Chapter 13
Economic Benefit of Management Options for a Suburban Forest (Kho Hong Hill) in South Thailand

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Abstract Kho Hong Hill (KHH) is located close to Hat Yai City in Songkhla Province, South Thailand. Almost half of its forested area has been deforested as a consequence of population increase, urbanization and the ongoing conversion of forest areas into rubber plantations. This study assesses the net economic benefits of three forest resource management strategies based on information derived from interviews and discussions with relevant KHH stakeholders. The three strategies are represented as three scenarios: Scenario I is the base case or the business-as-usual (BAU) scenario; Scenario II involves the establishment of protected areas to preserve the remaining forest areas in KHH; and Scenario III assumes the implementation of forest restoration and rehabilitation initiatives designed to increase the forest areas on KHH. Six ecosystem services are selected as the environmental variables for the study: (a) the provision of timber, (b) carbon dioxide sequestration, (c) oxygen generation, (d) water supply, (e) flood control and (f) biodiversity. Market valuation is used to estimate the values of provision of timber, CO_2 sequestration, O_2 generation, water supply and flood control, while the value transfer approach is used to value of the service derived from KHH biodiversity. The results show that under Scenario I, the annual benefits from the ecosystem services from KHH would become negative after 15 years, whereas positive net present values would be yielded under Scenarios II and III. The study recommends that rubber farmers should be encouraged to convert their rubber plantations back to

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forest areas. Introducing a payment for ecosystem services (PES), mechanism is also recommended to induce rubber farmers to reforest. Further studies would be needed, however, to establish an effective PES system.

Keywords Thailand • Forest • Economic benefit • Ecosystem services • Management options

Introduction

Ecosystem Services

Ecosystem services are commonly defined as benefits that people obtain from ecosystems (USDA 2010). Ecosystem services can also be the processes through which natural ecosystems, and the plants, animals and microbes that live in those environments, sustain human life. Ecosystems provide valuable services to humans through their natural functions. As habitats become fragmented, the services that natural systems provide become less effective (Tawna 2010). Climate change, pollution, over-exploitation and land-use change are some of the drivers of ecosystem loss, as well as resource challenges associated with globalization and urbanization (USDA 2010).

The concept of ecosystem services encompasses the delivery, provision, production, protection or maintenance of a set of goods and services that people perceive to be important (Chee 2004). It includes both tangible and intangible goods and services. Forest ecosystems, in particular, play an important role in providing the goods and Earth's life-supporting system. Tangible goods and services from forest include timber, non-timber forest products (NTFPs), water supply, medicine, tourism, biomass and nutrition. Intangible services from forest are providing clean air and oxygen, regulating the atmospheric abundance of carbon dioxide (Murray 2000; Stinson and Freedman 2000), assimilation of waste, recreation and aesthetic benefits, educational opportunities and spiritual enrichment (Tong et al. 2007). Losing or degrading them can cause significant harm to the nation's economy and the welfare of humans (USDA 2007).

Kho Hong Hill

Kho Hong Hill (KHH) is situated in Hat Yai District and Thung Yai District, Songkhla Province in the south of Thailand. It is the last forest area closest to Hat Yai City, the well-known urbanized area on the east coast of lower south Thailand. It lies north–south and is 5.6 km in length. The highest point is 371 m above sea level. The total area is 1,212.42 ha. Of this, 699.7 ha (57.71 %) remains as primary

Table 13.1 Area of forest and other encroachment on KHH

Type	Area (rai)	Area (ha)	Percentage
Forest	4,373.14	699.70	57.71
Rubber	2,757.35	441.18	36.39
Land with no cover	342.29	54.77	4.52
Buildings	104.82	16.77	1.38
Total	7,577.60	1,212.42	100.00

and secondary forest. Thirty six per cent of the total area has been converted to rubber plantation (see Table 13.1).

The Hill provides ecosystem services to a population of 157,682 living in the Hat Yai Municipality and 67,892 living within 3 km from KHH (Hat Yai Municipality 2010), not yet mentioning other off-site benefits. Previous studies show that the forest is still fertile with primary forest area intact. The ecosystem support system of KHH is recognized by biologists in the Prince of Songkla University (PSU) in terms of oxygen provider, CO_2 sequestration and a source of water supply for the downstream community. Moreover, the forest is home to many wild animals and plants, some of which are endangered or rare species, i.e. slow loris and Malaysian giant ant which can be found only in fertile areas, and a temporary home for the plain-pouched hornbill. Biodiversity is one of the greatest benefits from this forest.

KHH is an ever green forest with a mixture between dry forest and moist forest. Because this type of forest comprises of both deciduous and non-deciduous plants, organic matter can be generated throughout the year. Nutrient cycling and energy flows within the forest are thus at a maximum.

Threats to Ecosystem Services Provided by KHH

Like other threatened forest areas around the world, almost 40 % of KHH forest area has been deforested because of the pressure from increasing population, income and consumption to make way for rubber plantations or the construction of housing and urbanization because of its closeness to the city. Recently, the problem has become more serious. Flooding has occurred in areas that have never been flooded before, soil erosion is increasing, and there is prolonged drought during the dry season and a loss of wildlife, to name just a few examples. Because many of these services from forests are usually viewed as free benefits to society, or ‘public goods’, lacking a formal market, these natural assets are traditionally absent from society’s balance sheet, and their critical contributions are often overlooked in public, corporate and individual decision-making. When forests are undervalued, they are increasingly susceptible to development pressures and conversion. Recognizing forest ecosystems as natural assets with economic and social value can help promote conservation and more responsible decision-making (USDA 2010).

