The application of economics in the policy formulation to manage peat swamp forests as important ecosystems in climate change

N A Ulya[1], A Nurlia[1], and E A Waluyo[1]

Environment and Forestry Research Development Institute of Palembang , Ministry of Environment and Forestry, Jl. Kol. H. Burlian Km 6.5 Puntikayu Palembang, South Sumatra, Indonesia.

email: nurarifatululya@gmail.com

Abstract. Forest resources can provide benefits according to their capacity if there is an efficient resources allocation. Efficient allocation requires an assessment of value of benefits for the entire economy, not just financial benefits for business entities. Currently, degraded natural peat swamp forests within production forest areas are faced with the choice of being managed as natural forests, plantations forests or converted into plantations. Financial benefits are seen as more tangible and prominent benefits than economic benefits in policy formulation. This study aims to apply appropriate economic analysis methods to formulate policies for allocating forest resources efficiently. A comprehensive cost benefit analysis framework by internalizing environmental costs is used to formulate management policy of degraded natural peat swamp forest. This research is a case study in Sungai Merang-Sungai Ngirawan Peat Hydrological Unit (PHU). The results indicate that secondary peat swamp forests are more appropriately managed as secondary natural production forests rather than if it is managed as industrial plantations or converted to plantations. The use of a science framework in the practice of policy formulation is expected to support the sustainable forest development, especially in relation to climate change.

1. Introduction

Forest ecosystems provide benefits in the form of goods and services resulting from processes that occur in the forest ecosystem. Not all goods and services produced by forests can be traded in commercial markets [1,2]. Goods and services that can be traded or captured by commercial markets are often referred to as tangible benefits. Conversely, goods and services or benefits that are not traded or captured by commercial markets are referred to as intangible benefits. The tangible benefits are closely related to commodities consisting of timber and non-timber forest products such as rattan, honey and fruits. While intangible benefits are closely related to forest services such as hydrological benefits, land, protection from floods and landslides, biodiversity. These intagible benefits are often given a low value or even considered has no economic value [1–4].

The benefits of intangible forest ecosystems which are often considered low or not even captured by the commercial market are very important for human life. Forests are one of ecosystems that play an important role in the balance of the earth's ecosystem, whose economic benefits are one of the

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contributors to the total economic value of the earth. The intangible benefits that are more beneficial to ecosystems are a major support for the survival of human life on the earth. The intangible benefits forests affect human welfare both directly and indirectly [1,2,5,6].

The value of intangible benefits that tend to be rated low or not captured by the commercial market cause the bargaining position of forest ecosystems to be weak when it is faced with activities that are considered to produce economic benefits captured by commercial markets [1,7]. Development activities that have high economic value according to the commercial market often defeat forest ecosystems in the contestation of forest area utilization. The formulation of economic development policies that neglect the value of economic benefits in the long run period will threaten economic development itself or even the survival of humans on earth. Economic development that sacrifices development capital in the form of natural resources will eventually lead to costly overcome environmental disasters or to improve the condition of damaged natural capital [7–10].

Economic costs that occur as a result of damage to natural capital or the environment can be prevented if the formulation of economic development policies is carried out by referring to the true economic benefits of various alternative development activities. In addition, forest ecosystems can provide optimal benefits if there is efficient resources allocation [9,11,12]. Assessment of economic benefits from forest ecosystems becomes an important tool in efficient resources allocation for policy formulation that can be scientifically accountable and the maintain sustainable economic development[1,6,13].

Peat swamp forest is one of the important forest formations for human life. Peat swamp forests have an irreplaceable ecological role, especially in relation to climate change. Tropical peat swamp forests in Indonesia consist of peatland that is composed from the remnants of litter and wood that are not completely decomposed and that are covered by tropical rainforests. This composition makes peat swamp forests in Indonesia store carbon stocks both in soil (peatlands) and aboveground in the form of peat swamp forests [14–16] . As an illustration of the potential for tropical peat carbon deposits, tropical peatlands covers around 11 percent of the world's peatlands with deposits of C around 17-19 percent of the world's carbon content [17].

