seedlings along skid trails may be largely ineffective, because skid trails are likely to be re-used for subsequent harvests (in 35 years). Seedlings will not have reached a commercial volume during this period.

10.2.5 Inhutani have observed relatively high levels of mortality (30-40% in year one), particularly in road-side plantings. They do not have any longer-term records of survival or growth of planted seedlings. Inhutani have included enrichment planting as a treatment within their PUP series, but are not monitoring the survival or growth of these seedlings.

10.2.6 Inhutani staff consider that the choice of species suggested by the TPTI regulations are inappropriate, particularly for roadside plantings. In the current year (1998-99) they are trying an exotic fast growing species (*Khaya anthotheca*) which appears to have higher survival rates. There are however alternative indigenous species that are likely to be equally successful.

10.2.7 Successful planning and implementation of reduced impact logging techniques (including roading activities) should eliminate the requirement for enrichment planting and significantly reduce rehabilitation planting

10.3 Recommendations

10.3.1 It is inappropriate to plant slow growing dipterocarp species on skid trails. Well-planned trails are likely to be re-used for subsequent harvests, and seedlings will not obtain a merchantable volume over this period. **(10.2.4)**

10.3.2 Species used for rehabilitation of road edges and skid trails should be indigenous species selected for high survival and growth rates in these relatively open environments. Most dipterocarp species are not suited to this application. **(10.2.6)**

10.3.3 BFMP should assist Inhutani to establish a research programme designed to monitor the survival and growth rates of planted seedlings. Alternative indigenous species should be included in this programme. **(10.2.5)**

10.3.4 BFMP should assist Inhutani to establish a research activity to monitor the survival and growth rates of the enrichment planting carried out in the Inhutani PUP series. **(10.2.5)**

11 Pemeliharaan Tanaman Pengayaan/Rehabilitasi, Tending planted seedlings (Et+3,4,5)

11.1 Overview

11.1.1 Tending of planting seedlings aims to promote the growth of these seedlings through clearance of competing understorey vegetation. Any dead seedlings should be replaced at the same time.

11.2 Implementation

11.2.1 Inhutani appear to complete the tending operation for most planted areas. The requirements to replace a significant number of dead seedlings (up to 40 % each year) significantly add to the cost of this activity.

11.2.2 During the clearing activity, there is a high risk that natural regeneration of commercial species may be killed in order to promote the growth of planted seedlings, which often are less vigorous.

11.3 Recommendations

11.3.1 Seedling mortality should be reduced through the choice of more appropriate species for rehabilitation planting. **(11.2.2)**

12 Pembebasan Tahap Kedua and Ketiga, Second and third liberation treatment (Et+4,6)

12.1 Overview

12.1.1 The second and third liberation treatments are similar to the first. They are used to release the commercial regeneration from interfering understorey vegetation. In addition, the second and third liberation treatments specify that competing overstorey vegetation is to be poisoned or removed by felling (vertical liberation). This is effectively an early thinning treatment for the stand.

12.2 Implementation

12.2.1 Inhutani do not currently implement the second and third liberation through most of the concession. In the few areas that have been completed, the activity has been limited to clearing of the understorey vegetation.

12.2.2 The reasons for suggested for discontinuing the first liberation treatment also apply to the second and third treatments **(7.2.3,7.2.4)**. This treatment is associated with the risk of loss of biodiversity, inadvertent clearance of commercial species and possible soil erosion.

12.3 Recommendations

12.3.1 The second and third liberation treatments should not be included as an activity in new silvicultural guidelines. **(12.2.2)**

12.3.2 The liberation of crop trees from competition with canopy or overstorey trees should be considered as a thinning activity and included in the thinning guidelines. **(12.1.1)**

13 Penjarangan Tegakan Tinggal, Thinning (Et+10,15,20)

13.1 Overview

13.1.1 Thinning aims to promote the growth of commercial species in the residual stand by killing or removing competing vegetation. The TPTI guidelines stress thinning as an activity to reduce above ground competition through the removal of the canopies of adjacent non-commercial species, or commercial trees with bad form characteristics.

13.1.2 Many systems of thinning are based on the concept of using a reduction in total basal area to promote the growth of the residual stand. An example of this was the thinning treatments imposed in the STREK project in Berau, where thinning was specified as up to a 30 % reduction in basal area. Thinning treatments can therefore be specified in relation to an inventory of the stand. Neither of these approaches are used by the TPTI system.

13.1.3 Thinning is difficult to justify on economic grounds for management of natural forests. The costs of these activities need to be discounted over the length of the cutting cycle. It is thus necessary to demonstrate very significant increases in yield to be offset against the costs of implementation.

13.2 Implementation

13.2.1 Inhutani have not yet implemented thinning treatments on an operational basis. There are two trials in the concession in RKL 1. The STREK project established a trial in 1992 and more recently, Inhutani established a trial in 1996.

13.2.2 Inhutani plans to conduct training in thinning techniques during December 1998 in conjunction with Dr Maman Sutisma of Univerisatas Mulawarman in Samarinda. They then intend to implement up to 500 hectares of thinning during the remainder of the 1998/99 operating year.

13.2.3 If thinning treatments were to be fully implemented as specified in the TPTI regulations, it would eventually require each HPH to thin three times the area of their average RKT. For Inhutani, this would represent approximately 3,000 ha annum^{-1}. In the absence of any information on the costs and manpower requirements for such extensive post-logging activities, it is impossible to assess the practicality of this option.

