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Economic Benefits of Watershed Protection and Trade-off with Timber Production: A Case Study in Malaysia

Mohd Shahwahid H.O., Awang Noor, A.G.,
Abdul Rahim N., Zulkifli Y. & Ragame U.

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Mohd Shahwahid H.O., Awang Noor A.G., Abdul Rahim N., Zulkifli Y. and Razani U.

Abstract

This project attempts to estimate the costs and benefits of managing forested catchments in Peninsular Malaysia. Two land use options are simulated in four selected catchments in the Hulu Langat Forest Reserve (HLFR), Selangor. The land use options considered are total protection (TP) or no logging in the catchment and reduced impact logging (RIL).

The project computes the potential sedimentation impacts of each option on the dam and water intake ponds in the catchments. It then estimates the benefits derived from logging, hydroelectric power (HEP) generation, water regulatory dam for water treatment, and costs associated with sedimentation under the two options. The estimation made use of data collected from previous studies conducted in adjacent areas with similar hydrological characteristics, and secondary data from published reports by various departmental agencies and personal surveys in the study site. The findings highlighted the substantial external costs from increased sediment yield caused by logging. The RIL land use option in combination with water utilization is the more efficient economic use of forested catchments in the HLFR. It is recommended, however, that efforts be made to internalize the costs of increased sediment yield.

The findings of this study cannot be extended to other forested catchments owing to the unique setups of the water regulatory dam and three HEP water intake ponds at the study site. Furthermore, the study did not consider the impacts of the two land use options on other attributes of forested catchments, such as biodiversity conservation.

Forested catchments provide various goods and services. These include commodities like water, timber, and rattan; and environmental services such as carbon storage, climate regulation, nutrient cycling, flood control, and biodiversity conservation. Not all of these goods and services are being extracted on an industrial scale to create a significant impact on the economy. Others either have not reached the prospecting stage, or are of global importance but with their benefits not realized locally. Timber and water, and their respective uses and benefits, appear to be the two most important goods and services from forested catchments that have a significant impact on the economy.

Forested catchments are important sources of water supply for both consumptive and non-consumptive uses. In fact, they supply virtually all of the fresh water used for agriculture, industry, households, and recreation in Peninsular Malaysia. Water catchment forests, covering a total area of 270,000 hectares (ha), play a crucial role in sustaining major dams and reservoirs in three states: Pedu and Muda dams in Kedah, Kenyir Dam in Terengganu, and Temenggor Dam in Perak.. Smaller forested catchments scattered throughout the country also play an important role in protecting downstream areas from flooding and sedimentation.

In 1990, the total water demand in Malaysia was estimated at 11.6 billion cubic meters (m^3). Continuous provision of water supplies to domestic users in both urban and rural areas is an important objective of the government. Rapid economic growth also implies an increasing demand for water by the industrial sector. Other non-consumptive uses such as irrigation and hydroelectric power (HEP) are important and will continue to increase. The total growth in demand for water (for domestic and industrial uses) in Peninsular Malaysia is estimated at about 10 percent per annum.

Forests are also sources of timber. The government forest conservation policy calls for a reduction of the annual logging coupes in the productive forest reserves and an intensive agricultural management program whereby the clearance of state forests would decline (Mohd Shahwahid 1995). Areas available for logging are expected to become scarcer as logging areas in state forests are rapidly exhausted and the annual logging coupes from the productive forest reserves are reduced. The official annual logging coupes have been reduced from 71,200 ha per year in the Fifth Malaysia Plan (1985-90) to 52,250 ha per year in the Sixth Malaysia Plan (1991-95). Yet, log consumption in the peninsula does not seem to show any sign of declining. In 1985, the two major consuming industries - sawmills and plywood manufacture - consumed 7.4 million m^3. In 1992, their consumption increased to 9.9 million m^3. With the more accessible forests within and outside the productive forest reserves being exhausted, it is expected that pressure to log in the forested catchments will increase.

1. PURPOSE OF THE CASE STUDY

The growing demand for water and timber and the potential adverse impacts of uncontrolled logging on the hydrological attributes call for increased attention to integrated watershed protection and sustainable timber production objectives in the forested catchments. Moreover, the development of large-scale economic infrastructure implies an increased risk of significant losses due to flooding and sedimentation linked to logging and conversion of forested areas. Substantial areas of forested catchments, previously managed mainly for water, need to be reassessed in terms of their role in water supply as well as timber production. Likewise, substantial areas of production forests, previously managed mainly for timber, will need to be reassessed in terms of their role in water supply and watershed conservation. It is recognized, however, that in highly unstable areas, some forest areas may ultimately be designated solely for watershed protection. Forest managers need improved methods for evaluating watershed protection benefits at specific sites and assessing the economic trade-off between timber production and watershed protection objectives. Ultimately, new forest management systems that integrate timber production, watershed protection, and other objectives will be required.

A fundamental question is how to assess the potential physical impacts of timber production on reservoir management and downstream activities. There is also the need to value and compare the intangible, non-priced, but real benefits of forested catchment protection (and of other non-marketed environmental benefits) with the tangible, economic benefits of timber production. This challenge must be addressed since policy makers in developing countries, like Malaysia, require monetary estimates to help them decide on land use options. A comprehensive assessment of all costs and benefits and the achievement of a sustainable forest management plan necessitate integrated and multidisciplinary research efforts of hydrologists, foresters, and natural resource economists.

This study will contribute to this effort through the testing and development of practical and reliable methods for measuring the physical and monetary impacts of forested catchment protection. It will also help assess trade-off between environmental protection and production objectives. The project is thus of direct and immediate relevance not only to Malaysian forestry but to the environment at large. In addition, the study has potential global significance to the extent that it generates new and original results in a field characterized by an extreme dearth of rigorous applied research.

1.1 Objectives

This project is concerned with the valuation of the benefits and costs, and an analysis of the trade-off between managing forestland for timber and/or for water supply. Forested land may be managed for different outputs: single use--either timber or water, or multiple uses-- timber and water jointly produced in technically variable proportions. The specific objectives of the study are

(i) to identify the uses of the forested catchment;
(ii) to model sediment yield in forested catchments under total protection and reduced impact logging land use options;
(iii) to value the benefits and costs of managing forested catchments for water production, with and without logging options, and to establish their trade-off; and
(iv) to evaluate the potential economic rents from timber production and industrial water use, and show their distribution among interested parties.

1.2 Hulu Langat Forest Reserve

The study area is the Hulu Langat Forest Reserve (HLFR), located in Selangor State, Peninsular Malaysia (Figure 1). Site selection was based on a range of physical and economic criteria: availability of relevant potential timber or stumpage inventory and hydrological data, and the economic significance of water uses or protection services linked to the site, particularly industrial water supplies and the generation of hydroelectric power (HEP).

The HLFR is one of nine reserves (representing about 26 percent of the total forest reserves) in Selangor. The HLFR is covered with hill dipterocarps at altitudes ranging from 120 m to 1,265 m above sea level. The main river in the HLFR is the Langat River, which flows in a southwesterly direction into the Strait of Malacca on the west coast. The downstream reaches of the Langat River are not actively used by local people, although occasionally, leisure fishing and recreation activities take place. The residents obtain their drinking water from a water treatment facility supplied by the Water Supply Department. This water treatment facility was recently privatized to an independent water supplier. The facility receives a regular supply of raw water from the Langat River. There are several upland catchments, each named after the stream draining the respective basins, providing water to the area. They are the Langat, Lupok, Pangson, Lolo, Chongkak, and Lui rivers (Figure 1), which are tributaries of the Langat Main River.

The Langat Dam is located within the Langat Catchment (C1). It is a water regulatory dam, releasing water for the water treatment plants, located some 13 kilometers (km) downstream, when the plants expect to experience shortage of water supplies at the intake points. The total area of C1, inclusive of the inundated dam area, is 3,823 ha. Three other catchments are located beside C1: Lolo Catchment (C2, with an area of 473 ha), Pangson Catchment (C3, 265 ha), and Lupok Catchment (C4, 455 ha). Three mini-dams or water intake ponds are located in these catchments (see Figure 1). The mini-dams serve as the water intake points through a system of pipelines for two HEP plants. Still other catchments feed the Chongkak and Lui rivers that eventually flow into the Langat River.

