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An Environmental and Economic Assessment of Forest Management Options: A Case Study in Malaysia

Kanta Kumari

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Glossary

AAC	Actual Annual Cut
EOP	Effect on Production Method
GEF	Global Environmental Facility
IADP	Integrated Agricultural Development Project
NFA	National Forestry Act
NPV	Net Present Value
NTFP(s)	Non-timber Forest Product(s)
PV	Present Value
RAC	Recommended Annual Cut
SFM	Sustainable Forest Management
SS	Study Site
TEV	Total Economic Valuation (Value)
WTP	Willingness to Pay

Abstract

The capacity of natural forests to supply, if properly managed, a perpetual stream of timber and non-timber goods and services has been overlooked virtually everywhere; and Malaysia is no exception. It has been established that one of the most urgent enabling measures for sustainable forest development is the valuation of the resource, in order to highlight the full extent of benefits that can be provided. The framework for valuation adopted in this study was the total economic valuation (TEV) approach which represents both a pragmatic and consistent approach.

A TEV of the flow of benefits from the forests under a range of management options was derived for the peat swamp forests of North Selangor. The analysis sought to illustrate what such TEV would mean in the context of the management of a particular forested site. A variety of methods, such as use of market prices (where available), damage cost avoided approach, surrogate/replacement cost approach and production function effect, were adopted to value some key goods and services of that could be appropriated from the forests of the Study Site. The results of this case study show that even when local benefits alone are considered it is financially profitable to shift from unsustainable to sustainable options. For the shift to more sustainable options to be actually adopted, however, there is a further requirement for new international financial mechanisms. These mechanisms would facilitate the local appropriation of globally provided forest conservation benefits.

The results are significant at both the national and international level. At the national level, a dual strategy must be adopted, one that targets concurrently both the forest and non-forest timber policies. In particular, Peninsular Malaysia must take advantage of its exemplary forest policy and legislation, and take the step towards its practical enforcement. At the international level, the global public good nature of conservation benefits require that new resource transfer mechanisms are agreed and implemented.

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1 Introduction

The omission of non-timber benefits in conventional financial and economic analysis has resulted in the continuous undervaluation of forest resources. This in turn has led to unsustainable paths of timber extraction or to the conversion of forest land to alternative land uses, since both of these options are financially more attractive. Recent research has demonstrated that the real (or potential) magnitude of conservation benefits from forests is substantial and there is a growing willingness to include these benefits as an opportunity cost that would be incurred if forest resources are lost or mismanaged.

The situation with regard to forests, however, is not always one of discrete choices i.e. of development versus preservation. Vast tracts of forests in various countries have been set aside as production forests where the key operative rule is that of 'sustained timber yield.' For example, in Peninsular Malaysia alone, of the 4.75 million ha of forest, 60% will be managed as production forests. 'Sustained timber yield' is not, however, synonymous with 'sustainable forest management.' Often, timber harvesting, the major extractive activity conducted within production forests, can have disruptive or devastating effects on the flow of the other goods and services from the forest. However, if the harvesting is conducted 'carefully' it is possible to ensure continuity of many of the environmental services including hydrological and recreational services, and carbon sequestration. The task at hand then is to demonstrate that this is an economically viable option.

This study seeks to demonstrate, using the total economic valuation (TEV) approach, the economics of shifting from the narrow 'sustained timber practice' to a 'sustainable forest management' system for a specific forest site in Malaysia. The results have management and policy relevance, both at the national and global levels. The incremental costs and benefits of shifting from less sustainable to the more sustainable forms of management provide meaningful insight into whether 'sustainable forest management' is a realistic option at the national level. The initial results indicate that adoption of more sustainable forms of management are practicable, but some form of commitment needs to be made at both the national and global levels. All of this has immediate and direct relevance to the Global Environment Facility, which uses the incremental cost principle to determine what portion of any activity it can finance.

This paper is set out in five chapters. The next chapter, Chapter 2, sets out the theory of the TEV framework used in this case study. Chapter 3 will introduce the study site and provide an overview of the characteristics of the peat forests, including the diversity of forest interactions between the various goods and services within the forests. Chapter 4 details the valuation methodology for each of the TEV components and presents estimates of the value for selected benefits provided by the forests at the Study Site. The last section, Chapter 5, provides an aggregate measure of the TEV under the alternative management regimes and discusses the implications of these results for future forest management strategies, from the local, national and global perspectives. In addition to direct policy relevance of this case study to Malaysia, the approach can also be applied to forests elsewhere in the world.

2 The 'Total Economic Value' Concept and the Valuation of Forests

The concept of 'total economic value' (TEV) (Pearce, 1990) recognizes a taxonomy of economic values as they relate to the natural environment; the main elements of which can be expressed as:

$$\begin{aligned} TEV &= UV + NUV \\ &= DUV + IUV + OV + EV + QOV \quad (1) \end{aligned}$$

where *TEV* = total economic value;
UV = use value;
NUV = non-use value;
DUV = direct use value;
IUV = indirect use value;
OV = option value;
EV = existence value; and
QOV = quasi-option value.

User values or user benefits derive from the actual use of the environment and can further be divided into direct use, indirect use and option values. Values accruing from direct and indirect use of the environment are fairly easy to comprehend. These include logging and fishing which bring direct benefits, whilst a lot of the environmental benefits (e.g. watershed protection) are of a more indirect nature. Slightly more complex are values expressed through options to use the environment (option value) in the future. These are essentially expressions of willingness to pay for the conservation of the environmental system or components of systems against some probability that the individual will make use of them at a later date. Non-use values comprise existence values and quasi-option values. Existence values relate to valuations of the environmental asset that are unrelated either to current or to optional use. Existence value has most recently been re-termed passive use value. These values are still anthropocentric but may include a recognition of the value of the very existence of a species or whole ecosystem. Quasi-option value relates to willingness to pay to avoid an irreversible commitment to development now, given the expectation of future growth in knowledge relevant to the implications of development.

This TEV concept can be applied to the forest resource. Figure 1 provides a classification of the concept in the context of sustainable forest management.

Direct use values include timber and non-timber forest products and tourism (recreation). Although straight forward in concept, they are not necessarily easy to measure in economic terms. The output of 'minor' forest products (e.g. rattan, latex and fruit etc.) is measurable in terms of market data; but other outputs such as medicinal plants or house building materials may be more difficult to measure and value.

Indirect values are essentially the ecological functions of the forests; such as their watershed protection and mineral cycling functions. When the tropical forest systems are intact at the 'landscape' level (Norton and Ulanowicz, 1992) they help to protect watersheds, but their removal or contraction beyond some threshold level may result in increased water pollution and siltation, depending on which alternative use the forest land is put to. This watershed function, as with some other

Figure 1:
Classification of the Total Economic Value Concept for Sustainable Forest Management

Total Economic Value =

Use Value + **Non-use Value**

(1)	(2)	(3)	(4)	(5)
Direct Value +	Indirect Value +	Option Value +	Bequest Value +	Existence Value
Sustainable Timber	Nutrient Cycling	Future Uses as per (1) + (2)	Future Generation Uses as per (1) + (2) + (3)	Preserving Biodiversity
Non-Timber Products	Catchment Protection			
Recreation	Air Pollution			
Medicinal Plants	Micro and Macro Climate			
Education				
Research				
Human Habitat				

Source: Adapted from Pearce (1990)

indirect functions, is not bought and sold in the market place. Tropical forests also 'store' carbon dioxide which when the forests are burnt for clearance, is released into the atmosphere contributing to greenhouse gas atmospheric warming. Another type of indirect use is linked to the efficient nutrient cycling that takes place in the forests. The capture of above and below ground nutrients is crucial to the forest's stability and resilience (Nykvist et. al., 1994).

Individuals may also express an *option value* linked to the conservation of the forest stock. Option value is like an insurance premium which individuals are prepared to pay to ensure the supply of something (the forest and its multiple goods and services provision), the availability of which would otherwise be uncertain. A related form of value is *bequest value,* a willingness to pay to preserve the forest for the benefit of one's descendants. It is not a use value for the current individual valuer, but a potential future use of non-use value for his or her descendants.

Values conferred by humans on the forests regardless of use constitute *existence value.* Its intuitive basis is easy to understand because a great many people are willing to pay for the existence of environmental assets, and highly endangered species (e.g. bald eagle, blue whale) through wildlife and other environmental charities, but without taking part in the direct use of the wildlife through recreation.

In the context of this study, the TEV concept will be applied to a range of forest management options investigated. What is important to understand here is that the TEV for a particular tract of forest (in this case the Study Site) is not a fixed value; rather, the total value at any one time is a function of the type of management practiced at that forest site.

3 The Study Site

Location and Current Status

The Study Site selected for analysis consists of the peat swamp forests located in the Malaysian state of Selangor (Map 1). These swamp forests lie adjacent to the biggest single agricultural investment in the state i.e. the Integrated Agricultural Development Project (IADP), a padi producing scheme consolidated in 1978 (Map 2). The World Bank in its scheme appraisal, recognized these peat swamps as vital to the viability of the IADP scheme because of their water storage and supply roles, and they attached great importance to Government assurances that the peat swamps would be protected as Forest Reserves, and not drained (IBRD, 1978). The Selangor State Authority endorsed this position when it gazetted the area into two reserves which are contiguous to each other, and which extend over 72,816 ha (Map 2). Prior to their status as Forest Reserves, the forests were classified as Stateland forests, and had been subject to logging for more than 30 years. Logging in Stateland forests is not subject to the more stringent rules which apply to reserved forests, and consequently the forests are not in an entirely satisfactory ecological condition.

The major rivers in the vicinity of the Study Site are the Bernam River which lies just north of the Study Site, and the Tengi River which traverses the swamp forests from east to west (Map 2). These two rivers are linked by an artificial canal referred to as the Feeder Canal. The natural drainage density is very low, but quite a large number of drainage canals have been dug by logging companies in recent years to allow for the movement and transportation of logs out of the peat forests (Pons et. al., 1988; Chan, 1989). The effects of such modifications will be discussed shortly.

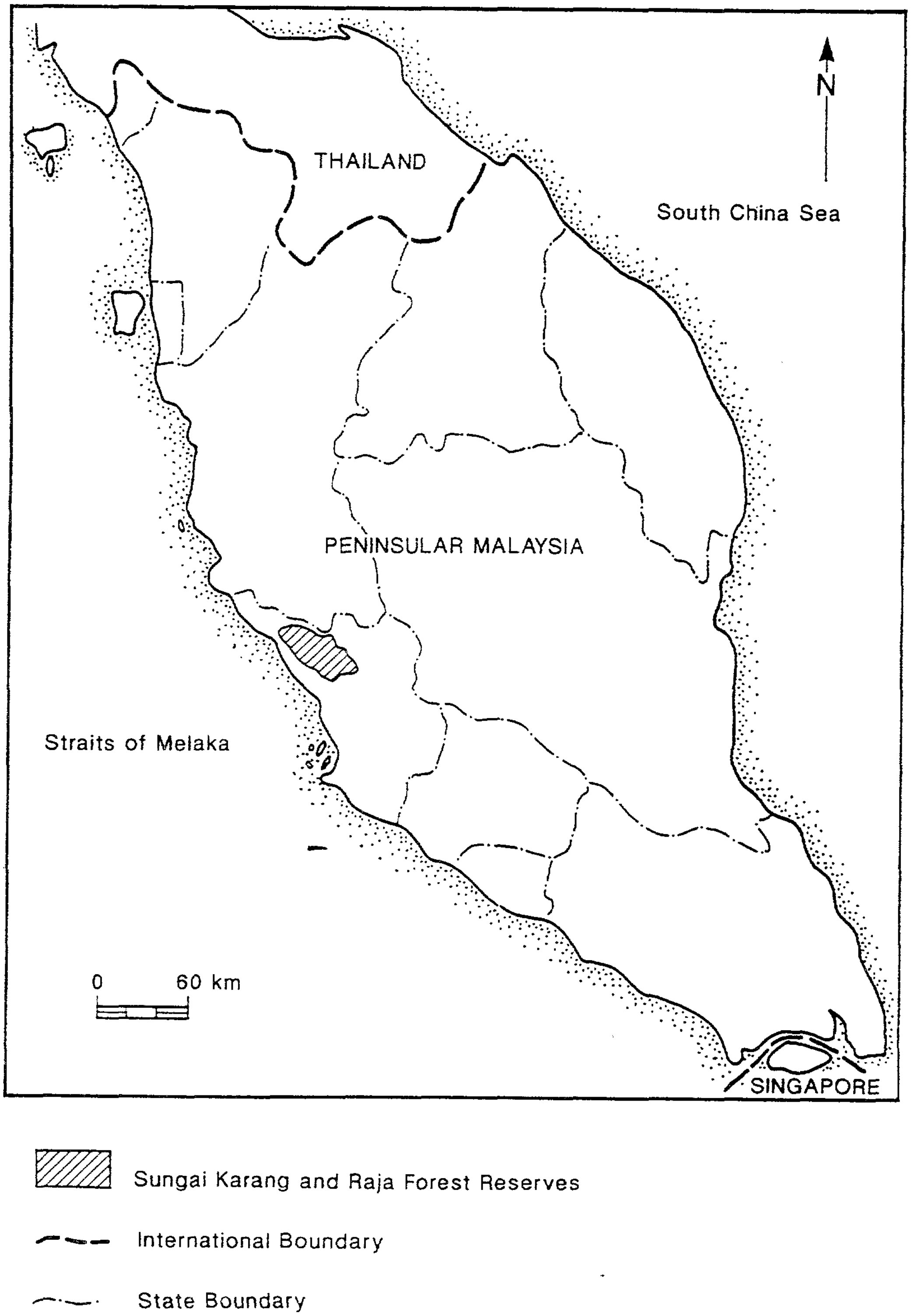
Characteristics of the Study Site

An understanding of the natural characteristics of the peat swamp forests is integral to the derivation of its TEV, as they relate directly to the flow of goods and services from the forests.

Peat swamps form where there are permanent waterlogging and anaerobic conditions (Coulter, 1950). There is considerable scientific evidence that these forests have an important regulating or controlling function on the hydrology of entire catchments; and in their natural conditions they have been deemed to act as a balancing reservoir, smoothing the pattern of outflow during periods of heavy rainfall and drought (Andriesse, 1988). At the Study Site four distinct hydrological benefits have been identified, namely the agricultural water supply, flood mitigation, regulation of ground water table against saline intrusion from the coast (IBRD, 1978; Low and Balamurugan, 1989; Prentice, 1990) and provision of domestic water needs to the IADP residents. A fair amount of evidence exists which is indicative of real and potential dangers to the continuity of these hydrological services from the Study Site owing to the indiscriminate patterns of logging prevalent there.