13.2.4 It is likely that few HPH will have sufficient trained staff to fully implement the thinning treatment. It would therefore be more appropriate to consider implementing a smaller area of thinning treatments in areas of forest most likely to show an economic return on the investment. These areas are likely to be characterised by a high density of potential crop trees, high basal area, and gentle topography with good road access. There is consequently a need to characterise or zone land for this activity. Thinning would then effectively become an optional treatment at the discretion of the forest managers. This option is not currently available under the existing regulations.

13.3 STREK Thinning Trial

13.3.1 The thinning trial from the STREK project was implemented in RKL 1, an area of forest first logged in 1980. The treatments were applied in November 1992. There have been four measurement campaigns carried out at two yearly intervals. A fifth campaign will be completed early in 1999.

13.3.2 Preliminary analysis of the STREK data has demonstrated that there are significant diameter and volume growth increments associated with the thinning treatments. The data suggest that growth was significantly enhanced in the thinned plots over the period up to the last measurement in 1996. There are a number of problems with the current release version of the database that limit further analysis. The main problem is associated with a high percentage of non or misidentified species in many of the plots (up to 64 %). Some of these problems will be solved when the database is recompiled following measurement campaign 6 in March 1999. More detailed analysis of the thinning data should then be completed.

13.4 Inhutani Thinning Trial (km 18)

13.4.1 Inhutani established a thinning trial at km 18 in RKL III, an area logged during RKT 1987/88. Twelve one hectare plots were established in 1996 and tree position, species and diameter recorded. Thinning treatments were applied in September 1997 and the first remeasurement was completed in 1998. Data from both measurements have been entered into a spreadsheet, but were not yet available to the consultant.

13.4.2 Data have been recorded for all trees with DBH greater than 10 cm, showing trees to be promoted and those killed by poison or felling. Tree positions have been recorded relative to each 10*10 m recording unit. These co-ordinates should be re-coded relative to the base position of each plot.

13.4.3 The results from the first measurement interval will be confounded by the thinning treatment having been applied half way through the two-year period. It is doubtful that useful information will be obtained from analysis of these data. It is therefore important to ensure that further measurements are made at regular intervals (one or two years) to obtain benefit from the trial.

13.4.4 Data have been recorded in a spreadsheet and as such are not readily amenable to statistical analysis. It would be advisable to convert these data into a database format, compatible with the structure used for the STREK permanent sample plots. This approach would enable a common approach to data processing and analysis.

13.5 Thinning Training and Trial (1998/99)

13.5.1 The plans for training in thinning techniques in conjunction with Universitas Mulawarman are poorly defined. Inhutani intends to establish five one hectare plots for the training, and then to implement thinning over an area of up to 500 ha. The training plots will be monitored to establish the growth rates of the trees selected for promotion. There were no plans to establish control plots (no thinning) which will limit the usefulness of these data. The performance of the thinning teams will also be monitored over a period of six months. It will be important to obtain data describing the labour requirements and costs for the thinning treatments.

13.5.2 The consultant visited an area proposed for the thinning at km 50 in RKL III. This area had been logged in 1984 by contractors. The criteria for selecting the site were that the forest should

have been logged more than ten years previously, that it should have good access, and representative terrain and forest cover.

13.5.3 The proposed location was in an area of very steep terrain, the majority of which would currently be excluded from production because of excessive slope. The forest had apparently been very heavily logged resulting in excessive disturbance to the residual stand. Consequently there were very few large canopy trees and a very open canopy. The understorey had a high proportion of non-commercial light demanding species such as pioneers and vines.

13.5.4 The structure and condition of the forest at the km 50 site, is not representative of forest 14 years after logging. The apparently low basal area (visual estimate) and open canopy, suggest that there is not likely to be a significant growth increment resulting from the thinning treatment. The terrain will make the training exercise difficult and unrepresentative. It was thus concluded by BFMP and Inhutani staff that this location was not suitable for either the training or the implementation phase.

13.5.5 An alternative site was suggested by Inhutani staff. A location at km 24 in RKL 1 was visited. This area had been logged over twenty years previously. Four, four hectare plots (16 ha total) had been established previously for a thinning trial that subsequently had not been implemented. Data collected from the plots include tree position and girth. Species identification was not available, and a map had not been produced from the survey data. The forest had a high canopy, which was still relatively open. The mid-canopy was densely populated with a significant proportion of commercial species. Visual estimation of the basal area suggested that it was considerably higher than that of km 50, but still significantly lower than primary forest. The site was on gently rolling terrain with good road (and Helicopter) access. It was concluded that the km 24 site was a much better site for the training programme and if possible subsequent implementation.

13.5.6 Discussions were held with Dr Maman in Samarinda before the Consultant commenced work in Tanjung Redeb. He suggested that whilst thinning has clear benefits in terms of growth promotion, that a number of technical difficulties inhibit effective implementation. These are:

- Species identification.
- Training of field staff in thinning techniques.
- Correct inventory information is required to establish the correct thinning treatment.

13.5.7 Discussions with Inhutani and BFMP project staff identified the following issues that may negate any benefits in enhanced yield.

