Linking Growth and Yield Models with a Financial Model for Forest Concessions.

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Contents

List of Abbreviations

Abbreviation	Definition
BFMP	Berau Forest Management Project
DBH	Diameter at Breast Height (1.3 m)
DFID	(UK) Department For International Development
DIPSIM	Dipterocarp Growth and Yield Simulation Model
FORMIND	(Individual based) Rain Forest Growth Model
FORMIX	Rain Forest Growth Model
IRR	Internal Rate of Return
ITFMP	Indonesian Tropical Forest Management Project
MIN FMU	Minimum Forest Management Unit Model
NPV	Net Present Value
SYMFOR	Silviculture and Yield Management model for tropical Forests
YSS	Yield Scheduling System (Growth and yield model)

1 Introduction

The yield of timber from tropical forests can be predicted from the analysis of data from permanent sample plots or inventory, often through the application of growth and yield models. These models give realistic estimates of the timber yield from various management scenarios, but cannot estimate or compare the likely financial returns which are of equal importance when making policy or management decisions for forests. Such information would require the linking of growth and yield models with appropriate financial models. This technical note documents a study that has linked a growth and yield model for forests in East Kalimantan (Indonesia) with a financial model for a forest concession in the same area. The growth and yield model used in this study was SYMFOR (Phillips & van Gardingen, 2001) and this was linked to a financial model (Minimum Forest Management Unit Model, MIN-FMU) (Dadang Fadilah, 1997) that had been developed by the Berau Forest Management Project (BFMP, http://www.bfmp.or.id).

This document describes the methods used to link the models by specifying the type of information that SYMFOR can produce which is useful in financial analyses, and how this information should be inserted into the spreadsheet financial models. The detailed method specified in this report is specific to these models, but the approach is generic and could be replicated with any other suitable combination of models. The BFMP financial model was selected for this study because it had been developed for the same timber concession as used to calibrate the SYMFOR ecological model. The work described in this publication was implemented through a collaborative project with the BFMP. Other suitable models are available for Indonesia, including the DFID ITFMP forest concession model (Scotland & Whiteman, 1997), and a generic approach to linking growth and yield and financial models is described in section 8.

This technical note should be used as a guide to assist people wanting to perform similar analyses for forest management or policy purposes. The linkage of a growth and yield model with a suitable financial model permits the analysis of the likely financial implications of different management options providing an entry point to the discussion of ecological and financial criteria for sustainability. The current study only considers the production of timber products from forests and hence excludes the many other non-timber goods and services produced by forests that would need to be considered to extend this analysis to a full economic and social appraisal of sustainability. It is hoped that the approach described in this report will represent an important first step towards achieving this goal.

2 Growth and Yield Models: SYMFOR

2.1 Growth and yield models

Growth and yield models are designed to make predictions of potential yield from managed forests, based upon data from static inventory and permanent sample plots. There is a range of such models now available for most types of forests in both temperate and tropical regions. Natural moist tropical forests are an important source of tropical timber that is often produced through selective management systems involving multi-cyclic harvesting. The high biodiversity of tropical forests, combined with the selective harvesting system, presents particular challenges to the development of growth and yield models for tropical forests. Hence growth and yield models for tropical forests need to be able to deal with a range of species (or species groups) with mixed age (or size) distributions.

Growth and yield models are now available for many areas of tropical forests covering the main regions of the tropics (Vanclay, 1994). In Asia, these models include FORMIX and FORMIND developed for Malaysia (Kohler & Huth, 1998; Huth & Ditzer, 2000), DIPSIM for Malaysia and Indonesia (Ong & Kleine, 1995), YSS (Rombouts, 1998) and SYMFOR (van Gardingen *et al.*, 2001) both developed for Indonesia. In Latin America there are models for Brazil (Alder & Silva, 2000), French Guiana (Gourlet-Fleury & Montpied, 1995; Gourlet-Fleury & Houllier, 2000) and Guyana (Alder, 2000). Similar work has been carried out for African forests in Uganda and Ghana using approaches described by Alder (Alder, 1995; Alder *et al.*, 2001). In addition to the SYMFOR ecological model for Indonesia (Phillips *et al.*, 2002b), there are also models for Guyana (Phillips *et al.*, 2002c) and Brazil (Phillips *et al.*, 2002a). Further developments are likely and will be published as SYMFOR technical notes (http://www.symfor.org/technical).

2.2 The SYMFOR framework

SYMFOR (Silviculture and Yield Management model for tropical Forests) is a framework that links simulation models of the growth, recruitment and mortality of individual trees with a forest management model that was originally developed for lowland Dipterocarp forests in Indonesia. The growth model (Phillips *et al.*, 2002b) describes the growth of each individual tree as a function of its species, size and position in relation to other trees. The model also describes the probability of tree mortality and new tree recruitment as ingrowth above the 10 cm minimum diameter of the dataset.

The management model in SYMFOR (van Gardingen *et al.*, 2002) allows the user to design, implement and compare different silvicultural and management practices. The management model helps users to compare the effects of management including yield regulation systems and silvicultural treatments. The SYMFOR framework can then be used to describe the likely outcomes of management interventions in terms of the production and ecological characteristics of the resulting forest stand. Such studies can describe the:

- Timber yield which can be expected from harvesting an area of forest;
- Damage done to the forest as a result of harvesting;
- Regeneration and regrowth of the forest following logging (or silvicultural treatments).