The preliminary survey conducted with people living within three km from the centre of the hill revealed that people do not fully appreciate the ecological value of the forest. Compared with the tangible benefit of rubber plantation, many of the benefits of KHH are perceived to be intangible and immeasurable, thus having no meaning to them. To make matters worse, institutional arrangements establishing who has authority over the forest are weak. People who use the land in KHH claim that they have a customary right as their ancestors took over areas of land on the hill before any legal issues arose regarding encroachment of the forest. Some people have encroached the forest illegally due to the weakness of law enforcement.

Initiatives to Protect Ecosystems of KHH

Academics from Prince of Songkla University have realized the importance of KHH and the seriousness of the problem of deforestation. They have initiated a social movement to conserve KHH under the project 'Help Conserve Kho Hong Hill'. Various activities aimed at restoring and conserving the forest have already been undertaken. An ultimate goal of the project is to use KHH to sustain human well-being for the people in Hat Yai City and nearby areas. Accordingly, a best management option is being sought to provide the right direction on how to conserve it. To reverse the loss and degradation of ecosystem services, economic and financial motivations must include a conservation objective, and the value of ecosystem services needs to be incorporated into any decision-making (USDA 2010).

Research Objectives

The general objective of the research is to determine the value of net economic benefit of different management options for KHH in order that the involved parties will be informed of the most economically efficient option. The more specific objectives are:

- To determine economic value of some ecosystem services of KHH, namely, timber, freshwater supply, CO_2 sequestration, flood protection, O_2 provider and biodiversity
- To examine three likely scenarios (management options) which are possible for KHH, including the status quo
- To conduct a cost-benefit analysis of different management options for KHH, taking into account those ecosystem service values in objective 1
- To compare management options to see which option yields the maximum benefit to society
- To use this information in preparing for policy analysis and implication for Kho Hong Municipality, Hat Yai Municipality and Thung Yai Tambon Authority Organization

Methodology

Incorporating Environmental Values in Policy Analysis

It is now widely accepted that in order to make sound decisions in favour of sustainable resource use, the total economic value of natural resources and environment should be included in policy analysis. As pointed out by Ranganathan et al. (2008), 'Decision- makers - including those whose goals and actions might not at first seem connected to ecosystems - need to examine the dependence and impacts of their goals on ecosystem services. Making decisions for policy implementation by taking ecosystem services into account can strengthen decisions.'

The key principle is that any producer surpluses and/or consumer surpluses that are predicted to occur over time under the 'without' or baseline case but are reduced or foregone under the 'with' alternative policy scenario case are considered an economic cost, while increased or new producer and consumer surpluses generated from the 'with' alternative policy case are considered an economic benefit. One means of doing this is to carry out an economic cost-benefit analysis (CBA). As is well recognized in the professional literature, provided the discounted incremental economic benefits of a proposed policy exceed the discounted incremental economic costs, then the proposed policy is deemed to provide a net benefit to the community and an improvement in the economic efficiency of resource management, relative to a base case scenario.

Categorizing Ecosystem Services

The concept of ecosystem services was comprehensively documented by the Millennium Ecosystem Assessment (MA), which set out between 2001 and 2005 to assess the consequences of ecosystem change for human well-being and to establish the scientific basis for actions needed to enhance the conservation and sustainable use of ecosystems and their contributions to human well-being. Categorization of ecosystem services has been attempted by numerous authors and organizations including Olewiler (2004), MA (2005a, b), Anielski and Wilson (2005), Ranganathan et al. (2008) and Stenger et al. (2009). A widely accepted categorization is the following (MA 2005a; Irwin and Ranganathan 2007; USDA 2010):

- *Provisioning services* or the provision of food, fresh water, fuel, fibre, genetic resources, natural medicine, pharmaceuticals and other goods
- *Regulating services* such as air quality regulation, climate regulation, water regulation, erosion regulation, water purification and water treatment, disease regulation, pest regulation as well as pollination and natural hazard regulation
- *Supporting services* such as soil formation, photosynthesis and nutrient cycling

- *Cultural services* such as educational, aesthetic, cultural heritage and spiritual values as well as recreation and tourism

Valuing Ecosystem Services

The total economic value of the environment comprises the direct use value plus the indirect use value plus the non-use value of the environment. The challenge of valuing the environment often lies within non-market valuation, particularly indirect economic benefits of environment and non-use value (Brown et al. 2007). Nonmarketed benefits are often large and sometimes more valuable than the marketed benefits (MA 2005b). Valuation is necessary if markets and institutions are to be established to promote the efficient and sustainable use of ecosystem services (Abel et al. 2003). Such valuation is also required to incorporate environmental values within a CBA. There are several valuation techniques to estimate ecosystem service values (Farber et al. 2002; Brown et al. 2007) and numerous studies on valuing ecosystem services. Selected examples involving the valuation of ecosystem services in general are Curtis (2004), Olewiler (2004), Anielski and Wilson (2005), Tianhong et al. (2008) and Tong et al. (2007).