- Increases in yield may not be sufficient to justify expenditure when discounted over the period of the cutting cycle.
- Problems in species identification and inventory data quality may result in trees being wrongly assigned to the groups that are either promoted, or killed.
- It is impossible to assess market conditions at the time of the next harvest. Some of the species that are currently removed during thinning may become economically important before the next harvest.
- The removal of non-commercial species during thinning will lead to changes in biodiversity of the forest.
- There are significant risks of environmental degradation associated with thinning. There are risks of erosion associated with thinning by felling. If trees are thinned by poisoning, it is likely that the arbocide and its breakdown products will leach into the soil and ground water.

13.6 Recommendations

13.6.1 Data from the STREK and Inhutani plots should be further analysed to obtain estimates of the growth increment resulting from thinning treatments. **(13.3.2)**

13.6.2 Thinning should be considered an optional treatment at the discretion of the forest manager. It should be limited to areas of forest most likely to yield an economic return on the investment. **(13.2.4)**

13.6.3 Thinning treatments should be specified in relation to adequate inventory data, specifying the proportion of or maximum basal area to be removed. **(13.1.2)**

13.6.4 Data from the Inhutani trial at km 18 should be converted into a database format compatible with data entry, processing and analysis systems used for the STREK data. Tree position information should be re-coded relative to the base-point of each plot. **(13.4.2, 13.4.4)**

13.6.5 Objectives for the training course and subsequent implementation of thinning treatments are poorly defined and should be refined with Dr Maman from Universitas Mulawarman. **(13.5.1)**

13.6.6 The site at km 50 is not suitable for the training course in thinning and subsequent implementation. The alternative location at km 24 is considered better suited for these activities. **(13.5.4, 13.5.5)**

13.6.7 Inhutani should be given assistance to establish monitoring programmes for the results of the thinning training (trial). Data should be collected describing the manpower requirements and costs of thinning. Control plots (no thinning treatment) should be established and monitored with the thinned plots to establish the growth response. **(13.5.1)**

14 Series PUP, Permanent Sample Plots

14.1 Overview

14.1.1 Every HPH are required to establish at least one set of permanent sample plots (PUP) per RKL (five year plan). Guidelines for the establishment and implementation of PUP have been issued by Badan Litbang in Bogor. HPH are required to send their PUP data to Litbang for analysis.

14.1.2 The DFID funded Indonesia UK Tropical Forest Management Project (ITFMP) established a clearing house for growth and yield data in Kalimantan with BPK Samarinda. The clearing house has developed a database system and associated software for data checking, processing and limited analysis.

14.2 Implementation

14.2.1 The Inhutani PUP series was established at km 28 in RKL4, in an area logged during RKT 1993/94. The site has previously been visited by DFID and BPK staff from the growth and yield data clearing house, who established that the PUP have been implemented correctly.

14.2.2 Data have been collected by Inhutani staff and collated in a spreadsheet. There is no checking of data quality. These data have been sent to Litbang for analysis, but no results have been returned to the HPH. The data have also been sent to the growth and yield clearing house where they have been integrated into the clearing house format.

14.2.3 There has been minimal analysis of the PUP data. Inhutani staff have collated a report that includes estimates of individual tree diameter increments. Examination of these results show a high occurrence of data or processing errors indicated by excessively high increment measurements.

14.2.4 Inhutani has completed enrichment or rehabilitation planting in open areas of the PUP plots. They have not been monitoring the survival or growth rates of these planted seedlings.

14.2.5 The main problems with the implementation of the PUP series are associated with procedures for data processing and analysis. These activities would be greatly improved if the procedures used for the STREK plots are adopted by Inhutani for use with their PUP series (and thinning trials).

14.3 Data Analysis

14.3.1 Inhutani have not produced a statistical summary of the results from the PUP trial. Data were available for the first two measurements (1995, 1996) that had been collated in the BPK Samarinda, growth and yield clearing house. These data were subjected to a simple preliminary analysis to illustrate the potential utility of these data.

14.3.2 The analysis demonstrated that a number of trees appeared to have excessively high diameter increments (> 2.5 cm annum^{-1}) indicating that measurement or data entry errors were present in the database. This suggests that data should be subjected to more rigorous checking and quality control.

14.3.3 The results of the analysis of diameter increment are shown as Table 3. These data show that the highest mean increments were observed for the Meranti group. There were insignificant differences between the other commercial species. These data can be further subdivided into diameter class groups showing minor differences in diameter increments between size classes for most species. The highest increments tended to occur in either the 20-30 or 30-40 cm diameter classes. Similar results were obtained during regression analysis to develop a yield simulation system for the BFMP {Rombouts 1998 ID: 6481} and GTZ SFMP {Rombouts 1998 ID: 6485}projects.

14.3.4 The cutting cycle for the TPTI system assumes a constant diameter increment of 1 cm annum^{-1} for Meranti species. The results from this analysis (and the STREK data) support this assertion, but it should not be assumed that this will continue throughout the prescribed 35 year cutting cycle. It is likely that the rate will decrease significantly as canopy closure occurs, with rates decreasing to the values of 0.4 to 0.5 cm annum^{-1} typically observed in primary forest.

