Tropical Wetland Journal
Journal homepage: twj.ulm.ac.id | Published by Postgraduate Program - Lambung Mangkurat University | e-ISSN: 2654-279X

Original article
DOI 10.20527/twj.v9i2.121

Economic Valuation of Pesanggrahan Forest in Malang Regency

Fresha Aflahul Ula, Fatchur Rohman*, Vivi Novianti

Biology Department, Faculty of Mathemathic and Natural Science, State University of Malang, 65145, Indonesia

*Correspondence: fatchur.rohman.fmipa@um.ac.id; Tel. +62-812-3390529

Received: December 12, 2023; Accepted: January 17, 2024; Published: February 19, 2024

ABSTRACT

Economic valuation is a method for revealing the importance of a forest based on monetary value. The economic valuation of the Pesanggrahan Forest is carried out to reveal the economic value of Direct Use Value, Indirect Use Value, Option Value, Existence Value, and Bequest Value to obtain the Total Economic Value (TEV) of the Pesanggrahan Forest area. The methods used to determine the economic value are Market Price, Replacement Method, and Contingent Valuation Method. The results show that Pesanggrahan Forest have a Total Economic Value IDR. 268,962,582,306. This total value is the value of the protected forest IDR. 145,753,885 and production forest IDR 123,209,166,421. This value describes the magnitude of the benefits of forest as an economic and ecological function in the Pesanggrahan Forest Area, Malang Regency. Protected forest have greater economic value than production forest, so it is hoped that forest conversion will not occur again, both in the Pesanggrahan Forest and other forest in Indonesia.

Keywords: Economic Valuation, Total Economic Value, Pesanggrahan Forest

1. Introduction

Forest are areas with renewable natural resources and are one of the largest providers of ecosystem services on earth (Amacher *at al*., 2014). Forest is divided into several types including protected forest and production forest which have their respective roles and functions (Nurofiq *at al*., 2020). Forest have big potential in mitigating climate change and mitigating natural disasters which are currently a popular issue in various parts of the world (Loomis *at al*., 2019). Forest have also an important role in providing economic and social benefits for society, including income from the forestry sector, reducing poverty, and increasing community welfare and can even influence the economy of country (Anggraeni *at al*., 2017). This can be seen in Indonesia's Gross Domestic Product (GDP), which is still very dependent on the forestry and agricultural sectors (Malahayati, 2018). All these forest roles are the cause of the availability of forest ecosystem services.

Ecosystem services are the benefits that the environment provides to humans through the transformation of resources into goods and services such as wood, food, clean water, oxygen, shelter, medicine, food, industry, and traditional ritual needs (Rohman *at al*., 2019). The existence of ecosystem services in forest under ideal conditions will be maximally available, while under non-ideal conditions, the availability of ecosystem services will decrease and their economic value will be low (Rohman *at al*., 2021). The availability of ecosystem services is closely related to the ecological conditions of an ecosystem (Grizzetti *at al*., 2019). The condition of deforested forest

causes a decrease in the supply of ecosystem services including water reserves, forest products in the form of wood and non-timber forest products which ultimately also has an impact on the economy of surrounding communities (Deuteronomy *at al*., 2019). A conservation approach in forest management can maintain ecosystems and their diversity, thereby also maintaining the availability of ecosystem services (Eguiguren *at al*., 2019). The availability of ecosystem services in an area can be estimated using an economic valuation approach. Studies on the economic valuation of forest ecosystem services in Indonesia show that the economic value of forest ecosystem services can reach billions to trillions of rupiah every year (Tripathi, 2015).

One of the forests that needs to be valued is Pesanggrahan Forest in Malang Regency. The vegetation condition of the Pesanggrahan Forest is currently still relatively dense, both in protected and production forest areas (Insani *at al*., 2023). However, these conditions may change due to pressure from human activities such as tourism activities, hunting and even land conversion. This kind of potential forest damage could occur due to open road access, namely the Southern Cross Route or Jalur Lintas Selatan (JLS). Opening roads acces in forest areas can lead to damage to the forest ecosystem (Kleinschroth & Healey, 2017). Economic valuation, which provides information about ecosystem services and the monetary value of an area, can be the basis for anticipating ecosystem damage such as forest conversion into other functions in the Pesanggrahan Forest. Other than that, this research will also help the authority determine losses or incentives if ecosystem damage occurs as the result of human activities using an ecological compensation approach. Ecological compensation has become an important tool to reduce ecosystem destruction because assessing an ecosystem comprehensively based on ecological benefits and functions can help strengthen legal prosecution and guarantee monetary compensation to restore natural resources (Blicharska *at al*., 2022; Phelps *at al*., 2014).

2. Materials and Methods

Study Area

The research was carried out from April to October 2023. Research data collection was carried out in the Pesanggrahan Production Forest and Protected Forest area, Malang Regency which is located at 8°23'34" S - 8°24'15" S and 112°32'58" E -112°33'42"E. The Pesanggrahan Forest Area is under the authority of Perum Perhutani. The total area of Pesanggrahan Forest is 95,286 Ha with protected forest covering 45.61 Ha and production forest 49.28 Ha (Figure 1).

This research was also carried out at the Ecology Laboratory, Department of Biology, State University of Malang. Analysis of the physical properties of the soil was carried out at the Soil Laboratory of the Department of Geography, State University of Malang and the soil organic matter analysis was carried out at the Soil Laboratory of the Indonesian Coffee and Cocoa Research Center (PUSLIT KOKA).

Materials

The materials used in this research were plastic specimens, tape, plastic bags, raffia rope, and paper labels. The tools used in this research were pencil, ballpoint, notebook, ruler, rollmeter, Global Positioning System or GPS, camera, measuring tape, knife, hammer, shovel, sprayer, soil drill, soil ring, and machete.