Growth and yield models such as SYMFOR can provide objective predictions on all these aspects of timber yield and forest ecology for several cutting cycles into the future. Such models can therefore be used to compare the long-term effects of different forest management and silvicultural strategies on the productivity and ecology of tropical forests. The predictions of yield by SYMFOR can be used as input into financial analyses of production forest management. Information on gross timber yield (disaggregated by species if necessary) at specified points in the future is the primary information required for financial analysis as described in this report. More sophisticated analysis may require a description of the number of individual stems comprising this harvest, and their size (DBH). This information can also be produced by SYMFOR.

2.3 SYMFOR technical notes

This technical note describes the linking of SYMFOR with a financial model for a timber concession in East Kalimantan in Indonesia. The note does not describe the operation of the growth and yield model but assumes that users are familiar with the operation and application of the SYMFOR framework. If required, guidance is available from other technical notes in this series, which are all available from the SYMFOR web site http://www.symfor.org/technical/.

3 Financial and Economic Analysis

3.1 Introduction

This technical note is restricted to describing the link between growth and yield models and financial analysis of forest operations. For more general information on financial or economic analysis refer to standard texts (e.g. (Price, 1989; Tietenberg, 1999) or more specific reports (e.g. (Barbier *et al.*, 1994; Davies & Richards, 1999). This section provides a brief introduction to the concepts used in the current analysis.

3.2 The difference between 'financial' and 'economic' analysis.

An important difference exists between the meaning of the terms 'financial' and 'economic'. These are often (wrongly) used interchangeably, which is misleading. In this document and the work it describes, benefits and costs of a financial and economic nature are defined as follows:

- **Financial benefits / costs** are those cash flows that are relevant to the private entrepreneur undertaking a project. Such flows tend to be related to the use and/or the production of resources that are valued at prevailing market prices. The sale of timber is a prime example of a financial benefit to be gained from forestry, whilst the market price of machinery or labour is a financial cost. Financial flows can, however, also be augmented or reduced by grants and tax benefits or obligations. While these so-called transfers represent real costs or revenues that appear in the entrepreneur's balance sheet, they do not necessarily correspond to the use or production of any real asset. A private concessionaire assessing competing rotation options might typically undertake financial analysis.
- **Economic benefits / costs** are the resource flows that are relevant from the perspective of society or government. Here the objective is to allocate resources to the marginal project that maximise net benefits to society rather than any private operator. The key point here is that market prices (used in a financial analysis) may be inappropriate or insufficient for conducting an economic appraisal. Using market prices would be tantamount to allocating scarce resources using the wrong signals. Many market prices of inputs and outputs do not represent true resource scarcity. This is because they are frequently distorted by subsidies and taxes that drive a wedge between the market price and the value that society truly derives from consuming the resource. Recall that it is the latter that we are searching for. For some project outputs (e.g. external environmental costs and benefits) no market prices exist at all. It is this true, resource scarcity plus the presence of external impacts that needs to be reflected in a societal decision to allocate resources to one project in preference to another. Financial analysis therefore needs to be extended to an economics analysis through a process known as shadow pricing. Economic analyses are typically taken by, or on behalf of, the government. Many of the flows involved are relevant to society but may not be captured by (and are therefore of no interest to) private entrepreneurs.

A full economic analysis (e.g. a forest rotation policy for public stands) takes into account all of the above benefits and costs, and therefore decisions are made with the input from a much wider base of information. Economic analyses are potentially very different from financial analyses. An economic analysis may, for example, sanction an activity that is wholly unprofitable from a financial standpoint.

The model described and applied in this technical note is a purely financial model, and this document describes only how SYMFOR should be linked with it for the purposes of financial analyses. This means that little attention is paid to the process of shadow pricing for forest related inputs and output, and that the following discounting discussion will be limited to a consideration of private sector discount rates.

Further explanation and an example of the process to extend the discussion to a more comprehensive economic analysis can be found in a previous technical note in this series (McLeish & Farida Herry Susanty, 2000).

3.3 Discounting

The financial model described below (Section 4) considers a net revenue (benefits minus costs) cash flow accruing over a number of years. The example uses a twenty-year time horizon and the net revenue stream is one of many that reflect the specific harvesting decision including accelerating or delaying the harvest.

When to harvest and how much timber to extract in a selective logging system are common decision problems for forest managers. Essentially, a way must be found to collapse the future revenue stream back to the present to enable the relative profitability of management options to be compared. **Discounting** is the formal process of converting future net revenues to their present value equivalents or Net Present Value (see below). Mechanically it can be thought of as the converse of compound interest, except that the rationale derives from several arguments that assume that future revenues should be given less importance relative to present revenues.

The actual rate of discount that reduces the value of future flows arising is derived conceptually in two ways. For simplicity, the private entrepreneur will generally only consider the opportunity cost argument in discounting. The logic is as follows. Any forest revenue stream involves some initial and on-going outlay, offset against income or revenues. As such, the stream has an implicit **Internal Rate of Return** (see below), which may be positive if, over time, and allowing for some time decay for the value of money, the outlays (costs) are exceeded by the returns. The private entrepreneur will only be attracted to this rate of return if he knows that it exceeds the flow from the next best investment opportunity, the opportunity cost of capital. It follows that the entrepreneur should use this best alternative rate of return as the discount rate to collapse future flows he is interested to evaluate. If the result produces a positive net present value, the entrepreneur will be earning a higher rate of return on the stream under consideration than on the alternative.