Species Group	Number of Stems	Diameter Increment (cm annum^{-1})
Meranti Group	119	1.11±0.07
Fast growing Dipterocarps	35	0.83±0.10
Slow growing Dipterocarps	194	0.83±0.04
Non Dipt. Commercials	106	0.76±0.07
Minor Commercials	285	0.76±0.05
Protected	58	0.79±0.07
Non Commercial	999	0.69±0.02
Ulin	52	0.61±0.06

Table 3. Analysis of diameter increment obtained from the Inhutani PUP plots over the one-year period October 1995 to October 1996. Data are averaged over six plots, each of one hectare. The species groups are the same as used for the BFMP inventory, with the exception that Ulin has been listed separately. Data are reported as mean ± 1 standard error.

14.4 Recommendations

14.4.1 Inhutani should be encouraged to monitor the survival and height growth rates of planted seedlings in the PUP **(14.2.4)**

14.4.2 Improved procedures for data checking, processing and analysis should be implemented by Inhutani. These should be designed to be compatible with those used for the STREK plots, and also applied to the thinning trials. **(14.2.5, 14.3.3)**

14.4.3 Data from the Inhutani and STREK PUP should be analysed to obtain estimates of diameter and volume increment and these results applied to define future management of the concession. **(14.3.3)**

15 Hydrological Monitoring Station

15.1 Overview

15.1.1 All HPH are required to establish one hydrological station in each RKL (five year working plan). More information is available from a BFMP project report on hydrology of the Inhutani Labanan concession.

15.2 Implementation

15.2.1 Inhutani established one SPAS station, but this was essentially destroyed in floods. They were given some technical assistance in establishing the station.

15.2.2 Laboratory analysis of sediment was carried out by concession staff at base camp Labanan.

15.2.3 The consultant has observed a similar facility established in Sumatra. There are a number of easily identified issues with this activity.

- Most HPH do not have staff with adequate technical training to establish and run such a facility.
- The guidelines for locating and establishing the station are poorly defined.
- There are no environmental standards that could be used in comparison with results from the stations.
- HPH staff do not fully understand the objectives of the guidelines.
- The activity is essentially focused on research, but as the "experiment" is unreplicated and lacks a control, the data will be difficult to analyse.
- Data from the station are sent to Jakarta. HPH receive no feedback or analysis.
- The facility is expensive to establish and run and there are no perceived benefits to the HPH.

15.2.4 It is very difficult to justify the establishment of this type of hydrological station as part of operational forest management. The activity seems to have been designed to collate data from a wide range of locations within Indonesia, but it is difficult to see how these data can be used.

15.3 Recommendations

15.3.1 The requirements for establishment of hydrological stations need to be reviewed to clarify the objectives for this activity. If these are essentially research orientated, it would be difficult to justify the continued requirement for HPH to implement this as part of operational forest management.

16 Growth and Yield Prediction

16.1 Background

16.1.1 The prediction of forest growth and yield for commercial species is a key requirement for sustainable management of forest resources. The TPTI regulations are based on assumed growth rates (e.g. 1 cm annum^{-1} diameter increment). The KPHP regulations state that improved methods of prediction are required to establish the annual allowable cut for compartments.

16.1.2 Yield regulation for sustainable forest management requires:
(1) adequate data sources;
(2) data analysis; and
(3) suitable predictive tools.

16.2 PUP / PSP data

16.2.1 The Inhutani I concession at Labanan has some of the best permanent sample plot data available in Indonesia. The plots developed by the STREK project cover a ten year measurement period. In addition Inhutani, have set up a very good set of sample plots following the PUP regulations.

16.2.2 The potential of these data to assist forest management have been largely unrealised. It is important that BFMP assists Inhutani to start using this information for planning and operational management.

16.3 Inventory data

16.3.1 There have been a series of problems in obtaining a low intensity (≈0.3 %) inventory of the Labanan concession. The first inventory used a series of concentric circular plots located 100 m apart on transects running across the concession at an azimuth of 120 °. This inventory gave adequate results for stand volume for logging purposes. The quality of species identification was poor and for this reason data from this inventory will be difficult to apply for yield prediction.

16.3.2 For these reasons, a new inventory was implemented commencing in the second half of 1998 using a new design. This design utilised a 12.5 m strip for trees with DBH greater than 50 cm, a 4 m strip for trees with DBH 20 – 49.9 cm and a 2 m strip for trees with DBH 10-19.9 cm. This inventory has been very time consuming, mainly because most trees are being identified to botanical species level. The sampling design, consisting of a continuous transect has also been criticised as being inefficient and difficult to process for statistics.

16.3.3 The current inventory design has the largest sample plot area (12.5 m strip width) for trees with DBH greater than 50 cm. These represent trees that could be potentially harvested immediately. The inventory will however be used to make yield predictions, and it is thus important to include in this sample, the population of trees likely to grow into commercial size before harvesting. For this reason, it is suggested that the diameter limit for sampling should be reduced to either 35 or 40 cm. This approach is consistent with the inventory design developed by the GTZ Sustainable Forest Management project.

16.3.4 It is suggested that a more appropriate inventory design would use fixed area plots (circular or square) using either systematic or stratified random sampling. The number of plots should be

determined by either, total area of each stratum, or if known, the variability within a stratum such that errors are constant.

16.3.5 This approach would result in more effective statistical analysis and make the data more readily amenable to use for modelling growth and yield. The use of a circular or square plot will minimise the effects of any additional environmental gradients with plots, (minimising error) while maximising differences between strata.