Chan (1989) records that in terms of timber production, the Study Site is one of the most

Map 1
Peninsular Malaysia and the North Selangor Peat Swamp Forests



Map 2
Location of the Peat Swamp Forests (Study Site) and the Integrated Agricultural Development Project (IADP)

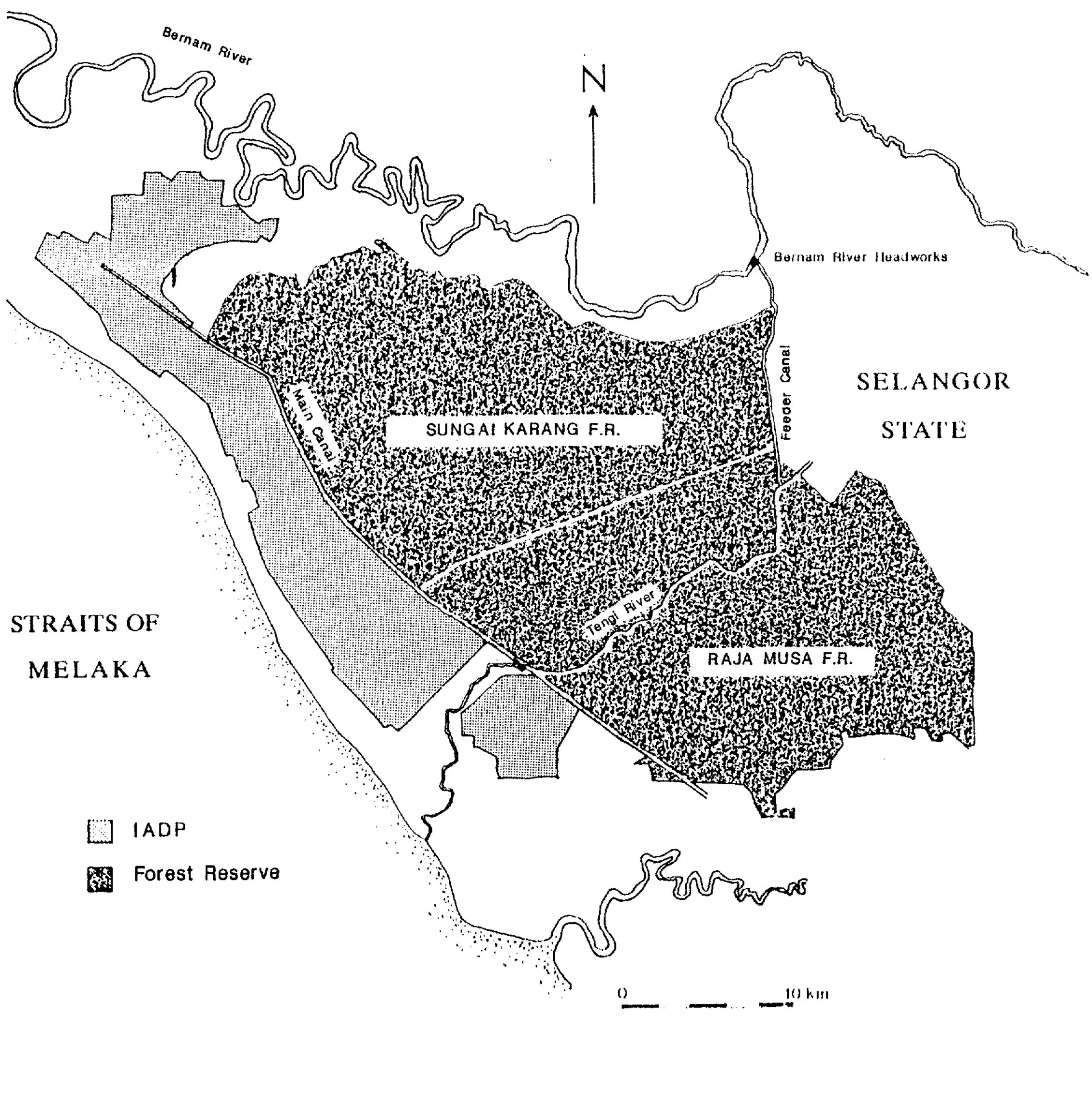


Table 1
Summary of the Effects of the Different Logging Methods on the Peat Swamp Forests

Logging method	Logging costs	Silvi-cultural costs	Timber stand damage	Hydrology & habitat modification	Other adverse effects	Overall status
Kuda-kuda	L/M	L	L	L	L	S
Winch						
+ tramline	M/H	L/M	M	L	L	S
+ canal	L/M	M/H	M	M/H	M/H	U
Traxcavator						
+ tramline	M/H	M/H	M/H	M/H	M/H	S/U
+ canal	L/M	H	H	H	H	U

Notes:
1. The effect of the logging methods are graded as low (L), medium (M) and high (H).
2. The overall status gives some qualitative indication as to whether the overall resultant habitat will be unsustainable (U) or sustainable (S).

productive peat swamp forests in the country. Logging in peat swamp forests, however, poses special problems because of the water-logged nature of the soil, which cannot withstand the high pressure exerted by logging equipment typically used in dryland forests. Consequently, special methods have evolved for logging in these swamp forests. The logging operation is divided into two phases, namely, extraction and transportation. The extraction involves the felling of trees and their transfer to a common hauling point. Felling can be done using the *kuda-kuda* (timber sledges), the winch or the traxcavator. These logs have then to be transported from the hauling point to the nearest road system from which they can then be taken to the sawmills. The transportation can be done by the use of *panglongs* (special pathways, where logs are dragged by man), along tramlines or along canals dug out in the peat forests. The logging method used for each phase, and in particular its precise combination of practices, has important implications on the sustainability of the overall ecosystem. This is because the logging method has the effect of not only altering the habitat structure and the rate and type of regeneration, but also the effectiveness of hydrological services from the forests. Annex 1 provides background information on the evolution of these three logging methods with particular emphasis on their effects on the peat swamp habitat during logging. Table 1 provides a summary of the likely intensity of effects of the different logging methods used in peat swamps.

4 Total Economic Valuation at the Study Site under Alternative Management Options

Framework for Analysis

Up to very recently, the forests at the Study Site have largely been managed for timber; operating at highly unsustainable rates of extraction. The TEV model was applied to the Study Site for a series of alternative management options reflecting a shift from unsustainability to sustainability. This shift to sustainability can be made explicit through a two step move (Figure 2).

In Step 1 the shift is from the current option A which operates at unsustainable rates of timber extraction to a hypothetical option B where the sustained timber yield principles are observed. The main variable addressed in this step is that of timber. This shift from unsustained timber harvests to sustained timber harvests is a necessary but not sufficient condition for overall sustainability of the forests. That is to say that even if the 'sustained timber yield' constraint is observed, the method of logging practiced could still disrupt the continued flow of the environmental services from the forests. Hence there is a need for further environmental constraints to be observed.

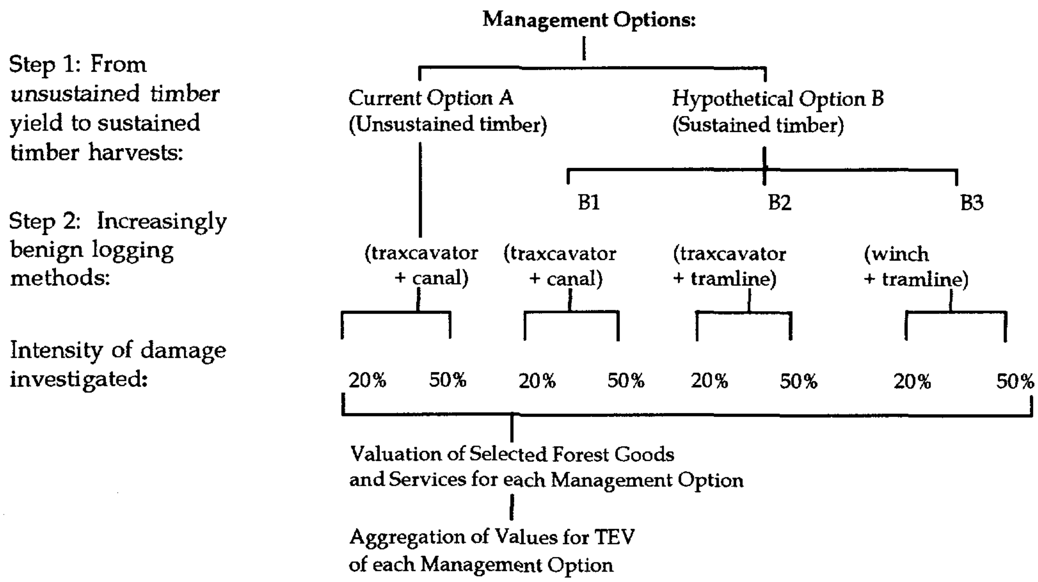
In Step 2 the hypothetical option B is subject to increasingly benign methods of logging which would have less adverse impacts on the continued flow of the environmental services from the forests. In effect, the more environmentally benign logging methods can be likened to environmental constraints. Three combinations of logging methods were considered here: traxcavator + canal (currently the most popular), traxcavator + tramline, and winch + tramline; in order of decreasing damage to the environment[1]. To demonstrate the effects of such improved forest management the hypothetical option B was examined at three levels, represented here as options B1, B2 and B3. These three options represent sustained yield harvests, but under increasingly benign logging methods which would incur a decreasing amount of damage to the environment.

Hence a total of four options were investigated here for their TEV: option A (at current unsustainable timber harvests rate, using prevailing destructive logging method (traxcavator + canal)); hypothetical option B1 (at sustained timber harvests, using destructive logging method (traxcavator + canal)), hypothetical option B2 (at sustained timber harvest but with improved logging method (traxcavator + tramline)) and hypothetical option B3 (at sustained timber harvest and an even more benign logging method (winch and tramline)).

Habitat damage of the remaining stand during logging has been reported to be very variable, from between 15-50% (World Bank, 1991) to 79% (Lanly, 1982; Liew and Ong, 1986; Chin, 1989). Each of the four options was investigated for 20% and 50% damage intensities, approximating to the mean lower and upper bounds of damage.

Figure 2 provides a schematic diagram of the management options investigated in this study, and for which the resulting value of the forest 'outputs' was derived as the 'total economic value'. The following steps were performed for each of these management options:

Figure 2
Forest Management Optins for Which the Total Economic Value Was Estimated



- a physical audit of each good and service at the Study Site under sustainable and unsustainable management regimes;
- valuation and discounting of benefit flow for each good and service in order to estimate its net present value (in M$/ha); and
- aggregation of the values to derive the TEV, and discussion of the implications of the results on forest management and policy.

Table 2 provides a summary of the goods and services valued in this study. The details of the valuation method, assumptions and limitations in deriving the value for each of these TEV components will be outlined in the relevant sections. The value of each of these goods and services is expressed on a per hectare basis so as to allow for the later aggregation of these components to obtain the TEV at the Study Site under each management option. All projections were carried out over a 100 year period so as to facilitate the proper construction of a physical impacts audit. The period also approximates to an infinite period, in discounting terms. A conventional discount rate of 8% and a lower 2% rate was used. The latter was used in order to give full weight to the long run sustained conservation benefits.

The Value of Timber Benefits

To enable the estimation of the current and potential annual value of the timber resource from one hectare of forests at the Study Site the following steps were taken:

- an assessment of the state of the forests at the Study Site;
- estimation of the total physical stock from the stocking density, and from it the potential annual stock available for harvest under sustainable and unsustainable management options; and
- potential annual value of the timber resource from the Study Site, discounted to give the net present value per hectare.

State of the Forests

There is sufficient information and evidence to show that the Study Site has been subject to escalating levels of deterioration (Pons et. al., 1988; Chan, 1989). From an inspection of aerial photographs taken in 1983 and the maze of cut lines (representing present and previous extraction tracks and canals) in the Study Site, Chan (1989) observes that it is unlikely that there is any virgin, primary forest remaining in the Study Site. This ubiquity of the tracks

Table 2
Goods and Services Valued at the Study Site

Type of Good/ Service:	Product/ Function:	Type of Value:	Valuation Method:	Data Source/ Approach:
Timber	Wood	Direct	Market Price	From forest harvest levels, mean annual increments, etc. National Forest Inventories (FFD, 1987)
Non-timber	Rattan, bamboo	Direct	Market Price	National Forest Inventory 2 (FFD, 1988)
Hydrological	Agricultural	Indirect	Effect on production	Equal to second crop of rice. Data on the hydrological disturbance in the swamps used to determine the effect on water shortage on the crop of padi.
	Domestic	Direct	Market price	Water abstracted from the Main Canal to meet the domestic requirements for the residents at the agricultural scheme.
Recreation	Recreation	Indirect	Surrogate trave cost	Derived potential recreational value of the Study Site based on information from existing visitor numbers to the Nearly Kuala Selangor Nature Park. Valued using result of consumer surplus derived using TCM for visits to forest recreational sites in Malaysia.
Carbon sequestration	Carbon sink	Indirect	Damage avoided cost	Used information on the biomass and carbon stock in peat swamp forests to determine the amount of carbon stored in the forests. Establish the rate of carbon sequestration from the growth activity.
Sumatran rhino	Endangered	Existence	Contingent valuation Opportunity cost	Used mean CVM estimate from other to calculate WTP by Malaysians for the population of rhinos at the Stud Site. Foregone timber benefits deducted out for area set aside for preservation.

was further confirmed from land satellite photographs taken more recently (obtained through the Malaysian Centre for Remote Sensing (MCRES) for 1987, 1990, 1991), and analyzed in the course of this study. What percentage of this logged forest is damaged is a more difficult issue to resolve. This information is necessary for the derivation of stocking density and physical stock of timber, since both these parameters get reduced in logged over and damaged forests. Based on the available information on the Study Site: the land satellite pictures, logging history of the area and the recent study by Pons et. al. (1988), the assumption that 10% of the Study Site is damaged would seem fairly conservative.

For the analysis at the Study Site, the percentage and extent of forests assigned to each category is as follows:

primary forests:	0%	0 ha
logged forests:	90%	65,534 ha
damaged forests:	10%	7,282 ha.

Stocking Densities and Potential Annual Stock Harvested at the Study Site

From the second National Forest Inventory (FFD, 1987), the volume of wood available for harvest at dbh (diameter at breast height) greater than or equal to 45 cm (the official cutting limit for commercial harvests) over a 45 year cycle was estimated as 48.1 cu.m/ha. Operating at sustainable levels of harvest, this gives a mean annual increment (MAI) of 1.07 cu.m/ha/year. Unsustainable harvests in the states of Peninsular Malaysia were known to operate at 80% above the recommended annual cuts i.e. giving a harvest of 1.92 cu.m/ha/year. Table 3 provides a summary of the main features for each option investigated for their timber value, at the different damage levels.

Estimation of the Value for Timber

Timber from the peat swamps represents a direct use good and the method used for its valuation is that of direct market analysis. An export restriction on all, except small diameter logs has been in force in Peninsular Malaysia since 1985. To correct for this distortion information was drawn largely from two sources: EPU's (1993) natural resource accounting for timber in Malaysia, and the World Bank Forestry Sector Review for Malaysia (World Bank, 1991).

Using the export price for Sabah, but retaining logging costs for Peninsular Malaysia, the analysis by EPU (1993) showed stumpage values for Peninsular Malaysia to have risen from M$100/cu.m to M$135/cu.m between 1970 and 1990. Extrapolating from the Sabah and Sarawak situation, the World Bank cites the corrected stumpage value as M$184/cu.m for 1990; with logging costs of M$70/cu.m (World Bank, 1991). According to the same report, helicopter logging which is supposed to be the most environmentally friendly gives a stumpage value of only c. M$65/cum because of the higher costs (M$115/cum) of the sophisticated equipment.

The stumpage value or resource rent represents the difference between the price of logs paid by a mill or exporter and the average total cost of harvesting logs and transporting them to the point of sale (i.e. log price - average total logging cost). Now in the case of the Study Site, the logging costs at any one time would be determined by the logging method used: the higher the costs the lower the stumpage value. Thus, at any one time, different stumpage values estimated in the above studies can be used as proxies to reflect the variation in logging methods.