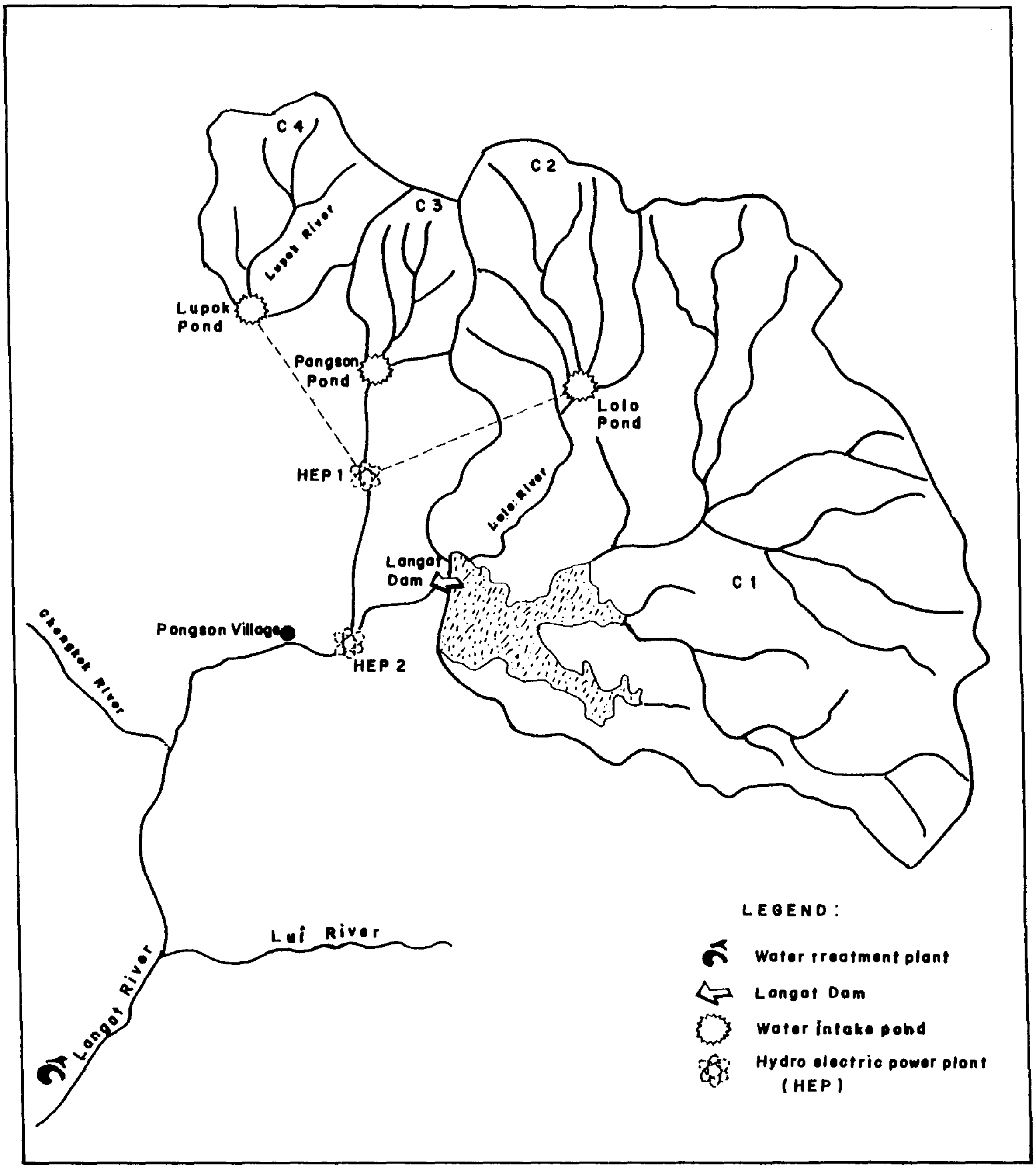


Figure 1. Hulu Langat Forest Reserve study site

Prior to the establishment of the Langat Dam, HLFR had been logged for timber production as early as 1944 in the Chongkak catchment. However, logging was stopped in 1987. Timber harvesting has continued in the Lui catchment.

The main direct use of the watershed in C1 is the impounding of water in the Langat Dam. The dam forms part of the Langat River Scheme, which was designed to augment the water supply in Kuala Lumpur and the Klang Valley region. This program was implemented in 1976 by the Selangor State government with a total investment of RM31.8 million (US$1 = RM2.5). The dam impounds 37.5 million m^3 of water at top water level of 220 m, and regulates the flow of the Langat River in the dry season according to the demand of the water treatment plants downstream. The reservoir serves as a security to enable 386.4 thousand m^3 per day of water to be continuously abstracted at the existing river intake for the water treatment plants. The water production capacity of the Langat treatment plants is 141.0 million m^3 per annum, worth an estimated RM46.5 million at full capacity.

Another direct use of the HLFR catchments is HEP generation. There are currently two mini-HEP subplants operating on water supplied through water pipelines from the three water ponds within the C2 , C3, and C4. The HEP facility is operated by an independent power supplier and has a generating capacity of up to 33 kilovolts (kV)(37,440 kilowatt-hours [kWh]) of electricity per day. The annual potential capacity is worth RM22.5 million.

The Chongkak River is currently used as a forest recreation area. Efforts to develop Sungai Chongkak began in 1992 with the provision of some basic facilities for the increasing number of visitors. The fast-flowing streams are characterized by a pool-riffle sequence, which is one of the main attractions for visitors at the site. However, it is not really known whether there is a positive relationship between the number of visitors and benefits from clean water.

The main activities in the forest area are in three classes: (i) daily use, (ii) camping, and (iii) limited access core zones. These activities may influence the number of visitors.

Apart from the above major uses of the HLFR, the rural communities also collect non-wood forest products (NWFP) from the reserve. A socioeconomic survey was conducted to obtain information on the current status of the utilization of goods and services in the study area. In general, the local community is involved in the collection of various traditional goods, and the business of providing lodging and food to picnickers. Daily domestic use of the river water is limited since the communities living downstream of the Langat Dam have piped water.

The local community in the study area comprises indigenous people from the Temuan tribe who live adjacent to the forest reserve, Malay villagers a few miles downstream, and Chinese residents from the nearest town of Simpang Balak. The 585 indigenous population are in 60 households in a 2.5-ha village. The Malay and Chinese residents are estimated at 150 in 30 households.

A total of 22 villagers (19 indigenes, 1 Malay, and 2 Chinese), who are known to be involved in utilizing goods and services from the study site, were interviewed to obtain information on NWFP utilization. All the 19 indigenes collect traditional goods from the forest: wild fruits such as durian, petai, and banana, vegetables and condiments, fiber materials such as bamboo, bertam, and rattan; and parts of medicinal plants. The Malay operates a lodge for recreationists during weekends, while the two Chinese prepare joss sticks from bamboo bought from the indigenes.

The full range of goods and services provided by the HLFR, including information on the average physical unit of utilization and income derived from collecting traditional goods, providing lodging, and processing bamboo into incense sticks are given in Table 1. On the average, a household could earn RM217/month from the collection of traditional goods from the HLFR. The Malay could obtain an income of about RM240 a month, assuming that the lodge is fully rented during the weekends. The Chinese entrepreneurs who process bamboo earn an average gross income of RM3,043 a month.

Table 1 Full range of goods and services obtained from the study site as per household survey

Items	Physical quantity	Income derived from sales[a] (RM/month)
Banana leaves	1,700 /month	120
Leaf shoots (*Stenochlaena palutaris*)	120 bundles/month	12
Banana	45 kg/month	22
Petai	Seasonal	17
Durian	Seasonal	82
Fibers		
• Bertam	1,900 pieces/month	63
• Bamboo	135 pieces/month	147
• Rattan	20 manau pieces/month	60
Medicinal herb	4 packs/month	40
Joss sticks	0.7 million sticks	6,086
Lodge rental (family size)	Seasonal	30[b]
Hydroelectric power generation	1,560 kWh continuously	187,902
Water treatment	141 million m^3/yr	3,878,636

[a] US$ 1= RM2.50 (1995) [b] Per night

1.3 Study Site

This study involves only catchments C1, C2, C3, and C4. C1 has a water regulatory dam and the three others each have a mini hydroelectric dam or water intake pond. The main uses of the catchments would include extraction of timber on a sustainable basis, water impoundment for the Langat Dam, and HEP generation. Two land use options are simulated on the catchments: total protection (TP) and reduced impact logging (RIL).