Valuing Forest-Based Ecosystem Services

Examples also exist for valuing forest-related ecosystem services. They include a study estimating the annual economic value of certain ecosystem services (water conservation, soil conservation and gas regulation) by forest ecosystems in the Xingshan County in China, using simulation models and geographic information system (Guo et al. 2001); valuations by the Millennium Ecosystem Assessment (2005b); and a study of forest benefits such as timber, hunting, CO_2 fixation and non-use and recreation benefits by Moons (2002). Jim and Chen (2009) reviewed studies on the major ecosystem services provided by urban forests in China, including microclimatic amelioration (mainly evapotranspiration-cooling effects), carbon dioxide sequestration, oxygen generation, removal of gaseous and particulate pollutants, recreational and amenity. Kuosmanen and Kortelainen (2007) proposed a new approach for environmental valuation within an environmental CBA framework that is based on data envelopment analysis (DEA) and does not require any monetary estimation for environmental impacts using traditional revealed or stated preference methods.

Table 13.2 Valuation techniques for ecosystem service accounting of KHH

KHH ecosystem services	Valuation techniques application
Provisioning services	
Timber	Market approach
Freshwater supply	Market approach
Regulating services	
CO_2 sequestration	Market approach/replacement cost approach
Oxygen provider	Market approach/replacement cost approach
Flood control	Market approach
Supporting services	
Habitat/biodiversity	Value transfer

Estimating Monetary Value of KHH Ecosystem Services

For the present study, six ecosystem services were evaluated: *provisioning service* of timber; *regulating services* of C stocks and CO_2 sequestration, O_2 production, flood prevention and water supply; and the *supporting service* of biodiversity. The services are those relating to KHH natural forest as well as to its competing use: rubber plantation. Where possible, primary data from field studies was used to estimate the values of the ecosystem services provided by KHH. Secondary data was obtained from a literature review of documents, research reports, journal papers, data collected by governmental offices, statistical data, case studies and so forth. Table 13.2 presents a list of the valuation techniques that were used to estimate monetary values of the six ecosystem services selected for the study of KHH.

Timber Value

This value was estimated using data from another research project conducted by the authors. The gross value of timber was calculated by multiplying the volume of timber by its price. Cost of harvesting was deducted from this value to estimate the net benefit of this service. This timber value was entered in the CBA only in the year during which forest is converted to rubber plantation. NTFPs were not included in the analysis. Total timber value was estimated at 632,974 Bt/ha.

Carbon Dioxide Sequestration

There are several ways to assess the economic value of forest CO_2 sequestration. Guo et al. (2001) suggested three ways, comprising (1) a formula for photosynthesis and respiration, (2) test and survey and (3) a mathematical model. Guitart and Rodriguez (2010) evaluated carbon fixing value using alternative compensation value for silvicultural regimes. Whenever trees are cut, CO_2 kept in the trees or carbon accumulated in the forest in terms of wood, leaves, roots and soil is released back into the atmosphere. This loss of carbon becomes a cost of deforestation. Conversely, a benefit is derived when forest trees are kept intact: they can sequester existing CO_2 from the atmosphere. This is true also for rubber farms which can sequester CO_2 though at a much lower rate.

Anielski and Wilson (2005) suggest methods of valuing carbon store in terms of the damage cost of climate change, carbon fee, replacement cost, carbon credit trading and the cost of timber income foregone in lieu of protecting the carbon stored in the forest ecosystem. In this study, the authors applied a method devised by Yolasiğmaz and Keleş (2009), using the carbon credit trading price to calculate the value of carbon fixing. This approach readily communicates the value to stakeholders. The sequestration rate was obtained by field experiment. The price of carbon was multiplied by the amount of carbon fixed by KHH to obtain an estimate of the value for KHH. The results are shown in Table 13.3.

Oxygen Generation

Similar to the estimation of CO_2 sequestration value, oxygen provision by forest can be determined by the quantity of oxygen provided by the forest multiplied by the price of sold oxygen or the replacement cost of generating oxygen. Studies that have attempted to value oxygen provision services include Xi (2009), Zhang et al. (2009), Jim and Chen (2009), Tong et al. (2007) and Guo et al. (2001).

The annual oxygen generation rate was obtained by taking the CO_2 absorption rate previously calculated and multiplying by 1.2, following the method adopted by Yolasiğmaz and Keleş (2009). The price of oxygen was then multiplied to the amount of oxygen generated by KHH. The outcome of these calculations is presented in Table 13.4.

Water Supply

KHH is a head watershed for the Khlong Rian Canal below the catchment, which then flows to Songkhla Lake Basin. It supplies water to Hat Yai City, servicing in particular the Prince of Songkhla University and Senanarong Military Base. The authors identified 11 reservoirs that receive water from KHH, although only six of them can really be considered to receive their full capacity of water from KHH forest. Without water provided by KHH, the downstream communities would need to find substitute sources for their water supply, such as connecting their inlet pipes to the main pipeline of the municipal waterworks authority. The municipality would itself have to expand the operation of its water supply distribution to cover these communities, involving both capital and operating and maintenance costs.