Prevailing interest rates are sometimes used as the hurdle or comparative rate of return since, at the most basic level, the entrepreneur can simply put the money in the bank. The opportunity cost represented by a bank rate of return is relatively risk free. In comparison, forest investments are long term and subject to uncertainty. It is therefore fairly common to see this uncertainly factored into the analysis by the use of a hurdle rate that is somewhat higher than the bank rate. An added premium simply reflects the entrepreneur's concerns about an uncertain future. In developing countries both this uncertainty and a shortage of capital to spend on many high earning projects can combine to ratchet up discount rates. While there are no rules of thumb for selecting rates, analysts should present some sensitivity analysis by using rates between 8 and 15%.

As stated, the net profit (or loss) in a financial analysis is calculated over a period by balancing income against expenditure whilst allowing for the decaying effect of compounded discounting. This provides two important financial indicators, the **Net Present Value** of a resource and an estimate of the **Internal Rate of Return**. These are described in more detail below.

The rationale behind discounting is that a $100 profit one year into the future is not as valuable as a $100 profit today. There are two reasons for this. Firstly, $100 today is certain, there is no risk that you will not get this money if you hold it in your hand today. The promise of receiving $100 in one year's time is less certain – anything could happen between now and then. Secondly, if you had $100 today, you could invest it (e.g. in a bank account), and it would be worth more than $100 in a year's time.

For these reasons, (cash) values at any point in the future are reduced ('discounted') on a yearly basis to give them an equivalent magnitude in today's values. The overall result of this method of dealing with future cashflows is that **future income** does not have as strong an influence upon decision-making as **current income**.

3.4 Net present value (NPV)

Most projects being subjected to financial analysis will have income and expenditures in each year of the project. Financial analysis calculates the net cashflow for each year and then this amount is discounted back to a present value equivalent. The sum of these present value equivalents gives an estimate of the **Net Present Value** (NPV) of a project or resource. The example below demonstrates this (**Table 1**). If a project has a positive NPV (as this one does), it means it is a worthwhile proposition as it will produce a positive return on investment (i.e.

make money). If it has a negative NPV, it is unattractive as it will lose money when compared with alternative activities that can produce returns at, or exceeding the, specified discount rate.

Year of Project	Expenditure ($)	Income ($)	Net Cashflow ($)	Present value ($) discounted at 10 %
0	- 1000	+ 500	- 500	- 500
1	- 800	+ 800	0	0
2	- 500	+ 700	+ 200	+ 156
3	- 400	+ 700	+ 300	+ 225
4	- 400	+ 700	+ 300	+ 205
Net Present Value				**+ 86**

Table 1 The calculation of NPV.

The NPV of a project is usually calculated before it goes ahead, in order to see if it is likely to be a profitable activity. If the NPV is negative, a project is unlikely to commence. The NPV can also be used to compare between alternative ways of carrying out the same project (i.e. using different amounts of machinery, or buying equipment at different stages in the project). In this way it can be predicted which is the most cost effective way of undertaking an activity.

3.5 Internal rate of return (IRR)

The Internal Rate of Return (IRR) is a measure of the worth of an investment, expressed as a percentage of the sum of money that is invested. It can be thought of as a parallel to the rate of interest offered by a bank account. Thus if a 5 year project offers an IRR of 17 %, it means that over the project period for every $100 invested, $117 will be received back. In more technical terms, the IRR is the discount rate that makes the net present value equal to zero.

As a general rule in the appraisal of an investment, if the IRR is greater than the discount rate, the NPV will be positive. If the IRR is less than the discount rate, the NPV will be negative, and the project will make a loss. As stated previously, the IRR is an implicit measure that can be used to compare a given forest investment with any number of alternative investments, for example, comparing the expected return to be made from running a forest concession with the expected return from building a hotel. Making this comparison will help an individual or company to decide where they are best to invest their money, taking into account their views of the risks involved in any venture.

4 The BFMP Model for Minimum Forest Management Unit MIN-FMU

The BFMP Minimum Forest Management Unit model (Dadang Fadilah, 1997) is a spreadsheet-based tool that was originally designed to calculate the minimum size that a timber producing concession can be, whilst still remaining profitable. The model can, however, also be used to compare the financial implications of contrasting forest management regimes being applied to the concession.

The model is an elaboration on the simple principle outlined in the previous section (Table 1). For each year over a 20 year period it takes the income gained from log sales and balances this against the expenditures incurred in producing these logs. It then discounts this value back to the year zero and calculates a NPV and a corresponding IRR.

Much of the data contained within the model have been collected from the concession of PT Inhutani I at Labanan, East Kalimantan. All prices and cost data relate to 1996. Whilst it would be desirable for any user of the model to have an equivalent set of data, the collection and analysis of this data is a significant task because of the level of detail required to differentiate between alternative management activities and scenarios and their associated costs. It may not be necessary to collect all of these data for some other locations in Indonesia. This means that whilst the actual costs of each activity in the model may relate only to this particular concession rather than being truly representative of all concessions within Indonesia, the *relationships* between management activities and concession size and costs are realistic and can be expected to be similar across Indonesia. Some of the categories of management costs are indicated in Figure 1.

4.1 Structure of the model

There are four sections to the model which are presented on separate sheets. The key components of each sheet are summarised as data input or model results.

Cash Flow Analysis Component.

This is the main interface of the model where the user can input important data such as the discount rate to be used, and obtain the most important financial measures, which are calculated – IRR and NPV. A description of the main features of this component is given in Table 2.

Unit Cost Component.