2. LAND USE OPTIONS

2.1 Total Protection

The first land use option is the status quo, where the four catchments are used as water sources for the intake ponds of the HEP plant and the water regulatory dam.

Benefits from water use would continue to be realized. The catchments are protected and no logging activity is permitted. Hence, there will be no timber benefits. Neither will there be negative externalities from logging operations, except those arising from the natural rate of sedimentation.

2.2 Reduced Impact Logging

Logging practices vary with regard to the status of forestlands. In state land forests (conversion forests), clear felling is practiced and there is no minimum-diameter cutting limit. In forest reserves where logging is permitted (productive permanent forest estate), selective logging is practiced, but strict rules and regulations are imposed. Selective logging is done by first determining the cutting cycle and then the minimum-diameter cutting limits. Only trees above the minimum-diameter cutting limits may be harvested.

The current management practice in the natural hill forest reserves is based on the Selective Management System (SMS). This system prescribes cutting regimes that yield an economically viable harvest volume while leaving sufficient residual trees to ensure future harvests at intervals ranging from 30 to 55 years. The interval depends on the density of the residual forest and the consequent cultural practices to be adopted. In practice, the SMS is implemented by setting minimum-diameter cutting limits for dipterocarp and non-dipterocarp trees based on analysis of data from pre-felling (pre-F) inventories. Cutting limits typically are no lower than 50 cm diameter breast height (dbh) for dipterocarps and 45 cm dbh for non-dipterocarp timber species. One requirement is a minimum residual stocking of not less than 32 marketable trees of good quality with a diameter of 30 to 45 cm or its equivalent per ha. Such a prescription is not necessarily optimal (Mohd Shahwahid 1985). Nevertheless, it is not the aim of this study to verify this issue, but rather to evaluate the impact of this logging system on land use efficiency.

In implementing the SMS, the Forest Department carries out the following activities: (i) boundary clearing before harvesting, (ii) pre-F inventory, (iii) tree marking of all commercial trees that are larger than the prescribed cutting limits, (iv) enforcement during and after harvesting, and (v) post-felling (post-F) inventory to determine the appropriate silvicultural treatments.

The SMS also takes into account environmental concerns that may arise from logging. There is now ample evidence showing that environmental damage associated with logging operations can be considerably reduced through a well-planned and carefully executed logging operation. While it is certainly helpful to have well-documented guidelines (e.g., Hamilton and King 1983, FD 1988), these guidelines need to be strictly enforced or put into practice. The existing guidelines generally encompass aspects of harvesting technique, silvicultural system, infrastructure (logging roads, log landings, skid-tracks), and log extraction. To reflect the embodiment of these guidelines, the logging land use option is termed as reduced impact logging (RIL). Among the various principles of RIL are the following:

(i) Climber cutting. Nine to 12 months before harvest, workers cut woody liana vines, which may be as dense as 2,000 per ha. The vines, which connect trees from crown to crown, can cause fallen trees to pull others down with them.

(ii) Mapping the forests. The entire area to be harvested is mapped out to Identify trees for felling, road and skid trail sites, and log collection points to minimize damage to the forest.

(iii) Careful planning and building of roads and skid trails. All roadways and trails are marked and built to minimize use of steep slopes and streams as they can cause increased erosion and sedimentation.

(iv) Directional felling. Trees are cut so that they fall toward skid trails and away from potential crop trees. Although the outcome is not always exact, most trees offer a skilled feller a range of options over about 90 degrees of arc.

(v) Minimal use of bulldozers. Careful pre-felling planning and skid trail mapping help minimize destruction caused by the use of bulldozers and other heavy machinery in the forest.

(vi) Riparian reserves. Buffer strips are left along waterways to prevent sedimentation that may harm fisheries and irrigation systems.

(vii) Landings ripped up. After harvest, log landings or collection points are ripped up to reduce soil compaction. The area is then sown with a new cover crop to minimize erosion.

(viii) Skid trail draining. Before a harvested area is left, loggers remove all objects that might obstruct streams and skid trails are drained.

(ix) Buffer strip. In forestry, buffer strips or stream protection zones comprise land areas of varying size along the stream that need to be left untouched during forest operations. Although buffer strips may occupy only a small portion of a catchment, they represent an extremely important component of the overall landscape. A buffer strip is the simplest conservation measure that is practical and effective in ameliorating the impact of land use activities. The importance of buffer strips for maintaining water quality has long been recognized, especially for filtering sediments and other forms of pollutants from entering streams. The streamside hill slope is considered an ecologically sensitive area, for it can be a primary source of saturation overland flow. As such, it may transport considerable amounts of sediment when the vegetation is removed. The usually wet soil zones near streamside areas are prone to compaction when encroached upon by heavy machineries. Keeping a buffer strip along streams undisturbed ensures that the bank will remain intact and stable, and channel erosion rate will be low. In addition, the overstorey will protect the stream from direct sunlight, thus maintaining water temperature and protecting aquatic flora and fauna.

An overriding issue, however, is the suitable width of an effective buffer strip. A very narrow buffer strip may not be adequate to filter sediments, while a wide buffer strip may increase the cost for loggers. Essentially, the size of the buffer strip must take into account soil erodibility, slope, stream condition, and the intensity of disturbance. For selective logging in a tropical rain forest, a minimum width of 20 m on each bank was found adequate to keep the stream water at a reasonably acceptable quality (Zulkifli and Abdul Rahim 1994). The Forestry Department harvesting guidelines specified the width of the buffer strip based solely on slope factor (FD 1988) as follows:

$$Buffer\ strip\ [m] = 7.6 + (0.6 \times slope\ in\ \%)$$

Thus, depending on the slope factor, the minimum buffer strip may be higher or lower than 20 m. Interestingly, a study at Berembun showed that the forgone cost of having a 20-m buffer strip is reasonably low. The buffer strip, which covers 5 percent of the catchment, consists of 117 m^3 of merchantable timber greater than 60 cm dbh. When translated into cost, it represents about 8 percent of the stumpage value (Abdul Rahim and Zulkifli 1994).

3. VALUATION OF COSTS AND BENEFITS OF ALTERNATIVE LAND USE OPTIONS

Different land uses have varying physical impacts that need to be valued. The study is carried out at two levels: first, enumerating the physical impacts of the land use options, and second, conducting the economic valuation of these physical impacts. The second stage also establishes the economic trade-off between watershed protection and logging.

The nature of the physical impacts of the alternative land use options can be better understood by referring to Table 2 showing changes in the sedimentation yield, timber harvest, loss of live storage of dam, and HEP generation. Quantitative estimates of the hydrological impacts can be obtained by transferring the existing data from nearby sites. Rainfall and streamflow data are currently being measured in four catchments, namely, those of Lui, Batangsi, Chongkak, and Lawing rivers. Two PhD theses (Lai 1993, and Low 1971) made use of the data from the four catchments. Sediment rates in undisturbed catchments and in catchments affected by logging were measured. The rainfall-runoff relationship was also analyzed. The hydrological impacts using simple hydrological models were also estimated.

An initial challenge faced by this study is to obtain reliable information on the interrelationships between different forest land use options and downstream impacts of sedimentation on dam storage and HEP. The study relied extensively on previous research in the biophysical sciences, especially on forestry and catchment hydrology. The impacts of timber harvesting on hydrological attributes have been well documented in several small catchment studies. These include aspects of rainfall and runoff relationship, water yield changes, streamflow response, soil erosion, sedimentation, water quality, and nutrient losses. Data on the volume of timber in standing trees (stumpage volume) were taken from information collected by the National Forest Inventories conducted in 1990.

Valuations of the impacts of these physical changes require data on relevant variables such as production cost, price of treated water, and HEP. These data are solicited from a market survey of logging contractors, and water treatment and HEP plants.

Table 2 Hypothetical Physical Impacts of Alternative Land Use Options in Selected HLFR Catchments

Land Use Option	Sedimentation[a]	Timber Harvest	Loss of Dam Storage	Loss of HEP
Total protection	Low	None	Normal	Normal
Reduced impact logging	Medium	Medium	Medium	Medium

[a] Results from the Berembun and Tekam River experimental catchments (Abdul Rahim 1988) revealed that sedimentation rates increased remarkably in the first year after catchment disturbance, but recovered to background level within three to five years. Degradation in the quality of stream water was observed especially for suspended solids, turbidity, and iron concentration. However, the impacts on water quality were short term and manageable. The magnitude of impacts generally depends on the intensity of disturbance and harvesting technique.