In order to calculate the amount of water provided by KHH, a Simple Hydrologic System Model was used. A continuity equation was applied to estimate water

Table 13.3 Value of carbon storage service by KHH

Types of ecosystem	Carbon capacity		Carbon price (/tCO_2)	Value	
	Carbon storage (ton/ha)	Annual carbon sequestration (ton/ha/year)		Carbon storage (Bt/ha)	Annual carbon sequestration (Bt/ha/year)
Primary forest	218.55	17.01	12.30 Euro or 524.32 Bt	114,595	8,919
Secondary forest	167.97	31.13		88,068	16,317
Average of forest	**193.26**	**24.07**		**101,331**	**12,618**
Rubber plantation	**100.79**	**7.12**		**52,847**	**3,738**

Exchange rate: 1 Euro = 42.6276 Baht

Table 13.4 Oxygen production capacity of KHH from field study

Type of ecosystem	Oxygen production (t/ha/year)	Price of oxygen (Bt/ton O_2)	Value (Bt/ha/year)
Primary forest	39.1145	US$74.31 or 2,328.11 Bt	91,063
Secondary forest	54.1101		125,975
Average of forest	*46.6123*		**108,519**
Rubber plantation	13.3934		**31,181**

flow. The value of this ecosystem service from KHH was assessed by multiplying the modelled volume of water held and released by KHH by the price of water per unit. Unlike CO_2 sequestration and oxygen generation, this ecosystem service was not considered relevant for rubber plantations, because it is known that rubber trees do not hold water well since their roots are shallow. It is often observed that rubber trees fall down when there is runoff water.

Flood Control

Large amount of water is being held by the vegetation cover on KHH. For the past 3 years with KHH being illegally converted to other land uses which have less plant cover area, the flash flood incidence also arises. Losing KHH forest will put pressure on flooding area. Volume, area flooded and flood depth in each scenario are simulated using the hydrological modelling. The water balance study, carried out by our engineering team, indicates how much volume and depth of water will be flooded in which area. The simple model figuring the relationship between forest area, flood depth and flooding area was simulated. Losing more forest means getting more of runoff water which impact the communities with floods. The damage cost corresponding with each change of forest area is then estimated.

The study of flood control benefits of KHH was conducted by the university engineering team. Different scenarios were modelled in terms of flooded areas (which can be shown on a GIS map), flood depth and volume of flood. On GIS map, the flooding area with the same flood depth is categorized into one zone. This enabled flood zones to be identified and mapped. For each flood zone, the number of households, business properties and agricultural land was determined. Average damage cost was then surveyed in these particular areas, according to its flood depth, based on primary data from 100 samples and damage cost estimates for different land-use types. The cost of flood for households includes damaged properties and household items, foregone income resulting from not working due to flooding, cost of illness due to flooding and cost of cleaning after flood. The survey data indicated, as expected, that the average damage cost increases as flood depth increases.

The damage costs for other land-use types are not included in the analysis, such as damage costs relating to infrastructure, governmental offices, educational institution buildings and agricultural production areas. This means the net benefits of flood control provided by KHH or any management regime would be higher than the value incorporated in the CBA.

Biodiversity

Due to limited time, the valuation of benefits from biodiversity could not be performed. In this study, the unit value transfer approach is used. The adjusted benefit estimate B_p at the policy site can be calculated as

$$B_p = B_s \left(\frac{Y_p}{Y_s} \right) \beta$$

where B_s = the original benefit estimate from the study site
Y_s and Y_p = the income levels at the study and policy site, respectively
β = the income elasticity of demand for the environmental good in question

Surveys and studies of biodiversity by researchers in the Department of Biology, Faculty of Science, Prince of Songkla University, have been ongoing since 1984. One particular study, carried out during 1984–1986, found 637 species of plants in 130 families, of which 19 species were ferns, 90 species were dicotyledon and 19 species were cotyledon. Due to limited time, the value of biodiversity of KHH could not be undertaken by survey. The benefit transfer method was therefore applied to value this ecosystem service. A literature review revealed that only a few studies have been done on valuing biodiversity in Thailand. More studies have been done in other countries, but according to Navrud and Bergland (2001), the simple unit value transfer approach should not be used for transfers between countries with different income levels and costs of living. This would be particularly true in the case of KHH.

Table 13.5 Value of biodiversity of KHH

Scale of beneficiaries	Average WTP (Bt/person/year)	Total of population	Value (Bt/ha/year)
Hat Yai district only	159	374,891	111,606
Three districts adjacent to KHH		560,336	**163,837**
Songkhla province		1,357,023	326,251

Note: This value is considered underestimate.

Various Thai studies were reviewed as a basis for benefit transfer, including the study of Huai Kha Khaeng (Krasuaythong 2000), Thung Yai Naresuan (Naruchaikusol 2002) and Phu Khieo Wildlife Sanctuaries (Wiwatthanapornchai 2001). They are well known and were all surveyed at the national level. However, the characteristics of those forests and their biodiversity are much different from KHH, so they may give an overestimated benefit for KHH. A contingent valuation study of Pa Krad, a tropical forest in Nathawee District near Hat Yai, was considered more appropriate. The willingness to pay to conserve Pa Krad was estimated at 128 Baht/person/year using 2001 values. Allowing for inflation, the relevant estimate for 2011 was 159 Baht/person/year. This value was transferred to three main groups of beneficiaries: only Hat Yai people, people in three districts around KHH and the population of the whole province. The results are shown in Table 13.5.