Despite having such an important role, peat swamp forests in Southeast Asia, including Indonesia face conversion for other uses [14,18–22]. Forest areas including peat swamp forests are converted into plantations, agricultural land and infrastructure under the pretext of development [2,14]. This conversion occurs because forest areas, especially in degraded conditions, are considered not to have economic values that can provide input to national income [2,7].

This study aims to apply appropriate economic analysis methods to formulate policies for allocating forest resources efficiently. The results of the study are expected to strengthen the importance of information about the economic value of various alternative uses of forest areas as the basis for policy formulation. The results of studies base on knowledge which are then is translated into forest resource allocation policies that would be carried out at the site level. It is, then, expected to support the sustainability of forest resources as ecosystems that are important for human survival, including sustainable economic development.

2. Methods

2.1. Reseach location

This research is a case study carried out at the Sungai Merang-Sungai Ngirawan Peat Hydrological Unit (PHU). This peat dome is administratively located in Bayung Lencir Sub District, Musi Banyuasin District, South Sumatra Province, Indonesia. The location is chosen because PHU is the largest peat dome in South Sumatra, on top of the area, there do happen degraded natural peat swamp forest which is faced with management other than for natural forest. Industrial plantations forest are an alternative management of peat swamp forests inside production forest areas. Oil palm plantations are a management alternative for peat dome areas that are not included in the forest area.

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2.2. Theoritical framework

Economic development exposes peat swamp forest areas to conversion for forestry sector's interest and other sector's interests. Management options by maintaining forest areas in their natural conditions or being converted for other uses must be based on comparison between the economic value of benefits provided by the forest ecosystem, and the economic value if the forest area is used for other purposes. The conversion of peat swamp forest areas into other forms, as well as development activities in general, expects benefits in accordance with the costs incurred. Benefits and costs incurred must be assessed within the framework of financial analysis also that is also using economic analysis

Financial analysis is an analysis carried out from the perspective of the business owner entity. Economic analysis is an analysis of costs and benefits from the point of view of society as a whole. Financial costs are spendings that are sacrificed to produce output, when it is viewed from the perspective of the business owner entity. Economic costs are expenditures sacrificed to produce output, if it is viewed from the point of view of the community as the owner of economic resources. In addition to the costs incurred, conversion of natural forest areas will provide financial and economic benefits derived from each form of management.

In the framework of economic analysis, development activities that are initiated by the conversion of peat swamp forest areas, in addition to the direct costs, there are also indirect effects. The indirect effect comes from forest benefits that lost due to the conversion of peat swamp forest areas. The benefits of peat swamp forests are reflected in the economic value of natural forests. The economic value of forests lost as a result of conversion activities is expressed as negative externalities. Negative externalities are calculated (internalized) as part of the cost component in economic analysis. The very large value of negative externalities allows a development activity which is initiated with the conversion of peat swamp forest areas to be unsuitable, because the market price of the products is unable to cover the costs of the lost economic value of the forest. Thus the price of products originating from the area must be higher than the market price. Internalizing negative externalities is one way that can be taken into account so that the resource allocation is efficient [7,9].

Cost and Benefit Analysis (CBA) is commonly used for economic assessments of projects and policies. CBA is an economics-based tool that can be used for decision making by comparing costs (disadvantages) and benefits (advantages) of an activity or policy [7,23–25]. Within the CBA framework, an activity or policy can be carried out if:

$$Ba - Ca > 0 \quad (1)$$

where :

Ba = benefit of projets/policy a (including environmental benefit)

Ca = cost of projets/policy a (including environmental cost)

In the context of choosing alternative uses of resources, the opportunity cost of choosing Option A is therefore the net benefits of Option B (the next best alternative). The net benefits of A (NBa) must then exceed the net benefits of B (NBb) if A is to be the preferred land use options.

$$NBa - NBa > 0 \quad (2)$$

Suppose there are two alternative tropical forest land use options: Option A (conversion) and Option B (sustainable traditional use of the forest). If the forest is to be cleared for conversion (Option A), not only should the direct costs of conversion (e.g., clearing and burning the forest) be included as part of the costs of this land use option but also the foregone benefits of the forest that has been converted. Without conversion, the forest could have been conserved closer to its natural state through limited and sustainable use (Option B). Foregone benefits associated with Option A may include the loss of important environmental functions.