This sheet contains all the data describing the operational and investment costs associated with running the concession. The section on forest management costs can be used to enter the costs of the particular management practice which is being simulated using the growth and yield model (SYMFOR). The costs are grouped into investment costs (rows 3-106) and operational costs (rows 112-200). Users of the model have the option of changing individual costs to reflect the management regime being simulated. In practice, these data may not be readily available, and it is often simpler to modify existing costs using a percentage multiplier.

Cost Processing Component.

The main calculations for the model are contained in this sheet. *Users should not modify this sheet.*

Analysis Output Component.

This sheet provides summary statistics and graphics describing overall costs and how they are distributed between various aspects of managing the concession (e.g. wages, machinery costs, taxes and levies).

Cell	Data Item	Description / Information
	Data input	
E3	Net minimum area	This is the productive area of the concession.
E4	Cutting Cycle	The length of the cutting cycle.
E5	Discount Factor	The discount rate with which the model is operating.
G4	Log Price	In US$ per cubic meter.
	Model output	
E6	Financial internal rate of return (IRR)	The IRR calculated by the model.
E7	Net Present Value (NPV)	The NPV calculated by the model.
E14	Annual Logging area	The net minimum area (E3) divided by the cutting cycle (E4).
E25	Net timber yield from primary forest	Calculated in cubic meters per ha.
E26	Net timber yield from logged-over areas	Calculated in cubic meters per ha.

Table 2 Summary of the key parameters in the Cash Flow Analysis component of the BFMP MIN-FMU model.

4.2 Data requirements

The application of the MIN-FMU model in conjunction with a growth and yield model requires the information given in Table 3.

Information	Possible Source / clarification
Concession size (ha)	Concession
Average log value (domestic / export, at roadside)	Market journals
Discount rate	Set by forest manager / company
Cycle length and year of the current cycle	Simulated management regime
Method of log extraction	Simulated management regime
Management activities performed (for example thinning etc)	Simulated management regime
Costs of the management activities planned	e.g. how much cheaper is RIL skidding
Net timber yield per ha from virgin and logged over areas	Output from SYMFOR

Table 3 Data requirements to link growth and yield and financial models.

5 Linking SYMFOR and Min-FMU

The objective of using a silvicultural tool such as SYMFOR is to assess the impact of management activities upon the growth and future timber yield of the forest. The objective of linking this to a financial model is to assess how the costs of these silvicultural activities weigh against the overall (financial) benefits. It is therefore essential, when using the two models together, to check that any forest management activities are reflected in the costs of management described in the financial model.

5.1 Linking financial and growth and yield models

An interface to the MinFMU financial spreadsheet has been developed to aid interaction with the growth and yield model. This interface is shown as Figure 1. Input data are summarised in three sections: Management details, Management Costs, and Yield. The results section provides estimates of the internal rate of return, total net present value and net present value per hectare.

Financial Analysis of Growth and Yield Studies

Management Details	
Area of	5300
Year from first	45
Cutting	35
Apply Silv Treats	0
Discount	16.0

Yield	
SYMFOR Yield	60
SYMFOR Yield	51
Harvest	49
Log Price	90

Management Costs	
Felling and	0.00
Skiddin	0.00
Grading and	0.00
Loadin	0.00
Haulin	0.00
Unloadin	0.00
Cran	0.00
River	0.00
Working Area	0.00
Road alignment	0.00
Pre-felling	0.00
Documentation &	0.00
Trainin	0.00

Results		
IRR		11.2
NPV	$-	
NPV	$	-20

Figure 1 Growth and yield interface for the Min-FMU financial model.

The original approach to linking the models required users to modify cells within the Min-FMU spreadsheet described in the Appendix is complex and may result in erroneous changes being made to the model.

Management details

The management details specify the area of the concession, year from first harvest (how many years the concession has been managed), the length of the cutting cycle and the discount factor to be used in the analysis. This section also determines if post-logging silvicultural treatments (mainly thinning) will be applied.

There is an important relationship between the length of cutting cycle and the number of years that the concession has been managed. In the example shown (Figure 1) the number of years of management is greater than the length of the cutting cycle. This will mean that the financial model will have used the yield for logged over forest (LOA) for the entire twenty-year period of the financial analysis. If the number of years of management is less than the length of the cutting cycle, the financial analysis will use yield from primary forest for all or part of the financial analysis.

Management Costs

The management costs section is used to modify costs by fixed percentages. A positive percentage results in increased costs, whilst negative values decrease costs. This is most often used in conjunction with reduced impact logging operation. The costs most frequently modified in conjunction with reduced impact logging studies have been highlighted. Reduced Impact Logging (RIL) may increase the efficiency of some management operations. The management costs section of the user interface (Figure 1) is used to specify a percentage change in these costs. The highlighted items are those considered most likely to change and an example is shown as Figure 2.

Yield

SYMFOR produces estimates of yield specified as felled volume for either primary or logged-over forest. The Min-FMU model requires an estimate based on timber extracted to the logging yard. Studies in Indonesia have shown that harvest efficiency for this operation may be only 45-55 %. A suitable estimate must be entered here.

5.2 Interpreting the results

If the growth and yield interface is used to link the growth and yield model with the Min-FMU model, the results will be displayed automatically. The example shown in Figure 1 gives an internal rate of return of 11.2 % and total net present value of below –1 m \$US or -20 \$US ha^{-1}. If required, additional information may be obtained from the main body of the spreadsheet.