The three logging methods investigated here were assigned different stumpage values for the timber harvested (Table 3). The most destructive, but cheapest logging method (traxcavator + canal) used in option A and B1 was assigned the highest stumpage value of M$ 184/cu.m. The second method (traxcavator + tramline) used in option B2 represents a slightly more expensive method, and the stumpage value gets reduced to M$ 135/cu.m. Option B3 which uses the least destructive, but most expensive logging method (winch + tramline) was assigned a value of M$ 100/cu.m. It was assumed here that option B3 would have a stumpage value which is a mean of option B2 and the helicopter logging method.

Value of Timber for the Alternative Options

The more environmentally benign logging methods, and hence more expensive methods, can be likened to environmental constraints. The results in Table 3 show that at a discount rate of 8%, the sustainable B1 option gives NPVs which are slightly higher than those for the unsustainable A option. This suggests then that it would not pay the private logger to adopt a sustainable regime over the current unsustainable harvest pattern. At lower discount rates of 2%, the B1 sustainable option gives NPVs which are higher than the A option. These results hold true at both damage levels. The detailed discounted cash flows are presented in Annex 2 (Table 1).

It is important, however, to place the damage levels in their correct context. It is very unlikely that logging patterns under option A and B1, which employ very destructive methods, could operate at damage levels below 20%, and are more likely to range between the 20% and 50% damage levels. On the other hand, logging under option B3 is not likely to incur damages beyond 20%, and if executed carefully could be even less destructive; the same could be said of option B2. This suggests that at the 8% discount rate, the NPV per hectare under Scenario B1 could range anywhere between M$ 1453 - M$ 2360/ha, whilst under Scenario B2 the mean value would be c. M$ 1750/ha. This shows that although the financial returns from quick logging offer significant short term gains, the increased damage incurred during these operations may reduce the discounted long run financial benefits sufficiently to favour sound methods of logging.

Overall, it is difficult to decide which is the best scenario to pursue without considering the benefits, and especially the trade-offs, related to the other non-timber goods and services.

Value of the Hydrological Benefits

The hydrological benefits valued at the Study Site were confined to the agricultural and domestic water benefits. The other two benefits of flood mitigation and regulation of water table against saline intrusion were not valued. The rationale is that it is the water retained during the wet season (which helps in flood mitigation and prevention of saline intrusion) that is potentially available for the agricultural needs of the dry season and domestic water supply. This would also ensure against any double counting.

Agro-Hydrological Value

The production effect method was used to derive an estimate for the agro-hydrological benefits of the forests of the Study Site. The economic value of the second crop of padi (planted during the dry season) from the agricultural site adjacent to the Study Site was taken as a proxy of this agro-hydrological value.

The role of the forests at the Study Site in supplementing water to the padi production, especially that for the dry season crop, had recently been a subject of controversy due to the findings of a JICA (1987) study. A review of all the information, and further hydrological studies in the area, however, suggests that the balance of current evidence is in favor of a positive agro-hydrological role from the swamps of the Study Site (Kumari, 1994).

In this study the basic premise is that the agro-hydrological value of the swamp forests is at least equal to the economic value of the second padi crop which is planted in the dry season, since the latter relies on the swamps for the supplementary water supply. The analysis proceeds by establishing the link between measurable changes in the disturbance of the peat swamp forests and changes in the level of agro-hydrological services that can be accrued from the Study Site; and subsequently by linking these to changes in economic gains and losses of the padi crop. The following steps were taken to estimate the agro-hydrological value at the Study Site:

- to estimate the increase in the extent of canals and waterways, and the corresponding increased seepage (loss) of water out of the swamps;
- to establish the effect of this increased drainage and potential loss of water on the output of padi in the adjacent agricultural area; and
- to calculate the economic impacts of the agro-hydrological benefit using the 'Effect on Production' method.

The logging activity at the Study Site has resulted in an extensive network of drainage ditches and log extraction canals excavated for the transportation of logs out of the peat swamps. The increase in the extent of waterways has implications for the amount of water that potentially seeps outs of the peat swamp ecosystem. The estimated volume of seepage varies considerably, from 3.56 l/s/km reported by JICA (1987) to a higher value of 10-12 l/s/km by Low and Balamurugan (1989). The two seepage rates will be used to represent upper and lower estimates for the increasingly disturbed conditions of the peat swamps, and we calculate also a median (mean) estimate (Table 4).

Land Satellite pictures, taken over the Study Site were available for 1987 and 1991 through the MCRES (Malaysian Centre for Remote Sensing). These pictures, at a resolution of

Table 3
Features of the Logging Optionss at the Study Site

Feature:	Unsustainable Option A:	Option B1:	Sustainable Option B2:	Option B3:
Forest extent (ha)	72816	72816	72816	72816
Logged (ha)	65534	65534	65534	65534
Damaged (ha)	7282	7282	7282	7282
Mean weighted density (cu.m/ha)	48.06	48.06	48.06	48.06
Total potential stock (cu.m)	3499537	3499537	3499537	3499537
Actual annual cut (ha/yr)	2912	1618	1618	1618
Log cycle (y)	25	45	45	45
Annual harvest (cu.m/y):				
0% Damage	1.92	1.07	1.07	1.07
20% Damage	1.54	0.86	0.86	0.86
50% Damage	0.96	0.54	0.54	0.54
Logging method	Exc.+Canal	Exc.+Canal	Exc.+TL	Winch+TL
Stumpage value (M$/cu.m)	184	184	135	100
NPV/ha (8%) (M$/ha):				
0% Damage	4299	2981	2287	1964
20% Damage	3448	2360	1750	1276
50% Damage	2149	1453	1085	804
NPV/ha (2%) (M$/ha):				
0% Damage	7994	13388	12285	9100
20% Damage	6412	9693	6048	4477
50% Damage	3997	5163	3467	2573

Notes:

1. The forests at the SS was assessed as 90% logged, and 10% damaged; there being no undisturbed forests.
2. Mean weighted density for all trees > or = 45cm dbh, which represents the cutting limit for commercial trees.
3. The recommended log cycle for peat swamp forests is 45 years, which gives a RAC of 1,618 ha, and which is seen to represent the sustainable regime. The actual cur in the peat swamp is assumed to operate as for the rest of Selangor state i.e. 80% higher than the RAC. This corresponds to the unsustainable harvest of 2,913 ha.
4. For sustainable regime the harvest rate = mean annual increment i.e. 1.07 cu.m/yr. for the unsustainable regime it is 80% higher at 1.92 cu.m/yr. Losses due to damage are in proportion to intensity of damage.
5. At constant timber prices, stumpage value is seen to be the inverse of logging costs. For details on logging methods and costs see text.
6. All projections, physical and monetary, conducted over a 100 year period.
7. Exc. = excavator; TL = tramline.

30m X 30m, were analyzed for information on the level of dissection due to logging, as this has direct implications for the hydrology of the area. Use was also made of the Spot Imagery pictures which because of their higher resolution (10m X 10m) provide a closer magnified view which allowed waterways to be distinguished from other non-waterway tracks. The spot image pictures, however, were only available for 1990. Synthesizing the information from the Land Satellite and Spot Imagery, the total extent of the waterways was estimated at approximately 95km in 1987 and 130km in 1991, giving an annual increase of c. 8.8 km/y (Kumari, 1994). This annual increase in waterways was then used to establish projections for the extent of hydrological disturbance into the future.

The 'live' available storage capacity of water in the swamp forests of the Study Site was estimated by the World Bank (IBRD, 1978) to be c. 148 million cu.m.. It seems reasonable to

Table 4
Summary of the Hydrological Disturbance Scenarios

Scenario:	Seepage Rate (l/s/km):	Effective Length (km):	Total Seepage (cu.m):	% of 'Live' Moisture:	Critical year of hydrological disturbance:
A: Low	3.56	356	40 X 10^6	27%	Year 88 (2077)
B: Medium	7.28	356	82 X 10^6	55%	Year 18 (2007)
C: High	11.00	356	124 X 10^6	84%	Year 6 (1995)

Notes:
1. See page for baseline year; 1990 is deduced by back calculation from 1991 data.
2. Total extent of waterways in 1990 was 196 km (comprising feeder canal (14.5km), Tengi River (24.5km), Main Canal (36.0km) and logging canals (95 km)). The effective waterways is 356 because seepage losses from forests occur on both sides of the waterways, except for the Main Canal since one side is adjacent to the padi fields.
3. The maximum extractable volume ('live storage') of the swamps was cited as 148 X 10^6 cu.m. which represents the threshold limit, and abstraction beyond this limit is likely to impair the water balance.
4. The critical year represents that year at which the 'live storage' is exceeded, assuming projections in the increase of hydrological disturbance due to the increase in waterways (at c. 8.8km/year) and corresponding increase in seepage.

assume that as long as the abstraction of water from the swamps in any one year remains within that of the maximum 'live' storage capacity (IBRD, 1978), then the production of the second crop will not be affected, at least any damage cannot be attributed to water deficit conditions.

Incorporating the hydrological disturbance at a rate of 8.8 km/year, into the respective scenarios demonstrates the cumulative effects of such environmental disturbance. Table 4 suggests that at 1990 levels all three scenarios fail to breach the critical 'live' storage limit; but at high disturbance rates the threshold (i.e. of 148 million cu.m) will be exceeded by Year 6 (1995), whilst at moderate levels it will be exceeded by Year 18 (2007). The low disturbance scenario remains within the critical limits up till year 88 (2077).

The next step was to link these measurable changes in the disturbance of the peat swamp forests to changes in economic gains and losses in the production of padi. Based on information on production losses associated with drought in other parts of the country, the assumption was made here of a moderate 10% decline in production for every successive year that the seepage exceeded the threshold limit (Kumari, 1994). Although the wet season crop does not rely directly on the water from the swamps, it is likely that the disruption of the wider water table may have an effect on the crop. It is assumed here that beyond the critical year, the cumulative hydrological disturbances will also have the effect of reducing the wet season crop production by 2% per year.

The total rice production from the IADP for 1990 was 59,200 tons; which at a value of M$818/ton gave a total agricultural value of M$48.4 million[2]. Expressed on a per hectare basis for the entire Study Site (i.e. 72,816 ha), the agricultural value is estimated at c. M$665/ha. To be on the conservative side the agro-hydrological value in this study was taken to be 10% of this agricultural value i.e. M$66.5/ha/year (Table 5).

The agro-hydrological value was calculated on the basis of an incremental loss of productivity (of 10% for the dry season crop and 2% for the wet season crop) for each year that the live storage is exceeded. The present value, at 8% discount rate, of the agro-hydrological benefits is observed to decline from M$ 999/

Table 5
Estimation of the Agro-Hydrological Value for the Baseline Year, 1990

	1990
Cropped Area (ha)	16,000
Unit Yield (t/ha)	3.7
Production (t)	59,200
Price (M$/t)	818
Total Agricultural Value (M$)	48,425,600
Agricultural Value/ha (M$)	665
Agro-hydrological Value for Study Site (M$/ha/year)	66.50

Notes:
1. The data on crop production is for the off-season crop at the IADP.
2. The agro-hydrological value is calculated as 10% of the full agricultural value.

ha to M$ 730/ha to M$ 319/ha as the hydrological disturbance increases from low intensity to a high intensity. This represents a loss of benefit due to the increased hydrological disruption. Detailed discounted cash flows are presented in Annex 2 (Table 2). The divergence between the present value per hectare at the various levels of disturbance increases at the lower discount rate, because of the increased relative weight given to benefits accrued further into the time horizon. The estimated agro-hydrological values were based on very cautious assumptions and hence represent a very conservative, lower bound estimate. Under a risk averse strategy therefore hydrological benefit value could conceivably be estimated to be twice the value calculated here.

In assigning these agro-hydrological values to the management options, the following rationale was applied. Option A and B1 which use the most destructive logging method (traxcavator and canal combination) would incur the highest hydrological disturbance, and hence the value accrued from the agro-hydrological benefit would be the lowest i.e. of M$ 319/ha. For option B2 the medium value of M$730/ha was used; and for B3 which uses the most benign logging option, the agro-hydrological value provided by the forests would be the highest estimate of M$ 999/ha. For each of these management options, however, the value at the 20% and 50% logging damage is not envisaged to be different because the consequences of increased damage during logging are land based rather than water based i.e. as damage to the standing stock of forest.

This analysis suggests that if the agro-hydrological benefits are to be sustained over the long term, and inter alia the flood mitigation and water table regulation benefits, there has to be a definite change in the logging method adopted in the Study Site.

Domestic Water Value

The storage and supply characteristics of peat swamps facilitate year round abstraction of water to supplement the domestic and industrial water demand for the IADP area. Since 1988, about 6 mgd (million gallons per day, where 2200 gallons = 1 cu.m.) of water have been abstracted directly from the Main Canal in the Study Site to supplement the needs of c. 45,000 residents in the IADP area. At the present time, there is no alternative source of water for these residents. The treatment cost of this water at c. M$0.40/cu.m. is 25% higher than at other treatment plants due to the colouration of the water, its acidic nature and sedimentation load.[3] This incremental treatment cost will be used as a surrogate for the domestic water benefits derived from the Study Site. The cost of treatment quoted here corresponds to that incurred under current unsustainable logging practices and the corresponding sedimentation load produced.

With the shift to sustainable harvests, and the adoption of more environmentally benign logging methods, it is assumed that the treatment costs could be reduced. This reduction may, however, only be marginal because the main expense in water treatment is to counteract discolouration and acidity. Hence only a single value for domestic water benefits for all the management options appraised in this study.

The estimated domestic water benefits/ha are based on a projected annual increase of 2% in the annual volume of water abstracted from the swamps thought necessary to meet the growing needs of the community (JICA, 1986) at the marginal treatment costs assumed above. The present value for the benefits of domestic water at 8% and 2% discount rates was calculated as M$30/ha and M$230/ha, respectively (Annex 2, Table 3).

Value of the Fish Harvest Benefits

Intensive surveys of the freshwater and the other aquatic fauna in the waterways of the Study Site and adjacent areas revealed a very high biodiversity, including several new species and new records (Davies and Abdullah, 1989; Ng et. al., 1992). A total of 101 species of fish were recorded, constituting c. 40% of the known fish fauna of Peninsular Malaysia. One new genus, four new species of fish, three new records for Peninsular Malaysia and 30 new records for Selangor State were reported. In addition, species which had previously been recorded as rare were recorded in large numbers, suggesting that peat swamps represent an important stock area for the conservation of fish species.

Currently, the fish are harvested by the local fishermen for local sale, and fishing is restricted to the Main Canal and along the Tengi River. Ng. et. al (1992) recorded 18 species to be harvested and traded locally. In the valuation context an estimate was made of the actual value of fish harvested from the waterways of the forests at the Study Site. Interviews with the local fishermen and observation of fishing patterns were utilized in order to gain the necessary information.