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2.3. Data collections

The research data are obtained from respondents, government agencies, industrial plantation forest company, oil palm plantation company, Non-Governmental Organizations as well as activities or projects located in the research area. Data sourced are from government agencies, companies, non-governmental organizations as well as activities or projects in the study area that are collected by interviews and reports analysis. Some data are obtained from scientific publications.

The tool used to obtain data as material for the analysis of the benefits of oil palm plantations is a table detailing the costs and benefits of industrial plantation forest companies and oil palm plantations. Data sourced from the respondents of the study are obtained through interviews. Contingent valuation method (CVM) is applied with open ended question, using questionnaire. Research respondents are drawn from the population living in the vicinity of the study area during the research.

2.4. Data analysis

Data obtained are then analyzed by financial and economic analysis. Financial analysis is carried out to determine the benefits of development carried out by converting peat swamp natural forest from the perspective of the business owner entity. Economic analysis is carried out to determine the benefits of development activities carried out by converting peat swamp natural forests from the perspective of the wider community [23]. The criteria used to assess the feasibility of development are the value of Net Present Value (NPV), the ratio between Benefit Cost Ratio (BCR) and Internal Rate of Return (IRR) [23–25].

3. Result and discussion

3.1. Economic value of natural peat swamp forest

Economic value of benefits that are derived from peat swamp forest consists of economic value of timber, fish, water for households, water for transportation, protection of environment quality, carbon, value of flora and fauna, biodiversity and existence value. The assessment of economic value of natural forest timber in PSF area is done by calculating stumpage sales price (SSP). The economic value of fish is estimated by assessing the value of WTP of respondents to consume fish. The economic value of water is derived from peat swamp forest that is estimated by WTP of households that consume water from river for household needs and has made the river as transportation route both local and to other areas such as Palembang and Jambi. Environmental protection provided by PSF includes protection from floods and droughts and smoke from forest and land fires [26]. The carbon price used in the assessment of the economic value of PSF is obtained by the benefit transfer method [27]. Contingent Valuation Method is used to estimate the option value of PSF. The value of biodiversity of PSF is estimated using benefit transfer method [27]. The reference data is biodiversity value of Berbak-Sembilang National Park (BSNP). The existence value given by the community around pet swamp forest consists of spiritual, cultural and aesthetic benefits. The existence value of peat swamp forest is calculated using Contingent Valuation Method (CVM) with open ended question.

Table 1. Economic value of goods and services from natural peat swamp forest.

Goods/services	Economic value (USD ha^{-1} yr^{-1})
Timber	2,909.47
Fish	277.70
Water for households	191.77
Water for transportation	618.69
Protection of environment quality	6.83
Carbon	11,519
Option value	0.30
Biodiversity	30.00
Existence value	0.50
Amount	15,553.92

Source : [26]

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Economic value of peat swamp forest that consists of economic value of timber, fish, water for households, water for transportation, protection of environment quality, carbon, value of flora and fauna, biodiversity and existence is about 15,553.92 USD hectare^{-1} [26].

3.2. Financial and economic analysis of industrial plantation forest development in peat swamp forest area

The financial analysis of plantation forest development refers to the study conducted by [28] by adjusting the price and interest rate analysis components. The cost component consists of the costs of planning, nursery, land preparation and planting, plant maintenance, investment and maintenance of buildings and equipments, developing and maintaining roads and canals, education, training and counselling, research and development, protection and security, obligations to the environment, obligations to the social, general and administrative environment. Revenues are derived from the sale of wood to pulp and paper mills.