Summary of Ecosystem Service Values for KHH

The benefits associated with all six ecosystem services selected for KHH are shown in Table 13.6, and their corresponding estimated values are shown in Table 13.7. These values are used in the CBA of possible management scenarios for KHH, over the next 25 years. Table 13.7 Indicates that the value of water absorption is higher than for the other services, with the exception of timber value. However, the table does not reveal the fact that reducing the damage cost from flooding constitutes the greatest benefit from KHH. If KHH forest is lost, the communities around the area will be affected by worsening floods resulting from excessive runoff. The communities will also incur a reduction in the supply of water for daily consumption, since less water would be made available as the area of forest decreases. Biodiversity value is the next largest value, even though the figure is underestimated, as explained earlier. The oxygen generation value is higher than CO_2 sequestration value due to the higher price of substituted oxygen. All ecosystem service values associated with natural forest are higher than those for rubber plantations.

Table 13.6 Benefits from ecosystem services as basis for CBA

Ecosystem service benefit	Benefit or cost corresponding the type of land use on KHH[1]	
	Forest	Rubber
Timber	–	Benefit from selling forest wood[2]
		Release of CO_2 storage from logged tree and soil[2]
Water absorption	Benefit of water absorbed that will be used throughout the year by the people downstream	Reduced benefit of water absorbed by forest
CO_2 sequestration	Benefit from CO_2 being sequestered at the rate of forest sequestration	Benefit from CO_2 being sequestered by rubber plants
		Release of CO_2 when the rubber plants reach their maximum age and needed to be cleared
Flood prevention	Damage cost of flooding	Damage cost of flooding when forest is converted to rubber
O_2 provider	Benefit from O_2 providing by forest trees	Benefit from O_2 providing by rubber trees
Biodiversity	Benefit of forest biodiversity	–

[1]Benefit and cost is considered per area of land use
[2]Only when the forest is cut down to make rubber farms

Table 13.7 Summary of ecosystem service values of KHH

Ecosystem services	Value at current stage (Bt/ha/)	Explanation
From forest in tact		
Timber, Bt/ha/year	632,974	Will enter into CBA only when the forest is cut
CO_2 sequestration, Bt/ha/year	12,618	Annual benefit
CO_2 storage, Bt/ha	47,983	Will enter into CBA only when the forest is cut
Oxygen generation, Bt/ha/year	108,518	Annual benefit
Water absorption by forest, Bt for total area of forest in that year	118,954,045	This value is at the first year
Flood prevention, Bt for total area of forest in that year	–	Different in each year in each scenario
Biodiversity	163,836	Annual benefit
From rubber plantation		
CO_2 sequestration	3,738	Annual benefit
Oxygen generation	31,181	Annual benefit

Note that rubber farms are reported not to contain significant volume of water or biodiversity, therefore are not accounted hereby

Management Options for KHH

Constructing the Management Scenarios

Information for constructing management options was obtained from face-to-face interviews with stakeholders, focus group discussions and questionnaires. In all, eight focus group discussions were held with representatives of local people living in the forest, local authorities associated with the forest and local academic experts. The number of total representatives in each group was 10, following the number of between 6 and 10 suggested by Bryman (2001). Issues were considered to be important in constructing the management options which included the decline in wildlife species, food sources from the forest, land entitlement, water use and cultural values. From the people's perspectives, KHH is being destroyed by deforestation, illegal encroachment, converting forest to rubber plantations or orchards, buildings and building for tourist attraction.

Three Management Scenarios

The outcome of the consultation process with stakeholders and other interested parties resulted in the following three broad options for managing KHH:

- Base case scenario where the change in land use continues at their usual rate.
- Declaring KHH as a protected area.
- Rehabilitate the forest to its primary stage, with or without payment for ecosystem services to owners who practice agroforestry or replanting forest trees in rubber farms or keeping trees not rubbers for carbon market.

The planning horizon is assumed to be 25 years, equivalent to the expected life of rubber trees from the time of planting.

Scenario I: Base Case Scenario

The first scenario is the base case, where there is no intervention in the existing condition or no new management actions taken. Most stakeholders agreed that if there were no intervention with the current trend in land use, it is assumed that forest will continue to be cut at the current rate of 16.68 ha/year and the rate of forest conversion to rubber plantation is 14.30 ha/year.

Ecosystem services from forest area are therefore expected to be lower the next year than the current year. These include CO_2 sequestration value, O_2 generation value and biodiversity value. However, since rubber farms will be increasing, they also give ecosystem services, although not as much as natural forest. The services from rubber farms considered in the study are in accordance with forest services, i.e. CO_2 sequestration value and O_2 generation value. Biodiversity of rubber farms is far less than forest and thus not usually considered as ecosystem function. The same is true for water retention in rubber plantations.

Assumptions of this scenario include:

- Rate of forest reduction and rubber plantation is linear using current data available.
- Timber benefit is considered only when it is cut.
- Rubber product starts at year 8. Ecosystem services from rubber comprise of CO_2 sequestration and O_2 generation at rubber's rate.
- Current rubber farms are at the average age of 21 years.
- Released CO_2 from harvested forest include CO_2 stored in wood, poles, litter, shrubs and soil, where the CO_2 from wood is assumed to be released only 40 % of carbon storage in wood.

Benefits in the base case include revenue from sales of latex and the value of timber when the forest is cleared to make way for rubber plantations. Costs in the scenario include the benefits foregone from lost services of forest and the cost of rubber farming. Another cost is the value of carbon released from timber when it is harvested. This is assumed to be 40 % of the total carbon storage in wood as most of wood if used for furniture can still store carbon within. The rest of carbon storage (in litter, floor plants, poles and soil) is counted as carbon released back to atmosphere which therefore raises the level of CO_2 in the atmosphere. Table 13.8 shows cost and benefit items appearing in the CBA.