A couple of different methods are used to fish at the Study Site, the 'bubu' (bamboo basket traps) and the fishing rods. The bubu are casings made out of bamboo, and floated in the waterways, and fish are trapped upon entry. A total of 15 bubus were recorded along the waterways, and each bubu would produce a catch of about 20 fish (of 1 kg each) every 5 days (fishermen, pers. comm.). For a mean price of M$0.70/kg of fish, the total monthly income was M$1,260. The total annual income from the fish through the bubu traps was M$15,120. The fishing rods are fastened to the banks of the river at 10m intervals. These rods are checked regularly by the fisherman. Monitoring of a stretch of the waterway along the Tengi River and up the Feeder Canal, revealed a total of 300 fishing rods in use. Interviews with the fishermen showed that on average each rod would produce a catch of 10 fish every 5 days, with an average weight of 1kg. The mean price fetched per fish was reported to be M$0.70/kg. This gave an annual value of M$ 151,200. Together the rod and bubu methods of fishing gave an annual income of M$ 166,320.

The present value for fish catch from the Study Site was calculated as M$29/ha (or M$ 2.1 million for the total Study Site) at a 8% discount rate, and M$98/ha at a 2% discount rate. Although it is not realistic to express the fish harvest on a per hectare basis, this was done in order to be consistent with the other TEV components, and to allow for later aggregation. The future potential for a managed harvest is probably much higher, and also for recreational fishing (which is already a popular pursuit).

Fish harvesting at the present time seems to be confined to a small scale; and the threat to fish populations is not so much from over-harvesting but from habitat destruction or degradation due to the logging methods being applied. This would be due to the increase in sediments and oil pollution from the boats transporting the logs. The scant information available, however, did not allow for the consideration of the fish value obtained here to be scaled up or down for the various management options. Hence only one value of fish harvest was used here for all the options.

Value of the Carbon Stock

The carbon stock and active sequestration of carbon at the Study Site is largely a function of logging activity within the forests. To estimate the current and potential (annual) value of the carbon stock in one hectare of the peat swamp forest under sustainable and unsustainable harvesting options the following steps were undertaken:

- estimation of the total physical stock and corresponding carbon stock changes under the sustainable and unsustainable management options under the different levels of damage incurred during logging; and
- valuation of this carbon stock using the 'damage avoided approach'.

The initial biomass density of the productive loggable forests at the Study Site is taken as 150 Ct/ha, which gets reduced to 100 Ct/ha after logging (Kumari, 1994). For any one year t, the total carbon biomass at the Study Site is:

(1) $TBt = (a-h)150 + (b+h)100 + bm$

where TBt = total carbon biomass at year t
a = productive loggable forest at year t
h = area logged in year t
b = cumulative logged forests
m = mean annual carbon sequestration rate of 1.8 Ct/ha.[4]

At a sequestration rate of 1.8 Ct/ha it would take c. 28 years for any harvested area h to return to the initial density of 150 Ct/ha. Beyond year 28 the situation reaches an equilibrium position, i.e. although h hectares are logged and biomass density gets reduced from the initial 150 Ct/ha to 100 Ct/ha, the h hectares logged in year 1 would have returned to a steady state biomass of 150 Ct/ha, from the 100 Ct/ha after logging. But the calculation in equation (1) has assumed no forest damage due to logging. Thus for any year, where $t > 28$:

(2) $$TBt = (a-h+h)150 + (b+h-h)100 + bm = (a)150 + (b)100 + bm$$

When the damage factor is included in the analysis, the equilibrium position is not reached over the same period (i.e. by year 28).

If the damage factor is included into equation (1), then the total carbon biomass is:

(3) $$TBt = (a-h)150 + (b + (1-d)h)100 + (b + (1-d)h)m$$

and where $d = 0.2$, equation (3) can be expressed as:

(4) $$TBt = (a-h)150 + (b+0.8h)100 + (b+0.8h)1.8$$

For $t>28$ years, a part of the h (i.e. $0.8h$) reacquires a carbon stock of 150 Ct/ha i.e. there is a shift from b to a.

(5) $$TBt = (a-h+0.8h)150 + (b+0.8h-0.8h)100 + b(1.8) = (a-0.2h)150 + b100 + b(1.8)$$

Thus the backlog of carbon stock builds up slowly over time. Similar modifications are made to equation (4) and (5) for 50% damage levels. A detailed physical audit was undertaken for carbon stock changes over the 100 year projection period under each of the logging regimes. Table 6 provides a summary of information and the results of the carbon valuation exercise.

The NPV for carbon under the unsustainable option A is M$ 8,011/ha and M$ 7,080/ha at the 20% and 50% damage levels, respectively. For the sustainable options (B1, B2 and B3), the carbon value for the 20% and 50% damage levels would be M$ 8,677/ha and M$ 8,049/ha, respectively (Table 6). Because the carbon value is a function of logging activity and not logging methods, no distinction is made in the carbon value for the unsustainable option (A) and the sustainable options (B1, B2 and B3). The values quoted here are for the 8% discount rate. The values for the lower discount rate of 2% are also given in Table 6.

Benefit of Preservation of Part of the Study Site for an Endangered Species

The utilization of a part of the Study Site by an endangered species gives it a value-added which must be included when estimating its TEV. The north eastern corner of the Study Site is contiguous to the Sungai Dusun Wildlife Sanctuary, a totally protected area specially set aside for the in-situ conservation of the Sumatran rhinoceros (*Dicerorhinus*

Table 6
Paramerters Used for the Calculation of the Carbon Stock and Carbon Sequestration at the Stydy Site

	Sustainable Regime	Unsustainable Regime
Loggable area	172,816 ha	72,816 ha
Actual Annual Cut (AAC)[2]	1618 ha	2912 ha
Logging cycle[2]	45 years	25 years
Pre-logging carbon stock density[3]	150Ct/ha	150Ct/ha
Post-logging carbon stock density[3]	100Ct/ha	100Ct/ha
Rate of carbon sequestration	41.8Ct/ha	1.8Ct/ha
Damage scenarios investigated[5]	0%, 20% 50%	0%, 20%, 50%
Projection period[6]	100 years	100 years
Carbon value/ton	M$ 14	M$ 14
NPV (8%)		
0% Damage	M$ 9096/ha	M$ 8630/ha
20% Damage	M$ 8677/ha	M$ 8011/ha
50% Damage	M$ 8049/ha	M$ 7080/ha
NPV (2%)		
0% Damage	M$ 29326/ha	M$ 28576/ha
20% Damage	M$ 25133/ha	M$ 25343/ha
50% Damage	M$ 18859/ha	M$ 20384/ha

Notes:
1. It was assumed here that the entire Study Site was available for re-logging at year 1 (1990), the baseline year.
2. Details of the harvest regime, the AAC, the logging cycle have all been described in the section of timber. For the sustainable regime the AAC=RAC and hence after 45 years the forest is again available for logging. For the unsustainable regime, it is assumed here that the forests have to be left fallow for 25 years before there will be sufficiently merchantable timber to make logging economically viable.
3. The forests are not primary (virgin) and almost all of which have been logged before, hence they will be assigned an initial (pre-logging) density of 150Ct/ha, which upon logging will be reduced by c. 50Ct/ha to 100Ct/ha.
4. At a sequestration rate of 1.8Ct/ha, the logged forest (at 0% damage) will take c. 28 years to recover the biomass density of 150Ct/ha. The shift from post-logging to loggable forests must be registered when deriving the physical carbon stock of forest.
5. Areas damaged during logging will first decay to release CO_2, after which they will be colonized by new seedlings. At the same rate of sequestration (1.8Ct/ha), it will take c. 83.3 years (150Ct/1.8Ct/ha) for these areas to re-attain the initial density of 150Ct/ha. The time taken for the initial decay has been omitted, to simplify the analysis and because the necessary information is not available. This shift from damaged to mature forests must be registered in the projection.
6. As for the valuation for the other goods and services at the Study Site, the carbon valuation will be projected over a 100 year period, so as to approximate an infinite time. Each ton of carbon was given a value of M$14.

sumatrensis). The population of the rhinoceros within the sanctuary is believed to range between 4-6 individuals (Zuber, 1983); which represents about 8% of the total population of the rhinos in Peninsular Malaysia (which ranges from 50 - 75 individuals). This two horned Sumatran rhinoceros, the most primitive and smallest among the 5 living species in the Rhinocerotidae family (van Strien, 1974) is one of the most endangered mammals in the world.

Earlier work by Strickland (1967) and a more recent follow-up by Zuber (1983) confirmed that a part of the core range of the rhinoceros extends into the north eastern corner of the Study Site. Rhinos exhibit a form of wandering behaviour, whereby they traverse extensively beyond the core ranges. Although the reason for this behaviour is not quite understood, it is believed to be an integral part of their social behaviour. Based on ranges mapped by Zuber (1983), the extent of the core range of rhinos in the Study Site was estimated to be c. 2,590 ha. As a conservative estimate, the wandering behaviour range (buffer range) was assumed to be c. 50% of the core range, giving a total rhino range of c. 3,885 ha within the Study Site[5].

Recent evidence has shown that there is a WTP for the conservation of endangered species. By corollary then, this part of the Study Site which supports the rhinos has a value (albeit a partial value) equivalent to that which may be placed on the Sumatran rhino. There is at the present time no such estimate specifically for Sumatran rhinos, either in Malaysia or elsewhere. Information from other studies indicates that estimates of the per capita preference valuation for endangered species ranges between US$1.2-18.6/yr (leaving out the exceptionally high values accorded to the humpbacked whales), giving a mean value of US$9.85 (i.e. M$26) (Pearce, 1993). These values are, however, largely derived for the U.S. population surveys. Adjusting this for the Malaysian GNP (at 1990 prices) gives a value estimate of c. M$2.86/capita towards the conservation of endangered species. This adjustment based solely on GNP must be treated with caution because it is widely accepted that people in higher income countries have a higher WTP towards such conservation initiatives. Applying this value estimate for the endangered Sumatran rhino to Peninsular Malaysia's population (14.4 million) gives a total value of M$ 41×10^6. If one considers further that the rhino population at the site contiguous to the Study Site is c. 8% of the total in Peninsular Malaysia (see above), then on a proportionate basis the value that the population would place on the Sumatran rhinos would be c. M$ 3.3×10^6 or a value of M$45 for a hectare of the Study Site (72,816 ha). This scaling downwards to reflect the local population of rhinos at the Study Site is not a strictly valid one, especially in the context of the Sumatran rhinos in Malaysia where the population is at very critical levels and the increased survival probability of every individual should be highly valued. However, using the M$45/ha represents a conservative estimate. Discounting this at 8% over the projection period gives a present value of M$562/ha, and at the lower discount rate of 2% it is M$1939/ha.

If one accepts that the endangered species component should be brought into the TEV equation, then this would require one to consider the introduction of a biophysical constraint i.e. a 'set-aside habitat' of at least 3,885 ha. This is because rhino conservation is not compatible with logging, the prime activity conducted within production forests. The preservation of this extent of the Study Site primarily for rhinos through the complete abstention of logging would therefore reduce the timber benefits from this part of the forest to zero. This is an example of opportunity costs foregone. Preservation of the area for rhinos also has positive effects on the other services provided by the forests (e.g. hydrological services, carbon sequestration, biodiversity value etc.). In order to keep the analysis tractable we will model only the timber benefits foregone as a consequence of the preservation of the habitat. Since the set-aside area is 5% of the Study Site (3885/72816), the foregone timber benefits are calculated as c. 5% of the total timber benefits calculated in Chapter 4 (Table 3). Thus when deriving the aggregated TEV for each management option, the opportunity costs foregone from the harvest of timber (for the biophysical area set aside) must be deducted to get the net benefits of rhino conservation; otherwise, there will be double counting.

Value of Non-Timber Forest Products: Rattan and Bamboo as Indicators

Several recorded non-timber forest products (NTFPs) are extracted from the Study Site. Table 7 is a summary of the number of species utilized. Although most of these goods and services do not enter the market, they do provide an important part of the subsistence needs of the local population. The NTFPs are

Table 7
Utilization of Some Non-Timber Forest Products at the Study Site

Forest Product	Number of Species
Timber Structure	51
Medicinal	13
Food-fruits, seed and edible nuts	10
Food-vegetable	2
Fibre/Thatch	3
Ornamental	1
Exudates/latex/resin	2
Dyes and tannins	1
Feed plants	1
Occult magic	2
Species/flowers	1
Fuel/charcoal	2
Essential oils	1
Vegetable oils	1
Ceremonial	1

Source: Noor Azlin Yahya (1990), Said and Shahwahid (1992)

extracted on a rather informal basis, the frequency of which appears to have been declining, a pattern fairly common to Peninsular Malaysia (de Beer and McDermott, 1989).

This section seeks to derive the potential value that may be accrued from the Study Site through the harvest of two major NTFPs; namely rattan and bamboo. Rattan collection in other parts of the country has been estimated to contribute 14.8% of the economic activity of the residents in the swamp forests of south-east Pahang (Shahwahid and Mustapha, 1991; Shahwahid, 1992). Although such intensity of harvesting has not been recorded at the Study Site, its potential value should neither be neglected nor ignored.

Forest inventories for the state of Selangor have recorded the density of rattan and bamboo in the forests, for randomly selected sample sites (FFD, 1988a, 1988b). However, some data modifications have to be made in order to ascertain the stock of rattan and bamboo available from peat swamp forests, and specifically from the Study Site. For instance, cluster forming species such as *Calamus caesius* (sega) and *C. sciponium,* both of which are commercially attractive, are naturally found in peat swamps, whereas rattan manau, the most desirable species of rattan is not known to occur in peat swamps. Thus, to take these differences into account, the generalized stocking density for Selangor was adjusted using information from the state of Johore (in the southern part of Peninsular Malaysia).

Table 8 and Table 9 give the stocking density of rattan and bamboo at the study site, which based on their individual growth cycles would have slightly different harvest rates if sustainable harvest is to be a goal/objective. What is important here is to determine the potential economic value which can be derived from both these two NTFPs under sustainable and unsustainable logging regimes, especially in relation to the intensity of logging damage which takes place. It is assumed here that the damage to the rattan stock will be in proportion to the general forest damage sustained during logging. In the case of bamboo the reverse holds true, i.e. bamboo thrives under disturbed conditions. This means that the shift to sustainable regimes and lower damage during logging has the effect of reducing the benefits from bamboo. Table 10 gives a summary of the PV/ha for rattan and bamboo under the alternative management regimes.

Table 8
Valuation of Rattan at the Study Site

Types of Rattan:	Sega	Semambu	Dok	Dahan	Total
Stocking Density (clumps/ha)	0.60	1.10	1.10	12.40	
Stocking Density (m/ha)	28.80	49.50	49.50	446.40	
Price (M$/m)	0.40	0.40	0.25	0.10	
Years to maturity	10	10	10	10	
Annual Stock (m/yr)	2.88	4.95	4.95	44.64	57.42
Annual Value (M$/ha)	1.15	1.98	1.24	4.46	8.83
Adjusted Annual Value (M$/ha)	2.30	3.96	2.48	8.93	17.67

Note:
1. To correct distortions in price due to banning of the export of rattan in Peninsular Malaysia, a conversion factor of 2 was used (Veitch, 1986).

The results of the discounted values for rattan and bamboo are presented in Table 10. At 8% discount rates and for the 20% damage option, the PV of rattan at unsustainable levels was estimated at M$ 35/ha, this being c. 80% less than that at sustainable B1 option of M$ 177/ha. The PV of rattan systematically increases under increasingly sustainable options B2 and B3 to M$ 194/ha and M$ 214/ha, respectively. For bamboo the reverse is true, where the unsustainable management options (A and B1) produce more bamboo, giving an PV of M$ 157/ha and M$ 98/ha at 20% and 50% damage respectively. This gets reduced at the more sustainable levels (see Table 10).