The result of financial analysis of plantation forest development which is initiated with the conversion of peat swamp forest with an interest rate of 12% and 25-year analysis period are presented in Table 2.

Table 2. Financial NPV, Financial BCR and Financial RR development of industrial plantation which is initiated with conversion of peat swamp forest with an interest rate of 12% and 25-year analysis period.

FNPV (USD)	FBCR	FRR (%)
3,759.06	2,63	30

Development of industrial plantation forest which is initiated with the conversion of peat swamp forests has an environmental impact. The industrial plantation forest concession in the research area is carried out in the forest areas, where most of the land cover of (82,249 hectares or 59.51%) is peat swamp forest. Clear cutting are carried out at the beginning of the industrial plantation forest development. Clear cutting of peat swamp forest is assumed to cause the loss of the economic value of peat swamp natural forests.

Other environmental impacts occur because of the process of peat drainage. The drainage is intended to regulate the groundwater level so that the tree species developed by industrial plantation forest can grow well. Drainage of peatlands and emission, changing the function of peatlands from carbon sinks becomes a source of Green House Gasses (GHG) emissions. In degraded forest land due to logging and drainage, the carbon emissions will increase sharply because of many fresh organic materials that are easily decomposed in the degraded forest. The process of peat drainage produces major GHG emissions, namely CO_2, CH_4 and N_2O. CO_2 emissions that are much higher than CH_4 emissions and N_2O emissions. Thus CO_2 emissions data is strong enough to represent emissions from peatlands, especially if other GHG measurements such as CH_4 and N_2O are difficult to do [15,29,30]. CH_4 emissions are significant in inundated peat forest or peatlandwith shallow water table (<40 cm). With the increasing groundwater depth, CH_4 emissions become not significant. CH_4 emissions on agricultural land are relatively small because of the low supply of fresh organic matter which is ready to decompose anaerobically [30].

In this study the calculated GHG emissions are CO_2 emissions that occur as a result of peat drainage. The average depth of industrial plantation forest drainage in the study location is 55 cm. With reference to [29] the produced carbon emissions are 50.05 tCO_2 hectare^{-1} year^{-1}. Assuming a carbon price of US $ 4 per ton of CO_2 emissions and the negative externality value of CO_2 emissions due to drainage is 198.36 USD hectare^{-1}.

The negative externality value of exploitation of industrial forest plantations which is initiated with the conversion of peat swamp forest consists of the economic value of peat swamp natural forests lost due to clear cutting at the beginning of the industrial plantation development and CO_2 emissions from drainage. The negative externality values of industrial plantation development are presented in Table 3.

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Table 3. Negative externality value of development of industrial plantation forest which initiated with conversion of peat swamp forest.

No.	Negative externality	Value (USD ha^{-1})
1.	Economic value of peat swamp forest	15,553.93
2.	CO_2 emissions from drainage	198.36
	Amount of negative externality	15,752.9

The negative externality value is then calculated as part of the costs in the economic analysis of industrial forest plantation development which is initiated with conversion of peat swamp forests. The results of the Economic NPV (ENPV), Economic BCR (EBCR) and Economic Rate of Retur (ERR) estimates of industrial forest plantation at peat swamp forest at an interest rate of 12% and a 25-year concession period are presented in Table 4.

Table 4. Economic NPV, economic BCR and economic RR development of industrial plantation which is initiated with conversion of peat swamp forest with an interest rate of 12% and 25-year analysis period.

ENPV (USD)	EBCR	ERR (%)
-121,156,084.2	0,000051	3

The results of the analysis show that from the point of view of business owner entity, development of industrial plantation forests which are initiated with the conversion of secondary peat swamp forest with an interest rate of 12% and a 25-year analysis period are feasible and provide financial benefits. However, when the economic analysis framework is used, development of industrial plantations which are initiated with the conversion of secondary peat swamp natural forests are not feasible.