It is most likely that the objective of carrying out a financial analysis is to make a comparison between two (or more) alternative methods of managing the concession. An example might be comparing two systems for yield regulation. In this case the NPV and IRR for the first management scenario should be recorded, and the model re-run for the second management scenario. Results can then be compared.

The net present value is the most useful measure when comparing different forest management systems. The NPV will indicate which is the most profitable. The IRR is the more useful measure when comparing forest management with alternative investments.

5.3 Scenario analysis

The link between the financial model and a growth and yield model can be used to compare different management scenarios. For example, it is possible to compare the example shown in Figure 1 with an alternative system based on reduced impact logging techniques. In this scenario the costs associated with felling, road construction, inventory and training increase, whilst skidding costs decrease. There is also a 5 % improvement in the harvest efficiency. The results in Figure 2 show an increase in the IRR and NPV. The changes still do not achieve the desired rate of return, however.

Financial Analysis of Growth and Yield Studies

Management Details		Yield	
Area of	5300	**SYMFOR Yield**	60
Year from first	45	**SYMFOR Yield**	51
Cutting	35	**Harvest**	54
Apply Silv Treats	0	**Log Price**	90
Discount	16.0		

Management Costs		Results	
Felling and	20.00	**IRR**	14.6
Skiddin	-	**NPV**	$ -
Grading and	0.00	**NPV**	$ -6
Loadin	0.00		
Haulin	0.00		
Unloadin	0.00		
Cran	0.00		
River	0.00		
Working Area	0.00		
Road alignment	20.00		
Pre-felling	20.00		
Documentation &	0.00		
Trainin	20.00		

Figure 2 Financial analysis of data shown in Figure 1 using modified costs and timber recovery representing reduced impact logging.

The Min-FMU model has been implemented as a spreadsheet in Microsoft Excel™ (Version 8 / Office 97). This system has additional features for scenario analysis including the *Solver*. This tool can be used to perform non-linear scenario analysis to vary one or more cells in the spreadsheet in order to achieve a desired result. One example of such an application would be to use the solver to determine the increase in harvest efficiency required to return a net present value of zero and hence the desired internal rate of return. This example is shown in Figure 3. Running the solver gives the desired internal rate of return when the harvest efficiency increases to 56 %.

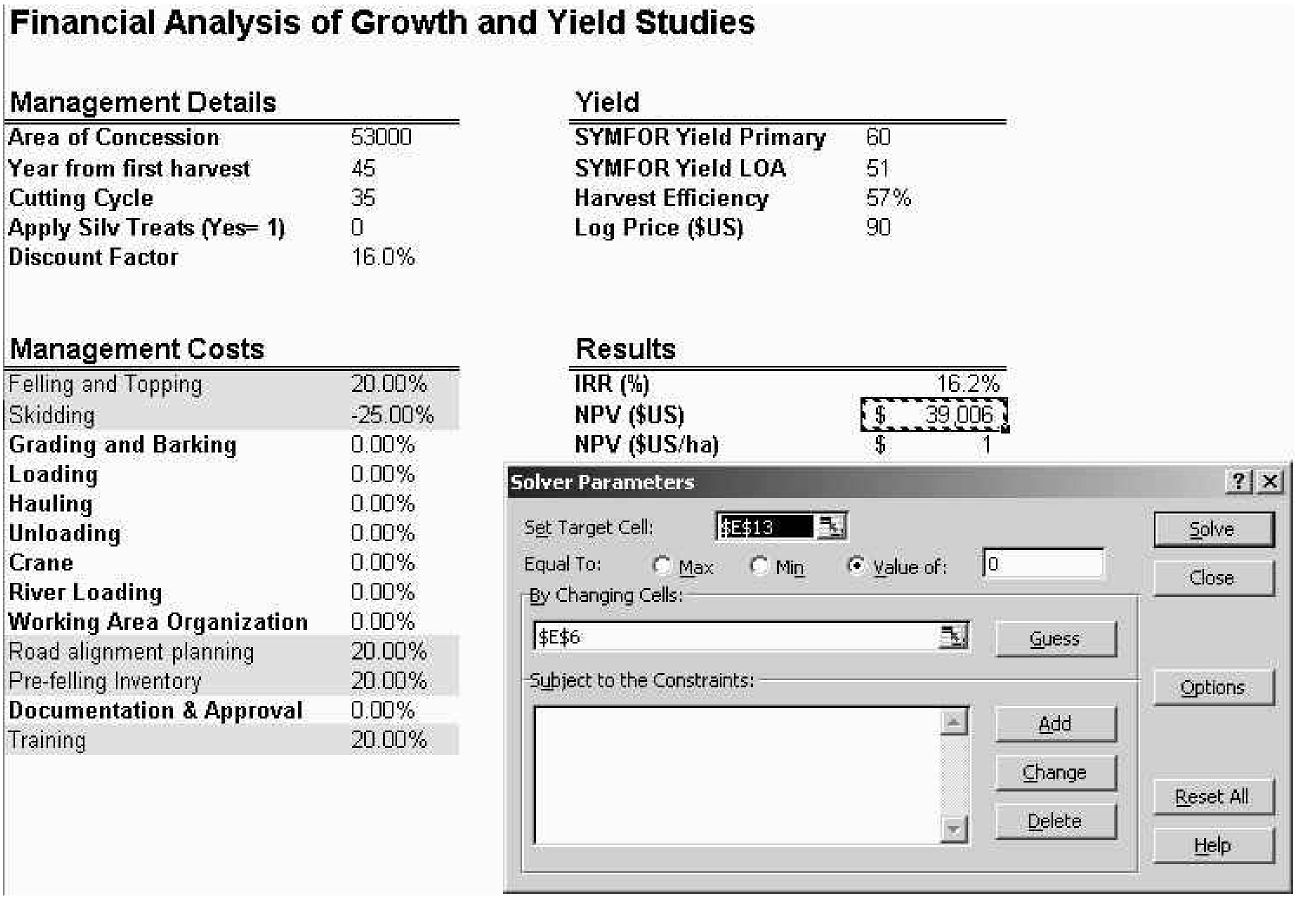

Figure 3 Application of the solver for scenario analysis in Microsoft Excel. The solver will change the value of the harvest efficiency (cell E6) until the net present value (cell E13) is equal to zero.