Potential Recreational Value

Currently, anywhere between 30-50 visitors have been sighted in the vicinity of the Study Site over any one weekend. Most of these visitors are bird enthusiasts who walk along the main canal to catch sight of birds at the fringe of the peat swamp forests. Those who have private boats also do some recreational fishing, or hire out their boats to others for the same purpose. Although these numbers are fairly small, the potential importance of the site has been noted, and the District Office is currently planning to develop this as a recreational cum tourist attraction, and package it together with the other attractions in the District (DOKS, 1992).

Conceptually, the District Office (Local Authority) proposal for recreational development at the Main Canal and Sungai Tengi seeks to package an attraction which will combine farming and forest scenes (DOKS, 1992). The access to the recreational area will be at the southern part of the Study Site, which is c. 10-15 km from Kuala Selangor. There is to be a high level of local participation, where the farmers would be encouraged to undertake the bed-and-breakfast concept. The presence of visitors, both local and foreign, would foster an increased amount of activity in local handicrafts manufacturing and sales. It is envisaged that this combination of activities would raise the income from $600/year to $1,000/year. The 'forest wilderness' experience will have a recreational and an educational element to it, and can be undertaken as a walk or along the tramline (which had conventionally been used to transport logs out of the forests). The Main Canal and the Sungai Tengi (Map 2) will be also developed for water borne activities; including boat rides up the Tengi river, from which circuit forest walks will be available. An additional suggestion is for the ride along the Tengi river to be extended along the Feeder Canal up to the Sungai Dusun Wildlife Sanctuary. This Sanctuary, especially set aside for promoting conservation of the Sumatran rhino, could serve as an added educational attraction to visitors. In view of the proposed

Table 9
Valuation of Bamboo at the Study Site

Types of Bamboo:	Betong	>3cm	<3cm	Total
Stocking Density (clumps/ha)	8.20	3.60	2.50	
Stocking Density (m/ha)	984	432	150	
Price (M$/m)	0.10	0.10	0.10	
Years to maturity	10	10	10	
Annual Stock (m/yr)	98.40	43.20	15.00	156.60
Annual Value (M$/ha)	9.84	4.32	1.50	15.66

Notes:
1. Betong and >3cm bamboo, per clump = 120m; < 3cm bamboo, per clump = 60m.
2. Pricing of bamboo (Shahwahid, 1990). PV is calculated only for the Betong species.

plans, and current informal use of the area, an attempt is made here to estimate the potential recreational value of the Study Site.

Because the Study Site is not yet operational as a forest recreational site, the visitor numbers to the Kuala Selangor Nature Park, located some 15km away, were used a proxy to estimate the potential recreational benefits that may be derived from it. The Kuala Selangor Nature Park which comprises a part of the mangrove coast and an artificial lake, was established in 1987. The overnight visitor numbers here have increased from less than 50 a month to well over 300 in most months of the year in 1991 (Kuala Selangor Nature Park, record book). The day visitor numbers are not strictly recorded, but are likely to double the total visitor count if included. It is envisaged that the Study Site would draw similar visitation numbers. Certain assumptions were made here:

- that the Kuala Selangor Nature Park and the Study Site will not be seen as competing/substitution sites, but as complementary reinforcing sites. The rationale for this is firstly that they offer different experiences to the recreationist, and secondly, if they are packaged together, the visitors are likely to visit both the sites. This potential recreational area falls within the 80km catchment area, which has been shown to be distance domestic visitors are willing to travel on their weekend breaks (Sabri, 1987); and
- visitor numbers will continue to increase, but only up to the year 2020, after which they would remain constant so as to ensure against congestibility.

The estimate of recreational benefits was derived using the results from Sabri's (1987) recreational model, based on the travel cost method for average Malaysian visitors to forest recreational areas. Because no entrance fee is charged the entire area under the demand curve represents the consumer's surplus, and hence the value placed by the visitor on the area. Sabri (1987) estimated the consumer surplus per visit to each forest reserve (within the 80 km catchment) to range from M$ 6 - M$ 12, giving a mean of c. M$ 9 per visit. The potential number of visitors to the forest recreational areas in the Study Site, based on an extrapolation of visitors to the Kuala Selangor Nature Park, and the discounted cash flow is provided in Annex 2 (Table 4). Multiplying this by the total visits to the site, the NPV of recreational value was estimated as M$ 4.1×10^6 at a 8% discount rate, or M$ 28.2×10^6 at a 2% discount rate. Expressed as recreational benefits per hectare of the Study Site, they give a potential value of M$ 57 and M$ 387, respectively.

Table 10
Discounted Value for Rattan and Bamboo (MS/HA)

	Unsustainable	Sustainable		
	Scenario A:	Scenario B1:	Scenario B2:	Scenario B3:
Rattan:				
NPV/ha (8%) (M$/ha)				
0% Damage	44 (4)	221 (18)	243 (19)	267 (21)
20% Damage	35 (3)	177 (14)	194 (16)	214 (17)
50% Damage	22 (2)	110 (9)	121 (10)	134 (11)
NPV/ha (2%) (M$/ha)				
0% Damage	152	762	838	921
20% Damage	122	609	670	419
50% Damage	76	381	419	461
Bamboo:				
NPV/ha (8%) (M$/ha)				
0% Damage	196 (16)	196 (16)	98 (8)	98 (8)
20% Damage	157 (13)	157 (13)	78 (6)	78 (6)
50% Damage	98 (8)	98 (8)	49 (4)	49 (4)
NPV/ha (2%) (M$/ha)				
0% Damage	675	675	337	337
20% Damage	540	540	270	270
50% Damage	337	337	169	169

Notes:

1. The value in brackets denotes the annual value (M$/ha) for rattan and bamboo respectively as derives from Table 8 and 9, but are adjusted to varying intensities of damage and shifts between the management options. The same base values were used for the 2% discount rate.

2. The adjusted annual value of rattan derived in Table 8 (c. M$18/ha) was derived for the sustainable regime harvest (B1) at 0% damage. The values for the remaining options are derived as a percentage of losses commensurable to those of timber harvests. Moving to more sustainable logging methods, as for options of B2 and B3, was assumed to increase the potential harvest of rattan by a further 10%.

3. The annual value of bamboo derived in Table 9 (c. M$16/ha) would hold true at current levels of disturbance, using the excavator + canal logging method method. The values for the remaining options are derived as a percentage oflosses commensurable to those of timber harvests. In the case of bamboo, the shift to better harvesting conditions B2 and B3 would reduce the available bamboo because it thrives in disturbed conditions.

Again this expression on a per hectare basis is to allow for a comparison of different benefits from the forest, and for subsequent aggregation to derive the TEV. No distinction was made here between the recreational value of the Site under a sustainable and unsustainable management regime, although presumably the aesthetic value under the latter operation would be less.

[1] The kuda-kuda method is not included here as an option because although it is an environmentally benign method of logging, the risks to the loggers are too high. In fact, currently this method is not being used anywhere.

[2] Because of the widespread nature of the intervention mechanisms on domestic rice production the value of the dry season crop was calculated using the import price of rice.

[3] Characteristics of water abstracted: coloration = 100 hazen units (standart < 5 units); natural turbidity unit = 53 (good areas have ntu of 5-10).

[4] For rational of this see Kumari (1994).

[5] Wandering ranges of animals are often much larger than the core ranges; hence an assumption of 50% here is quite conservative.

5 Total Economic Valuation Under Alternative Forest Management Options

Table 11 provides a summary of the 'total economic value' of forest conservation benefits that can be gained under the unsustainable (A) and sustainable (B) management options; and for the latter option under increasingly sustainable conditions (B1,B2 and B3), at a 8% discount rate. The results of each forest management option are expressed for the individual components, estimated for the two levels of damage. For each option the aggregate results are presented in terms of private, social and global benefits; the former two accrue to the nation, but the social benefits are more widely distributed. The private benefits are those derived from timber. The social benefits include the hydrological benefits (agricultural and domestic water abstraction), harvest of fish, and the potential benefits from non-timber forest products and recreation. The global benefits accrue to the world community, and include those from the carbon capital of the forests and that from the increased probability of survival of the Sumatran rhinoceros, a highly endangered species.

These results should not be seen as fine-tuned numbers, but more to indicate orders of magnitude which would enable an identification of the key sensitivity parameters relating to overall option results. More refined analyses can then be focused on these parameters and their valuation.

The base scenario (A) represents the current unsustainable practice, where the harvest rate is high and the logging method environmentally destructive. The hypothetical management options B1, B2 and B3 all represent environmentally less disruptive, sustainable harvest options. The method of logging used under scenario B1 is similar to A, but B2 and B3 represent increasingly benign methods of logging. At the 20% damage level, the TEV for A is higher than that for option B1, but at the 50% damage level this result is reversed. Both the social and global benefits streams increase over time, while the private benefits diminish with this shift. The reduction in private benefits corresponds to the reduced volume of timber extracted, in moving from the unsustained harvests to sustained harvest (Figure 2).

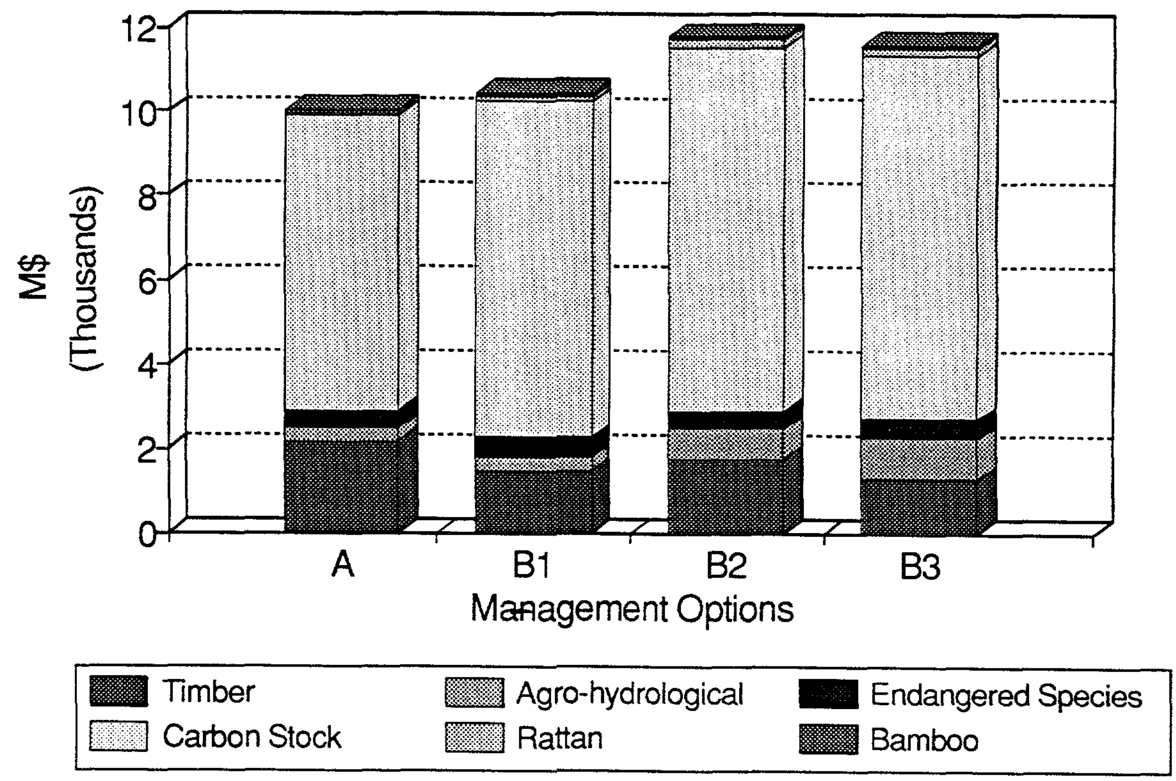
However, as discussed in Chapter 4, *The Value of Timber Benefits*, the damage levels must be placed in the proper context i.e. against the method of logging adopted under each management option. Logging, using the most destructive combination of traxcavators and canals, as is the case for option A and B1, is likely to incur damages close to the 50% levels; whilst the shift to more environmentally benign methods (i.e. B2 and B3) should reduce the damage closer to the 20% levels. A comparison of these cross-damage options shows the TEV for the Study Site to increase from M$ 745X10^6 to M$ 774X10^6 going from A to B1. In shifting from B1 to B2 option it increases further to M$ 874X106, but for option B3 gets reduced to M$ 863X10^6. The aggregate TEV of these most plausible damage options are shown in Figure 3 (recreation, domestic water and fish benefits which are equal for each of the options are not included in this figure). The results suggest that the higher damage incurred under option A and B1 could reduce the aggregate (TEV) discounted benefits sufficiently to encourage more sound logging methods to be adopted.

Table 11
Total Economic Valuation of Forest Conservation Benefits at the Study Site (M$/ha, 8% discount rate)

	Unsustainable A:		Sustainable B1:		Sustainable B2:		Sustainable B3:	
Good/Service	**20% Damage**	**50% Damage**	**20% Damage**	**50% Damage**	**20% Damage**	**50% Damage**	**20% Damage**	**50% Damage**
1. Timber	3448	2149	2360	1453	1750	1085	1276	804
2. Hydrological	319	319	319	319	730	730	999	999
3. Endangered Spp	378	447	436	484	469	504	494	519
4. Carbon Stock	8011	7080	8677	8049	8677	8049	8677	8049
5. Rattan	35	22	177	110	194	121	214	134
6. Bamboo	157	98	157	98	78	49	78	49
7. Recreation	57	57	57	57	57	57	57	57
8. Domestic Water	30	30	30	30	30	30	30	30
9. Fish	29	29	29	29	29	29	29	29
TEV/ha SS (M$/ha)	12464	10231	12242	10629	12014	10654	11854	10670
Total Social Benefits	627	555	769	643	1118	1016	1407	1298
Total Global	8389	7527	9113	8533	9146	8553	9171	8568
Total Private	3448	2149	2360	1453	1750	1085	1276	804
Social %	5.03	5.42	6.28	6.05	9.31	9.54	11.87	12.16
Global %	67.31	73.57	74.44	80.28	76.13	80.28	77.37	80.30
Private %	27.66	21.00	19.28	13.67	14.57	10.18	10.76	7.54
Total Social for SS (M$)	45,655,632	40,412,880	55,995,504	46,820,688	81,408,288	73,981,056	102,452,112	94,515,168
Total Global for SS (M$)	610,856,088	548,111,007	663,578,424	621,373,671	665,948,274	622,803,351	667,789,764	623,895,036
Total Private for SS (M$)	251,069,568	156,481,584	171,845,760	105,801,648	127,428,000	79,005,360	92,913,216	58,544,064
Grand Total for SS (M$)	907,581,288	745,005,471	891,419,688	773,996,007	874,784,562	775,789,767	863,155,092	776,954,268

Notes:
1. For details on the valuation of the individual components, refer to text.
2. Total Social Benefits: (2+5+6+7+8+10), Total Global Benefits: (3+4), and Total private Benefits: (1).

Figure 3
TEV of Management Options (M$, 8% discount rate)



In the management context, however, it is not the absolute values under each management option that are important, but the incremental changes in shifting from one management option to the next. The rest of the analysis and discussion will focus on these most plausible options for each management alternative (i.e. the 50% forest damage for options A and B1, and 20% damage for options B2 and B3), expressed in incremental terms.