Methods

Determining the economic value of the Pesanggrahan Forest area is carried out based on primary data and secondary data. Primary data was obtained through interviews and direct measurements of research parameters in forest areas. Interviews were conducted using Forum Group Discussion (FGD) with respondents who are forest user communities to obtain direct use value data in the form of non-timber forest utilization, option value data, existence value and bequest value. The number of respondents was 20 people who used production forest as planting land and 1 person who lived in a production forest area. Direct measurements in forest areas were

carried out using a 20x20 m^2 plot on an area of 5 Ha to obtain direct use value in the form of wood and indirect use value.

Wood Volume and Tree Carbon

Data collection on wood volume and tree carbon was carried out by recording data on tree height and tree diameter diameter breast height (DBH), tree canopy height and wide of tree canopy. The name of each species of plant that was found was recorded. The wood density to estimating the carbon storage is obtained through a database.

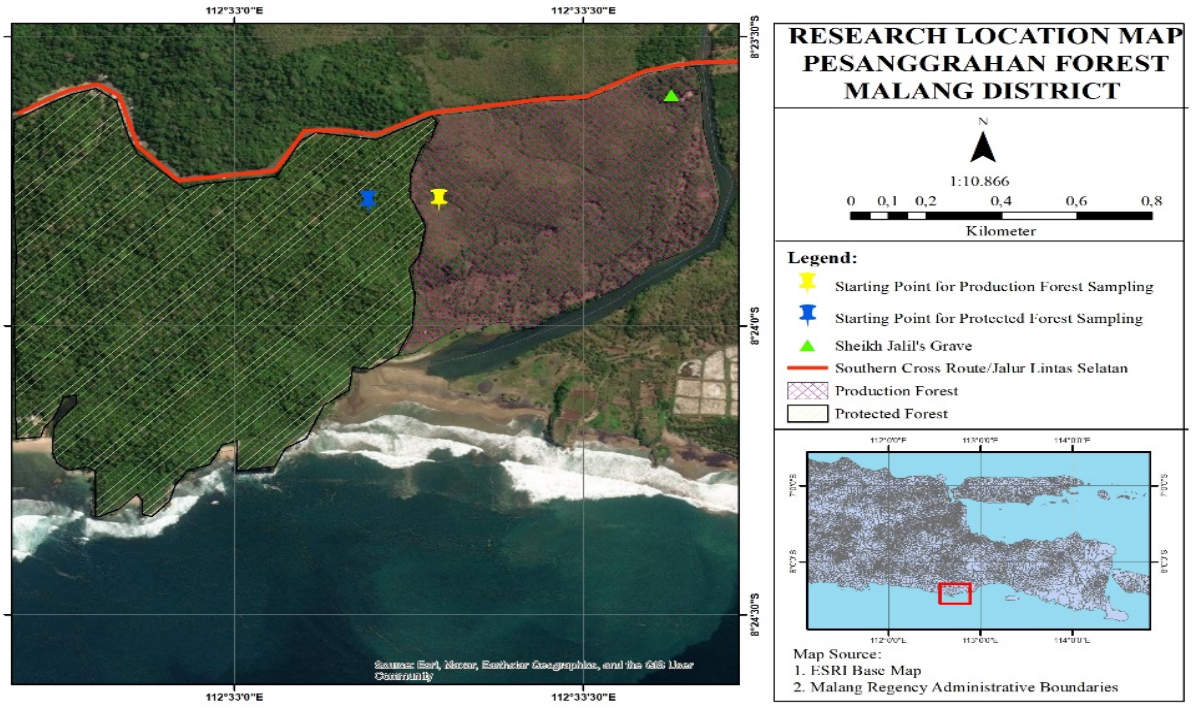
Necromass and Litter

The necromass data is in the form of wood necromass types which are divided into Snag, Log and Stump categories based on Miyamoto *at al.* (2018). Litter sampling was carried out in plots 1 x 1 m^2. The sample drying was carried out using an oven at 48°C for 48 hours. After drying, the sample was weighed to obtain the dry weight (Hairiah & Rahayu, 2007).

Soil Sample

Soil sampling to determine the soil organic matter content in the form of Nitrogen (N), Phosphorus (P), Potassium (K), and Carbon (C) was carried out by taking 500 grams of composite soil samples at a depth of 10 cm which represents top soil and sub soil (Sulistiyowati *at al.*, 2017). Sampling for soil erosion rates was carried out according to the USLE method procedure (López-García *at al.*, 2020). Soil samples, both composite soil samples and undisturbed soil samples, were taken 3 times at each point determined based on the presence of dominant plant species.

Secondary data that was used are Pesanggrahan Forest rainfall data from Meteorological, Climatological, and Geophysical Agency (BMKG), global carbon price data based on World Bank USD 6 /ton CO_2, Oxygen prices/lt, and prices of soil organic matter contained in soil (N, P, K, C) from the market. The wood price data was taken from the Ministry of Trade of the Republic of Indonesia 2023.



Figur 1. Research locations

Data analysis

Data analysis was carried out quantitatively to estimate Total Economic Value (TEV) which describes the total economic value of all ecosystem services in protected forest and production forest. The TEV value is obtained through the formula:

TEV = DUV + IUV + OV + BV + EV
Where TEV: Total Economic Value; DUV: Direct Use Value; IUV: Indirect Use Value; OV: Option Value; EV: Existence Value; BV: Bequest Value.

DUV value is obtained from the direct benefits of an ecosystem. Estimating the DUV for forest products in the form of wood can be formulated as follows:
DUV = Price x Quantity of Goods

Non-timber forest products are estimated using the same method as forest products in the form of wood, namely using the market price method(Balama *at al*., 2016).

