Valuation of goods and services derived from plantation forest in peat swamp forest area: the case of South Sumatra Province

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Abstract. Natural forest area is decreasing but planted forest is increasing by years. The main target of establishment of industrial plantation forest is rehabilitating unproductive production forest areas (mitigate land degradation). Plantation forest ecosystem also expected provide some goods and services even though timber production usually become the main service. This paper aims to present data and information about the value of goods and services derived from plantations forest with case studies in the South Sumatra Province. The Total Economic Value (TEV) concept used as the framework to quantify value of the goods and services derived from plantations forest. The TEV concept widely use to measure the utilitarian value of ecosystems to support efficient resources allocation. The result indicates that the economic value of goods and services derived from plantation forest that reflected by the TEV of plantation forest is about 17,242.72 USD. This value is higher than TEV of natural secondary forest and abandoned peatswamp forest. Its indicates that plantation forest can provide both timber and non-timber benefits that generated by the ecological functions of plantation forest. In peat swamps area, development of plantation forest with adaptive species will support timber production and mitigate forest land degradation.

1. Introduction

Forest area have changed substantially over the past 25 years. The world had 4,128 million ha of forest area (31.6 percent of global land area) in 1990. But by 2015 the area has decreased to 3,999 million ha (30.6 percent of global land area). In 2015 natural forest area is decreasing but planted forest is increasing. Indonesia is one country that responding to the global demand for wood by expanding pulp production and plantation forest holdings. As the result, in 2010 Indonesia become the world’s top 10 producers of pulp and paper, recording the production of 7 million tons of pulp and 10.5 million tons of paper. Both commodities generated about 6 billion USD in export earnings [1].

Industrial plantation forest in Indonesia established not only to generate national income through value added process in order to generate foreign exchange. Plantation forest also established in order to improve the potential and quality of production forest area by applying the intensive silviculture system. The main target of establishment of industrial plantation forest is rehabilitating unproductive production forest areas (mitigate land degradation) [2,3]. Based on those target, plantation forest ecosystem also expected provide some goods and services even though timber production usually become the main service.
Forest ecosystem goods and services represent the benefits for human populations derives directly or indirectly from ecosystem functions [4]. [5,6] state that forest ecosystem services consists of provisioning, regulating, cultural and amenity, and supporting services. Although plantation forest is different from natural forest in terms of their structure and function, plantation forest also can provide multiple benefits for society [7].

This paper aims to present data and information about the value of goods and services derived from plantations forest with case studies in the South Sumatra province. The result of the research presented in this paper is expected to be a reference in the formulation of forest management policy in Indonesia.

2. Materials and Methods

2.1. Research location
The Merang forest group with an area of 138,200 hectares is administratively located in Bayung Lencir Sub-District, Musi Banyuasin District, South Sumatera Province. Geographically the forest is located between 1°45' - 2°03' South Latitude and 103°51' - 104°17' East Longitude. The Merang forest group is a peat swamp forest. Peat depth at some point up to 4 - 5.5 meters. The soil conditions are sour to very sour with a pH of 4.51 to 4.98. The hydrological conditions at the study sites were influenced by Merang River [8]. The forest in the Merang forest group is currently managed by plantation forest cosessionaire. Acacia crassicarpa is the main plantation cultivated by the forest concessionaire that projected as raw material for pulp and paper industry.

![Figure 1. Research Location](image)

2.2. Analytical framework
The best management option identify trough the economics value of natural resources. The economic valuation conducted in order to identify the economic benefit value of the existing management options and the necessary sacrifices by taking into account the value of money over time. The economic value of natural resources is, among other things, useful as consideration in decisions making, to determine the best option for resource allocation with constraints such as time and resources availability. The efficient measure of resource allocation is expressed in the monetary value represented by the currency. In a market economy, the currency is considered a measure of universal economic value, because the amount of value a person wants to pay reflects how many other goods...
and services are sacrificed in order to get a certain desired goods and services. Formally this concept is referred as willingness to pay (WTP) [9,10]. Thus it can be stated that the economic value of resources is derived from the desire to maximize the satisfaction or utility, or is utilitarian.

The concept of Total Economic Value (TEV) has become a framework widely used to quantify the utilitarian value of ecosystems [5,11–13]. [5,11] state The TEV framework typically disaggregates the economic value of natural resources (including forest resources) into two categories: use values (UV) and non-use values (NUV). The classification chart of the economic value of environmental resources is presented in Figure 2.