6 Setting a Management System within SYMFOR

6.1 Points to look out for

In linking a growth and yield model such as SYMFOR with any financial model it is important to know the format and specifications of the data required by the financial model. The primary information that SYMFOR can provide is a prediction of the timber yield at specified points in the future for any simulated management regime.

The following issues are relevant:

- The timber yield information given by SYMFOR is an estimate of gross felled volume (Enggelina, 1998). This must be multiplied by a suitable 'utilisation factor' (conversion factor) in order to provide an estimate of the skidded volume at the logging yard required for use in the spreadsheet model. The growth and yield interface for the Min-FMU model (Figure 1) does this automatically. This net figure represents the actual volume of timber which is sold and therefore brings an income to the concessionaire.
- The financial model needs to be able to determine whether timber is being harvested from primary or logged-over forest. This is done by specifying the length of the cutting cycle and the number of years since the first harvest. If the years since the first harvest exceed the length of the cutting cycle, the financial model will assume that all timber is produced from logged-over areas. If the model starts with primary forest, financial analysis needs to know at what point in the 20-year analysis period (if any) the harvesting changes from primary to logged over forest. This is again determined by the relationship between the number of years that the concession has been managed and the length of the cutting cycle. It is assumed that the concession is being managed according to the Indonesian TPTI regulations which specify a fixed cutting cycle of 35 years.
- Silvicultural and post-logging treatments are included in both the SYMFOR model and the Min-FMU financial model. SYMFOR is, however, limited in that it is currently limited to simulate thinning treatments. It is essential to know exactly what management activities have been simulated within SYMFOR, and to ensure that these are represented by a cost in the financial analysis. If an activity has not been undertaken, it should not have an attached cost. This is an apparently obvious point, but should be noted as the BFMP model assumes that all post-logging silvicultural activities are carried out when these are selected.

7 Dealing with Periods longer than 20 years

7.1 Financial analysis period and cutting cycle length

The financial analysis of forest concession management scenarios described in this technical note is carried out for a period of only twenty years. At first there appears to be a discrepancy between the analysis period of 20 years and the cutting cycle of 35 years. This raises the question: 'how can the financial benefits of an improved management system be accounted for if they occur in the second cutting cycle, when the financial analysis covers only 20 years?'

Under this system of financial appraisal only those financial benefits that occur within the 20-year period will be taken into account. Any financial benefits (e.g. higher timber yield) occurring after the 20-year analysis period will not be represented. It would therefore seem desirable to extend the spreadsheet models to cover a period of 35 or even 70 years. However, this raises two points.

The rights to fell timber in a forest concession in Indonesia are typically granted for a period of 20 years, making this the financial planning time frame for a concessionaire. From a purely financial standpoint, forest concession owners and managers tend not to consider the period beyond 20 years because there is no certainty that they will retain the concession beyond this period.

A second reason that the 20-year analysis is appropriate for financial analysis relates to the effects of discounting (Section 3.3). Using the accepted method of discounting at any significant discount rate, income flows occurring beyond a certain number of years in the future are rendered insignificant. For example, the NPV (year 2000 value) of $1 in the year 2020 discounted at 20% is $0.02. Immediate income flows carry the greatest weight in any financial analysis, and hence extending the financial analysis beyond 20 years would have an insignificant impact upon the result.

There is therefore no point in simply extending the analysis period. It would be possible to reduce the discount rate to counter this problem, but this is generally not an option for private sector investment appraisal. Only an extension to consider a government perspective (i.e. an economic appraisal) might justify the use of (typically) lower rates of discount. Further information on social discount rates can be found in Markandya and Pearce (1988).

7.2 Ecological and economic analysis

Due to the timescale problems outlined above, the analysis of growth and yield predictions results beyond 20 years in the future should be approached from an economic angle (see Section 3.2). The economic analysis is concerned with all the benefits (goods and services) that the forest provides. Its aim is to assess whether or not a system that is financially viable will also be sustainable using other socio-economic measures (e.g. biodiversity and environmental services). An example of this type of analysis can be found in Technical Note 6 (McLeish & Farida Herry Susanty, 2000).

8 Conclusions.

The examples given in this technical note have detailed the methods required to link the SYMFOR growth and yield model with the BFMP Min-FMU financial model. The approach is relatively simple and could easily be extended to other growth and yield or financial models. The main constraint to such an approach has been the availability of suitable financial data and models that adequately describe the complexity of forest management systems in the tropics. Fortunately suitable models are gradually becoming available.