Scenario II: Establishing a Protected Area (PA)

This scenario is possible, as the prospect is currently being explored of including this area as a part of the greater Songkhla Lake Basin Protected Area. There have been some discussions with the Office of Natural Resources and Environmental Policy and Planning (ONEP) and with the movement to bring KHH into the agenda of PA establishment. With this option, all current land-use activities on KHH will have to cease, and no further conversion of forest to other land use will be permitted. Thus, the area of 666.35 ha of forest and 469.78 of rubber farms will remain. The existing condition of the forest will remain, and any further environmental deterioration will be prevented.

Benefits are mainly those yielded by ecosystem services to the community. The cost of this management option includes the cost of establishing the management regime and the budget of local authorities who have the responsibility of protecting and managing this area after being declared protected. Rubber farming costs also have to be included as the current area of rubber farm will still continue production. The relevant information for Scenario II is shown in Table 13.9.

Table 13.8 Scenario I: base case

Items	Year 1	Year 2	Year 3	...	Year 24	Year 25
Area of forest	666.35	649.67	632.99	...	282.74	266.06
Area of rubber plantation	469.78	484.09	498.39	...	798.78	813.08
Cost						
Management cost	0	0	0	...	0	0
Cost of rubber farming	Cost or rubber farming at the age of rubber farms per ha per year					
Ecosystem service losses (benefit foregone from losing forest)						
Loss of annual CO_2 sequestration capacity	The annual CO_2 sequestration of forest per ha × area of forest cut × price of CO_2					
Release of CO_2 from timber harvested into atmosphere	The CO_2 storage in wood and other parts of forest per ha × area of forest cut × price of CO_2					
Loss of O_2 provider	O_2 supplied per ha forest × area of cut forest × price of O_2					
Water supply	Amount of total forecasted lost water in each year × price of water					
Foregone benefit from biodiversity	Foregone benefit of biodiversity per unit area of forest × area of cut forest					
Damage cost of flooding	Total forecasted flood water of this scenario × damage cost					
Benefit						
Benefit from changing forest to rubber						
Harvested timber value	Timber value × area of cut forest					
Rubber latex	For present rubber plantation = net revenue of rubber sold. For newly planted, net revenue will start around year 7 after planting					
Benefit from intact forest						
Value of annual CO_2 sequestration	Amount of CO_2 sequestration by forest per ha × area of forest intact × price of CO_2					
Value of O_2 provider	Amount of O_2 provided per ha of forest × area of forest intact price of O_2					
Value of water supply	Amount of water supplied by forest × price of water					
Value of biodiversity	Value of biodiversity per unit of forest area × area of forest					
Benefit from intact rubber						
CO_2 sequestration	Amount of CO_2 sequestration by rubber farm per ha × area of rubber farm × price of CO_2					
O_2 provider	O_2 supplied by rubber × area of rubber farm × price of O_2					

Assumptions of this scenario include:

- PA saves the land use as it is at present. No further reduction of forest will be possible.
- Costs of establishing PA involves the PA preparation cost (mostly cost of study) and monitoring cost. The preparation cost is derived from other studies of similar nature in the area. The monitoring cost is assumed to be 10 % of study cost each year.

Table 13.9 Scenario II: declaration of KHH as a protected area (PA)

Items	Year 1	Year 2	Year 3	…	Year 24	Year 25
Area of forest	666.35	666.35	666.35	…	666.35	666.35
Area of rubber plantation	469.78	469.78	469.78	…	469.78	469.78
Cost						
Management cost	Establishment cost	Monitoring cost	Monitoring cost	…	Monitoring cost	Monitoring cost
Cost of rubber farming	Cost or rubber farming at the age of rubber farms per ha per year					
Damage from flood	Total forecasted flood water of this scenario × damage cost					
Benefit						
Benefit from intact forest						
Value of annual CO_2 sequestration	Amount of CO_2 sequestration by forest per ha × area of forest intact × price of CO_2					
Value of O_2 provider	Amount of O_2 provided per ha of forest × area of forest intact price of O_2					
Value of water supply	Amount of water supplied by forest × price of water					
Value of biodiversity	Value of biodiversity per unit of forest area × area of forest					
Benefit from intact rubber						
Rubber latex	For present rubber plantation = net revenue of rubber sold.					
CO_2 sequestration	Amount of CO_2 sequestration by rubber farm per ha × area of rubber farm × price of CO_2					
O_2 provider	O_2 supplied by rubber × area of rubber farm × price of O_2					

Scenario III: Rehabilitating Forest from Rubber Plantation Area

This option involves introducing a management regime that converts rubber plantations back to native forest and restores the forest to original condition. The Help Conserve KHH Project considers that this may be the most effective option for managing the area. Two cases are considered for converting rubber plantations back to forest: Case A which involves rubber farmers voluntarily handing back areas under rubber production, given the fact that most of the area dedicated to rubber was illegally occupied, and Case B which involves establishing a special fund to buy back the rubber plantation area and rehabilitate it to conservation area. Under this scenario, the area of natural forest will finally reach 100 %.