![Figure 2. Total economic value framework (Sources: [5,11], modified)](image)

Peat swamp forest is a forest that grows in wetlands, especially peat swamp area. The classification of total economic value for wetlands according to [14–16] presented in Table 1.

| Direct Use Value | Use Value | Non Use Value |
|------------------|-----------|---------------|
| - fish           | - nutrient storage | - potential future use (as a direct and indirect use value) |
| - agriculture    | - flood control   | - biodiversity |
| - firewood       | - storm protection| - culture, heritage |
| - recreation     | - ground water    | - bequest value |
| - transportation |                        |               |
| - wildlife dunting|                      |               |
2.3. Data collection

The data used in this study were obtained from respondents, government agencies, plantation forest company, Non-Governmental Organizations as well as activities located in the forest research sites. Data sourced from government agencies, companies, non-governmental organizations as well as activities in the study sites were obtained by interviews, and reports. Data sourced from the respondents of the study were obtained through interviews. Interview method used is contingent valuation with open ended question, using questionnaire. Research respondents were drawn from the population living in the vicinity of the study site during the research.

2.4. Data analysis

The economic value of peat swamp forests (PSF) in research area is derived from the calculation of total economic value (TEV). Total economic value is obtained by estimating the economic value of environmental goods and services produced by PSF. For the PSF area, TEV can be presented as:

\[
TEV = DUV + IU + IU + OV + EV
\]

where:

- \( V_t \) = value of timber
- \( V_f \) = value of fish
- \( V_{wh} \) = value of water for households
- \( V_{wt} \) = value of water for transportation
- \( V_p \) = value of protection of environment quality
- \( V_c \) = value of carbon
- \( V_{ff} \) = value of flora and fauna
- \( V_{bio} \) = value of biodiversity
- \( V_e \) = value of existence

The value used for each variable is the economic value. As long as the market price can reflect its economic value, the market price can be used directly. However, if market prices for goods or services are known to be distorted, adjustments are needed to determine their economic value. The price obtained from the adjustment process is also called the shadow price. Since not all of these variables can be traded directly in the conventional market, it is necessary to use proxy.

Monetary or financial valuation methods can be divided into three basic types; direct market valuation, indirect market valuation and survey-based valuation (i.e. contingent valuation). Market price, cost of illness, benefit transfer and contingent valuation methods use as methods for data analysis [5, 6, 12, 15].

3. Result and Discussion

3.1. Valuation of goods and services derived from natural forest

The assessment of economic value of natural forest timber in PSF area is done by calculating stumpage sales price (SSP). In this research, the SSP is the difference between the prices of timber at the timber sale (port sender) with production cost. The calculated production cost consists of the cost of harvesting and selling timber. The economic value of natural forest timber is estimated by
multiplying the SSP with the standing stock of natural forest (Table 2). Thus, the economic value of natural forest timber is about 2.909.47 USD ha⁻¹ [8].

Table 2. Timber value of natural forest

| Timber size                    | Volume (m³ hektar⁻¹) | Value (USD m⁻³) |
|-------------------------------|----------------------|-----------------|
| Log (diameter > 30 cm)        | 19.67                | 1,371.83        |
| Small log (diameter 10-30 cm) | 71.38                | 1,537.64        |
| Amount                        |                      | 2,909.47        |

Source: data analyzed

The economic value of fish derived from peat swamp forest was estimated by assessing the value of WTP of respondents to consume fish. Data obtained from the respondents through interviews, then analyzed by regression to calculate the value of willingness to pay from respondents to consume fish, in order to keep constant utilities.

\[
\ln Y = 17.1 - 0.98 \ln X_1 - 0.746 \ln X_4
\]

where:
- \( Y \) = amount of fish consumption (kg person⁻¹ year⁻¹)
- \( X_1 \) = fish procurement cost (USD kg⁻¹)
- \( X_4 \) = distance from home to forest (km)

Based on Equation (2), economic value of fish for the community around PSF is about 277.70 USD ha⁻¹ yr⁻¹[8].

The economic value of water for household derived from peat swamp forest was done by assessing the value of WTP of respondents in order to consume water to meet household needs.

\[
\ln Y = 6.16 - 0.431 \ln X_1 + 0.261 \ln X_7
\]

where:
- \( Y \) = consumption of water for households (m³ person⁻¹ year⁻¹)
- \( X_1 \) = water for households procurement cost (USD m⁻³)
- \( X_7 \) = number of family members (person)

Based on equation (3), economic value of household water for the community around PSF amounted 191.77 USD ha⁻¹ yr⁻¹[17].