An alternative financial spreadsheet for Indonesian forest concessions was developed by the DFID Indonesian Tropical Forest Management Programme (Scotland & Whiteman, 1997). This model was developed using data collected in a comprehensive survey of production forest concessionaires in Indonesia. The default data with which the model is loaded has been chosen to represent a 'typical' concession in Indonesia – in terms of size, costs and productivity. As with the BFMP model, the main financial measures reported are the NPV and the IRR. The main reason that the BFMP model was selected for the current study was that the cost data were considered more relevant as they were obtained for the same concession as used in the growth studies.

The future application of this approach to other locations may require the development of suitable financial or economic models. The work described in this technical note has identified some important areas where existing approaches could be improved. The most important is that both of the existing models for Indonesia are based on costs that have been expressed on the basis of extracted timber volume. This approach does not permit the models and associated analysis to fully reflect the likely benefits accruing from the improved planning and implementation associated with reduced impact logging techniques. For this reason, future models should, wherever possible, express costs on the basis of units of activity, for example, the extraction of individual logs or the construction of a unit length of road or skid trail.

9 Acknowledgement

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10 References

Alder,D. (1995) *Growth modelling for mixed tropical forests. Tropical Forestry Papers no 30,* 231 pgs.

Alder,D. (2000) *Development of growth models for applications in Guyana*. Department for International Development, Georgetown, Guyana, 47 pgs.

Alder,D., Oavika,F., Sanchez,M., Silva,J.N.M. & Wright,H.L. (2001) A method for calibrating growth models for tropical moist forest with minimal data. *Forest Ecology and Management*, *(Submitted)*

Alder,D. & Silva,J.N.M. (2000) An empirical cohort model for management of Terra Firme forests in the Brazilian Amazon. *Forest Ecology and Management*, **130,** 141-157.

Barbier,E.B., Burgess,J.C., Bishop,J. & Aylward,B. (1994) *The economics of the tropical timber trade,* Earthscan, London, 224 pgs.

Dadang Fadilah (1997) *Minimum area model. A financial approach to determine minimum area of forest management unit. Report and user guide.* Berau Forest Management Project, Jakarta, 36 pgs.

Davies,J. & Richards,M. (1999) *The use of economics to assess stakeholder incentives in participatory forest management: A review. European Union Tropical Forestry Paper 5.,* Overseas Development Institute, London, 45 pgs.

Enggelina,A. (1998) Volume equation. In: *Silvicultural research in a lowland mixed dipterocarp forest of East Kalimantan*, Bertault,J.G. and Kadir,K., (Eds.) Cirad-foret, FORDA, Inhutani I, 127-135.

Gourlet-Fleury,S. & Houllier,F. (2000) Modelling diameter increment in a lowland evergreen rain forest in French Guiana. *Forest Ecology and Management*, **131,** 269-289.

Gourlet-Fleury,S. & Montpied,P. (1995) Dynamics of dense tropical rain-forest communities - outline of a single tree model in Paracou (French-Guiana). *Revue D Ecologie-La Terre Et La Vie*, **IE,** 283-302.

Huth,A. & Ditzer,T. (2000) Simulation of the growth of a lowland Dipterocarp rain forest with FORMIX3. *Ecological Modelling*, **134,** 1-25.

Kohler,P. & Huth,A. (1998) The effects of tree species grouping in tropical rainforest modelling: Simulations with the individual-based model FORMIND. *Ecological Modelling*, **109,** 301-321.

Markandya,A. and Pearce,D.W. (1988) *Environmental considerations and the choice of discount rate in developing countries. Environment Department Working Paper #3*. The World Bank, Washington,

McLeish,M.J. and Farida Herry Susanty (2000) *Yield regulation options for Labanan. A financial and economic analysis of yield regulation options for logged over forest at PT Inhutani I, Labanan Concession.* http://www.symfor.org/technical/yield6.pdf Berau Forest Management Project, Tanjung Redeb, 45 pgs.

Ong,R. & Kleine,M. (1995) *DIPSIM. A dipterocarp forest growth simulation model for Sabah,* Forest Research Centre, Forestry Department, Sabah, Malaysia, 94 pgs.

Phillips,P.D., Azevedo,C.P., Thompson,I.S., and Silva,J.N.M. (2002a) *An ecological model for the management of natural forests in the Tapajos region, Amazonian Brazil. SYMFOR Technical Note Series 11.* http://www.symfor.org/technical/tapajos.pdf 33 pgs.

Phillips,P.D., Brash,T.E., Yasman,I., Subagyo,S. & van Gardingen,P.R. (2002b) An individual-based spatially explicit tree growth model for forests in East Kalimantan (Indonesian Borneo). *Ecological Modelling*, *(In Press)*

Phillips,P.D., van der Hout,P., Arets,E.J.M.M., Zagt,R.J., and van Gardingen,P.R. (2002c) *An ecological model for the management of natural forests derived from the Tropenbos permanent sample plots at Pibiri, Guyana. SYMFOR Technical Note Series 9.* http://www.symfor.org/technical/pibiri.pdf The University of Edinburgh, Edinburgh, 23 pgs.

Phillips,P.D. & van Gardingen,P.R. (2001) The SYMFOR Framework for modelling the Effects of Silviculture on the Growth and Yield of Tropical Forests. In: *Proceedings of IUFRO 4.11 Conference: "Forest Biometry, Modelling and Information Science"*, Rennolls,K., (Ed.) University of Greenwich, London, 1-12.

Price,C. (1989) *The theory and application of forest economics,* Blackwell Scientific, Oxford, 320 pgs.

Rombouts,J. (1998) *Growth model components and integrated yield simulation system for the Berau Forest Management Project area (East Kalimantan)*. Berau Forest Management Project, Jakarta, 53 pgs.