Incremental Changes Between Alternative Management Options

Table 12 shows the value for the goods and services as estimated for the base case (A), together with the incremental shifts in these values to the increasingly sustainable scenarios from this base position. The data source and methodology used for the valuation of each of the variables is given as notes in the Table 12 (see also Chapter 4). The net positive increments in shifting from A to B1, B2 and B3 are estimated as M$ 398/ha, M$ 1,782/ha and M$ 1,620/ha, respectively.

There are trade-offs between the different variables in making this shift towards sustainability. For example, financial losses are incurred for the timber and bamboo products, whilst all of the other variables show a positive financial effect. The losses in timber can be attributed to the reduced stumpage values as logging costs increase due to the adoption of increasingly environmentally friendly methods of logging. Bamboo thrives better in more ecologically disturbed conditions, and hence the shift to sustainability would also result in reduced bamboo growth.

The components which 'drive' or dominate the TEV are the timber and carbon stock which comprise c. 20% and c. 70% of the TEV, respectively. The shifts to increasingly sustainable regimes cause financial losses in timber

Table 12
Summary of Results for the Study Site (1990 prices, 8% discount rate)

(Most plausible damage level used for each option, see text).

Good/ Service	Base Option (Unsustainable, A) (M$/ha)	% of TEV	Change from Base Option to Sustainable Option B1 (MS/ha)	B2 (M$/ha)	B3 (M$/ha)
Timber	2149	21.3	-696	-399	-873
Agro-hydrological	319	3.1	0	411	680
Endangered species	454	4.4	35	20	44
Carbon stock	7080	69.2	969	1597	1597
Rattan	22	0.2	88	172	192
Bamboo	98	1.0	0	-20	-20
Recreation	57	0.6	0	0	0
Domestic Water	30	0.3	0	0	0
Fish	29	0.3	0	0	0
TEV	10238	100.0	396	1782	1620

Notes: On the source of data, assumptions and methodology used to establish the value for each variable.

1. *Management Options*: The base options (A) represents the current unsustainable practice where the harvest rate is high and the logging method environmentally destructive. Management options B1, B2 and B3 all represent sustainable harvest options. The method of logging for B1 is similar to A, but B2 and B3 represent increasingly benign methods of logging.

2. *Timber*: The physical stock information is derived from the National Forest Inventory, specifically for peat swamp forests. The level of overcut for the unsustainable option (A) is based on information for the state of Selangor, whilst the sustainable harvests (for B1, B2 and B3) are based on the recommended cuts for the Study Site itself. To derive the economic value for the timber harvest for each option, national stumpage values were used with adjustments made for increasing logging costs as one shifts to increasingly sustainable options (from B1 to B3). This was calculated as a net present value because use was made of the stumpage value which deducts for logging costs.

3. *Agro-hydrological Service*: The physical information for this is based on land satellite photographs taken over the Study Site in 1987 and 1990, verified against field checks. The total extent of canals and the rate of increase in these waterways was established from these photographs. The loss of water through seepage was established from detailed hydrological studies conducted in the Study Site itself, and this allowed the total water loss from the peat forests to be estimated. The production loss method, based on information on value of the padi crop from the adjacent agricultural area was used to estimate the value of the agro-hydrological service at the study site. This was calculated as a present value.

harvesting, whilst the forest's carbon stock function value increases substantially, by almost 13% from the base case. The agro-hydrological service and the conservation of the endangered species components constitute between 3-4% each of the TEV, but register further increases as the shifts towards B2 and B3 options take place, the former showing fairly substantial increases.

The highest overall benefits are incurred in the shift from A to B2 (Table 12). On the basis of this shift the private losses, estimated at M$399/ha, are more than made up for by the increase in net social benefits of M$563/ha (M$411 + M$172 - M$20); whilst the global community accrues incremental benefits of up to M$1,619/ha (M$1,597 + M$22). The subsequent shift to B3 (from A) more than doubles the losses to the private logger (M$ 873/ha) whilst still increasing the social (M$289) and global (M$24) benefits, the latter only marginally. The private losses in shifting from the unsustainable to the sustainable options are

4. *Endangered species*: The utilization of the north eastern corner of the Study Site by the endangered Sumatran rhino has been documented using census and ecological techniques which provide the necessary information on their range movements and local population numbers. The conservation value of the Study Site was estimated using the national WTP for the conservation of the local population of rhinos at the Study Site as a percentage of the total rhino population in Peninsular Malaysia. Economic value was based on the proxy contingent valuation estimate derived from international studies, but adjusted for the Malaysian population and GNP. This value does not exclude costs, and hence represents present values.

5. *Carbon stock*: The physical carbon stock for the Study Site was derived using information based on the forest inventory together with carbon biomass data for Peninsular Malaysia. The carbon flux was estimated for each logging regime (A, B1, B2 and B3). To assign the economic value, the global damage cost estimate of $14/tC was used.

6&7. *Rattan and Bamboo*: The physical stock calculation was based on the rattan and bamboo inventory for Selangor State; this was adjusted for the peat forest habitat. This information was synthesized with that on the biology and ecology of the relevant species to establish the potential annual sustainable harvest which could be derived from the Study Site. The economic value of rattan was based on market price but adjusted for distortions due to the bans and tariffs on the export of raw rattan. For bamboo the domestic price was used. Here to the discounted values represent present values.

8. *Recreation*: The nearby (15km away) Kuala Selangor Nature Park was used as a surrogate to derive the recreational value for the Study Site. The visitor numbers at this Park together with the estimate of recreational value of M$(/capita (based on TCM) for visitation to forest recreational areas in Peninsular Malaysia was used to derive the total recreational value at the Study Site. The data did not allow for differentiation between the alternative management options.

9. *Domestic Water*: The value of this service is based on the total water abstracted from the swamp forests multiplied by the incremental treatment costs due to the turbidity and colouration of water abstracted from the forests. This information was obtained from the Water Supply Department. Again the data did not allow for differentiation between alternative management options.

10. *Fish*: Fish harvest information was obtained from the fishermen at the Study Site. The number of fish traps along the waterways was enumerated and the fish catch estimated. The economic value was based on the market price of fish. Here too no distinction was made between the management options. The discounted values are present values.

11. *Present Value/Net Present Value*: Some of the discounted values represent PVs and others NPVs. This is not strictly satisfactory, but in view of the data constraints it ws difficult to attain a uniformity.

compensated for by the increase in social and global benefits, especially the latter, which more than compensates for the loss from timber and bamboo. The increase in social benefits with the shift towards sustainable forest management suggests that the local community could benefit substantially. The divergence between these private and social benefits suggest that incentive mechanisms should be devised to internalize these externalities into the decision making process. These social benefits, especially the hydrological benefits, are not only important in sustaining the forests but also in sustaining the agricultural community around it, the value of which is likely to be much larger than the surrogate 'effect on production' approach used here. In fact the agro-hydrological value here was estimated conservatively as 10% of the full agricultural value (Chapter 4, *Value of Hydrological Benefits*). A higher proportion could potentially raise the percentage of the service substantially (see Table 13). Thus it would appear that the TEV shows net positive gains even at the local level when trade-offs are considered between the private and social benefits.

The argument here is that if the shift is made from the current unsustainable practice

Table 13
Confidence Level for the TEV Components of the Recommended Management Option (M$)

Good/ Service	Recommended Option (B2) (M$/ha)	Unit/Range Value	Confidence Level	Precautionary Principle under a Strong Sustainability Approach
Timber	1750	M$135/cu.m	H	H
Agro-hydrological	730	M$67-665/ha	H	H*
Endangered species	474	M$3/capita	M	H
Carbon stock	8677	M$14-54/tC	H	M
Rattan	194	M$9-18/ha	M	L
Bamboo	78	M$16/ha	M	L
Recreation	57	M$6-12/visitor	L	L
Domestic water	30	M$0.40/cu.m.	M	H
Fish	29	M$1/kg	L	M

Notes:

1. *Unit Value:* This data represents the unit value (drawn from an estimated range) used to derive the total value for each variable. In the case of the carbon value a lower value of M$14/tC was used and for recreation the median value of M$9/visitor. A higher value of M$18/ha was used for rattan, to correct for the distorting effects of bans and tariffs.

2. *Confidence Level:* This represents our judgement of the confidence which can be placed on the variables in this study, low (L), medium (M) and high (H). The level of confidence is based on the following criteria: source of the data, its reliability, the valuation methodology used and the soundness of the assumptions made (see Table 12).

3. *Precautionary Principle under a Strong Sustainability Approach:* This scoring represents an appreciation of the degree of risk aversion which must be exercised if the Strong Sustainability position is to be attained, and critical natural capital retained in order to ensure the sustainable flow of locally and globally appropriable goods and services. Scoring is from low (L), medium (M) and high (H). For H* scoring, see text.

(option A) to the recommended sustainable option B2, the compensation payments which need to flow from the global community to Malaysia would be in the range of M$ 411-1619/ha. The former value represents the financial losses which would be incurred by the nation (timber plus bamboo losses), whilst the latter value represents the sum of the global benefits (carbon sequestration and conservation of the endangered rhino species). Thus it would appear that the minimum that should be transferred to the nation, if the sustainable option B2 is to be adopted (rather than A), would be equivalent to the loss of financial benefits.

Discounting at the conventional rate of 8% does not perhaps give sufficient prominence to the conservation benefits received further into the future. The beneficial effects of the sustainability criterion or constraint with respect to the continued harvest or flow of services is made more explicit when a lower discount rate of 2% was used. At this lower discount rate (2%), the optimum shift is from the current unsustainable scenario (A) to scenario B3.

The salient conclusion which can be drawn from Table 12 is that there are very positive gains to be made in the total economic value that can be accrued from the forests if one adopts more sustainable management options. But the consistent message coming out of this TEV audit is clear: the largest portion of the benefits accrue to the global community.

Therefore unless transfer mechanisms are forthcoming from the countries of the North, the incentive for Malaysia to adopt the more sustainable form (especially the B2 scenario) of forest management may not be powerful enough to overcome entrenched national 'special interests'.

However, before any recommendation for this shift towards the more sustainable management mode and negotiations for transfer mechanisms can be advocated and pushed to the decision and policy makers of Malaysia, it is imperative upon us to establish just how robust this TEV audit, and its individual estimates, are. Table 13 represents an effort in this direction, where two indicators, namely the confidence level and the precautionary (risk aversion) principle, are used to establish the robustness of this TEV, and to provide the necessary impetus towards objective decision making.

Confidence Level

The confidence level scoring represents our judgement of the confidence which can be placed on the estimate of the variables in this study and is based on the following criteria: source of data, its reliability, the valuation methodology used and the soundness of the assumptions made. Timber, for example, has a high confidence scoring because of the existence of fairly well defined market prices, and the fact that the physical stock was based on inventories specifically undertaken for peat swamp forests. Similarly, the hydrological value has a high confidence level because of the reliability of the data on hydrological disturbance which together with detailed hydrological studies at the Study Site allowed us to estimate the disruption to the service quite accurately. The conversion of this physical phenomena to economic value is based on the production loss (from the adjacent padi fields) where a very conservative assumption of 10% crop loss was made for each year that the critical 'live storage' limit of water in the swamps was exceeded. The continued degradation of the forest could, however, lead to a complete loss of the agro-hydrological benefit i.e. it could proximate to the maximum of its range value at M$665/ha. Although there is much scientific and economic uncertainty surrounding the issue of the global warming phenomena (and hence the carbon stock function of forests), the very rigorous carbon stock estimation undertaken in this study coupled with the conservative damage avoided cost estimates used, a high level of confidence level is placed on the value in Table 13.

On the other hand, the low confidence placed on potential recreational value at the Study Site is due to the fact that the visitor numbers are extrapolated from a nearby Nature Park; although the recreational value itself is based on a fairly intensive travel cost study which has been undertaken specifically for forest recreational areas in Selangor state. The notes in Table 13 (and details in Chapter 4) provide the basis for the scoring the confidence level for the remaining variables.

The Precautionary Principle

We have set out the types of benefits and values that can be derived from forests, and have made some progress in valuing these empirically and scoring their confidence level, but we do not want to give the impression that we are moving in an arena of 'comfortable certainty' with regard to the forest resource and its management. A range of uncertainties; biological, ecological, and economic still surround forest management. The precise dynamics of the tropical forests is still not well understood. We know less about the workings of this forest ecosystem than we do about any other biome on earth (Myers, 1983). The interactive processes in the tropical forests are complex and poorly understood; there are multiple potential synergisms available given the number of environmental assaults on the biosphere. Given this complexity, economic assessments and projections will necessarily be somewhat speculative. This, however, should not be construed as a criticism of all that has been done, but of the need to recognize its practical limitations.

The bottom line is that unless the 'health and integrity' of the ecosystem remains intact, the sustainable flow of its goods and services may be jeopardized (Turner, 1994). This coupled with the fact that we may be fast approaching the limits of the ecosystem tolerance to external stress and shock suggests that a precautionary approach should be adopted.

In essence, the precautionary principle asserts that there is a premium on a cautious and conservative approach to human interventions in environmental sectors that are (i) unusually short on scientific understanding; and (ii) unusually susceptible to significant injury, especially irreversible injury (O'Riordan, 1992).

In this context, a second scoring criterion was included in the analysis in Table 13: one based on the precautionary principle under a Strong Sustainability approach. This scoring reflects an appreciation of the degree of risk aversion which must be exercised if the Strong Sustainability position is to be attained, and the need to retain critical natural capital stock in order to ensure the sustainable flow of locally and globally appropriable goods and services. Thus the precautionary rating goes beyond the measurable or empirical analysis to include a reaction to uncertainty i.e. the adoption of a risk averse approach.

That is to say that although a variable may have a lower level of confidence, the importance of that service at local/global levels may make it imperative for a higher level of caution to prevail during developmental decision making. For example, let's consider the case of the endangered species. The confidence which can be placed on the estimate here is moderate, since the value was based on international (not Malaysian) studies for other endangered species; but on the other hand the irreversible consequences of any decreased probability of survival of the species if the forest is not set aside would necessitate a higher level of precaution to prevail on the issue (Table 13). This type of reasoning also holds true at the local level. Take the case of the domestic water service which has moderate level of confidence (although the quantity of water abstracted from the swamp forests is well defined, the treatment costs incurred are less sturdy). Nevertheless, the fact that at the present time the 45,000 residents of the adjacent agricultural scheme have no alternative means of water available to them should again mean that the precautionary principle must apply. Although the low, medium and high scoring have been used here, there may be cases where the scoring may not be quite so discrete. This would hold true in the case of the agro-hydrological function, where a precaution approximating to high starred (H*) may be more appropriate, especially if the forest continues to be degraded through indiscriminate logging practices (and the higher range estimate becomes pertinent) (Table 13 and Table 12).

Hence final decision making should seek to draw a balance between the two aspects of confidence and precaution. This should not be seen as undermining the importance of the empirical results, but rather as strengthening any decision by incorporating the 'Strong Sustainability' requirement. Inherent in the particular management option selected, and the confidence and precautionary level scorings, is the interactive nature of the multiplicity of benefits from the forests.

What is most important is that the variables which drive the TEV should have a high confidence level before they can be translated or adopted into policy or management decisions. In this context timber and carbon which take up the lion's share of the TEV both score well with respect to the two ratings assessed here[1]. A final caveat concerns the partial nature of our TEV analysis. We have not overtly included potential forest conservation option value or any non-use values.