3.1 Determination of Sedimentation Under Different Land Use Options

Calculation of sediment input in the reservoir resulting from the two land use options is based on sediment yield values, expressed as the volume of material removed per unit area at a given time (m^3/ha per yr). The basic calculation involves the conversion of the sediment yield into volume or depth, which needs data on soil bulk density.

$$\textit{Sedimentation rate } (m^3/ha/yr) = [\textit{Sediment yield (ton)}] \, / \, [\textit{Area (ha)} \times \textit{Density}]$$

$$\textit{Sediment yield (SY)} = \textit{Suspended sediment (SS)} + \textit{Bed load sediment (BS)}$$

where *SS* comprises fine materials suspended in the water,

BS comprises coarse materials normally deposited as bed materials.

In this study, the sediment yield values reported by Lai (1993) in the adjacent catchment, Batangsi River, were used. This particular catchment shared similar physical characteristics with the Hulu Langat catchment. The suspended sediment yield from logging activities amounted to 28.3 t/ha per yr. The 1993 study also showed that the total bed load was 12.67 t/ha per yr. The total sediment yield due to logging is therefore 40.97 t/ha per yr. Using a sediment density value of 1.5 t/m^3, the total sediment yield is 27.31 m^3/ha per yr.

Sediment from logging operations can come from three major sources:

(i) Harvesting operation, which includes road construction, tree felling, and log extraction. Previous studies revealed that the rate of sediment production due to logging tends to decrease after the harvesting operation, provided that no further encroachment occurs in the logged area (Baharuddin 1988, 1995). In the present study, the sediment yield is assumed to decrease at the rate of 5.26 m^3/ha per year till the sixth year.

(ii) Construction of access roads, silvicultural treatment, and transport of timbers. Previous studies showed that the logging road also contributes significantly to the total amount of sediment even after the area has been logged. This is because the main road is usually used to carry out silvicultural treatment activities in the remaining stand after logging. In this case, the amount of sediment contributed by the main road is calculated based on the following assumptions:

    (a) Logging road system contributes 90 percent of the sediment yield.
    (b) The main road contributes 46.7 percent of the above value. The entire forest road occupies 15 percent of the area, 7 percent of which is allocated for the main road.

(iii) Natural erosion in the undisturbed forest area. The undisturbed or unlogged forest also contributes a small amount of sediments generated mainly by rainfall impact. This study assumed the rate of sedimentation in the undisturbed forest to be 1 m^3/ha per yr, or equivalent to the sedimentation rate from the sixth year of logging.

The following general model is formulated to predict the amount of sediment yield produced as a result of a logging or harvesting operation, on an annual basis for a 30-year cycle.

$$SY = d \sum_{t=1}^{30} \sum_{h=1}^{6} \{ (LA_t \times SH) + (LA_{t+1} \times SR) + (TA - LA_t) SU \}$$

where *SY* - sediment yield,

SH - sediment from harvesting,

SR - sediment from road maintained for rehabilitating activities,

SU - sediment from undisturbed forest or remaining area,

LA - logging hectarage,

TA - total forest hectarage,

t - period from first cutting block to the 30th cutting block,

h - year after logging beginning in current year (h=0) until the fifth year (h=4); thereafter (sixth year), sediment yield reaches normal rate, and

d - reduction factor of 0.6 for RIL option is used based on expert opinion.

One of the main elements imposed for the RIL option to reduce the adverse impacts of logging is the provision of a buffer strip of 20 m from the stream and riverbanks. Retention of the buffer strip accordingly reduced the harvestable forest areas. An assumption associated with the RIL option is the reduction of the sediment yield output. The amount of sediment yield can be significantly reduced through use of control measures such as buffer strips, better road planning, and others. In this regard, a factor of 0.6 is adopted as associated with the RIL option. The factor used was based on expert judgments.

Based on all the assumptions and approach mentioned earlier, the amount of sediment yield under the two land use options was computed. The annual total sediment was then summed up over the 30-year cutting cycle. Deposition in the reservoir is normally governed by the slope of the inflow channel and the reservoir bed, the catchment-capacity ratio, and the trap efficiency (ability of the pond or the reservoir to trap and retain sediments). Trap efficiency is the percentage of sediments retained in relation to the total sediment flows. By the nature of the pond at C2, C3, and C4, the trap efficiency for the three catchments is approximately 70 percent.

Figures 2a-2d show the trend of the sediment yield in each of the four catchments for the two land use options. The accumulated volumes are given in Tables 3 and 4.

Table 3 Harvestable Forest Area and Sediment Yield in Langat Dam

Item	Reduced Impact Logging	Total Protection
Total area (ha)	3,551	3,551
Loggable area (ha)	2,871	-
Buffer area (ha)	680	-
Sediment yield (m^3)	497,244	106,530

Table 4 Harvestable Forest Area and Sediment Yield for HEP Pond

Treatment	Reduced Impact Logging	Total protection
Catchment 2		
Total area (ha)	473.0	473.0
Loggable area (ha)	387.8	-
Buffer area (ha)	85.2	-
Sediment yield (m^3)	39,903.0	14,190.0
Catchment 3		
Total area (ha)	265.0	265.0
Loggable area (ha)	217.4	-
Buffer area (ha)	47.6	-
Sediment yield (m^3)	22,369.6	7,950.0
Catchment 4		
Total area (ha)	455.0	455.0
Loggable area (ha)	373.0	-
Buffer area (ha)	82.0	-
Sediment yield (m^3)	38,380.2	13,650.0

Figure 2a Sediment load in Langat Dam (C1)

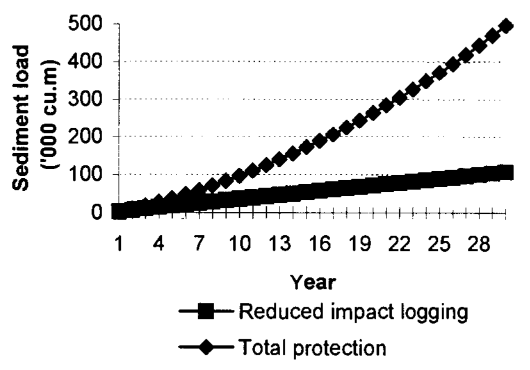


Figure 2b Sediment load in water intake pond (C2)

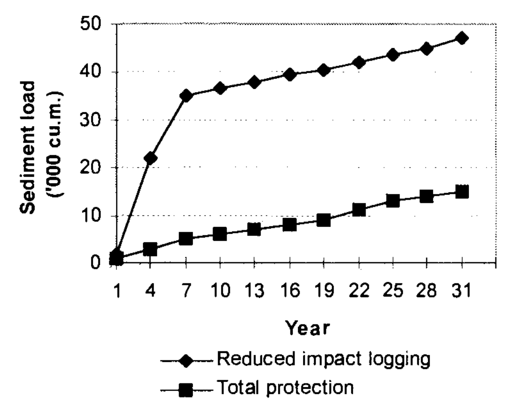


Figure 2c Sediment load in water intake pond (C3)

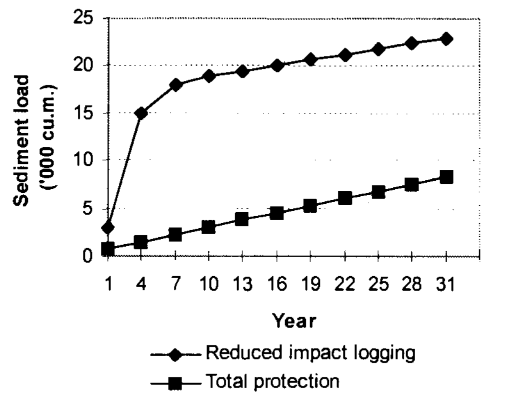
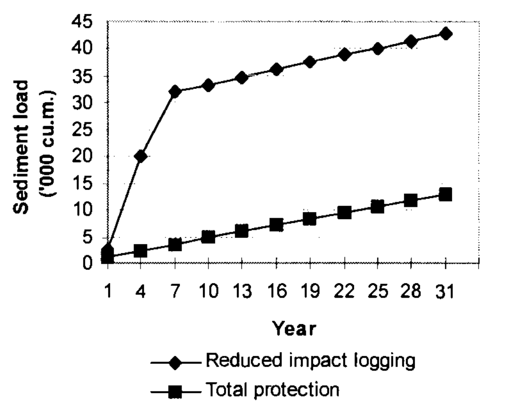


Figure 2d Sediment load in water intake pond (C4)



3.2 Determination of Water Volume Utilization Under Two Land Use Options

Valuation of water utilization, either as a good (in the case of the water treatment plant), or as a service (in HEP plant), requires the estimation of water volumes utilized for these functions. In valuing the role of forested catchments in the generation of treated water, the volume of water input into the treatment plants (that are sourced from the Langat Dam) becomes necessary. This considers the value of water when converted into usable consumer and industrial goods. In the case of the HEP plant, no direct estimation of the volume of water input is necessary since water is only used to turn the turbines to generate electricity. Hence, the quantity of electricity generated was estimated to calculate the net revenue in HEP production.