To estimate the value of water for transportation, interviews were conducted on the heads of households who made the river as transportation route both local and to other areas such as Palembang and Jambi. Community commonly used boat, ketek (small boat with outboard motor) and speedboat for local transportation. For long-distance water transportation, people usually ride jukung or large speedboat.

\[
\ln Y = 14.9 - 0.876 \ln X_1 - 1.01 \ln X_2 - 0.542 \ln X_5 + 0.919 \ln X_8
\]

where:
- \( Y \) = consumption of water for transportation (kilometer year⁻¹)
- \( X_1 \) = water for transportation procurement cost (USD kilometer⁻¹)
- \( X_2 \) = age of respondent (year)
- \( X_5 \) = education of respondent (year)
- \( X_8 \) = frequency of annual water transportation use (trip year⁻¹)
The economic value of water for transportation for the community around PSF (cased on equation (4)) amounted 618.69 USD ha\(^{-1}\) yr\(^{-1}\).

PSF located in peat dome as part of a watershed system that has a function to protect environmental quality, especially in relation with the hydrological system. Under undisturbed conditions, peat swamp forests are able to prevent excessive conditions and extreme water shortages in a region. Peat land disturbances such as land use change affect groundwater levels, and air and soil temperatures, thus increasing the risk of forest and land fires. The protection of environmental quality values in this study focused on the environmental protection function of PSF as a water regulator. Disturbance to forest hydrological functions is expected to cause droughts, floods and forest fires. Assessments are made by assessing the income loss in and the cost of medical care as a result of degradation of in environmental quality [18]. Degradation of in environmental quality leads to a decrease in the quality of health shown by outbreaks of diseases such as vomiting, diarrhea, itching, flu, coughing, and shortness of breath, fever, malaria and asthma. The value of environmental protection is approached with the cost of illness incurred and the opportunity cost due to drought, flood and haze. Environmental protection provided by PSF includes protection from floods and droughts and smog from forest and land fires. The average loss suffered by respondents due to the disruption of the PSF’s environmental protection function is 48,831.26 USD per person per year. The total value of the environmental protection of the PSF area which is approached with the loss suffered by the community due to the disturbance of the PSF area amounted 6.83 USD ha\(^{-1}\) yr\(^{-1}\)[8].

The carbon price used in the assessment of the economic value of PSF is obtained by the benefit transfer method [19]. The carbon price used as a reference is the price of carbon trading in Ulu Masen. The reason for choosing the Ulu Masen carbon price as a reference in the benefit transfer is the similarity of location (Indonesia). Ulu Masen carbon price is 4 USD per ton of CO\(_2\) emissions that can be prevented. The carbon content at the study sites is 2,879.66 ton CO\(_2\) per hectare (Table 3). The carbon value of PSF is 11,412.55 USD ha\(^{-1}\) yr\(^{-1}\)[8].

| Description                  | Carbon content (ton CO\(_2\) ha\(^{-1}\)) | Carbon value (USD ha\(^{-1}\)) |
|------------------------------|------------------------------------------|--------------------------------|
| Aboveground biomass          | 202.38                                   | 810                            |
| Belowground biomass          | 2,677.28                                 | 10,709                         |
| Amount                       | 2,879.66                                 | 11,519                         |

Source: data analyzed

Contingent Valuation Method was used to estimate the option value of PSF. The results of interviews with respondents indicate that most respondents agree to the protection of plants and animals because of their potential value in the future. [8] indicates that the economic value of option value of PSF is about 0.30 USD ha\(^{-1}\) yr\(^{-1}\) that represents by potential future value of benefits that are currently considered to have no economic value.

The value of biodiversity of PSF is estimated using benefit transfer method [19]. The reference data is biodiversity value of Berbak-Sembilang National Park (BSNP). The BSNP has similar ecological conditions and adjacent to the research location. The value of biodiversity of BSNP was amounted 30 USD ha\(^{-1}\) yr\(^{-1}\)[20].

The existence value given by the community around PSF are consists of spiritual, cultural and aesthetic benefits. The calculation of the existence value of PSF is done using Contingent Valuation Method with open ended question. Most respondents said they were willing to pay to maintain the existence of PSF. Based on the calculation results obtained the total value of the existence of PSF is 0.50 USD ha\(^{-1}\) yr\(^{-1}\)[8].
Total Economic Value of PSF is a sum of Direct Use Value, Indirect Use Value, Option Value and Bequest Value. Direct use value consists of the value of natural forest wood, the value of fish, the value of water for households, and the value of water for transport. Indirect use value consists of protection of environmental quality value and carbon value. The Option Value consists of the option of future management of flora and fauna and the value of biodiversity. Non-use value is the represent by existence value. The total economic value of peat swamp natural forest amounted 15,553.92 USD ha\(^{-1}\) yr\(^{-1}\) (Table 4).