Significance of Results at the National and Global Level

The 'incremental change method' as applied to the Study Site in the previous section of this chapter provides a powerful indicator for identifying the practical limits to changes or shifts in any course of action; and also identifies the trade-offs which have to be made by the major actors involved. One of the interesting facets of the approach used here is that it demonstrates that 'sustainable forest management' is not a 'fixed' state but a potential continuum reflecting weak sustainability through to strong sustainability regimes, where the latter approximates to the natural state. The exact trade-off position adopted or accepted by a country would depend on its own developmental constraints, and the willingness of the world community to effect the necessary transfers.

This detailed case study was based on the best available empirical data and was underpinned by consistent, practicable and conservative assumptions whenever a reasonable degree of uncertainty was present. In other words, the case study is, in a microcosm, a powerful test of the sustainability arguments that are being advocated through national and international agendas.

What is the significance of the results discussed in the previous section for management and policy? Any action taken must be mobilized at two levels: national and global.

The National Strategy: Implications for Malaysian Forest Policy and Management

What do these incremental differences mean in the context of, first, the Study Site and the surrounding community, and, second, at the national level?

The increase in social benefits with the shift towards sustainable forest management (SFM) suggests that the local community could benefit substantially. The divergence between these private and social benefits suggest that these externalities should be quantified and incentive mechanisms devised to internalize them into the decision making process. These social benefits, especially the hydrological benefits, are not only important in sustaining the forests but also in sustaining the agricultural community around it, the value of which is likely to be much larger than the surrogate 'effect on production' approach used here.

Although the comparisons thus far have been made from the baseline option (A) to B1, B2 and B3; the comparisons could be made between any two potential management options. These shifts between the B options can be related to the weak and strong sustainability criteria, where the latter requires a more binding condition in relation to the maintenance of the natural state. Table 12 provides a summary matrix of the incremental changes between options at the private, social and global levels. Such a summary if refined further could be used to make comparisons between these management options at different sites, from whatever scenario represents the baseline position.

The empirical quantification and verification of the sustainability arguments for this case study in Malaysia provides a convincing platform from which to argue for the much needed, and long overdue, changes to be effected in current forest management and policy in Peninsular Malaysia. Scaling from the Study Site up to the Malaysian level is likely to pose problems, not least because some of these environmental values are site-specific. Nevertheless, 4.75 million ha of the forests have been set aside in Peninsular Malaysia as production forests and there is a need for the true economic value of the forests to be understood, which, as shown in Table 11 and 12, is much higher than that of timber alone. Any course of action or management practice should reflect this total value.

It is true to say that an economic analysis that accounts for non-timber as well as timber values is the conceptually superior framework for evaluating forest management; and by corollary a policy framework that addresses both these facets of forest management will be optimal. Malaysia must now strive for one further step: to enforce or mobilize the exemplary policy and legislation that exists, but is not fully enforced. Peninsular Malaysia, in particular, has often been cited to have one of the best management practices for timber (Poore et. al., 1989). It is now well poised to make the leap into multi-use management, and to serve as a model to be replicated elsewhere in the developing world.

In this context, the multi-functional role of forests has been officially recognized and is legislated through the auspices of the National Forestry Act (1984), which has been endorsed and accepted by all of the Peninsular Malaysian states. A comprehensive identification of functions as required under Section 10(1) of the Act could (and should) lead to an equally comprehensive identification of the forest's TEV. Malaysian forest policy and management should capitalise on this legal platform as provided by the National Forestry Act, and efforts should be directed to overcome the current paucity of information on the economic valuation of environment-related services. This Act is potentially the most important vehicle for the practical enforcement of multiple use and management of forests in Malaysia, and Kumari (1994) provides a detailed critique into this perspective. It recommended here that the National Forestry Act (1984) be effectively enforced so as to promote multi-use management in line with sustainability criteria.

The Global Strategy: Implications for Transfer Mechanisms

The global public good nature of conservation benefits for Malaysia suggests that some form of resource transfer mechanisms at the international level is called for. The forests provide the benefits of carbon sequestration and biodiversity conservation, and the empirical evidence from this study provides convincing economic rationale for favouring the more sustainable forest management approaches. Carbon savings related to improved forest management represent a low cost way to achieving carbon sequestration goals, but unless these non-market values are made 'cashable', local/national asset owners and users are unlikely to change their behaviour. This positive economic case, already constituting a large percentage of the TEV, would be magnified if the full biodiversity impacts could be measured and valued.

Both the international conventions of Global Warming and Biodiversity have as their trading basis the incremental cost principle (Jordan, 1993; King, 1993). This principle forms the basis of operation of the Global Environment Facility (GEF): its application, however, has proven to be difficult (Jordan, 1993). Currently, much effort is being put into coming up with acceptable ways of determining these incremental costs, in order to operationalise this incremental principle for the financing of projects. In this context, the case study illustrated here represents a preliminary effort, not so much in the biodiversity context alone, but in the wider context of forest goods and services. The 'incremental cost method' derived here for a range of management options provides an important input to operational decision making for the GEF and general transfer mechanism. The results derived here provide an insight into the magnitude of transfer mechanisms for the negotiation of increasingly sustainable forest management, which have positive effects, especially in the context of global warming. This method has the potential for being extended to other areas and represents a replicable method.

It is beyond the scope of the work here to go into the details of the appropriation methods or tools, but some of the key mechanisms required to 'capture' these global values include international offsets, both public and private; property rights attenuation, debt for nature swaps and global transfers through the auspices of the Global Environmental Facility (GEF).

[1] Although there is much scientific and economic uncertainty surrounding the issue of the global warming phenomena, the very rigorous carbon stock estimation conducted in this study coupled with the conservative damage avoided cost estimates used, is the rationale for the high confidence level scoring.

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Annex 1: Logging Methods at the Study Site: Implications on the Peat Swamp Habitat

General

Logging in peat swamp forests poses special problems because of the water logged nature of the soil which cannot withstand the high pressure exerted by logging equipment used in dryland forests. The logging operation is divided into two phases, namely, extraction and transportation. The extraction involves the felling of trees and their transfer to a common hauling point, and the method to achieve this include the kuda-kuda (timber sledges), the winch and the traxcavator. The transportation of logs requires the transfer of logs from the hauling point to the nearest road system from which they could then be taken to the sawmills. Transportation could be via kuda-kuda, tramlines or canals dug out in the peat forests. The methods used for each phase, and in particular their combination, has important implications for the state of the forests following the logging operation.

The evolution of these logging methods will be described, with particular emphasis on their effects on the peat swamp habitat both during and after logging.

Kuda-kuda System

The first system of logging to be used in the swamp forests was the 'kuda-kuda'. This traditional method of log extraction involves the extensive use of manpower to load logs on timber sledges (the kuda-kuda) and to drag these sledges along special pathways (panglongs) constructed with poles. In this system the logs were then dragged to the tracks by teams of men. The materials used in this system were selected for their immediate strength and not their longevity. This high labor, low capital system although very environmentally sound, entails high risks to the loggers. This led then, over the years, to repeated attempts to find a method of log extraction which would obviate most, if not all, of the difficulties of the kuda-kuda method.

Winch

Winches represent a semi-mechanical method of felling trees. For this extraction method a long metal chain is strapped around the tree to be felled, and the tree is brought to the ground by way of an instant snap. The logs are assembled at loading platforms and then loaded onto log wagons by winch machine and taken out of the area by tramlines (Yap, 1966). Tramlines are wooden tracks used to transport logs out of the area; and these tracks are normally lifted after use, and laid down in the new logging areas.

Damage to the forest is thus relatively localized and drainage patterns are not significantly affected. This method and its combination with tramlines was indeed used to log a large part of the peat forests in southern Selangor. Although the combination of winch and tramline is not used in the SS, it was used in the southern peat swamps where the conditions are fairly similar, and was shown to inpose much less damage to the hydrology of the swamps than the construction of canals. Thus, subsequently there are less regeneration problems and silvicultural costs.

Table 1
Summary of the Intensity Effects of the Different Logging MethodsUsed in the Peat Swamp Forest

Logging method:	Logging costs:	Silvi-cultural costs:	Timber stand damage:	Hydrology & habitat modification:	Others adverse effects:	Overall status:
Kuda-kuda	L/M	L	L	L	L	S
Winch						
+ tramline	M/H	L/M	M	L	L	S
+ canal	L/M	M/H	M	M/H	M/H	U
Excavator						
+ tramline	M/H	M/H	M/H	M/H	M/H	S/U
+ canal	L/M	H	H	H	H	U

Notes:
1. The effect of the logging methods are graded as low (L), medium (M) and high (H).
2. The overall status gives some qualitative indication as to whether the overall habitat will function is a unsustainable (U), sustainable (S).

Excavator

In recent years traxcavators, the peat swamp equivalent of a bulldozer, have been developed by a local contractor specially to suit the peat environment. In essence they represent the bulldozers of the hill forests and in effect are almost as damaging to the environment, if not more so. The excavators are heavy machines which drag logs and topple vegetation along its path, without sinking into the peat. It does, however, compress that peat along its path, thereby retarding subsequent regeneration along its pathways. The ecological effects of the traxcavator on peat swamp forests (and its subsequent sustainability) are not very clear, but should be studied in order to generate guidelines for its use.

The logs brought to the hauling point by the excavator will subsequently be transported out of the forests either by tramline or canal. Currently both these transport modes are used in the Study Site, but with tramlines slowly being phased out in preference of the canals. The latter is preferred because they are faster and cheaper to the private contractor, although the environmental damage is much greater. If an environmentally more benign method of logging is used, then logging costs to the private logger will increase, but the external costs will be less (in terms of the reduced loss of benefits provided by other goods and services which are co-products of these swamps).

Effects of the Logging Methods

It has been shown that in the context of the peat swamps, sustainability of the overall system is highly dependent on the logging method, which has the effect of not only altering the habitat structure, but also the rate and type of regenerating species. This in turn has implications on the silvicultural treatement required in the forest system. This linkage between logging methods and macro-habitat is unique in the case of peat swamps, because of the sensitive hydrological balance which has to maintained. The different logging methods will induce varying intensities of disturbance on the habitat (Table 1). The combination of the amount of timber logged (actual annual cut, AAC) and the logging method used will be critical for the determination of the overall state of the habitat.

For the analysis here, three combinations of logging methods were assessed: excavator + canal (currently the most popular) (Scenario A and Scenario B1), excavator + tramline (Scenario B2); and winch + tramline (Scenario B3). The value of timber from the peat swamps is very much dependent on which harvest method is used. To assign a value to each of the logging methods, the stumpage value was used.

The stumpage value or resource rent is the term forest economists give to the net price of timber, which represents the difference between the price of logs paid by a mill or exporter and the cost of harvesting logs and transporting them to the point of sale (i.e. log price - logging cost). At any one point in time, the log price is fixed by both national and international demand and supply factors. The logging costs, however, are determined by the logging method used; the higher the costs the lower the stumpage value. Thus, at any one time, different stumpage values can be used as proxies to reflect the variation in logging methods. Because stumpage values in P.M. are strongly influenced by export restrictions, the bias had to be taken into account. The values used in the analysis will draw largely from two sources: EPU's (1993) natural resource accounting for timber in Malaysia and the World Bank Forestry Sector Review for Malaysia (World Bank, 1991).

The excavator + canal combination represents the cheapest logging method, and will be assigned the higher estimate of stumpage value of M$ 184/cu.m (World Bank, 1991). The excavator and tramline combination is a slightly more expensive logging method, and was assigned the EPU (1993) estimation of stumpage value of M$ 135/cu.m. Scenario B3 which would damage the peat swamp habitat the least has the highest logging costs. According to the World Bank report, helicopter logging which is supposed to be a more environmentally friendly method was estimated to give a stumpage value of only c. M$65/cu.m due to the higher costs of the sophisticated equipment. It is assumed here that Scenario B3 would have a stumpage value which is the mean of Scenario B2 and this helicopter logging method, giving a value of M$ 100/cu.m.

Annex 2

Table 1:

Discounted Cash Flow of Timber Benefits under Alternative Management Scenarios

Table 2:

Discounted Cash Flow for the Agro-Hydrological Value (M$/HA)

Table 3:

Benefits from Domestic Water Abstracted from SS (NPV M$)

Table 4:

Potential Visitation and Recreational Value (M$)

Table 1
Discounted Cash Flow of Timber Benefits under Alternative Management Scenarios

YEAR	MEAN ANNUAL INCREMENT (CU.M)	STUMPAGE VALUE - B1 (M$/CU.M)	STUMPAGE VALUE - B2 (M$/CU.M)	STUMPAGE VALUE - B3 (M$/CU.M)	TIMBER VALUE B1/ 0% DAM. (M$/CU.M.)	TIMBER VALUE B1/ 20% DAM. (M$/CU.M.)	TIMBER VALUE B1/ 50% DAM. (M$/CU.M.)	TIMBER VALUE B2/ 0% DAM. (M$/CU.M.)	TIMBER VALUE B2/ 20% DAM. (M$/CU.M.)	TIMBER VALUE B2/ 50% DAM. (M$/CU.M.)	TIMBER VALUE B3/ 0% DAM. (M$/CU.M.)	TIMBER VALUE B3/ 20% DAM. (M$/CU.M.)	TIMBER VALUE B3/ 50% DAM. (M$/CU.M.)
1	1.07	184	135	100	197	158	98	144	116	72	107	86	51
2	1.07	187	137	102	200	160	100	147	118	73	109	87	54
3	1.07	190	140	103	204	163	102	149	120	75	111	89	55
4	1.07	193	142	105	207	166	103	152	122	76	113	90	56
5	1.07	197	144	107	210	168	105	155	124	77	114	92	57
6	1.07	200	147	109	214	171	107	157	126	79	116	93	58
7	1.07	203	149	111	217	174	108	160	128	80	118	95	59
8	1.07	206	152	113	220	176	110	163	130	81	120	96	60
9	1.07	209	154	114	224	179	112	165	132	83	122	98	61
10	1.07	212	157	116	227	182	114	168	134	84	125	100	62
11	1.07	215	160	118	230	184	115	171	137	85	127	101	63
12	1.07	218	163	120	234	187	117	174	139	87	129	103	64
13	1.07	222	165	122	237	190	119	177	141	88	131	105	65
14	1.07	225	168	125	240	192	120	180	144	90	133	107	67
15	1.07	228	171	127	244	195	122	183	146	91	135	108	68
16	1.07	231	174	129	247	198	124	186	149	93	138	110	69
17	1.07	234	177	131	250	200	125	189	151	95	140	112	70
18	1.07	237	180	133	254	203	127	192	154	96	143	114	71
19	1.07	240	183	135	257	206	129	196	157	98	145	116	72
20	1.07	243	186	138	260	208	130	199	159	99	147	118	74
21	1.07	247	189	140	264	211	132	202	162	101	150	120	75
22	1.07	250	192	142	267	214	134	206	165	103	152	122	76
23	1.07	253	196	145	271	216	135	209	167	105	155	124	78
24	1.07	256	199	147	274	219	137	213	170	106	158	126	79
25	1.07	259	202	150	277	222	139	216	173	108	160	128	80
26	1.07	262	206	152	281	224	140	220	176	110	163	130	82
27	1.07	265	209	155	284	227	142	224	179	112	166	133	83
28	1.07	268	213	158	287	230	144	228	182	114	169	135	84
29	1.07	272	216	160	291	232	145	232	185	116	172	137	86
30	1.07	275	220	163	294	235	147	236	188	118	174	140	87
31	1.07	278	224	166	297	238	149	240	192	120	177	142	89
32	1.07	281	228	169	301	241	150	244	195	122	180	144	90
33	1.07	284	232	172	304	243	152	248	198	124	184	147	92
34	1.07	287	235	174	307	246	154	252	202	126	187	149	93
35	1.07	290	239	177	311	249	155	256	205	128	190	152	95
36	1.07	293	244	180	314	251	157	261	208	130	193	154	97
37	1.07	297	248	183	317	254	159	265	212	133	196	157	98
38	1.07	300	252	187	321	257	160	270	216	135	200	160	100
39	1.07	303	256	190	324	259	162	274	219	137	203	162	102
40	1.07	306	261	193	327	262	164	279	223	139	206	165	103
41	1.07	309	265	196	331	265	165	284	227	142	210	168	105
42	1.07	312	269	200	334	267	167	288	231	144	214	171	107
43	1.07	315	274	203	337	270	169	293	235	147	217	174	109
44	1.07	319	278	206	341	273	170	298	239	149	221	177	110
45	1.07	322	283	210	344	275	172	303	243	152	225	180	112
46	1.07	325	288	214	347	222	87	308	194	76	228	144	56
47	1.07	328	293	217	351	225	88	314	92	36	232	68	27
48	1.07	331	298	221	354	227	89	319	92	36	236	68	27
49	1.07	334	303	225	358	229	89	324	92	36	240	68	27
50	1.07	337	308	228	361	231	90	330	92	36	244	68	27