The estimation is a little more complicated in the water treatment plants as the water intake is not direct from the Langat Dam. Rather, the water input is pumped from the Langat River fed by the Chongkak, Lawing, and Lui rivers. Water is released from the Langat Dam only during the dry period at about 68 days based on the rainfall records at the HLFR. Assuming a 0.13 million m^3 per day of water deficit at the intake point during this period, it is estimated that the volume of water from the Langat Dam utilized by the treatment plants is 8.84 million m^3.

The estimation of the water requirements of the HEP to turn the turbines is obtained directly from the production figures of the plants. Using an average production of 1,560 kWh, the annual production of electricity is estimated at 13.5 million kW.

3.3 Estimation of Loss in Storage Capacity in the Reservoir and HEP Water Ponds

For the purpose of calculating the storage loss due to sedimentation in the reservoir, an average reservoir capacity of 3,850 million gallons or 17.5 million m^3 after deducting the dead storage of 540 million gallons was adopted. This capacity is 50 percent of the live storage capacity of Langat Dam. The 50 percent capacity is adopted, assuming that a dam would lose its technical efficiency at this level (Bali

1981). Accordingly, the loss of storage capacity for C1 after 30 years is 0.6 percent under TP and 2.8 percent under RIL.

The study covers one cutting cycle of 30 years. The period of 30 years is adopted to synchronize with a simulated cutting cycle of logging in the catchment. The loss in live storage capacity in the case of Langat Dam is small when logging operations are simulated. This effect can be seen clearly when the number of years needed to fill up the 50 percent live storage capacity of the dam was calculated.

In the case of the HEP water intake pond, the relevant variables are the number of times and days the ponds are dredged. Dredging is done to ensure that water fed into the pipelines is sufficient to turn the turbines at the HEP plants. It is therefore necessary to estimate the total volume of sediment that will be trapped in the water intake pond prior to dredging. An estimate of the total annual volume of sediment yield from each catchment (C2, C3, and C4) and the amount that would be trapped in the water intake pond is necessary. The sediment produced in these catchments will be adjusted to reflect the assumed 70 percent trap efficiency of the sediment pond. The sediment ponds constructed at each catchment are simple concrete dams strengthened with concrete banks. The capacities of the sediment ponds are 205 m^3 for C2, 113 m^3 for C3, and 195 m^3 for C4. From the total annual sediment volume retained in these ponds, it was possible to estimate the number of times and days needed to dredge the ponds throughout the year.

3.4 Computation of Benefits and Costs

The methodology for isolating the benefits of watershed protection is applied for two alternative land use options: TP and sustainable timber harvest through RIL. In adopting the methodology, it should be emphasized that trade-off of timber and water benefits from the land use options depends on the hydrological and biophysical impacts of said options. In Table 5, the environmental effect and economic outcomes of the two land use options are identified and various data requirements are specified. Identification of these impacts is important in assessing the costs and benefits of the land use options.

Table 5 Identification of Data Requirements for a Benefit Cost Analysis of the Two Options

Land Use Option	Environmental Effects	Economic Effects
Total protection	Sedimentation Needs estimates of: • volume of sediments trapped in water intake pond • frequency of dredging and its cost • maintenance cost of turbines in HEP plants • forgone HEP output	Production of treated water and HEP Needs estimates of: • prices and quantities of treated water and HEP produced • cost of production
Reduced impact logging	Sedimentation Needs estimates of: • volume of sediments trapped in water intake pond • frequency of dredging and its cost • maintenance cost of turbines in HEP plants • forgone HEP output	Production of timber, treated water and HEP Needs estimates of: • prices and quantity of stumpage, treated water and HEP produced • cost of production

Analysis of the trade-off between total protection and logging entails analysis of the costs, benefits, and the net benefits of the land use options in the four catchments of the HLFR. The analysis covers a 30-year period to coincide with the 30-year cutting cycle. Although the forest is managed on a sustainable yield basis, the cutting cycle is used in the analysis to reduce possible errors that could be caused by uncertainty in predicting timber growth and yield, log prices, and logging costs.

The principles of accounting for costs and benefits have some similarities with those of Reyes and Mendoza (1983), Cruz et al. (1988), and Aylward et al. (1995).

Reyes and Mendoza studied management and erosion control in the Pantabangan Catchment of the Philippines while Cruz et al. evaluated the off-site economic effects of soil erosion in the Magat and Pantabangan catchments of the Philippines. Aylward et al. presented a conceptual framework for analyzing the catchment land use decision making from a private incentive issue toward a societal incentive issue.

In this study, the TP option does not permit any timber production. Consequently, no timber benefits are gained. The main benefits are the utilization of raw water to generate treated water and HEP. The forgone timber benefit is not considered an opportunity cost if, at the same time, there are alternative forest areas that the state government can license out. Being a relatively big state, Selangor has other forest areas apart from the HLFR. Stakeholders (state government and logging contractors) are thus not necessarily incurring forgone benefits under the TP option. The disbursement of logging areas is dictated by the annual coupe. It does not matter to the stakeholders whether logging is conducted in the HLFR or in other areas in the state. What could be included as an opportunity cost of logging at another site, however, is the additional logging cost to be incurred from such a shift in forest site. Within Selangor State, where road and other infrastructural facilities are good, this additional cost is considered negligible. A similar argument on estimating opportunity cost is pretty well elaborated by Dixon et al. (1994). In the RIL option, the benefits forgone are the loss in HEP generation during the days that the water intake ponds are dredged. Increased maintenance cost is also incurred in dredging the water intake ponds and in maintaining the turbines. Maintenance is necessary because sediments increase abrasiveness. With respect to the Langat Dam, there is no significant loss in live storage capacity, and hence, there is no forgone benefit.

With the simulated physical data on sedimentation, it is now possible to value the trade-off between timber and water benefits in adopting each of the two land use options (watershed protection, i.e. no logging and RIL). The main concern of logging in forested catchments is the quantity of sediments deposited at the Langat Dam reservoir and the water intake ponds for the HEP plant. Under the TP option, there is still natural deposition of sediments in the reservoir and water intake ponds. This has impact on the operation of the dam and HEP plants, which would have to be valued as well. However, since the physical impact of the sedimentation yield on the live storage of the Langat Dam is insignificant, there is practically no loss in net benefits involved within the 30-year cutting cycle. Consequently, irrespective of the two land use options and using a discount rate of 10 percent, the total discounted benefits generated from the use of water released from the Langat Dam are similar.

The price of treated water is determined by negotiation between the independent water supplier and the Waterworks Department. There is thus a need to estimate the economic price of water through shadow pricing. Shadow pricing can be done using the production function approach. This approach entails the estimation of the value of the marginal productivity of water in the production of goods and services. Unfortunately, this approach was not attempted in this study. Instead, the price of treated water produced from an alternative and newly established treatment plant was used.

The study used a price of RM0.33 per m^3 for treated water and a production cost estimate of RM0.20 per m^3. It assumes a zero annual rate of growth in real prices of water and a 2% rate of growth in production cost. Although, prices of treated water sold by the Waterworks Department to consumers are regulated and not periodically adjusted, the prices charged by the independent water supply company to the Waterworks Department are periodically adjusted. This adjustment is negotiated to take into account the effect of inflation. The rate of growth in prices of chemicals and labour exceeded the inflation rate, thus resulting in positive rate of growth in the costs of production.