Assumptions of this scenario include:

- Forest can be fully restored to primary forest after 40 years.
- The growth of carbon sequestration rate from restored rubber farms is 7.3687 tC/ha/year. Oxygen generation is based on this figure multiplied by 1.2 as in other cases.
- The rate of restoration is considered in two cases. The first case assumed the forest is restored at the rate of reduction, namely, 16.68 ha/year. However, if there is some intervention such as purchasing rubber farms to be converted back to forest, it is assumed that 10 % of the rubber production area will be restored per annum.
- Land purchase prices are considered at two levels: full land price (2,500,000 Bt/ha) and half of land price. These represent simply a monetary incentive for rubber growers to relinquish their holdings, rather than real opportunity costs.
- With this management, rubber farms do not lose all benefit from rubber latex, but only part of it. This is because rubber latex can still be collected, but at a lower rate, from rubber trees that are abandoned. However, in the CBA, this benefit is ignored.

Costs in this scenario comprise the restoration expenses for nursery establishment, labour costs and seedlings costs. Since Case A is voluntary, there is no additional cost. In Case B, where the restoration rate is expected to be high, a market mechanism may be needed to accelerate the conversion. Rubber farmers may be paid either full land price or half to relinquish their present use. Details of Scenario III are shown in Table 13.10.

Cost-Benefit Analysis of Management Options

Conducting the Cost-Benefit Analysis (CBA)

All costs and benefits were entered into a spreadsheet model to conduct the BCA and calculate the net present value (NPV) of each management option relative to the base case scenario. The time horizon adopted for all three scenarios is 25 years, matching the cycle of rubber farms. Discount rates ranging from 1 to 7 % are assumed.

Table 13.10 Scenario III: full restoration of area to natural forest

Items	Year 1	Year 2	Year 3	...	Year 24	Year 25
Area of forest	666.35	713.32	760.30	...	1,157.50	1,157.50
Area of rubber plantation	469.78	422.81	375.83	...	0	0
Cost						
Purchasing land	Land price × area of land restored each year (only in Scenario III Case B)					
Cost of restoration	Cost of nursery, seedlings and labour cost for restoration					
Cost of rubber farming	Cost or rubber farming at the age of rubber farms per ha per year					
Ecosystem service losses (benefit foregone from losing forest)						
Damage cost of flooding	Total forecasted flood water of this scenario × damage cost					
Benefit						
Benefit from intact forest						
Value of annual CO_2 sequestration	Amount of CO_2 sequestration by forest per ha × area of forest intact × price of CO_2					
Value of O_2 provider	Amount of O_2 provided per ha of forest × area of forest intact price of O_2					
Value of water supply	Amount of water supplied by forest × Price of water					
Value of biodiversity	Value of biodiversity per unit of forest area × area of forest					
Benefit from intact rubber						
CO_2 sequestration	Amount of CO_2 sequestration by rubber farm per ha × area of rubber farm × price of CO_2					
O_2 provider	O_2 supplied by rubber × area of rubber farm × price of O_2					
Rubber latex	For present rubber plantation = net revenue of rubber sold					

Results for Scenario I

The results for Scenario I are presented in Table 13.11. Although rubber farmers may benefit from large financial benefits, the CBA demonstrates that in the base case, society as a whole itself does not benefit. NPV increases with higher discount rates, indicating that the net benefit is higher in earlier years compared with later years. Indeed, the annual net benefit begins to turn negative from year 15 onwards. This result demonstrates that it would be desirable in terms of the economic welfare of people around KHH to preserve the ecosystem service benefits provided by forest on KHH.

Results for Scenario II

Table 13.12 contains the results for Scenario II. When the current land use is maintained, the NPVs are positive for all discount rates and the BCAs all exceed 2. This means that establishing KHH forest as a protected area and allowing no further land-use change, society would receive significant net benefits for the next 25 years.

Table 13.11 Results of CBA of scenario I

Discount rate (%)	Net present value	Benefit cost ratio	Annual equivalent benefit
1	60,784,334	1.00	607,842
2	130,528,481	1.02	2,610,568
3	183,935,062	1.03	5,518,051
4	224,531,610	1.05	8,981,263
5	255,071,853	1.06	12,753,592
6	277,710,718	1.08	16,662,642
7	294,138,461	1.09	20,589,691

Table 13.12 Results of CBA of scenario II

Discount rate (%)	Net present value	Benefit cost ratio	Annual equivalent benefit
1	4,548,691,971	2.880	45,486,919
2	4,023,692,477	2.878	80,473,849
3	3,581,714,446	2.874	107,451,432
4	3,207,653,492	2.870	128,306,139
5	2,889,404,643	2.867	144,470,231
6	2,617,227,284	2.864	157,033,636
7	2,383,251,622	2.861	166,827,612

Results for Scenario III

The results for Scenario III are shown in Table 13.13. They indicate that positive NPVs are obtained at all discount rates, for both Cases A and B. This shows that the benefit we receive from restoring the forest is exceedingly greater than the cost. The magnitude of NPVs in voluntary case (Case A) is lower than the payment options (both Case Bs). This is because the rate of conservation is lower in Case A than in Case B; thus, the benefits generated from forest are therefore gained more slowly than in Case B. Or the faster we convert area back to forest, the higher benefit we will receive. When compared with the same faster rate of restoration, the cost of payment affects the NPVs. Naturally, the higher we pay for the land price, the lesser benefit we will receive. The details of NPVs are shown in Table 13.13.