The IUV value is calculated by adding up all IUV that consist of the value of water availability, the value of preventing erosion, the value of carbon absorption and oxygen production, the value of necromass carbon storage and the nutritional value of the soil.

Water Storage

The ecological function of water storage has a value that can be quantified using the following formula (Lin *at al*., 2021):

Vw: W x Pw

Where Vw: Water Storage Value; W: Water storage quantity (m3); Pw: Water price per cubic meter from PT. Jasa Tirta (IDR).
The quantity value of water storage in the soil can be determined using the FJ Mock method (Ishak *at al*., 2020).

Soil Erosion Control

The rate of soil erosion is calculated to determine the maximum amount of soil loss on land using the Universal Soil Loss Equation (USLE) formula which was developed by Wischmeier & Smith, (1978) as follows:

A = K x R x LS x C x P

Where A: Maximum amount of soil lost (t/ha/year); R: Rain erosivity factor; K: Soil erodibility factor; LS: Slope length and slope slope factors; C: Crop management index factor; P: Soil conservation index factor.

Determining the economic value of erosion control is carried out using the replacement method. The calculated erosion rate is used as a value to determine retained sedimentation. The retained sedimentation value is used to determine the economic value of erosion control based on the price of controlling the erosion rate (Bahruni *at al*., 2022). The price for controlling the rate of erosion obtained from Ministry of the Environment IDR. 1,225,000 per ha.

Plant Carbon Sequestration and Oxygen Production

Determination the value of plant carbon storage is carried out using the allometric formula of Chave *at al*. (2014). The canopy biomass value is estimated based on the equation, Ponce-Hernandez, (2004) while the root carbon estimation uses the biomass ratio according to Macdicken, (1997). The total carbon stock stored in the roots, stems and canopy is then multiplied by a conversion factor (0,5) which represents the average carbon content in biomass. The value of carbon dioxide (CO_2) absorption by plants is determined using the following formula:

$CO_2 = C \times 3.67$

Where C: Tree Carbon (Tons/Ha).

The economic value of CO_2 absorption is calculated using the market price method by multiplying the amount of CO_2 with the carbon price on the global carbon market. The value of oxygen supply is also calculated using the market price method by multiplying the market price of oxygen with the amount of oxygen production which is calculated using the formula (Quitain, 2021):

$$O_2 = CO2 \times 2.67$$

Carbon Storage in Plant Necromass

Determining the amount of carbon storage can be calculated by determining the volume of dead trees based on snags, logs and stumps categories based on Miyamoto *at al*. (2018). Carbon in litter can be calculated using the equation according to(Hairiah & Rahayu, 2007).

Soil Organic Matter

The results of the analysis of soil organic matter content from the laboratory are then analyzed further by multiplying the amount of each element by the market price. Determining the weight of elements to be a multiplying factor with market prices is calculated using the following formula (Sulistiyowati *at al*., 2017):

- Weight C (Mg/ha) = % Organic C x soil weight Mg/ha
- Total N weight (Mg/ha) = % total N x soil weight Mg/ha
- P weight (Mg/ha) = P2O5 ppm x soil weight Mg/ha
- K weight (Mg/ha) = (K2O me 100/gx soil weight Mg/ha) /(2*100).

Option Value, Existence Value and Bequest Value is obtained through the respondent's willingness to pay (WTP) as a form of effort to maintain forest sustainability and protect the ecosystem using the contingent valuation method (CVM). The formula used is (Sari *at al*., 2022):

$$EV = \Sigma WTP rx N$$

Where ΣWTP: Willingness to pay (IDR/year); N: Total Population.

3. Results and Discussion

Direct Use Value (DUV)

The direct use value (DUV) of the Pesanggrahan Forest can be found in the presence of forest wood and non-timber products that are used by the community. The research reveals that the DUV of the Pesanggrahan Forest is IDR. 53,129,568,234. This value is based on the market price of mixed forest wood in protected forest that consisting of 43 types of plants and based on market price of teak wood in production forest with volumes shown in Table 1. The direct use value also comes from non-timber forest products with price about Rp. 70,000,000. Non-timber forest products are the result of agricultural products that was planted in production forest areas such as sugar cane, chilies, tomatoes, corn, coconuts, bananas, and soybeans which are planted using an agroforestry model that running by as many as 20 people.

Non timber forest products (NTFPs) are basically also found in protected forest such as Manon (*Helminthostachys zeylanica)*, Gebang Fruit (*Corypha utan*), Gadung (*Discorea hispida)*, Rattan (*Calamus rattan)*, Bamboo (*Bambusa* Sp.) forest honey, mushrooms, and grasses. However, the economic value of NTFPs in protected forest have not been revealed because the people arround do not take and utilize them. Direct use value is the economic value obtained from the direct use of a resource in the ecosystem (Dewsbury *at al*., 2016). This value includes the value of consumptive use such as the use of food products, wood for fuel or construction, medicines, natural products, and animals for consumption. Apart from consumption use value, there is also non-consumptive use value such as recreational and cultural (Keske, 2022).

Table 1. Economic Value of Pesanggrahan Forest Wood

No	Forest Type	Volume (m^3)	Economic Value (IDR)
1.	Protected forest	1,686	22,809,777,712
2.	Production forest	1,517	30,249,790,522
	Total		53,059,568,234

Indirect Use Vale (IUV)

The economic value of IUV in Pesanggrahan Forest is IDR. 214,625,627,034. This value is the value of the ecological function which consists of the following functions:

Water Storage.