3.3. Financial and economic analysis of oil palm plantation development in peat swamp forest area

The financial analysis of the development of oil palm plantations refers to studies conducted by [28] (by adjusting the price component and interest rate analysis. The cost component consists of costs of planning, nursery, land preparation and planting, maintenance of immature plants, maintenance of producing plant, investment and maintenance of buildings and equipments, manufacturing and maintenance of roads and canals and operational costs. Revenues are derived from the sale of fresh fruit bunches (FFB) to palm oil processing plants.

The results of the financial analysis of oil palm plantation operations which begins with the conversion of secondary peat swamp forest with an interest rate of 12% and a 25-year analysis period are presented in Table 5.

Table 5. Financial NPV, financial BCR and financialc RR development of oil palm plantation which initiated with conversion of peat swamp forest with an interest rate of 12% and 25-year analysis period.

FNPV (USD)	FBCR	FRR (%)
11,064.12	1,23	15

Development of oil palm plantations which are initiated with conversion of peat swamp forests has an environmental impact. Logging of peat swamp forests is assumed to cause a loss of the economic value of natural peat swamp natural forests. Environmental impacts also occur due to the land preparation and regulation of water level which causes peat drainage [29]. Development of oil palm plantations on peatlands generally also cause the happenings of fires on peat surface and fire/decomposition of initial vegetation biomass [15].

In this study, the economic impact that is taken into account is the loss of the economic value of peat swamp forests and carbon emissions. CO_2 emissions in the construction of oil palm plantations by the conversion of peat forests come from peat drainage, fire/decomposition of initial vegetation biomass and fires on peat surface [15]. The average drainage on oil palm plantations in the study location is 60 cm. With reference to [29] it is known that annual emissions are around 54.6 tCO_2

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hectare^{-1}. Assuming a carbon price of US $ 4 per ton of CO_2 emissions, the value of carbon emissions due to drainage is 216.39 USD hectare^{-1} per year^{-1}. CO_2 emissions from fire/decomposition of initial vegetation biomass are amounted to 14.7 tons hectare^{-1} per year^{-1} [15]. The value of CO_2 emissions from fire/decomposition of initial vegetation biomass is 58.26 USD hectare^{-1} per year^{-1}. The amount of CO_2 emissions from fires on peat surface is 11 tons hectare^{-1} per year^{-1} [15]. So the value of CO_2 emissions from fires on peat is 43.59 USD. Thus the value of the negative externality of CO_2 emissions in oil palm plantations is 318.24 USD hectare^{-1} per year^{-1}. The value of the negative externalities of oil palm plantation development which is initiated with the conversion of secondary peat swamp forest is presented in Table 6.

Table 6. Negative externality value of development of oil palm plantation which initiated with conversion of peat swamp forest.

No.	Negative externality	Value (USD ha^{-1})
1.	Economic value of peat swamp forest	15,553.93
2.	CO_2 emissions	318.24
	- drainage	216.39
	- fire/decomposition of initial vegetation biomass	58.26
	- from fires on peat surface	43.59
	Amount of negative externality	16,190.40

The negative externality value is then calculated as part of the costs in the economic analysis of development of oil palm plantation which is initiated with conversion of peat swamp forests. The results of the assessment of economic NPV, economic BCR and economic RR of development of oil palm plantations which are initiated with conversion of peat swamp forests at an interest rate of 12% and a 25-year concession period are presented in Table 7.

Table 7. Economic NPV, economic BCR and economic RR development of oi palm plantation which initiated with conversion of peat swamp forest with an interest rate of 12% and 25-year analysis period.

