Economics of Land Use Changes in Cambodia

Kasper Hansen and Dr Top Neth describe the basic principles of a model developed by the Natural Resource and Environment (NRE) unit at CDRI to analyse economic consequences of forest conversion in Cambodia.*

The objective of this part of the NRE unit's research is to assess the economic consequences of forest conversion to other land uses. This is done by comparing the total economic value (TEV) of natural forests and relevant alternatives (e.g. sustainable forest management vs. cashew nut plantation). As part of this economic analysis of changes in land use, the natural resources and environment (NRE) programme of CDRI has developed a model to compare different land use changes in a consistent manner.

This article takes a closer look at what the current model can and can not do, and points out some of the trade-offs between a static model and a more dynamic and complex model that can be adapted continuously as more data become available.

The analysis is based on two kinds of models. One analyses the financial yield of different land use options and converts potential production into expected cost and benefit flows. The second model compiles the economic cash flows from different land use templates and analyses the net present value of different land use changes.

Cost-Benefit Analysis

The main analytical tool used in the model to analyse the economics of different land uses is cost-benefit analysis (CBA). CBA is one of the most commonly used tools in environmental economics and is also used to evaluate the economic viability of investment projects. It calculates the present value of a stream of costs and benefits in a project, and adds this up to a total net present value (NPV). The NPV can be described as the difference between the present discounted value of benefits and the present discounted value of costs. A project is generally considered profitable if the NPV is positive. An important factor in the analysis is the discount rate, which is used to convert all costs and benefits to a comparable present value. Discounting incorporates the time value of money into the analysis in order to make culculations comparable. It assumes that a person would rather have one dollar today than one dollar in one year since today's dollar can be invested into an alternative project and hence be worth 1 + the interest rate of that project in one year. Choosing an appropriate discount rate is therefore one of the most important factors in the CBA, as it affects how much value is put on present flows compared to future flows. The general formula for the NPV is:

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

where n is life span of the project, t is the time in years, Bt is benefit at time t, Ct is cost at time t, r is the discount rate, 1/(1 + r)t is the discount factor at time t, and $\sum$ is sum of flows.

Another important concept in environmental economics and economic CBA is externalities. Land use systems have positive and/or negative short or long-term effects on their surroundings that provide additional benefits and costs to the society. These values are not included in a financial CBA, which includes cost and benefits only from a private point of view. An important part of the economic analysis is to value all services provided by forests and other land uses, such as local use of minor products, watershed protection and erosion control. This is included in the model using a TEV approach, in which both direct and indirect values are included in the valuation of forests and other land uses (e.g. Gregersen et al. 1995).

Basic Principles of the Model

The model developed for the project is essentially a collection of connected spreadsheets in Microsoft Excel 2003. The user can choose from among six different land use categories: natural forests, plantation forests, perennial plantation crops, annual crops, eco-tourism and livestock. Each land use category has a template in which data can be entered and yields modelled based on the characteristics of a given land use system (Figure 1).

The yield modelling is more or less complex depending on the land use system. Modelling of sustainable yields from natural forests is, for example, very complex, involving a mix of species in uneven age classes. The natural forest part of the model is therefore not easily understood by a standard user, as technical knowledge on forestry is needed to grasp the concepts of forest growth modelling. It should also be noted that the yield modelling is based on the very limited data available from permanent sample plots in Cambodian natural forests (MAFF 2004). An important feature of the model, however, is that input data can be changed over time as

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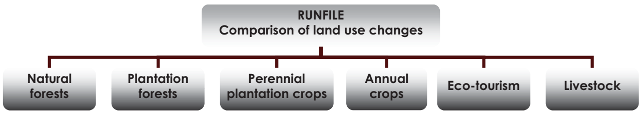
more data become available. The model should in this sense not be viewed as static because it can be adjusted to fit local conditions and improved over time.

Figure 1: Basic principle of how different components in the model are linked to a central RUNFILE, in which different land use changes can be defined and analysed.



In other sheets of the template, costs of inputs and prices of products and by-products (including indirect values) can be entered, and the output of cost and benefit flows over a defined period is summarised in a sheet for each land use. Each summary sheet is then linked to a central file in which different land uses can be defined and the associated NPV calculated based on the data from the land use sheets. The analysis of different scenarios in the central file is based on a comparison of a user-defined baseline and a user-defined alternative. It should be noted that this is not an optimisation model, which tells the user which land use system is optimal. It can only predict how much is lost or gained in a given user-defined land use change.

Baseline and Alternative Scenarios in NRE Research

The baseline chosen for the analysis in the ongoing research at the NRE programme at CDRI covers natural forests, including evergreen, semi-evergreen and deciduous forest types valued for:

Direct values: Non-timber forest products are assessed in market prices based on actual consumption revealed in household surveys, converted to per hectare values.

Indirect values: Forests provide many local, national and global indirect values. Important local factors include watershed protection, soil conservation, animal habitat and cultural values. Globally, forests provide important functions such as carbon storage, mitigating global warming, as well as conserving biodiversity and genetic material for future generations. Most of these values are not well studied in Cambodia. Carbon sequestration and watershed protection, including soil conservation, are valued based on studies undertaken elsewhere in the region (e.g. Brown 1997; Gou 2001).

Option values: In the analysis, it is assumed that in addition to direct and indirect values, the natural forest also represents a potential value in the form of sustainable timber harvesting. This is, however, not practised at present, and the value is therefore included as an option value.

Different types of plantation forest (acacia, eucalyptus and teak), perennial crop plantations (rubber, cashew nuts, oil palm) and agriculture (rice, soy bean, cassava, maize) represent the alternative land uses that will be compared to the baseline using different discount rates (r) while applying a 50-year time frame (n).