The results of estimating the groundwater storage capacity in the Pesanggrahan Forest are 4,347,484 m^3 /year with the economic value is IDR. 19,998,425,633/ year (Table 2). Protected forest have a larger water volume than production forest. This is because the presence of protected forest vegetation is denser and more diverse than production forest. The presence of plants can help increase soil productivity, connect soil absorption pathways, reduce soil density, improve soil structure so that the presence of plants can increase the rate of soil infiltration which causes an increase in soil water storage capacity (Chandler *at al*., 2018; Guo *at al*., 2021).

Forest have an important role in water conservation through the mechanism of water absorption, formation of rainfall or weather regulation, thereby creating rain and forming the water cycle (Boscolo *at al*., 2021). Groundwater also helps the process of absorbing soil nutrients into plants and is used by plants in the process of photosynthesis by absorbing carbon dioxide (Gavrilescu, 2021). For forest-using communities, the presence of water is important because it is a primary need for various purposes, including supporting the continuity of the agroforestry system.

Erosion Control

The Pesanggrahan Forest Area, which is divided into two types of management, protected forest and production forest, has different erosion rate values. Amount of 0.60 tons/ha for protected forest and 17.34 tons/ha for production forest. The erosion rate value can be used as a basis for determining the value of retained sedimentation. The results show that the economic value of controlling erosion in the Pesanggrahan Forest is IDR.3,355,799,399/year (Table 3).

Table 2. Economic Value of Water Storage

No.	Types of Forest Cover	Area (Ha)	Total Water Capacity (m^3)	Economic Value (Rp/Year)
1.	Protected forest	45.61	3,253,440	14,965,825,231
2.	Production forest	49.28	1,094,044	5,032,600,402
			4,347,484	19,998,425,633

Table 3. Economic Value of Erosion Control

No.	Forest Type	Land Area (Ha)	Retained sedimentation (Tons/Ha)	Economic Value (IDR)
1.	Protected forest	0.60	38.41	2,145,774,545
2.	Production forest	17.34	21.66	1,210,024,854
	Total Economic Value			3,355,799,399

The economic value of controlling erosion in protected forest is greater than production forest. This is because the erosion rate value in protected forest is smaller, and the retained sedimentation value is greater than in production forest. This value shows that the Pesanggrahan Protected Forest have erosion control function of 1,571.65 tonnes over the entire area of the protected forest or equivalent to the replacement cost *of* restoring the area about IDR. 2,145,774,545 if the area is damage.

Erosion can result in ecological and economic consequences such as depletion of the topsoil and causing a decrease in soil quality. Protected forest areas which have lower erosion rate values than production forest can be caused by the presense of vegetation that forming forest stratification (Issaka & Ashraf, 2017). Stratification of vegetation can reduce the force of rainwater which can cause erosion (Supriyono *at al*., 2021). In addition, the presence of vegetation can restrain the rate of water movement, thereby inhibiting the rate of erosion and holding the soil into retained sediment. (Chau & Chu, 2017).

Carbon Sequestration and Oxygen Production (O_2)

The results of data analysis on carbon storage by trees in Pesanggrahan Forest is 772,315 tons/year, which is the result of absorbing CO_2 about 2,834 tons/year and producing 7,547 tons of O_2. The economic value of the forest's function as a carbon absorber is IDR. 260,757,119 and as a producer of O_2 amounting to Rp.188,699,449,033 (Table 4).

Carbon storage is greater in protected forest areas than in production forest, although the difference is not very significant. The greater value of carbon absorption in protected forest is due to the presence of more diverse and dense vegetation so that the absorption of CO_2 in the atmosphere is greater and produces greater oxygen. Natural forest with a greater diversity of plants are the places to high carbon stored. If the forest have changed its function to become agricultural land or plantations, the stored carbon stock and oxygen production will decrease (Nunes *at al*., 2020).

The difference in the amount of carbon sequestration from production forest and protected forest is not very significant even though the vegetation conditions of the two forest are very different. This can be caused by differences in vegetation density between the two forests in the same area. Production forest have a denser tree density than protected forest. This difference in density has a direct impact on carbon storage because vegetation density influences the carbon sequestration capacity of a land (Poorter *et al*., 2015). However, even though the density of protected forest is lower, the carbon storage value of protected forest is still greater than that of production forest.

Necromass Carbon Storage

The results of the analysis of the necromass carbon storage of the Pesanggrahan Forest in the form of wood and litter is 5,051 / Ha or equivalent with amount of 230,039 tons in the total area. Based on this data, the economic value obtained is IDR. 21,195,591 (Table 5). This value is quite small because there were not many dead trees or wood necromass found in the Pesanggrahan Forest area.

Necromass carbon storage in protected forest is smaller than in production forest. This is because wood necromass in the form of stumps is more commonly found in Production Forest, which are leftovers from logging or harvesting teak wood. The presence of necromass is important for forest ecosystems because it functions as a source of soil organic matter (Fonsêca & Meunier, 2019). Necromass contains organic acids, cellulose, hemicellulose, and lignin which will decompose and enter the soil to become nutrients for soil organisms and plants (Maas et al., 2020; Jia et al., 2021). This shows that necromass helps in maintaining nutrient balance through nutrient cycling and keeps the ecosystem healthy. Necromass is also a habitat for many microorganisms (Pastorelli et al., 2022). Necromass such as litter also plays a role in interception of rain and slows down the rate of runoff so that it can suppress soil erosion (Li et al., 2014; Tu et al., 2023).