16.3.6 The approach used by GTZ for inventory has been designed specifically for use for yield prediction with a new version of the model Dipsim. Discussions with GTZ staff in Samarinda suggested that the current BFMP inventory design produces data that cannot readily be used for yield prediction using DIPSIM. They recommended the use of systematic sampling with fixed plot sizes.

16.4 Statistical Analysis

16.4.1 The example shown in section **14.3.4** (Table 3) illustrates how simple statistical analysis can be used to obtain information of direct relevance to future forest management. The STREK and Inhutani PSP data sources should now be comprehensively analysed for this purpose.

16.5 Modelling approaches

16.5.1 The Integrated Yield Simulation System developed for the BFMP predicts yield applying a transition matrix model to inventory data {Rombouts 1998 ID: 6481}. This approach has been applied to investigate the long-term sustainability of forest management in the Labanan concession using different management options. Varying the annual allowable cut showed that levels of 30 000 m^3 $annum^{-1}$ can be sustained but with a reduction in the average volume of the stand. A further reduction to 25 000 m^3 $annum^{-1}$ resulted in volumes also being maintained. This approach to modelling the productivity of the Labanan concession will be further extended by the BFMP and integrated with the GIS for the concession.

16.5.2 There are currently two alternative approaches to modelling growth and yield being developed y other programmes in Indonesia. The GTZ funded, Sustainable Forest Management Programme (SFMP) is implementing a new version of DIPSIM for concession scale yield regulation using inventory data. This is an improvement of a system first developed in Sabah, which is now used operationally by the Sabah Forestry Department. The DFID funded, Forestry Research Programme (FRP) is developing a new version of SYMFOR to be used with PSP data for yield prediction and evaluation of alternative silvicultural treatments. It may also be possible to modify SYMFOR for use with suitable inventory data.

16.5.3 Growth and yield analysis and modelling should be given a high priority, so that the methods and results can be integrated into the GIS and Management Information Systems being developed for the Labanan concession. The implementation of DIPSIM to the Labanan concession will require a change in the inventory design, preferably to use systematic sampling and fixed plots.

16.6 Recommendations

16.6.1 Data from the PSP plots and KPHP inventory at Labanan should be subjected to comprehensive statistical analysis and used for modelling future growth and yield. **(16.2.2, 16.4.1, 16.5.1)**

16.6.2 The BFMP inventory should measure all trees with DBH greater than 35 or 40 cm in the largest plot size. (Replacing the current 50 cm limit). **(16.3.3)**

16.6.3 The design of the BFMP inventory should be modified to make it more efficient and maximise it's potential for statistical analysis and modelling. **(16.3.4, 16.3.5, 16.3.6)**

16.6.4 Modelling approaches including **DIPSIM** and **SYMFOR** should be applied to the PSP and inventory data from the Labanan concession. **(16.5.2)**

17 Research & Development

17.1 Background

17.1.1 The consultant has identified a number of areas where BFMP and Inhutani should collaborate in research and development activities with the objective to improve forest management practice in the Labanan concession. It is expected that these activities will lead to improvements to the existing TPTI regulations and suggestions for alternative silvicultural regimes to be applied with KPHP systems. It will be important, for these reasons, to actively involve staff from the Ministry of Forestry and Estate Crops (DGPH) in the planning and implementation (BPK Samarinda) of this work.

17.2 Data checking, processing, analysis and interpretation.

17.2.1 Inhutani currently collect data as part of operational management and research activities. Inhutani staff are skilled in processing these data to produce summary tables as required by regulation. There is, however, little effort to check the quality of data, or to further process data so that results from such analysis can be applied to improve forest management.

17.2.2 An example of the problems in data quality, processing and analysis was illustrated in section **16** discussing the PUP series. The PUP data have been collected and collated for reports. The results have been analysed to give the diameter increment of individual trees. Examination of the results illustrate that there are important errors in the source data, which may be related to either measurement errors, or transcription (coding) errors. The same errors were identified by the BPK growth and yield clearing house. To date, these errors have not been checked by Inhutani staff.

17.2.3 These observations illustrate the urgent need for BFMP to assist Inhutani staff to implement procedures for data processing, analysis and interpretation. It would be appropriate for BFMP to transfer the technology and skills that have been developed from the research component (i.e. STREK Plots) to similar activities for Inhutani, specifically the PUP and thinning trial plots.

17.2.4 Inhutani staff will require training in these activities. It should be stressed that it is not sufficient to train staff how to operate the relevant computer programmes. They need to understand what they are doing in terms of the justification for, and objectives of each activity.

17.2.5 It is essential that a link is made between data analysis and practical forest management. This will help to motivate the staff involved in data processing and analysis and demonstrate the benefits of such activities to Inhutani management. Data processing activities require investment in quality staff and equipment. Of these, the most important is investing in staff and their training. Equipment costs are insignificant when compared with the investments required for the harvesting or transport operations. Management will only accept these statements when direct benefits can be demonstrated.

17.3 ITSP

17.3.1 A number of suggested improvements to the pre-logging (ITSP) inventory have been implemented by BFMP and Inhutani. The performance of this system and its associated costs will be assessed in phase II of the project. It is also appropriate to consider if these data can be further analysed for management purposes.

17.3.2 An important modification to the ITSP has been to record information about the quality of individual trees allowing more accurate identification of "real" crop trees {Matikainen, Herika, et al. 1998 ID: 6480}. Data from the ITSP should also be analysed to further assess the impact of the suggested limit on the density of harvested stems (8 stems ha^{-1}).