Similarly, prices of electricity set by the National Electric Company, whether petroleum-based, gas-based, coal-based, or from HEP, are also regulated. The costs of production of each production base are not similar. The prices paid by the national company to the independent power suppliers are also periodically adjusted for inflation. On this basis, a zero rate of growth in real prices is also assumed. A positive rate of growth for input prices is likewise assumed. As in the case of treated water, the price of HEP is imputed from the price of the alternative and new production facility established in the country. The price used in this analysis is

RM0.165 per kWh, while production cost is RM0.125 per kWh. Using a discount rate of 10 percent, the total discounted net benefits from HEP production under the two land use options are computed .

For sediment accumulated in the water intake ponds, it was assumed that the sediment yield trapped and retained will have to be dredged. A small portion of these trapped sediments seeps through the pipelines and pass through the turbines of the HEP plants. The intensity and cost of dredging increase from the TP option to the RIL option. The total discounted costs of dredging and of the maintenance works for HEP plants are also computed. The dredging and plant maintenance works can lead to underutilization of production capacities. The total discounted net benefits of HEP forgone or loss are also calculated.

In the case of timber production, the real prices of logs are assumed to increase at 3.5 percent per annum. The direct logging cost in the first year is estimated at RM75 per m^3 plus timber fees paid to the government in the form of royalty, premium, and silvicultural cess. It is further assumed that the direct cost of logging in the second year would be reduced to RM70 per m^3 since there is no new construction of main roads in the current logging area. It is further assumed that the logging cost would increase by 2 percent per year until the end of the cutting cycle in year 30. The net price for each log species is multiplied by the total annual harvest to obtain the total annual benefits from RIL. The total discounted benefits of timber production for TP and RIL are given in Table 6.

To establish the selection criterion between the TP option and the RIL option, the basic benefit-cost analysis rule was adopted whereby their total discounted net benefits are compared. Let NB^{W} denote the discounted net benefits from TP while NB^{RIL} is the discounted net benefits of the RIL option. Logging is a better land use option over total protection if the incremental discounted net benefits of the logging option over total protection, i.e. (NB^{RIL} - NB^{W}), is positive. Ideally in all options, all benefits and costs should be included in the analysis. However, some of these benefits (non-timber forest products, recreation, etc.) at both levels (on-site and off-site) are not included in the analysis because they are relatively small and not significant. Many of these forest uses are more likely to be available in the TP option. Thus, we would expect the incremental discounted net benefits of $(NB^{RIL} - NB^{W})$ to be biased upward. As a result, the choice of forest land use option is likely to be in favor of sustainable timber harvest.

3.5 Computation of Resource Rent and Its Equity

The resource rent that can be derived from allocating a logging compartment and from the utilization of water resources is basically the value of the standing timber (often termed as stumpage value among foresters) available in the compartment prior to logging. This is also that portion of the net benefit obtained in treating water and in generating HEP that can be associated with raw water utilization (both as a good and a service). In the case of standing timber where a formal market exists, two estimation methods are available: market evidence method and residual value method.

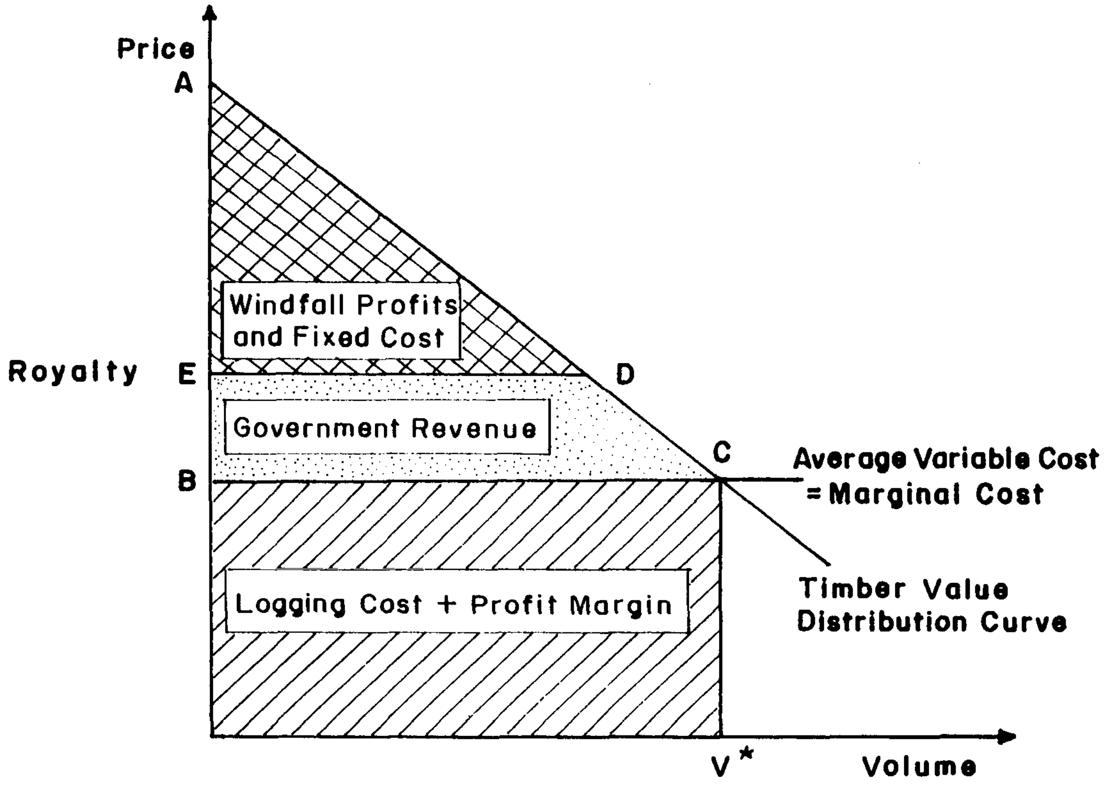


Figure 3 The distribution of timber resource rent among interested parties

Table 6 Net Present Values of Forested Catchments Under Two Land Use Options

Present Value of Net Benefits	Total Protection (RM)	Reduced Impact Logging (RM)
Timber	-	16,692,434
Treated Water	7,694,319	7,694,319
Hydroelectric Power	2,736,918	2,211,635
Total Net Benefits[a]	**10,431,237**	**26,598,388**

[a] Net benefits after deducting external costs of forgone HEP generation, dredging and maintenance cost.

In this study, the valuation of the resource rent from the extraction of standing timber and water utilization is carried out using the conventional residual valuation method (Sinden and Worrell 1979). This method is adapted in stumpage and water appraisal techniques by Awang Noor (1994) and Awang Noor and Mohd Shahwahid (1995). The market evidence method estimates the stumpage value of a timber stand through a comparison of prices at stumpage that is recently sold from stands with characteristics similar to those of the subject stand. This method is a good first estimate of the stumpage value. However, its limitation lies in the fact that no concession is exactly similar to another in terms of species, volume, wood quality composition, accessibility, and steepness.

The residual valuation method calculates the value of standing timber and raw water use by subtracting production and marketing costs, inclusive of a fair margin for profit and risk, from the selling price of the final products (whether logs, treated water, or HEP). These values are obtained for each year during the 30-year cutting cycle and discounted using a discount rate of 10 percent.

In the case of standing timber, the resource rent from logging at the compartment level and at a particular point in time is demonstrated in Figure 3. The horizontal axis gives the cumulative timber volume in m^3 and the vertical axis gives prices and costs on a per volume basis (RM/m^3). It is assumed that the marginal logging costs are constant within a given compartment and log prices vary by species. For a given forest compartment, the average variable cost (AVC) is constant. The inputs (labor, machinery, etc.) are needed in constant proportions, and payments for logging activities like felling, skidding, log handling, and forest transportation are on piecemeal basis (per cubic meter basis). Thus, AVC is equal to the marginal cost (MC) of extracting each m^3 of timber. Prices of tropical logs vary according to species, grade, and log diameter. The downward sloping timber value distribution curve indicates the distribution of timber value according to descending order of log prices. The logic of this curve lies in the fact that contractors normally select and extract the higher priced timber first, and leave the lower priced timber standing in the forest.