Table 4. Economic Value of Carbon Absorption and Oxygen Production

No.	Types of Land Cover	Total C Stored (Kg/Yr)	$_2$ Absorption (Tons/Th)	Oxygen Production (Ton/Th)	Economic Value of CO_2 Absorption (Rp/Year)	Economic Value of O_2 Production (Rp/Year)
1.	Protected forest	423,585	1,555	4,135	143,016,157	103,378,056,373
2.	Production forest	348,730	1,279	3,412	117,740,962	85,321,392,660
	Total	772,315	2,834	,7,547	260,757,119	188,699,449,033

Table 5. Economic Value of Necromass Carbon Storage

No.	Types of Land Cover	C Stored (Tons/Ha)	Total C Stored (Kg/Yr)	Economic Value (Rp)
1.	Protected forest	2,265	103,324	9,505,608
2.	Production forest	2,786	127,068	11,689,982
	Total Economic Value	5,051	230,392	21,195,591

Soil Nutrients

The results of the analysis of the economic value of soil nutrition through the availability of soil organic matter (SOM) in the form of Nitrogen (N), Phosphorus (P), Potassium (K) and Carbon (C) show a value of IDR. 3,478,307,297/year. The existence of SOM in protected forest is different from production forest (Table 6). Soil organic matter in protected forest is greater than in production forest in all elements including N, P, K, and C. Soil in forest with natural vegetation has higher nutrient elements than in teak forest (Isienyi *at al*., 2022). Monoculture forest such as teak forest can cause soil deterioration and have an impact on reducing soil nutrients (Dachung *at al*., 2019).The presence of soil nutrients is greatly influenced by the density and diversity of vegetation, rhizobiome composition and better erosion rates in protected forest areas (Monkai *at al*., 2018). Apart from that, the presence of more litter can provide more soil nutrients (Novianti & Choesin, 2014). The presence of nutrients is important in forest communities because they are one of the most important elements in supporting the life of various organisms from plants to soil organisms (Giweta, 2020).

Table 6. Economic Value of Soil Nutrients

No.	Soil Nutrients	Protected forest		Production forest	
		Weight (Kg)	Economic Value (Rp)	Weight (Kg)	Economic Value (Rp)
1	N	22,045	265,640,242	13,798	166,270,720
2	P	156,594	2,012,237,183	78,848	1,013,196,800
3	K	271	5,710,068	184	3,881,950
4	C	213,759	6,412,766	165,252	4,957,568
Total Economic Value			2,290,000,259		1,188,307,038

Option Value

The option value that was revealed in this research is IDR. 6,300,000 from protected forest and production forest. The option value of protected forest is IDR. 3,840,000 meanwhile the production forest is IDR. 2,580,000. Option value is a value that shows the potential benefits of a diverse ecosystem in the future based on the perception of people who use the forest (Díaz at al., 2015). This known option value reflects that the Pesanggrahan Forest ecosystem have long-term benefits. This benefit is a potential that can have greater value in the future, so it is important to keep the Pesanggrahan Forest sustainable.

Existence Value

The estimated result of the existence value of the Pesanggrahan Forest is IDR. 6,300,000. This value is the value of the existence value of protected forest about 3,780,000 and production forest of Rp. 2,520,000. This existence value describes people's perception of the existence of forest, regardless of

whether the forest have benefits or not. Existence value is the intrinsic value possessed by a forest ecosystem which cannot be ignored as part of the ecosystem value(Davidson, 2013).

Bequest Value

Based on the results of the analysis, the Bequest value in the pesanggrahan forest is IDR. 6,360,000 with different amounts between protected and production forest. Protected forest have a bequest value IDR. 3,840,000 while production forest have a value IDR. 2,520,000. Bequest value is a value that describes the community's desire to protect an ecosystem so that it is passed on to future generations (Oleson *at al*., 2015).

Economic values based on public perception such as *option value, existence value* and *bequest value* in the Pesanggrahan Forest are relatively small. This was influenced by the small number of people interviewed, namely 21 people consisting of 20 land users and 1 person who lived in a forest area. Apart from that, the economic factors of people who have relatively low incomes also influence of this value. Economic limitations are one of the factors that influence community perceptions and assessments of forest, resulting in the low economic value of a forest.

Total Economic Value (TEV)

The total economic value of Pesanggrahan Forest is IDR. 268,962,582,306 (Table 7). The largest value with 79.87%, was contributed by IUV in the form of forest ecological functions such as of water storage, erosion control, carbon sequestration, carbon storage, oxygen supply and soil nutrition. This value is simply the value of some of the ecosystem services that make up the TEV. Basically, there are still many ecosystem services in the Pesanggrahan Forest that have not yet been discovered, so they have the potential to have greater economic value. The Pesanggrahan Forest Area, both protected forest and production forest, has a variety of ecosystem services in the form of goods and services that can maintain the sustainability of the ecosystem itself and support community welfare. Based on the results of this research, protected forest, and production forest each make different contributions to the TEV value. Protected forest have high economic value, especially in terms of ecological functions which are reflected in the IUV value. This function makes an important contribution in providing water, protecting erosion, providing oxygen and soil nutrients, and reducing the impact of climate change through absorbing CO_2 in the atmosphere.

This reseach shows that protected forest have diverse ecological functions which contribute to the very high economic value of the forest, even higher than the *use value* which often receives attention because it is considered to have great economic value. Preserving and protecting protected forest is very important to maintain the balance and sustainability of the earth as well as supporting efforts to mitigate and handle climate change which is an important component in sustainable development goals (SDGs) no. 13. Beside supporting the achievement of SDGs 13, maintaining protected forest such as the Pesanggrahan Protected Forest also supports efforts to achieve SDGs 15 that was protecting terrestrial ecosystems (United Nations, 2022).