### Table 4. 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: data analyzed

3.2. Valuation of goods and services derived from plantation forest

Species planted in plantation forest are *Acacia crassicarpa*, *A. mangium* and *Eucalyptus pellita*. The plant cycle used is 6 years. Based on the results of the research on permanent sample plots owned by the forest concessiinaire company, it is known that the first cycling plant is 25 m\(^3\) per hectare per year, while for the next cycle 30 m\(^3\) per ha\(^{-1}\) yr\(^{-1}\).

The price of timber used for the calculation of plantation forest income is the price of Stumpage Sales Price (SSP). SSP of plantation forest is the difference between the price of timber in port sender and production cost. The SSP value before tax is obtained by reducing the selling price of wood from plantation forest with the cost of harvesting and selling. The SSP value after tax is obtained by reducing the selling price of wood by the cost of harvesting, sales and tax. The SSP of plantation forest timber is 21.59 USD. The timber value of plantation forest is 727.62 USD ha\(^{-1}\) year\(^{-1}\). The financial income of plantation forest concession in PSF for 25 years is about 18,190.73 USD ha\(^{-1}\).

### Table 5. Timber value of plantation forest

| Timber classification | Volume (m\(^3\) hectare\(^{-1}\)) | Value (USD ha\(^{-1}\) year\(^{-1}\)) |
|-----------------------|----------------------------------|-------------------------------------|
| Main plantation       | 25                               | 539.99                              |
| Livelihood plantation | 8.69                             | 187.63                              |
| **Amount**            |                                  | **727.62**                          |

Source: data analyzed

The existence of plantation forest does not eliminate people’s access to fish, although there decrease in fish catch due to environmental degradation. [21] state that the decrease of fish production in Merang River that located in the research location from natural forest era of 1975 to 2004 (plantation forest era) reached 70%. Damage to vegetation causes damage to the habitat of mammal...
and avifauna fauna so that its sustainability is also threatened. Based on [8,21], the total economic value of fish with the existence of plantation forest concession amounted 83.31 USD ha\(^{-1}\) yr\(^{-1}\) (decreased by 70% when compared to natural forest).

The availability of water for household and transportation purposes is assumed to be unchanged due to changes in natural forest cover to plantation forest. So the economic value of household water and transport water is considered equal to the value in TEV of natural forest. Plantation forest concessions also eliminate the value of environmental protection of natural forests.

The value of carbon from plantation forest was approximated by the biomass value per plant of A. crassicarpa [22]. Aboveground carbon values of natural forest biomass of PSF in research location is lower than plantation forest stands are suspected to occur because not all land cover in PSF is consist of trees. There are 45,040 hectares (33%) of land cover in the form of water, shrubs, shrubs, agricultural land, plantations and mining with low even zero CO\(_2\) absorption. The value of carbon of plantation forest is the sum of the economic value of aboveground and belowground biomass amounted 13,227 USD ha\(^{-1}\) yr\(^{-1}\) (Table 6).

| Description                | Carbon content (ton CO\(_2\)/ha) | Carbon value (USD ha\(^{-1}\)) |
|----------------------------|----------------------------------|-------------------------------|
| Aboveground biomass        | 2,494.93                         | 2,518                         |
| Belowground biomass        | 13,105.40                        | 10,709                        |
| **Amount**                 | **15,600.32**                    | **13,227**                    |

Source: data analyzed

The biodiversity value of plantation forest is 21 USD (about 70% of the value of natural forest biodiversity) [8,23]. The existence value is also lost due to clear-cutting of natural forests [23].

Total Economic Value of plantation forest in PSF is about 17,242.72 USD. Carbon value makes the largest contribution. Overall TEV of plantation forest in PSF is smaller when compared with TEV of natural forest (Table 7).

| Goods/services              | Economic value (USD ha\(^{-1}\) yr\(^{-1}\)) |
|-----------------------------|-----------------------------------------------|
| Timber                      | 727.63                                        |
| Fish                        | 83.31                                         |
| Water for households        | 191.77                                        |
| Water for transportation    | 618.69                                        |
| Protection of environment quality | lower                                   |
| Carbon                      | 15,600.32                                     |
| Option value                | lower                                         |
| Biodiversity                | 21.00                                         |
| Existence value             | lower                                         |
| **Amount**                  | **17,242.72**                                 |

Source: data analyzed

### 3.3. Economic assessment for sustainable forest management

The result of the Total Economic Value assessment shows that PSF as natural forest has higher economic value compared to plantation forest. Although natural forests have high benefits (reflected by their total economic value), natural forests with forest use as production forests are confronted with conversion for development of the forestry sector as well as other economic sectors such as
agricultural cultivation, plantation, mining and infrastructure development. On the other hand, there are forest areas designated as production forests with current conditions such as abandoned land. In the context of forest area management, forest area such as abandoned land will be faced with forest and land fires during the dry season and/or illegal activities.