Example of Application of the Model

Table 1 illustrates the difference between financial and economic analysis of converting one hectare of deciduous forest to eucalyptus plantations. If only private costs and benefits are included, it seems like a viable option to convert deciduous forests to eucalyptus plantations, assuming a growth rate of 15 m3/ha/year and no changes in costs and prices. However, when lost values from local collection of non-timber forest products, and other non-use values, are included in the analysis, the same project turns negative. This underlines the importance of including externalities in calculations evaluating whether land use changes are viable for Cambodia as a whole.

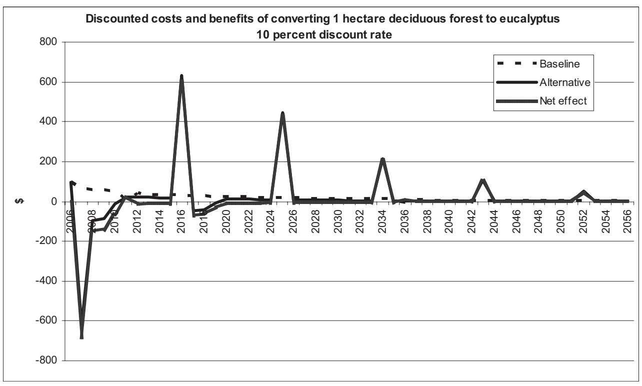
Table 1: Results of converting 1 ha. deciduous forest to eucalyptus*

CBA	NPV
Financial analysis	US$ 395
Economic analysis - including lost values from natural forest	US$ -197

*Based on a 10 percent discount rate

The principle of the calculations in the model is illustrated in Figure 2, where the discounted flows of costs and benefits over a 50-year cycle are shown. In the analysis, both land uses are valued for their TEV, and the model attempts to calculate the net changes in use and non-use values when converting from one land use to another.

Figure 2: Flow of discounted costs and benefits in a scenario in which one hectare of deciduous forest is converted to eucalyptus plantation (growth of 15m3/ha/year) applying a 10 percent discount rate.



The example illustrates that the initial costs of establishing eucalyptus plantations create a large negative net effect in the beginning of the period and that the present value of benefits from harvesting eucalyptus decline in each cycle due to discounting. Altogether, these discounted cash flows add up to a NPV of US$ -197, as listed in Table 1.

Testing the Model and Sensitivity Analysis

It is important to note that models always reflect the quality of the data entered into them. Much effort has therefore been put into cross-checking data, but currently only very limited data are available on production parameters, prices and costs. The results generated by the model are therefore very sensitive to yield predictions and assumptions about costs and prices. An important part of working with any CBA model is, therefore, to test the model's sensitivity to changes in the main parameters. This is included in the model through a sensitivity analysis, which can analyse how sensitive the overall results are to changes in different parameters.

A word of caution should also be included in relation to scaling up the results. Costs and benefits will differ significantly between locations according to factors such as local growth conditions and different transportation costs depending on distances to sawmills, ports or markets. It is therefore not recommended that results be scaled up to a national level, as they will be valid only within a smaller defined area.

Current Gaps in Economic Data for Natural Resource Planning

During data collection and modelling, many data constraints were identified in terms of the yields that can be expected from different land use systems as well as studies on non-use values. Some of the main observations and suggestions for future research areas are summarised below.

Natural forests: Data describing growth in Cambodia's natural forests are limited to those from permanent sample plots in Kompong Thom. Only a few growth data, based on measurements in 1998 and 2000, have been published by the Forest Administration (FA, 2003). The data, however, are analysed only at an overall forest level, which complicates adapting the data to local distribution of tree species. The raw data behind the results are also not published, and it is not possible to analyse growth separately for different species in different forest types. The usefulness of the published data is therefore limited. The planning of forest utilisation at local and national level would benefit greatly if additional data from the plots were analysed and published.

Plantation forests: Data on the growth of fast-growing exotic species, such as Eucalyptus spp. and Acacia spp., in different locations or growth zones of Cambodia are also lacking. Current decisions on establishing plantations are therefore based on very questionable assumptions about growth. Growth of these species is normally fast, but often not as fast as expected due to poor soil quality, poor management practices, low planting densities and poor quality of planting material (see e.g. Barr 2004). Field measurements of the actual production of different exotic species in already established plantations at different locations could be an easy way to get an indication of what realistically can be expected from these plantations.

Perennial crops: Data on yields from perennial crops are also often limited to estimates by companies. These data often represent an optimal situation in order to attract investors and, as a result, the numbers should be interpreted with caution. Data on non-use values of different systems are also lacking. Rubber plantations, for example, have a great deal of positive non-use values from the standing trees through carbon sequestration, erosion control and other services. These values also require more attention from environmental economic researchers.

Indirect values: Environmental valuation in Cambodia is still in its infancy and, consequently, there is still a lack of studies looking at indirect values of different land uses. A few studies provide a description of non-use values of forests or protected areas (Bann 1997; Lopez 2003), but very little research has been conducted on an actual valuation of such areas. A next step in environmental economics in Cambodia would be to conduct more research on valuation of indirect uses to provide decision makers with some more precise numbers of what long-term values they can expect to lose when converting natural forest to other land uses.

Current Target Group and Future Applications of the Model

Due to the complexity of yield modelling and the many constraints on data availability, the model is currently in a very flexible form that tries to make the best of the available data. It is primarily designed to be used by researchers with appropriate technical knowledge on growth parameters and an understanding of environmental economics and the use of Excel. The model could be more user friendly, but this would render it somewhat static, and the possibility of adapting the model to local conditions over time would be lost. A simple model should be based on reliable research data to make appropriate assumptions on main factors, such as growth and yields. Such data are, as mentioned above, currently not available for Cambodia, and there is a high risk that a simple model would lose its accuracy. The current model

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