Table 7. Total Economic Value of Pesanggrahan Forest

No.	Value	Information	Method	Economic Value (Rp)
1	*Direct Use Value*	Wood	*Market Price*	53,059,568,234
		Non-Timber Forest Products	*Market Price*	70,000,000
2	*Inderect Use Value*	Water Storage	*Market Price*	19,998,425,633
		Erosion Control	*Replacement Method*	3,355,799,399
		Carbon Sequestration	*Market Price*	260,757,119
		Necromass	*Market Price*	21,195,591
		Oxygen Production	*Market Price*	188,699,449,033
		Soil Nutrients	*Market Price*	3,478,307,297
3	*Option Value*	Public Perception	CVM	6,420,000
4	*Existence Value*	Public Perception	CVM	6,300,000
5	*Bequest Value*	Public Perception	CVM	6,360,000
Total Economic Value				268,962,582,306

Production forest and protected forest are two types of forest whose designation is different according to Minister of Environment and Forestry Regulation No. 8 of 2021. Protected forest are designated as protected areas with utilization directions in the form of area utilization and environmental services such as water management, erosion control, flood prevention, maintenance of soil nutrients and use of non-timber forest products (NFTPs). Meanwhile, production forest besides being designated as areas for the use of environmental services, are also designated as forest areas with the main function of producing wood forest products and non-timber forest products. The main function of producing wood forest products causes production forest to adopt a monoculture forest system by reducing biodiversity which supports the ecological function of forest which have enormous economic value.

4. Conclusions

The total economic value (TEV) of Pesanggrahan Forest is IDR. 268,962,582,306. This total value comes from the economic value of protected forest IDR. 145,753,885 and production forest IDR 123,209,166,421. Protected forest have more ecosystem services with a higher TEV than production forest. Thus, preserving protected forest in the Pesanggrahan Forest area by protecting and maintaining their existence is very important to ensure that the benefits of the forest are maintained and support people's lives and the balance of the earth. It is hoped that forest conversion into other functions, including production forest, will no longer occur in the Pesanggrahan Forest or other forest in Indonesia. Existing production forest need to be managed with sustainable forest management to support production forest functions according to those that have been determined such as economic and ecological functions. It is hoped that the existence of economic value information with monetary value units in the form of prices or *price tags* that have been calculated can also be important and easy to understand information for both the public and the relevant authorities.

Acknowledgments

We would like to thank the Lembaga Penelitian dan Pengabdian Masyarakat (LPPM) State University of Malang for funding this research through the Competitive Research Grant Scheme Number 5.4.481/UN32.20.1/LT/2023.

References

Amacher, G. S., Ollikainen, M., & Uusivuori, J. (2014). Forest and ecosystem services: Outlines for new policy options. In *Forest Policy and Economics* (Vol. 47, pp. 1–3). Elsevier B.V. https://doi.org/10.1016/j.forpol.2014.07.002

Anggraeni, P., Daniels, P., & Davey, P. (2017). The contribution of natural resources on economic welfare in Indonesia. *Jurnal Perencanaan Pembangunan: The Indonesian Journal of Development Planning*, *1*(3), 210–223.

Bahruni, Haryanti, Shiddiq, Di., Ermyanyla, M., & Setiatiaji, F. (2022). *Valuasi Ekonomi Jasa Ekosistem Hutan Di Kawasan Areal Penggunaan Lain Kabupaten Ketapang, Kalimantan Barat*.

Balama, C., Augustino, S., Mwaiteleke, D., Lusambo, L. P., & Makonda, F. B. S. (2016). Economic Valuation of Nontimber Forest Products under the Changing Climate in Kilombero District, Tanzania. *International Journal of Forestry Research*, *2016*, 7893143. https://doi.org/10.1155/2016/7893143

Blicharska, M., Hedblom, M., Josefsson, J., Widenfalk, O., Ranius, T., Öckinger, E., & Widenfalk, L. A. (2022). Operationalisation of ecological compensation–Obstacles and ways forward. *Journal of Environmental Management*, *304*, 114277.

Boscolo, M., Leonardi, A., Masiero, M., Amato, G., Laghetto, G., & O'Driscoll, C. (2021). Valuing water from forest. In *A guide to forest–water management* (Vol. 185, pp. 75–106). FAO, IUFRO, USDA.

Chandler, K. R., Stevens, C. J., Binley, A., & Keith, A. M. (2018). Influence of tree species and forest land use on soil hydraulic conductivity and implications for surface runoff generation. *Geoderma*, *310*, 120–127.

Chau, N. L., & Chu, L. M. (2017). Fern cover and the importance of plant traits in reducing erosion on steep soil slopes. *Catena*, *151*, 98–106. https://doi.org/10.1016/j.catena.2016.12.016

Chave, J., Réjou-Méchain, M., Búrquez, A., Chidumayo, E., Colgan, M. S., Delitti, W. B. C., Duque, A., Eid, T., Fearnside, P. M., Goodman, R. C., Henry, M., Martínez-Yrízar, A., Mugasha, W. A., Muller-Landau, H.

C., Mencuccini, M., Nelson, B. W., Ngomanda, A., Nogueira, E. M., Ortiz-Malavassi, E., … Vieilledent, G. (2014). Improved allometric models to estimate the aboveground biomass of tropical trees. *Global Change Biology*, *20*(10), 3177–3190. https://doi.org/10.1111/gcb.12629

Dachung, G., Anjembe, B., & I. Amonum, J. (2019). CHANGES IN CHEMICAL PROPERTIES AS INFLUENCED BY TEAK, Tectona grandis PLANTATION ON A TROPICAL SOIL IN AKANGA FOREST RESERVE OF NASARAWA STATE, NIGERIA. *International Journal of Agriculture Environment and Bioresearch*, *04*(05), 16–29. https://doi.org/10.35410/ijaeb.2019.4427

Davidson, M. D. (2013). On the relation between ecosystem services, intrinsic value, existence value and economic valuation. *Ecological Economics*, *95*, 171–177. https://doi.org/10.1016/j.ecolecon.2013.09.002

Deuteronomy, K., Elijah, P., & Imasiku, N. (2019). Deforestation impact on ecosystem services in Kamfinsa sub-catchment of Kafue River Basin in Zambia. *Journal of Ecology and The Natural Environment*, *11*(4), 33–45. https://doi.org/10.5897/jene2018.0692

Dewsbury, B. M., Bhat, M., & Fourqurean, J. W. (2016). A review of seagrass economic valuations: gaps and progress in valuation approaches. *Ecosystem Services*, *18*, 68–77.