Economic value of abandoned forest land has possibility lower than both natural forest and plantation forest. The economic value of abandoned forest land compared with natural forest and plantation forest assessed by using approach used by [6] that use combination of two approaches, that is (1) qualitative assessment using expert or user opinion and (2) quantitative assessment based on field-based biophysical outcomes, local and regional proxies. Table 8 presented the economic value of total forest area with peat swamp forest as natural forest, plantation forest and abandoned land.

Table 8. Total Economic Value of Peat Swamp Forest.

| No. | Goods/services       | Economic value (USD ha⁻¹) | Natural forest | Plantation forest | Abandoned land |
|-----|----------------------|---------------------------|----------------|------------------|---------------|
| 1.  | Wood                 | 2,909.47                  | 2,909.47       | 727.63           | lower         |
| 2.  | Fish                 | 277.70                    | 277.70         | 83.31            | lower         |
| 3.  | Water for households | 191.77                    | 191.77         | lower            |
| 4.  | Water for transportation | 618.69                  | 618.69         | lower            |
| 5.  | Protection of environment quality | 6.83                 | 6.83           | lower            |
| 6.  | Carbon               | 11,519                    | 11,519         | 15,600.32        | lower         |
| 7.  | Option value         | 0.30                      | 0.30           | lower            |
| 8.  | Biodiversity         | 30.00                     | 30.00          | 21.00            | lower         |
| 9.  | Existence value      | 0.50                      | 0.50           | lower            |
|     | **Amount**           | **15,553.92**             | **15,553.92**  | **17,242.72**    |               |

Source : data analyzed

The data in Table 2 shows that in research location, plantations forest have a relative high carbon storage compared with natural forest. Plantation forest in peat swamp area can be both sources and sinks of carbon, depending on their age, operation, and the environmental boundary conditions such as location and climate [24]. Therefore emissions trading mechanisms can be considered to be important new incentives for investments in plantations forest in the tropics. [25] give an overview of African carbon projects, which include many plantation forests indicate that cash incomes for households can be increased significantly. In one project in Mozambique, local households received a cash payment of 242 USD ha⁻¹ over seven years for carbon sequestered on their farms (planted forest). In abandoned land, the rest tree in the area are prone to being logged illegally, so the potential for timber might be lower than natural forests and plantations.

The economic value fish, water for households, water for transportation, protection of environment quality, carbon, option value, biodiversity and existence value from abandoned land lower than natural and plantation forest. Degradation of forest lead to lower economic value that derived from forest ecosystem [5,6].

Based on data analyzed, it can be stated that the plantation forest is able to provide non-wood benefits that is quite diverse although not as big as the non wood benefits provided by natural forests. These benefits are generated by the ecological functions of the plantation forest. For plantations forest located in peat swamps area, development of of plantation forest with species that more adaptive to the biophysical conditions of peat lands that are in their natural state associated with water should be considered. With the adaptive species, the plantation forests expected to provide higher benefits from both wood products and environmental services. So that, development of plantation forest with adaptive species in peat swamp area can be the part of revegetation effort in degraded abandoned peat swamp forest area. Forest areas in conditions such as abandoned land on peat land are vulnerable to
forest and land fires during the dry season and illegal activities as long as there is no attempt to manage. Planned and focused management and supervision is required to provide benefits in accordance with their potential and capabilities to reduce problems caused by unmanaged forest area.

4. Conclusion
Although plantation forest is different from natural forest in terms of their structure and function, plantation forest also can provide multiple benefits for society. Plantation forest located in peat swamp area can provide wood, fish, water, protection for environment quality, carbon, option value, biodiversity and existence value. So that plantation forest as one of revegetation effort in degraded peat swamp area also can provide multiple benefits for society.

TEV of natural peat swamp forest was estimated 15,447.81 USD ha\(^{-1}\) yr\(^{-1}\). TEV of plantation forest is lower than natural peat swamp forest, but higher than abandoned land. Development of plantation forest in the peat swamp area also potentially reduces the likelihood of forest and land fires when compared to abandoned land use of sections to divide the text of the paper is optional and left as a decision for the author. Where the author wishes to divide the paper into sections the formatting shown in table 2 should be used.

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