Comparison of the Three Scenarios

The results indicate that the NPVs for Scenario III are the highest, in particular Scenario III Case B, where there is a restoration scheme at the rate of 10 % per annum, and payment is made at half the price of land. Scenario II has the next highest NPVs. The lowest NPVs resulted under Scenario I.

Table 13.13 Results of CBA of scenario III

Discount rate (%)	Net present value	Benefit cost ratio	Annual equivalent benefit
Case A			
1	5,666,960,203	3.52	56,669,601
2	4,975,243,925	3.48	99,504,877
3	4,395,466,924	3.45	131,864,007
4	3,907,004,334	3.42	156,280,172
5	3,493,360,286	3.39	174,668,013
6	3,141,288,730	3.36	188,477,323
7	2,840,111,000	3.33	198,807,769
Case B purchasing at full price			
1	5,029,490,834	2.07	50,294,907
2	4,379,783,815	2.05	87,595,675
3	3,835,386,731	2.03	115,061,601
4	3,377,040,814	2.01	135,081,631
5	2,989,311,362	1.98	149,465,567
6	2,659,779,319	1.96	159,586,758
7	2,378,412,682	1.94	166,488,887
Case B purchasing at half price			
1	6,322,756,976	2.86	63,227,569
2	5,526,260,077	2.83	110,525,200
3	4,857,939,295	2.79	145,738,178
4	4,294,416,476	2.76	171,776,658
5	3,816,950,306	2.73	190,847,514
6	3,410,456,557	2.70	204,627,392
7	3,062,746,242	2.67	214,392,236

Conclusions and Recommendations

Research Conclusions

This study has shown that the net present values (NPVs) from the analysis prove that it is highly undesirable on economic grounds to continue losing KHH forest at its current rate. Although there are private benefits for rubber farmers, for society as a whole it is not worth converting natural forest to rubber plantations. Further loss of forest area should therefore be prevented. The analysis shows positive NPVs if the current areas of forest and rubber plantation are frozen, meaning that it is better to stop converting forest to rubber farms now. However, the best option is to convert existing rubber plantation areas back to natural forest. The main benefits arising from this management option take the form of increased value of ecosystem services.

It is worth noting that the benefits associated with ecosystem services evaluated in this study are only a part of the total ecosystem services of KHH. For example, the services such as tourism, preventing soil erosion, soil fertility, pollination and microclimate regulation are not accounted for. These services are more difficult to evaluate because of their complex nature and thus require longer study time, closer observation, more physical data and a fuller understanding of the system.

Policy Recommendations

Table 13.14 compares the advantages and disadvantages of each management scheme. It is clear that to leave things as they are at present without any intervention will be detrimental to society as a whole, especially after year 15. To implement the

Table 13.14 Advantages and disadvantages of the three management schemes

Criteria	Scenario I: doing nothing	Scenario II protected area	Scenario III	
			Restoration Case A	Restoration Case B
Economic feasibility	Positive NPV with annual net benefit turns negative from year 15 onwards	Positive NPV	Positive NPV	Positive NPV
Implementation cost (Present value at 7 % discount rate)	None	3,077,137	6,611,929	1,387,236,025 (Case B1) and 702,902,465 (Case B2)
Impact on communities/ acceptance	Rubber farmers have no impact, but they are illegal farmers	Current rubber farmers have no impact but it may create a problem of fairness with other prospect rubber farmers	Current rubber farmers lose part of their income as the rate of latex collection is not in full as before	Current rubber farmers have no impact as they are compensated
	Other people, e.g. people in Hat Yai, PSU people, media and some businesses enterprise, may not accept this	Other communities can accept this alternative		
Political acceptance	Governmental officers are in the position of taking action to deal with illegal encroachment	Local politicians may lose their political support from rubber farm owners	Local politicians may lose their political support from rubber farm owners	Local politicians may not lose the support as rubber farmers are compensated
Management possibility	Nothing has to be done	Possible and not so complicated once the area has been proclaimed	It is quite uncertain who will voluntary join the restoration	May be complicated as KHH lands are not legally owned and it raises some concerns about justice and fairness
Enforceability	Encroachment is against laws, but lack of enforcement makes it possible	Enforcement should be constant and strong for those who violate the laws	No enforcement needed since it is voluntary	No enforcement needed because the management is based on cooperation

most preferred option – Scenario III – several actions could be taken. The first would be to declare KHH as a protected area. The next phase is to improve the understanding of stakeholders, especially land owners with illegal land holdings, regarding land use on KHH. Raising awareness and implementing programmes of environmental education regarding the importance and value of KHH can assist in encouraging people to appreciate the value of KHH. The Help Conserve Kho Hong Hill Project has been doing that and is gaining more support from the wider community.

Attempting to reduce rubber plantation area and restoring natural forest is more challenging, yet this is the ultimate goal of the Help Conserve Kho Hong Hill Project. It would be desirable to achieve this goal through voluntary action by rubber farmers, but more likely, payments would have to be made to encourage them to relinquish their land holdings. If such a policy were to be announced, would it perhaps result in further encroachment in the short run in order to be paid later? Where might the funding come from to make such payments? Action would also be required to prevent people from illegally harvesting timber from the forest. A careful study of appropriate incentives is clearly warranted to achieve these outcomes, but that is beyond the scope of the present study.

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