Díaz, S., Demissew, S., Carabias, J., Joly, C., Lonsdale, M., Ash, N., Larigauderie, A., Adhikari, J. R., Arico, S., Báldi, A., Bartuska, A., Baste, I. A., Bilgin, A., Brondizio, E., Chan, K. M. A., Figueroa, V. E., Duraiappah, A., Fischer, M., Hill, R., … Zlatanova, D. (2015). The IPBES Conceptual Framework - connecting nature and people. In *Current Opinion in Environmental Sustainability* (Vol. 14, pp. 1–16). Elsevier. https://doi.org/10.1016/j.cosust.2014.11.002

Dushin, A. V, & Yurak, V. V. (2019). Total Economic Value Concept: Essence, Evolution and Author's Approach. *International Scientific Conference" Far East Con"(ISCFEC 2018)*, 91–97.

Eguiguren, P., Fischer, R., & Günter, S. (2019). Degradation of ecosystem services and deforestation in landscapes with and without incentive-based forest conservation in the Ecuadorian Amazon. *Forest*, *10*(5), 442.

Fonsêca, N. C., & Meunier, I. M. J. (2019). Evaluation of the Plant Necromass Component: Methodological Approaches and Estimates in Atlantic Forest, Northeast Brazil. *Floresta e Ambiente*, *26*.

Gavrilescu, M. (2021). Water, soil, and plants interactions in a threatened environment. *Water*, *13*(19), 2746.

Giweta, M. (2020). Role of litter production and its decomposition, and factors affecting the processes in a tropical forest ecosystem: A review. In *Journal of Ecology and Environment* (Vol. 44, Issue 1). BioMed Central Ltd. https://doi.org/10.1186/s41610-020-0151-2

Grizzetti, B., Liquete, C., Pistocchi, A., Vigiak, O., Zulian, G., Bouraoui, F., De Roo, A., & Cardoso, A. C. (2019). Relationship between ecological condition and ecosystem services in European rivers, lakes and coastal waters. *Science of the Total Environment*, *671*, 452–465. https://doi.org/10.1016/j.scitotenv.2019.03.155

Guo, F.-X., Wang, Y.-P., Hou, T.-T., Zhang, L.-S., Mu, Y., & Wu, F. (2021). Variation of soil moisture and fine roots distribution adopts rainwater collection, infiltration promoting and soil anti-seepage system (RCIP-SA) in hilly apple orchard on the Loess Plateau of China. *Agricultural Water Management*, *244*, 106573.

Hairiah, K., & Rahayu, S. (2007). Pengukuran karbon tersimpan di berbagai macam penggunaan lahan. *World Agroforestry Centre. Bogor*, *77*.

Insani, N., Purwanto, P., Rochman, F., Dharmawan, A., Akhsani, F., Majid, Z., A'Rachman, F. R., Billah, E. N., Apsari, R. W., Rohmah, R. M., Sandra, E. D., Dhia, S. I., Sulistio, I., & Permata, E. S. (2023). Vegetation cover analysis for sustainable coastal forest management in Pesanggrahan, Bantur District, Malang Regency. *IOP Conference Series: Earth and Environmental Science*, *1183*(1). https://doi.org/10.1088/1755-1315/1183/1/012108

Ishak, M. G., Sutapa, I. W., Basong, A., & Dedi, A. (2020). Analysis of water availability in omu watershed. *MATEC Web of Conferences*, *331*, 04003.

Isienyi, N. C., Ihediuche, C. I., Akinyemi, G. O., Woghiren, A. I., & Oluwaponle, A. I. (2022). Comparative Study of Soil Nutrient Status at Onigambari Forest Reserve, Oyo State, Nigeria. *Journal of Applied Sciences and Environmental Management*, *25*(12), 2037–2041. https://doi.org/10.4314/jasem.v25i12.6

Issaka, S., & Ashraf, M. A. (2017). Impact of soil erosion and degradation on water quality: a review. *Geology, Ecology, and Landscapes*, *1*(1), 1–11.

Jia, T., Liang, X., Guo, T., & Chai, B. (2021). Impact of nutrients on protozoa community diversity and structure in litter of two natural grass species in a copper tailings dam, china. *Microorganisms*, *9*(11). https://doi.org/10.3390/microorganisms9112250

Keske, C. (2022). *Using mixed methods research in environmental economics: The case of conservation easements*.

Kleinschroth, F., & Healey, J. R. (2017). Impacts of logging roads on tropical forest. In *Biotropica* (Vol. 49, Issue 5, pp. 620–635). Blackwell Publishing Ltd. https://doi.org/10.1111/btp.12462

Li, X., Niu. Jianzhi, & Xie, B. (2014). The Effect of Leaf Litter Cover on Surface Runoff and Soil Erosion in Northern China. *PloS One* , *9*(9).

Lin, J.-C., Chiou, C.-R., Chan, W.-H., & Wu, M.-S. (2021). Valuation of Forest Ecosystem Services in Taiwan. *Forest*, *12*(12), 1694.

Loomis, J. J., Knaus, M., & Dziedzic, M. (2019). Integrated quantification of forest total economic value. *Land Use Policy*, *84*, 335–346.