The vertical distance between the timber value distribution curve and the MC curve gives the net price of a given unit of standing timber. Conceptually, in the absence of fixed cost of logging, this net price is the total standing timber (stumpage) value or resource rent. This same conceptual presentation can be applied in describing raw water resource rent. But the water value distribution curve and the MC curve may no longer be downward sloping and constant, respectively. Instead, the earlier curve is anticipated to be constant while the latter is the normal U-shaped curve. This occurs since raw water is more of a standard commodity whose price is a flat rate while the production cost is dependent on the economies of scale since water treatment and HEP plants are operated on an industrial scale.

In the application for timber resource rent appraisal, various data are needed including timber growth and yield, log prices, harvesting costs, and an average profit margin that loggers could obtain in a competitive logging market. Similarly, in water appraisal, data on treated water and HEP prices, water treatment and HEP production costs, average profit margins in the treated water and HEP markets, and production quantities of water intake and HEP are required.

The estimation of the normal profit margin to be allocated to the logging contractor or the water treatment and HEP plants is critical in distributing the resource rent among the stakeholders. The method of stumpage appraisal, popularized by Davis (1966), is adopted in this study. The basic formula to calculate the firm's profit margin is

$$M = PR / (1 + P)$$

where M is the firm's margin for profit and risk ;

P is the average normal profit ratio in the industry, assumed at 20 percent for timber, treated water, and HEP industries; and

R is the product selling value.

Having obtained the margin for profit and risk, the resource rent can be calculated:

$$S = R - C - M$$

where S is the resource rent,

R is the product selling value,

C is the direct cost of production (not inclusive of government fees and taxes), and

M is the firm's normal margin for profit and risk.

From the estimation of these resource rents, it is possible to determine the potential rent captured by state governments against what is likely to be captured by logging contractors, the water treatment independent supplier, and HEP independent supplier. This distribution of resource rent among interested parties can better be understood by referring to Figure 3. In the case of logging, contractors normally select and extract the higher priced timber first, and leave the lower priced timber standing in the forest. This relationship is depicted by the timber value distribution curve. Contractors would extract timber as long as their prices exceed the marginal cost, which is equal to the constant average variable cost in logging operations. State governments obtain timber revenues from the granting of logging concessions in the form of forest premium, royalty, and silvicultural cess (area BCDE in Figure 3).

Government revenues from timber extraction are the current (partial) resource rent collected by the state, which, in most cases, do not cover the full resource rent due to the government as steward of forest resources. The full resource rent can be captured through the estimation of stumpage prices (area ABC). When stumpage prices are obtained and compared with existing partial resource rent (area BCDE), it is possible to identify the portions of the full resource rents that are actually collected by state governments and those that are reaped by logging contractors (area ADE). The latter (area ADE) of course also includes part of the fixed cost incurred by the contractor. The total profits obtained by logging contractors can be divided between the normal profit margin (being part of average variable cost) and windfall or excess profit (part of area ADE).

When no competitive bidding for logging licenses is conducted, apart from the normal profit margin, logging contractors can squeeze windfall profits away from potential government revenues, leaving the government with a small proportion of the total timber resource rent. For a detailed discussion of this equity issue, see Vincent (1990), Awang Nor (1994), and Mohd Shahwahid and Awang Nor (forthcoming). In this study, the average government timber revenue in non-bidding logging licenses was deducted from the stumpage values of the four compartments under the logging options to obtain the windfall profits reaped by the contractors.

4. THE FINDINGS

The results of the calculations of the benefits and costs emanating from the two land use options are presented in Table 6. The present values of the net benefits from timber production are zero under the TP option and RM16.7 million under the RIL option. Meanwhile, the present value of net benefits from water use for the generation of treated water are estimated at RM7.69 million in both TP and RIL. The present value of water use for the generation of HEP is positive under both TP and RIL options.

The estimated water use net benefits for HEP generation were adjusted for loss of water use net benefits arising from the reduced capacity of the HEP plants during dredging work and for the costs incurred in dredging and maintenance works. The forgone opportunity cost of water use benefits is increasingly proportional to the sedimentation at the water intake ponds. The cost of dredging follows the same trend, with the lowest occurring in the TP land use option. The present value of forgone water use net benefits in HEP generation and the dredging and maintenance cost under the two land use options are shown in Tables 7 and 8.

The main source of net benefits under the two logging options is timber, which outweigh net benefits from water use. Water use net benefits in treated water production are similar in TP and RIL because there is no economic loss in water use for treatment and because sediment yields have no effect on the large live storage capacity of Langat Dam. However, water use benefits in the production of HEP are affected to a great extent by the land use option. Positive net benefits are obtained only from the TP option.

For the logging option, the forgone HEP generation and the maintenance costs owing to increased sediment yield are large enough to cause a 20% reduction in present value of benefits to the HEP operator. Nevertheless, the net benefits from timber production are so large that they override the loss of water use net benefits. Consequently, the present value of net benefits derived from the RIL option far outweighs the benefits from the TP option.

Table 7 Present Value of Water Use Benefits Forgone Under Two Land Use Options

Catchment	Total Protection (RM)	Reduced Impact Logging (RM)
C2	20,771	149,845
C3	11,828	85,432
C4	20,206	145,735
Total	**52,805**	**381,012**

Logging results in high external costs due to dredging of the water intake ponds, increased plant maintenance, and forgone HEP net benefits. The quantum of the external costs in the RIL option was more than seven times than in the TP option. This valuation exercise shows that with logging, there is sufficient basis to compute for the compensation payment of the polluter (logger) to the affected party (HEP plant operator).

Table 8 Present Value Maintenance Costs Under Two Land Use Options

Catchment	Total Protection (RM)	Reduced Impact Logging (RM)
C2	47,875	112,950
C3	34,713	100,918
C4	46,907	112,702
Total	**129,495**	**326,570**

4.1 Trade-off Between Watershed Protection and Logging

Table 9 shows the economic trade-off between two simulated land use options over four selected catchments in HLFR. From the benefit-cost analysis framework described earlier, the present value net benefits of the RIL option are compared with those of the base case situation of total catchment protection. The RIL option is superior to the base case situation in terms of net benefits generation.

In compartment C1, where water is collected in the Langat Dam to regulate water flow to the downstream treatment plants, logging does not impair the efficient production of treated water. In compartments C2, C3, and C4, sediment yields from logging activities incur external costs, but are not large enough to outweigh the net benefits derived from HEP generation. In all these compartments, combining water use and logging is inefficient. Nevertheless, the problem of frequent dredging, high cost of maintenance, and high value of forgone HEP loss can be minimized if mitigation efforts are taken. One solution to the problem is the construction of larger water intake ponds.

Table 9 Trade-off Between Forested Catchment Land Use Options

Land Use Option	Incremental Net Benefits (RM)
Base case or TP (NB^{W})	**10,431,237**
RIL (NB^{RIL}-NB^{W})	**+ 16,167,151**

4.2 Distribution of Timber and Water Resource Rents Among Interested Parties

The trade-off analysis evaluates the economics of alternative land use options in the four compartments of the HLFR catchments. This study also aims to evaluate the potential economic rents from timber production and industrial water use and to determine their distribution among the various stakeholders. The study has identified two major resources, timber and water, both providing opportunities for generating net benefits.

In the case of timber production, the RIL option could generate the present value of resource rents of RM13.9 million (Table 10). These rents are distributed between the two stakeholders: (i) state governments, as trustee of natural resources; and (ii) the logging companies, as the contractors undertaking the business risk. Which parties or stakeholders capture the higher proportions of the resource rent depends on whether or not a tender system of allocating logging licenses is adopted.

Under a non-tender system, the state government is at the losing end with only a 16.7 percent share of the resource rent, with much of the resource rent ending up as windfall profits to the logging contractors (67.6 percent). This issue has been well documented by Sulaiman (1977), Boado (1988), Gillis (1988a), Vincent (1990), Vincent et al. (1993), Awang Noor et al. (1993), and Mohd Shahwahid and Awang Nor (forthcoming). Estimates of the percentage rent captured by forest royalties vary from 11.4 percent in the Philippines (Boado 1988), 33.2 percent in Indonesia (Gillis 1988a), 12.1 percent in Peninsular Malaysia (including forest premium payments as computed from Vincent 1990), to 82.8 percent in Sabah (Gillis 1988b). As early as 1977, Sulaiman has pointed out that a high proportion of the forest resource rent in logging (about five times the share for timber revenues that the state government actually received) was siphoned off by the licensees and logging contractors. A similar observation was cited by Vincent (1990).