17.4 Harvesting

17.4.1 Previous sections have emphasised the importance of implementing improved reduce impact logging (harvesting) activities. These are already well established and there is little need to further research their implementation. It will be necessary to monitor the costs and time associated with the modified activities compared with conventional harvesting and this will be done in phase II of the BFMP. The benefits will be monitored separately as part of the post-logging assessment

17.5 Commercial volumes and wastage

17.5.1 Data from the ITSP can be used to estimate the volume of individual trees. These data should be derived for all harvested crop trees and compared with production data (volume per stem) collected by Inhutani. This comparison will give information on both the accuracy of the ITSP and the proportion of wastage linked to harvesting. This approach should be compared with measurements obtained from the sample plots established in petaks 43 and 44 in RKL 98/99.

17.5.2 This activity will require data from Inhutani describing the commercial volumes obtained for each tree cross-referenced against the tree number from the ITSP.

17.6 Post-Logging Assessment

17.6.1 The development of a system for post-logging assessment should be one of the main field research and development activities in the current phase of the BFMP project. Research activities should be designed to (1) establish environmental standards for good forest management, (2) develop an assessment system that can be applied as part of operational forest management and (3) develop an incentive system for implementation of reduced impact logging techniques. This research should be developed using data from RIL trial areas, but the benefits could be assessed using an extensive survey of areas previously logged using conventional techniques.

17.6.2 It is likely that an effective operational post-logging assessment could be combined with the ITSP to effectively remove the need for the 100 % post-logging inventory (ITT).

Skid trails and harvested trees.

17.6.3 The implementation of planned skid trails has been stressed as a key component of reduced impact logging. The assessment of the implementation of skid trails will therefore be important in operational post-logging assessment.

17.6.4 Immediately after logging is completed a team should enter the plot and using the ITSP map as a guide, record the following:

- Location and ITSP tree number of harvested trees.
- Reasons for selected trees not being harvested (e.g. hollow stem, inadequate access, and species identification).
- The quality of felling technique, excess height of stump, damage to log.
- Map the length and width of skid trails.
- Information on the degree of blading, slope of skid trails, cross cutting and soil disturbance.
- Description of the environmental impact of the construction of the main road network and associated camps and loading areas.

17.6.5 These data can then be used to assess how well the original plan has been implemented and implement the incentive system. Further analysis of the data can be used to calculate the total area and length of skid trails and number of stems extracted per trail. This information can be used as part of operational research and development to monitor performance against environmental standards and assess improvements in work practice and efficiency.

17.6.6 The map produced from the post-logging assessment should be implemented as an overlay in the GIS containing the results from the ITSP. This will enable analysis of aspects such as the risk of environmental damage as a function of topography.

Data collection in sample plots.

17.6.7 A number of sample plots have been established within petaks 43 and 44 in RKT 98/99. It is intended to use these to record more detailed information assessing the impacts of logging and the subsequent recovery of the residual stand. It has been agreed that the following information will be collected:

- Logged trees.
- Method and success of felling.
- Direction of felling.
- Height of stump.
- Logging waste left in forest.
- Type and degree of damage to stems in the residual stand.
- Map of disturbance
- Map of residual canopy cover on a 10*10 m grid obtained using a canopy densitometer.
- Regeneration, recruitment and mortality.

17.6.8 In addition, if possible data should be obtained from Inhutani describing the commercial volume obtained from each harvested tree in the plots.

17.6.9 The post-logging assessment should be integrated into the development of procedures for certification or eco-labelling. The assessment will provide an objective and quantitative description of the successful implementation of a logging plan for each compartment. The results can also be compared against a set of defined environmental standards.

17.7 ITT

17.7.1 It is suggested that the post-logging inventory could be replaced using data from the ITSP and post-logging assessment. In order to test this, it will be necessary to collect an ITT from one of the areas that have been logged and monitored using this system. Under normal logging practice the ITT would be carried out two years after logging (Et+2). In order to provide data more rapidly it is suggested that an ITT is carried out on petaks 43 and 44 of RKT 98/99 during 1999.

17.7.2 It is suggested that post-logging assessment and maps of skid-trails could be used to define areas requiring rehabilitation planting. Comparison between the maps from the ITT and the post-logging assessment will be used to determine if this is a valid assumption.

17.8 Replanting

17.8.1 It is expected that the requirement for enrichment and rehabilitation planting will decline through the successful application of reduced impact logging techniques and a review of the implementation of the ITT. It is recognised, however, the need for replanting will continue to exist in areas of excessive damage, and it is necessary to collect data describing the success of this activity.

17.8.2 Collection of data on the success of planting can also be used as an exercise in data collection, processing and interpretation. Measurements should be recorded at 3, 6 and 12 months after planting and subsequently at yearly intervals. Further details are given in Appendix I.

17.8.3 A small-scale trials should be established to determine:

- Percentage survival of planted seedlings.
- Height growth of seedlings
- Comparison between alternative planted species

Road side planting.

17.8.4 Road side planting aims to rapidly stabilise exposed soil and provide cover. It is important to use species that can tolerate the high light intensities in this environment and provide rapid canopy coverage. Plantings with Dipterocarp species have been observed to be ineffective in many areas. Data are required to estimate the success of this activity in terms of percentage survival and growth of the seedlings.