Scotland,N. & Whiteman,A. (1997) *The ITFMP forest concession model operators manual,* Indonesia-UK Tropical Forest Management Project, Jakarta, 62 pgs.

Tietenberg,T. (1999) *Environmental and natural resource economics,* 5, Longman, 640 pgs.

van Gardingen,P.R., Phillips,P.D., McLeish,M.J., Brash,T.E., Farida Herry Susanty, Slamet Gadas, Boen Purnama, Edy Sardjono & Irysal Yasman (2001) SYMFOR: A silvicultural and yield management tool for tropical forests. *Integrated Management of Neotropical Rain Forests by Industries and Communities*, *(In Press)*

van Gardingen,P.R., Phillips,P.D., McLeish,M.J., Brash,T.E., Farida Herry Susanty, Slamet Gadas, Boen Purnama, Edy Sardjono & Irysal Yasman (2002) SYMFOR: A silvicultural and yield management tool for tropical forests. *Integrated Management of Neotropical Rain Forests by Industries and Communities*, *(In Press)*

Vanclay,J.K. (1994) *Modelling forest growth and yield: applications to mixed tropical forests,* CAB International, Oxford, 312 pgs.

Appendix 1. Details of the Min-FMU model

The following Tables go through all sections of the spreadsheet model, pointing out cells in which the user *must ensure* that the relevant data appear or are entered. However, note that this section is intended only as a guide to the work that has been done in linking SYMFOR with Min-FMU, not as an explanation of all the workings of the spreadsheet itself.

The following sections identify the key components of the financial model that may need to be modified by advanced users.

Cash-flow Analysis component			
Step	***Cell***	***Required entry***	***Reason / Information***
	H8	2	Allows the model to be run with the user's scenario (Box -1), rather than one of the 48 pre-set scenarios
	G4	100	Simple base figure for log price, which can be inflated or deflated
	E3	Size of the concession	Aim is to look at the profitability of your concession under current management practices
	E4	The cutting cycle	Model calculates annual cutting area
	BOX-I		Selecting 'scenario selection' 2 in cell H8 allows the user to input information to create his own scenario in box-I
	I4	-	Changes automatically
	J4	Discount factor	Discount rate - Cell E5 should show the same figure
	K4	Log price	Enter as a percentage of the figure in cell G4. The figure which the model is using is shown in cell G5
	L4	Management costs	Enter as a percentage of the mgmt. costs detailed in the Unit Cost Component. Best to keep at 100% and alter individual costs in UCC (see below)
	M4	Mean Annual Increment – Primary forest	Changing this figure influences the Net Yield figure in cell E25. SYMFOR will give a gross yield from virgin forest, which multiplied by a 'utilisation factor' (usually 0.52) will give the net timber yield. Use cell M4 to get the desired figure for *net* yield in cell E25
	N4	Mean Annual Increment – Logged over area	As above, this influences the figure (in cell E26) for net yield from second cycle forest
	Q3	Current year	Tells the model what stage of the cycle you are at and when (if) you will start to harvest from logged over areas. The figure in cell Q5 automatically changes.
	S3	First cutting year	
	E27	Timber from non TPTI sources	e.g. roadbuilding areas. SYMFOR will not provide this information. Usually enter 0 here.

Cells E43-E66 also contain figures in green that the user can change if he feels this would better represent his concession.

It is obvious from the table above that only the green figures (in the spreadsheet model) should be changed by the user. This is the case on all sheets of the model. Note: whilst only the green figures should be altered, it is not always necessary to alter all of them.

<table>
<tr><th colspan="4">Unit cost component</th></tr>
<tr><th>Step</th><th>Cell</th><th>Required entry</th><th>Reason / Information</th></tr>
<tr><td></td><td>H116</td><td>0% or 10%</td><td>The entry here influences the figure in cell E116. Entering 0% (for conventional logging) leaves cell E116 unaltered. Entering 10% inflates the cost of Pre-felling inventory in cell E116 by 10% (this figure has been used to reflect the increased costs of RIL).</td></tr>
<tr><td></td><td>H133</td><td>0% or –50%</td><td>The entry here influences the figure in cell E133. Entering 0% (for conventional logging) leaves cell E133 unaltered. Entering –50% deflates the cost of Skidding in cell E133, to reflect the benefits of RIL.</td></tr>
<tr><td></td><td>H182</td><td>0% or 10%</td><td>The entry here influences the figure in E182. 0% has been used for conventional logging, and 10% for RIL, to reflect the cost of increased training requirements.</td></tr>
<tr><td></td><td>D142</td><td>1 or 2</td><td rowspan="2">These figures influence whether or not forest management activities 1-9 (cells B 146-154) are performed. If 1 is entered, a unit price for each activity appears in column E, and this can be changed by altering the green figures in column G. If 2 is entered, management activities 1-9 have a cost of zero. In analyses linking SYMFOR with this model to date, these forest management activities have not been employed (therefore have been given a cost of zero)</td></tr>
<tr><td></td><td>G142</td><td>1 or 2</td></tr>
</table>

<table>
<tr><th colspan="4">Cost Processing Component</th></tr>
<tr><th>Step</th><th>Cell</th><th>Required entry</th><th>Reason / Information</th></tr>
<tr><td colspan="4">Unless the user has an accurate and comprehensive set of data relating to machine productivity and operating costs, it is recommended that all figures in this component should be left as they are. In all linkages with SYMFOR to date, these figures have remained unaltered.</td></tr>
</table>