Table 10 Distribution of Timber Resource Rent Among Interested Parties

Stakeholder	Timber Resource Rent			
	Non-tender Concession		Tender Concession[a]	
	RM	%	RM	%
State government	2,782,072	16.7	13,353,948	80.1
Logging contractor (windfall profit)	11,128,290	66.7	556,414	3.3
Total resource rent[b]	13,910,362	83.3	13,910,362	83.3
Logging contractor (profit margin)	2,782,072	16.7	2,782,072	16.7
Total net benefits	**16,692,434**		**16,692,434**	

a Timber resource rent based on the tender system of allocating logging concessions in Kedah State, Malaysia (Mohd Shahwahid and Awang Nor, forthcoming).

B Subtotal does not tally owing to rounding up of decimals.

However, if a tender system is adopted, it is more likely that the state governments would capture a large proportion of the resource rents (80.1 percent). This suggestion is supported by a recent investigation on rent capture when a tender system is adopted. This has shown that as high as 96 percent of the resource rent from timber production is captured by the state government (Mohd Shahwahid and Awang Nor, forthcoming).

In the case of resource rent from the utilization of water by the water treatment and HEP plants, no rent is being captured by the state government agencies, either by the Forestry Department or the Waterworks Department. As such, any resource rent available goes as windfall profits to the water treatment and HEP independent suppliers (Tables 11 and 12). Under this circumstance, state governments should capture a portion of these windfall profits. Under the RIL option, however, the HEP plant did not realize a normal profit as shown by the negative windfall profit. There is no excess profit to be collected by the state as resource rent.

Table 11 Distribution of Water Resource Rent in Hydroelectric Power Production Among Interested Parties

Stakeholder	Water Resource Rent			
	Total Protection		Reduced Impact Logging[a]	
	RM	%	RM	%
State government	-	-	-	-
Windfall profit	9,260	0.3	- 473,214	- 21.4
Total resource rent	9,260	0.3	- 473,214	- 21.4
Profit margin (HEP Co.)	2,727,659	99.7	2,684,849	121.4
Total net benefits	2,736,918		2,211,635	

[a] Negative windfall profit and resource rent imply that the HEP plant fails to obtain a fair and normal profit under the RIL option. This amount is assumed to be 15% for an average industry in Malaysia

Table 12 Distribution of Water Resource Rent in Water Treatment Production Among Interested Parties

Stakeholder	Total Protection/reduced impact logging	
	RM	%
State Government	-	-
Windfall profit	4,107,337	53.4
Total resource rent	4,107,337	53.4
Profit margin (Water treatment Co.)	3,586,982	46.6
Total Net Benefits	**7,694,319**	

[a] Since treated water production remains constant under both options, the distribution of water resource rent is similar.

5. CONCLUSION AND POLICY IMPLICATIONS

The study aimed to evaluate the trade-off between two land use options in forested catchments. Although forested catchments provide natural resource commodities, biodiversity conservation, and environmental services, this study considers only two tangible goods: timber and water. The findings of the study, therefore, cannot be considered comprehensive.

The findings seem to show that complementing water uses with logging in forested catchments is efficient. This is particularly true for C1 where a water regulatory dam is in place to ensure that the downstream water treatment plants can operate at their normal capacity. In the case of compartments C2, C3, and C4, however, this joint production involves considerable external costs of dredging and forgone net benefits of HEP generation.

The above conclusion suggests that the incidence of the external costs of sedimentation would be borne by the HEP plant, even though the polluting agent is the logging contractor and not the plant. There exists a case for the aggrieved party, i.e. the HEP plant, to be compensated for the external cost.

The study has shown that the HEP water intake ponds are more susceptible to sedimentation yields following logging operations, causing high maintenance costs on regular dredging works. This finding is important considering that many of the HEP plants located throughout the peninsula are being fed by water sourced from intake ponds classified as mini-dams similar to the ponds in the HLFR. Any plan of permitting logging in forested catchments with mini-dams should consider the threat of high sedimentation impact and the resulting high maintenance costs. It is recommended that this effect be an important consideration in environmental impact assessment of logging in forested catchments.

Furthermore, a mini-hydro dam (intake pond) is not the most efficient method of generating HEP when compared with the conventional HEP dam. One of the factors contributing to the lower efficiency of the mini-hydro dam is that its operation cost in relation to generating capacity is relatively higher because it relies on small rivers or catchments and thus provides less hydraulic head. Any increase in sedimentation in the intake pond would drastically affect the generation capacity.

This finding cannot be applied to other forested catchments owing to the unique setups of the Langat Dam and the three HEP water intake ponds. If the Langat Dam had a smaller live storage capacity, the observation would have been different. Further, Peninsular Malaysia is facing acute shortage of logs for processing. Consequently, log prices are high, making standing timber expensive. This sways the value of forested catchments toward timber use.

The issue of the distribution of resource rent among stakeholders is important. In logging, the institution to capture the rents is already in place and it is a matter of implementing a tender system, which has proven to be successful. Capturing the rent from water use is more difficult. In the first place, can a landowner lay claim to water flowing from his land, given that the water is sourced from rain? Further, can the forestland owner prevent others from using the water without investing in some kind of a dam? In this regard, the Langat Dam, which was built by the Waterworks Department, can exercise its property rights over the regulation of water flow. The water eventually is extracted downstream where water treatment plants are operated by the independent water supplying company. In the case of HEP generation, the Forestry Department cannot actually prevent the HEP plants from using the water flow for running the turbines. The water intake ponds are built by the independent power supplying company. As such, it can claim any resource rent from water use. But there is still a moral issue involved in that the forest cover plays a role in regulating water flow into the stream. There are time lags between the rain falling on the forest canopies and the eventual flow of water as surface runoff and as groundwater flow into the streams. In this sense, the state government as trustee of forested catchments may want to extract a portion of the water resource rent.

This study has several policy implications:

(i) One of the many issues faced by forest managers and policy makers in managing forested catchments relates to the question of whether or not to permit logging. This is an important decision since a large portion of catchments in Malaysia is still covered with forests. At the moment, there is no clear policy as to whether logging should be permitted in forested catchments that serve either as source of domestic water supply or for HEP generation.

Forests are under the states' jurisdiction. Some states allow logging activities in catchment areas, while others do not. The present study supports selective logging operation in forested water-regulating catchments. Such an arrangement is feasible since the water from the affected catchment serves to augment water supply only during the dry season. However, the arrangement, in the case of direct intake water supply, requires further study.

(ii) Since logging causes an increase in sediment yield, state governments are advised to closely supervise the logging activities in forested catchments. Further, despite the imposition of buffer strips, an increase in sediment yield has been shown to be large enough to cause an increase in the external costs to the HEP plants.

One way of mitigating the external effects is by building larger water intake ponds; however, the question of who should bear the external cost of dredging and the forgone net benefits or the construction cost of the larger water intake pond still remains. Since logging is an alternative option to the status quo or TP option, the Forestry Department could incorporate in the licensing agreement a requirement for logging contractors to internalize the external cost of increased sediment yield. This is similar to purchasing the rights to pollute/release sediment. In the event that this policy is accepted, there remains the difficulty of estimating the appropriate sediment yield since sediment yields would only return to normal after about six years after logging.

6. LIMITATIONS AND FUTURE STUDIES

Further efforts are needed to improve the study of the economics of forested catchments and the trade-off among land use options in Malaysia.

(i) The study has imputed the prices of treated water and HEP from alternative and new production facilities being built in the country. This was done to avoid using regulated prices as bases for calculating the net benefits. Future studies should consider using shadow prices of these outputs using the production function approach.

(ii) The study was conducted at one site. Its findings are site specific. Duplicating this study in other catchments, particularly where water treatment plants obtain direct water intake from dams, is necessary before any concrete recommendation can be given to allow logging in forested catchments. Further, the selected site is managed for industrial water use. Sites that have other downstream uses such as irrigation and recreation would have to be selected. Competing uses such as highland agriculture should also be considered. Studies of this kind at other sites could provide a more holistic view on the economic trade-off between various land use options in forested catchments. These studies would help government agencies formulate and classify types of forested catchments that can withstand logging activities without causing the environment to deteriorate.

(iii) The study limits its trade-off analysis to the net benefits of timber and water use under the two land use options. In this sense, it is not comprehensive since net benefits from other forest attributes were not considered. Further research on the valuation of these other attributes is necessary.

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