ENPV (USD)	EBCR	ERR (%)
-61,607.65	0,10	6

The results of the financial analysis show that from the point of view of the business owner entity, oil palm plantation cultivation which is initiated with the conversion of secondary peat swamp forest with an interest rate of 12% and a 25-year analysis period is feasible and provides financial benefits. However, within the framework of economic analysis, oil palm plantations which are initiated by the conversion of natural secondary peat swamp forests are not feasible.

3.4. Economic analysis as a reference for the formulation of forest area management policies

The economic value of peat swamp forests is higher when it is compared to the value of the economic benefits of industrial plantation forest and oil palm plantation development which begins with the conversion of secondary peat swamp forests. This value indicates that a forest area in its natural form is able to provide economic benefits to the wider community. Forests are able to maintain the quality of life of the community by preventing disasters, providing food and water material which are an absolute requirement for survival. Forests can affect the quality of human life, including economic sustainability. Forests also provide a sense of psychological comfort, affect culture and provide spiritual values.

[31] reminds that the economic value of natural peat swamp forests based on the concept of Total Economic Value (TEV) delivered by [10], is actually not really a total economic value because the actual value is still greater. The reason is that the value does not cover all forest values except its economic value, and many ecologists state that total economic value cannot be calculated by a simple formula because there are several basic ecological functions that are synergistic so that the value is far greater than the value of a single function. Besides, that the forest also has a multipurpose function,

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namely as a producer of wood, regulation of the water system, shelter for wildlife, food producers, environmental services, absorption of CO_2, tourist attractions, and others. However, all experts acknowledge that it is very difficult to define the boundaries of these functions with each other explicitly because these functions interact dynamically.

The economic value of peat swamp forests when it is compared to alternative management economic values shows that natural peat swamp forests as scarce economic resources needed by the community are more suitable to be maintained as natural peat swamp forests than converted into industrial plantation forestor oil palm plantations. The economic value of peat swamp forests is naturally higher than the alternative uses, which reflect the economic benefits provided by peat swamp forests for the community.

The results of this study also show that the results of the assessment of the benefits of development financially and economically give different results even though in principle the stages can be said to be the same. So far, the decisions taken in the formulation of management policies for an area, especially if there are alternative management, use financial analysis as a comparison of the value of natural forests. There is a generalization of understanding so that there is confusion about the use of the term economic analysis for activities that are actually financial analysis that do not take into account the value of depletion of natural resources. In the management of forest resources in Indonesia, this confusion leads to the view that forest resources in their original form are considered not to provide benefits to the wider community, even it is considered as cost centers even though the forest areas in their original form have really provided economic benefits to the community as it is reflected in the total economic value of natural forests .

The difference in the results of financial analysis and economic analysis according to development of industrial plantataion forest and oil palm plantations which are initiated by the conversion of peat swamp forest shows that financial analysis is not enough to be used in the formulation of the policy of converting peat swamp forest in the study area. Peat swamp forest in the research location is a forest area controlled by the state with benefits felt by the community at the local to international level. State ownership requires management decisions that provide benefits to the entire national economy, not only to business entities.

This researsh shows that the use of a science framework in the practice of policy formulation is intended to support sustainable forest development, especially in relation to climate change. The policy of converting peat swamp forests as an important ecosystem for climate change is proven to cause damage to peat swamp forests. The peat swamp forest which is supposed to be a store of carbon reserves is a source of carbon emissions originating from emissions due to peat subsidence and forest and land fires. Instead of generating benefits for the national economy, damage to peat swamp forest ecosystems caused by proper management will actually be a source of economic costs.

4. Conclusion

There are differences in the results of the analysis between policy formulation using a commonly used paradigm with policies formulated based on appropriate scientific justification. Policy formulation using an appropriate scientific framework provides results that can be scientifically accounted. Taking into account the economic benefits of peat swamp forests for the whole economy, peat swamp forest areas as important ecosystems for climate change, and scarce and needed economic resources for communities are more suitable to be maintained as natural peat swamp forests rather than to be converted into industrial forest plantation or oil palm plantations.

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