17.8.5 The trial should include a comparison between a number of species. These species should be selected from locally occurring species that are known to be light demanding and rapidly growing.

Success of skid trail planting

17.8.6 Skid trail planting aims to stabilise disturbed soil following extraction. Skid trails are currently planted with dipterocarp species with some degree of success. It has been suggested that Dipterocarps may not be the most appropriate choice, as planned skid trails are likely to be re-used during subsequent harvesting operations. Alternative fast-growing species could be evaluated which are more likely to give an economic yield over 30-50 years.

Enrichment planting with the forest margin.

17.8.7 Inhutani currently undertake enrichment planting in a zone for up to 500 m left and right of the main roads. The success of this activity is not known. A trial should be established monitoring the growth and survival as a function of distance from the road edge. In addition to the standard data for monitoring seedlings (above) additional data should be collected to describe the degree of canopy cover above each seedling.

- Canopy cover should be monitored using a canopy densitometer above each seedling.

17.9 Thinning

17.9.1 The section of thinning activities (**13**) stressed the importance of the analysis of existing growth and yield data from the STREK and Inhutani thinning trials. There is no need to implement additional trials to supplement these data. Inhutani plans to conduct training in thinning techniques during December 1998 or early 1999. It is important that data are collected on the labour requirements and costs of these activities so that the results from growth and yield studies can be combined with an economic analysis. Inhutani should be encouraged to monitor the growth response to thinning in the trial plots in comparison to appropriate control plots.

17.10 Summary and Recommendations

17.10.1 The research activities suggested in this section are intended to develop procedures for management such as the post-logging assessment and operational R&D (yield prediction). It is important that a distinction is made between pure research and operational activities. It is an important principle that operational activities should involve the minimum data collection required to achieve stated objectives.

17.10.2 Inhutani staff require training to develop and implement improved procedures for data processing analysis and interpretation and their application to forest management. **(17.2.3 & 17.2.4)**

17.10.3 The costs of implementing reduced impact logging techniques should be monitored and compared with conventional logging techniques. **(17.4.1)**

17.10.4 Commercial volumes obtained from harvested trees should be monitored,, cross-referenced and compared with data from the ITSP. **(17.5.1)**

17.10.5 An assessment should be implemented to monitor the condition of the forest immediately after logging. **(17.6.4)**

17.10.6 The post-logging assessment should be developed to be linked into the process of certification for sustainable forest management. **(17.6.9)**

17.10.7 A post-logging inventory (ITT) should be conducted in at least one petak (43 or 44) of RKT 98/99 following the completion of logging and compared with the results from the post-logging assessment. **(17.7.1)**

17.10.8 The survival and growth rates of planted seedlings should be assessed for: road side; skid trail and forest margin plantings. **(17.8.3)**

17.10.9 Data should be collected to describe the costs and labour requirements for thinning activities. **(17.9.1)**

18 An alternative silvicultural system

18.1 **Justification**

18.1.1 This report has reviewed the implementation of TPTI by Inhutani I in Labanan. It has identified a series of activities that could be improved within existing regulations. An alternative approach would be to design a new silvicultural system to complement the concept of KPHP. This section summarises the essential features of one possible alternative to TPTI.

18.1.2 It is intended that this system will be developed as a proposal to the Ministry of Forest and Estate Crops in conjunction with staff from Inhutani I, BPK Samarinda and DGPH. This will require additional information to be collected from field studies, and extensive analysis of existing data sources.

18.1.3 The design should be based on the following principles:

- The silvicultural system should be based upon clear management objectives, e.g. sustained production, environmental standards, maintain biodiversity.
- Emphasise desired outcomes of forest management
  (as opposed to prescriptive based activities).
- Include technical guidelines (not prescriptions).
- Specify minimum data requirements for good forest management.
- Require forest managers to achieve defined minimum standards, but not prevent them from exceeding these through alternative approaches to forest management.
- Minimise the requirements for post-logging treatments.
- Some treatments such as thinning should be optional and left to the discretion of the forest manager, based on economic decisions within the constraints of environmental standards.

18.2 **Principle Activities**

1. Environmental standards.

18.2.1 The HPH will agree a set of environmental standards for the concession. These could include standards for road construction, harvesting guidelines, skid trail area and soil damage and definition of exclusion zones.

2. KPHP or compartment inventory

18.2.2 A low intensity inventory should be implemented at five or ten year intervals to establish the status of forest compartments. These data should be integrated into the management information system for the concession and used for yield regulation or the determination of annual allowable cut (AAC). This inventory should include data describing the proportion of crop trees that are damaged or have bad form.

3. Pre-logging compartment (RKT) inventory and topographic survey.

18.2.3 The purpose of the pre-logging inventory is to identify crop trees and provide information required for the planning of harvesting. For this reason the minimum data requirement will be to identify and map all "real" crop trees. Collecting data on other species, and smaller size classes may not be necessary. It may however be desirable to collect information on the

proportion of trees with defect or bad form, or from other species groups. It has been suggested that this could be done at little additional cost.

4. Planned harvesting activities.

18.2.4 The pre-logging inventory and topographic maps should be used to plan harvesting activities within limitations of the environmental standards, relating to the selection of trees for harvesting and definition of exclusion zones.

5. Reduced impact logging.

18.2.5 Skid trails will be established in the field before logging using the plan, by pre-cutting of skid trails using a team of labourers before tractors are used to complete construction. Directional felling should be used where possible, and harvesting should be implemented to reduce waste.