51	1.07	340	314	232	364	233	91	336	92	36	249	66	27
52	1.07	344	319	236	368	235	92	341	92	36	253	66	27
53	1.07	347	324	240	371	237	93	347	92	36	257	66	27
54	1.07	350	330	244	374	240	94	353	92	36	261	66	27
55	1.07	353	335	249	378	242	94	359	92	36	266	66	27
56	1.07	356	341	253	381	244	95	365	92	36	270	66	27
57	1.07	359	347	257	384	246	96	371	92	36	275	66	27
58	1.07	362	353	261	388	248	97	378	92	36	280	66	27
59	1.07	365	359	266	391	250	98	384	92	36	284	66	27
60	1.07	369	365	270	394	252	99	391	92	36	289	66	27
61	1.07	372	371	275	398	255	99	397	92	36	294	66	27
62	1.07	375	377	280	401	257	100	404	92	36	299	66	27
63	1.07	378	384	284	404	259	101	411	92	36	304	66	27
64	1.07	381	390	289	408	261	102	418	92	36	309	66	27
65	1.07	384	397	294	411	263	103	425	92	36	315	66	27
66	1.07	387	404	299	414	265	104	432	92	36	320	66	27
67	1.07	390	411	304	418	267	104	439	92	36	326	66	27
68	1.07	394	418	309	421	270	105	447	92	36	331	66	27
69	1.07	397	425	315	424	272	106	455	92	36	337	66	27
70	1.07	400	432	320	428	274	107	462	92	36	342	66	27
71	1.07	403	439	325	431	276	108	470	92	36	348	66	27
72	1.07	406	447	331	435	278	109	478	92	36	354	66	27
73	1.07	409	454	337	438	280	109	486	92	36	360	66	27
74	1.07	412	462	342	441	282	110	494	92	36	366	66	27
75	1.07	416	470	348	445	285	111	503	92	36	373	66	27
76	1.07	419	478	354	448	287	112	511	92	36	379	66	27
77	1.07	422	486	360	451	289	113	520	92	36	385	66	27
78	1.07	425	494	366	455	291	114	529	92	36	392	66	27
79	1.07	428	503	372	458	293	114	538	92	36	398	66	27
80	1.07	431	511	379	461	295	115	547	92	36	405	66	27
81	1.07	434	520	385	465	297	116	556	92	36	412	66	27
82	1.07	437	529	392	468	300	117	566	92	36	419	66	27
83	1.07	440	538	398	471	302	118	575	92	36	426	66	27
84	1.07	444	547	405	475	304	119	585	92	36	434	66	27
85	1.07	447	556	412	478	306	120	595	92	36	441	66	27
86	1.07	450	566	419	481	308	120	605	92	36	448	66	27
87	1.07	453	575	426	485	310	121	616	92	36	456	66	27
88	1.07	456	585	433	488	312	122	626	92	36	464	66	27
89	1.07	459	595	441	491	315	123	637	92	36	472	66	27
90	1.07	462	605	448	495	317	124	648	92	36	480	66	27
91	1.07	466	615	456	498	255	82	659	74	18	488	54	14
92	1.07	469	626	464	501	257	83	670	74	18	496	54	14
93	1.07	472	637	472	505	258	83	681	74	18	505	54	14
94	1.07	475	647	480	508	260	84	693	74	18	513	54	14
95	1.07	478	658	488	511	262	84	705	74	18	522	54	14
96	1.07	481	670	496	515	264	84	716	74	18	531	54	14
97	1.07	484	681	504	518	265	85	729	74	18	540	54	14
98	1.07	487	693	513	522	267	85	741	74	18	549	54	14
99	1.07	491	704	522	525	269	86	754	74	18	558	54	14
100	1.07	494	716	531	528	270	86	766	74	18	568	54	14
					B1-0%	B1-20%	B1-50%	B2-0%	B2-20%	B2-50%	B3-0%	B3-20%	B3-50%
				NPV 8% (M$/HA)	2961	2360	1453	2267	1750	1065	1694	1296	604
				NPV 2% (M$/HA)	13368	9693	5163	12265	6048	3467	9100	4477	2573
				NPV 0% (M$/HA)	36255	24494	11466	37356	12690	6663	27671	9392	4958

Notes:

1. For sustainable regime the annual harvest is equal to the mean annual increment i.e. 1.07 cu.m/year, while for unsustainable regimes the harvest is 80% higher, at 1.93 cu.m/year.

YEAR	CU.M./YR (A) 0% DAMAGE	CU.M./YR (A) 20% DAMAGE	CU.M./YR (A) 50% DAMAGE	TIMBER VALUE A/ 0% DAM. (M$/CU.M.)	TIMBER VALUE A/ 20% DAM. (M$/CU.M.)	TIMBER VALUE A/ 50% DAM. (M$/CU.M.)
1	1.92	1.54	0.96	353	283	177
2	1.92	1.54	0.96	359	288	180
3	1.92	1.54	0.96	365	293	183
4	1.92	1.54	0.96	371	298	186
5	1.92	1.54	0.96	377	303	189
6	1.92	1.54	0.96	383	307	192
7	1.92	1.54	0.96	389	312	195
8	1.92	1.54	0.96	395	317	198
9	1.92	1.54	0.96	401	322	201
10	1.92	1.54	0.96	407	327	204
11	1.92	1.54	0.96	413	332	207
12	1.92	1.54	0.96	419	336	210
13	1.92	1.54	0.96	425	341	213
14	1.92	1.54	0.96	431	346	216
15	1.92	1.54	0.96	437	351	219
16	1.92	1.54	0.96	443	356	222
17	1.92	1.54	0.96	449	360	225
18	1.92	1.54	0.96	455	365	228
19	1.92	1.54	0.96	461	370	231
20	1.92	1.54	0.96	467	375	234
21	1.92	1.54	0.96	473	380	237
22	1.92	1.54	0.96	479	385	240
23	1.92	1.54	0.96	485	389	243
24	1.92	1.54	0.96	491	394	246
25	1.92	1.54	0.96	497	399	249
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YEAR	CU.M./YR (A) 0% DAMAGE	CU.M./YR (A) 20% DAMAGE	CU.M./YR (A) 50% DAMAGE	TIMBER VALUE A/ 0% DAM. (M$/CU.M.)	TIMBER VALUE A/ 20% DAM. (M$/CU.M.)	TIMBER VALUE A/ 50% DAM. (M$/CU.M.)
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	A-0%	A-20%	A-50%
NPV 6%	4209	3448	2149
NPV 2%	7994	6412	3997
NPV 0%	14220	11405	7110

Table 2
Discounted Cash Flow for the Agro-Hydrological Value (M$/HA)

YEAR	AGRO-HYDRO VALUE (M$/HA)		DISTURBANCE SCENARIO LOW	MEDIUM	HIGH
1	80	50	80	80	80
2	80	50	80	80	80
3	80	50	80	80	80
4	80	50	80	80	80
5	80	50	80	80	80
6	80	50	80	80	
7	80	50	80	80	
8	80	50	80	80	
9	80	50	80	80	
10	80	50	80	80	
11	80	50	80	80	
12	80	50	80	80	
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14	80	50	80	80	
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89	80	50			
90	80	50			
91	80	50			
92	80	50			
93	80	50			
94	80	50			
95	80	50			
96	80	50			
97	80	50			
98	80	50			
99	80	50			
100	80	50			

SUMMARY OF NPV/HA OF THE AGRO-HYDRO BENEFIT AT VARIOUS DISCOUNT RATES

	LEVEL OF DISTURBANCE LOW	MEDIUM	HIGH
NPV 2%	3286	1143	377
NPV 4%	1934	973	356
NPV 6%	1325	838	337
NPV 8%	989	730	319
NPV 10%	800	642	303
NPV 12%	533	484	288

Notes: 1. For each year that the water abstracted from the swamps and within the limits of the live-storage, the agro-hydrological value is assumed to be 12% of the total agro-hydrological value 10% for the dry season crop and 2% for the wet season crop.

Table 3
Benefits from Domestic Water Abstracted from SS (NPV M$)

YEAR	Annual volume Treated (gallons)	Incremental Cost (M$)
1	2190000000	49773
2	2628000000	59727
3	3066000000	69682
4	3504000000	79636
5	3942000000	89591
6	4380000000	99545
7	4818000000	109500
8	5256000000	119455
9	5694000000	129409
10	6132000000	139364
11	6570000000	149318
12	7008000000	159273
13	7446000000	169227
14	7884000000	179182
15	8322000000	189136
16	8760000000	199091
17	9198000000	209045
18	9636000000	219000
19	10074000000	228955
20	10512000000	238909
21	10950000000	248864
22	11388000000	258818
23	11826000000	268773
24	12264000000	278727
25	12702000000	288682
26	13140000000	298636
27	13578000000	308591
28	14016000000	318545
29	14454000000	328500
30	14892000000	338455
31	15330000000	348409
32	15768000000	358364
33	16206000000	368318
34	16644000000	378273
35	17082000000	388227
36	17520000000	398182
37	17958000000	408136
38	18396000000	418091
39	18834000000	428045
40	19272000000	438000
41	19710000000	447955
42	20148000000	457909
43	20586000000	467864
44	21024000000	477818
45	21462000000	487773
46	21900000000	497727
47	22338000000	507682
48	22776000000	517636
49	23214000000	527591
50	23652000000	537545
51	24090000000	547500
52	24528000000	557455
53	24966000000	567409
54	25404000000	577364
55	25842000000	587318
56	26280000000	597273
57	26718000000	607227
58	27156000000	617182
59	27594000000	627136
60	28032000000	637091
61	28470000000	647045
62	28908000000	657000

YEAR	Annual volume Treated (gallons)	Incremental Cost (M$)
61	28470000000	647045
62	28908000000	657000
63	29346000000	666955
64	29784000000	676909
65	30222000000	686864
66	30660000000	696818
67	31098000000	706773
68	31536000000	716727
69	31974000000	726682
70	32412000000	736636
71	32850000000	746591
72	33288000000	756545
73	33726000000	766500
74	34164000000	776455
75	34602000000	786409
76	35040000000	796364
77	35478000000	806318
78	35916000000	816273
79	36354000000	826227
80	36792000000	836182
81	37230000000	846136
82	37668000000	856091
83	38106000000	866045
84	38544000000	876000
85	38982000000	885955
86	39420000000	895909
87	39858000000	905864
88	40296000000	915818
89	40734000000	925773
90	41172000000	935727
91	41610000000	945682
92	42048000000	955636
93	42486000000	965591
94	42924000000	975545
95	43362000000	985500
96	43800000000	995455
97	44238000000	1005409
98	44676000000	1015364
99	45114000000	1025318
100	45552000000	1035273

Notes:

1. Domestic water abstracted is 6 million gallons/day, and the incremental treatment cost M$0.05/cu.m (1cu.m. = 2200gal).
2. Domestic water abstraction is projected to increase at 2% per year to meet the growing needs of the residents.

SUMMARY OF NPV FOR DOMESTIC WATER BENEFITS AT THE SS (M$)

	Total SS	NPV/ha
NPV 2%	15726070	230
NPV 4%	6825333	94
NPV 6%	3535205	49
NPV 8%	2170910	30
NPV 10%	1492351	20
NPV 13%	971851	13

Table 4
Potential Visitation and Recreational Value (M$)

YEAR	NO. OF VISITORS	RECREATIONAL VALUE @M$9/TRIP	YEAR	NO. OF VISITORS	RECREATIONAL VALUE @M$9/TRIP
1	1281	11529	57	108171	973539
2	4335	39015	58	108171	973539
3	7389	66501	59	108171	973539
4	10443	93987	60	108171	973539
5	13497	121473	61	108171	973539
6	16551	148959	62	108171	973539
7	19605	176445	63	108171	973539
8	22659	203931	64	108171	973539
9	25713	231417	65	108171	973539
10	28767	258903	66	108171	973539
11	31821	286389	67	108171	973539
12	34875	313875	68	108171	973539
13	37929	341361	69	108171	973539
14	40983	368847	70	108171	973539
15	44037	396333	71	108171	973539
16	47091	423819	72	108171	973539
17	50145	451305	73	108171	973539
18	53199	478791	74	108171	973539
19	56253	506277	75	108171	973539
20	59307	533763	76	108171	973539
21	62361	561249	77	108171	973539
22	65415	588735	78	108171	973539
23	68469	616221	79	108171	973539
24	71523	643707	80	108171	973539
25	74577	671193	81	108171	973539
26	77631	698679	82	108171	973539
27	80685	726165	83	108171	973539
28	83739	753651	84	108171	973539
29	86793	781137	85	108171	973539
30	89847	808623	86	108171	973539
31	92901	836109	87	108171	973539
32	95955	863595	88	108171	973539
33	99009	891081	89	108171	973539
34	102063	918567	90	108171	973539
35	105117	946053	91	108171	973539
36	108171	973539	92	108171	973539
37	108171	973539	93	108171	973539
38	108171	973539	94	108171	973539
39	108171	973539	95	108171	973539
40	108171	973539	96	108171	973539
41	108171	973539	97	108171	973539
42	108171	973539	98	108171	973539
43	108171	973539	99	108171	973539
44	108171	973539	100	108171	973539
45	108171	973539			
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53	108171	973539			
54	108171	973539			
55	108171	973539			
56	108171	973539			

Notes: 1. Recreational demand projected from Kuala Selangor Nature Park, upto year 37, then assumed to level off.
2. Consumer surplus @M$9/visitor.

SUMMARY OF NPV OF RECREATIONAL VALUE (M$)

NPV 8%	4142799
NPV 2%	28213029
	Per Hectare
NPV 8%	57
NPV 2%	387

Environment Department
The World Bank
1818 H Street, N.W.
Washington, D.C. 20433
202 473 3641 202 477 0565 FAX