6. Decommissioning skid trails.

18.2.6 Skid trails should be decommissioned as the tractors leave the area. This involves the construction of cross drains on slopes.

7. Post-logging monitoring.

18.2.7 Post-logging monitoring should be carried out immediately after logging has been completed. This activity will be used to give immediate feedback to field teams on their performance allowing more rapid improvement in work practices. The results in the field should be assessed against environmental standards for the operation. Skid trails should be mapped and their area assessed as an indicator of logging damage. This information can be used to assess requirements for enrichment planting.

8. Rehabilitation

18.2.8 There should be little need for any form of rehabilitation if good harvesting practice has been implemented in the field. Rehabilitation planting aims to establish ground cover in areas of high disturbance and should us rapidly growing light demanding species. This should be restricted to damage resulting from poor road construction, skid trails with excessive soil disturbance, and in log yards or landings.

9. Decommissioning minor roads. ("Locking the forest")

18.2.9 If these guidelines are implemented correctly there will be no need for extensive or complex post-logging activities. This removes the need to maintain the network of minor roads serving each area. This would have two major advantages, firstly reducing the costs of road maintenance, but also reducing access to the forest and thereby reducing illegal logging. It may be appropriate to extend this concept by decommissioning minor roads by removing bridges thus "locking" the forest until the next harvest. This may not be possible in many areas, where road access may be required, for example, for fire prevention or forest security.

10. Post-logging treatments.

18.2.10 The requirement for post-logging treatments would be minimised when compared to the current TPTI system. Some labour or capital intensive treatments such as thinning should be allowed as optional activities at the discretion of the forest managers. The decision should be based on environmental and economic considerations, including access, risk of erosion and prediction of the economic yield.

19 Acknowledgements

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21 Appendix I.
Enrichment and Rehabilitation Planting Trials.

21.1 Site Selection

21.1.1 The trials will be implemented in three categories of planting location:

- Roadside plantings (Rehabilitation)
- Skid trail planting (Rehabilitation)
- Enrichment planting by roads.

21.1.2 Each location should be chosen such that the conditions are representative of the logged area and environmental conditions should be relatively uniform.

21.2 Trial locations.

Roadside rehabilitation planting.

21.2.1 The trial should monitor the survival and height growth for a number of species. These should include:
1. Fast growing dipterocarp species
2. Light demanding indigenous species (up to three)

21.2.2 Inhutani staff should be asked to suggest suitable species for the trial. The species should be selected from local material that has good seed or seedling availability. Preference should be given to species that are likely to grow well in very open conditions. Pioneer and early successional species are likely to be best suited to this situation. It would be an added benefit if the trees were likely to produce commercial timber. The trials should have no more than three light demanding indigenous species.

21.2.3 For each species planted, two hundred seedling should be monitored. This should be carried out using:

- Five different locations
- At each location establish a transect of each side of the road (left and right)
- Monitor twenty seedlings on each side of the road.

Skid-trail rehabilitation planting.

21.2.4 The trial should monitor the survival and height growth of the species used for replanting of skid-trails. Two types of species should be monitored.
- dipterocarp species
- fast growing non-dipterocarp (e.g. early successional species).

21.2.5 For each species planted, two hundred seedlings should be monitored. This should be carried out using:

- Five different locations
- At each location establish a transect of each side of the skid trail (left and right)
- Monitor twenty seedlings on each side of the road.

Roadside enrichment planting.

21.2.6 The trial should monitor the survival and height growth of dipterocarp seedlings used for enrichment planting under partial canopy cover.

21.2.7 The seedlings will be monitored along at least five transects established from the edge of the road. These are normally between 200 and 500 m long with planting at 5 m intervals. Each transect will thus have between 40 and 100 seedlings.

21.3 Definition of measurements

21.3.1 Measurements of mortality and seedling height will be used to assess the success of planting.

21.3.2 Seedling will be recorded as being dead when:
- The seedling is no longer present. *or*
- The leaves are dry, brown or have fallen. *or*
– The stem is dry and brittle.

21.3.3 Seedling height is defined as the vertical distance between the base of the stem and the highest shoot apex. This should be recorded to the nearest mm.

21.4 Establishing the trials (First measurement).

21.4.1 The trials should be established at the time of planting. Seedlings will be monitored along the transects established for planting. The following data will be collected:

For each transect:

- Date of planting.
- Date of first measurement.
- Precise location of planting
  - start of transect, relative to ITSP or ITT map or BFMP GIS coverage
  - compass bearing for transect
  – record side of road or skid trail (left/right *and* compass direction)

For each seedling:

- Identification number
  (unique for each seedling and marked on the pole next to the seedling)
- Location (m from start of transect)
- Species
- Height of seedling
- Canopy cover, assessed using spherical canopy densitometer.

21.5 **Remeasurements.**

21.5.1 The seedlings should be assessed at 3, 6, 12 and 24 months after planting. If dead seedlings are replaced by replanting, a new record should be created for each replacement. The following data will be recorded:

For each transect:

- Date of measurement

For each seedling:

- Identification number
- Mortality (alive / dead)
- Height of seedling

For replacement seedlings:

- Identification number
  (unique and different from previous number, to be marked on the pole next to the seedling)
- Location (m from start of transect)
- Species
- Height of seedling