López-García, E. M., Torres-Trejo, E., López-Reyes, L., Flores-Domínguez, Á. D., Peña-Moreno, R. D., & López-Olguín, J. F. (2020). Estimation of soil erosion using USLE and GIS in the locality of Tzicatlacoyan, Puebla, México. *Soil and Water Research*, *15*(1), 9–17. https://doi.org/10.17221/165/2018-SWR

Maas, G. C. B., Sanquetta, C. R., Marques, R., Machado, S. do A., & Sanquetta, M. N. I. (2020). Quantification of carbon in forest necromass: State of the art. *Cerne*, *26*, 98–108.

Macdicken, K. (1997). *A Guide to Monitoring Carbon Storage in Forestry and Agroforestry Projects*. Winrock Internationl Institute for Agricultural Development. https://www.researchgate.net/publication/237434580

Malahayati, M. (2018). The role of the forest-related sector to the Indonesian Economy: SAM Multiplier Analysis 1985-2008. *Open Agriculture*, *3*(1), 171–179.

Miyamoto, K., Sato, T., Arana Olivos, E. A., Clostre Orellana, G., & Rohner Stornaiuolo, C. M. (2018). Variation in tree community composition and carbon stock under natural and human disturbances in Andean forest, Peru. *Forest*, *9*(7), 390.

Monkai, J., Goldberg, S. D., Hyde, K. D., Harrison, R. D., Mortimer, P. E., & Xu, J. (2018). Natural forest maintain a greater soil microbial diversity than that in rubber plantations in Southwest China. *Agriculture, Ecosystems and Environment*, *265*, 190–197. https://doi.org/10.1016/j.agee.2018.06.009

Novianti, V., & Choesin, D. N. (2014). The relation between soil sulfate concentration and proanthocyanidin content of Selliguea feei Bory from around Ratu crater, Mount Tangkuban Perahu. *AIP Conference Proceedings*, *1589*, 373–377. https://doi.org/10.1063/1.4868821

Nurofiq, H. F., & dkk. (2020). *Status Hutan dan Kehutanan Indonesia* (S. Nurbaya, Efransjah, S. Murniningtyas, Erwinsyah, & E. K. Damayanti, Eds.). Kementerian Kehutanan dan Lingkungan Hidup.

Oleson, K. L. L., Barnes, M., Brander, L. M., Oliver, T. A., Van Beek, I., Zafindrasilivonona, B., & Van Beukering, P. (2015). Cultural bequest values for ecosystem service flows among indigenous fishers: A discrete choice experiment validated with mixed methods. *Ecological Economics*, *114*, 104–116. https://doi.org/10.1016/j.ecolecon.2015.02.028

Pastorelli, R., De Meo, I., & Lagomarsino, A. (2022). The Necrobiome of Deadwood: The Life after Death. *Ecologies*, *4*(1), 20–38. https://doi.org/10.3390/ecologies4010003

Phelps, J., Hariyanti, B., Sinaga, A. C., & Dermawan, A. (2014). Valuasi lingkungan di Indonesia. *Brief.[Indonesian]*.

Ponce-Hernandez, R. (2004). *Assessing Carbon Stocks and Modelling Win-Win Scenarios of Carbon Sequestration Through Land Use Changes*. https://www.researchgate.net/publication/242563428

Quitain, R. A. (2021). Describing The Greenhouse Gas Reduction Capacity Of Mangroves By Carbon Stock Assessment Using Allometric Data In Sukol River, Bongabong, Oriental Mindoro, Philippines. *Ioer International Multidisciplinary Research Journal*, *3*, 139–147.

Rohman, F., Lestari, S. R., Utomo, D. H., Juma, Y., Arifah, S. N., & Annisa, Y. (2019). The utilization of plant diversity by Tengger Tribe around Bromo Tengger Semeru National Park, East Java, Indonesia. *IOP Conference Series: Earth and Environmental Science*, *276*(1), 012042.

Rohman, F., Priambodo, B., & Akhsani, F. (2021). Evaluation of ecosystem services based on amphibian community of the seven water springs in Malang Indonesia. *AIP Conference Proceedings*, *2353*(1).

Sari, E. K., Mulyana, A., Antoni, M., & Adriani, D. (2022). Economic Values Of Environmental Services Of Three Forest Areas In South Ogan Komering Ulu District, South Sumatra, Indonesia. *Biodiversitas Journal of Biological Diversity*, *23*(12).

Sulistiyowati, H., Winarso, S., Macandog, D., Sotto, R., Baguinon, N., & Buot Jr, I. (2017). Ecological Value Of Soil Organic Matter (SOM) at Tropical Evergreen Aglaia-Streblus Forest of Meru Betiri National Park, East Java, Indonesia. *Journal of Tropical Soils*, *21*(3), 129–140.

Supriyono, S., Utaya, S., Taryana, D., & Handoyo, B. (2021). Spatial-Temporal Trend Analysis of Rainfall Erosivity and Erosivity Density of Tropical Area in Air Bengkulu Watershed, Indonesia. *Quaestiones Geographicae*, *40*(3), 125–142. https://doi.org/10.2478/quageo-2021-0028

Tripathi, S. S. (2015). Forest ecosystem valuation study: Indonesia. *United Nations Office for REDD Coordination in Indonesia (UNORCID), Jakarta*.

Tu, Z., Chen, S., Chen, Z., Ruan, D., Zhang, W., Han, Y., Han, L., Wang, K., Huang, Y., & Chen, J. (2023). Hydrological Properties of Soil and Litter Layers of Four Forest Types Restored in the Gully Erosion Area of Latosol in South China. *Forest*, *14*(2). https://doi.org/10.3390/f14020360

United Nations. (2022). *The Sustainable Development Goals Report*.

Wischmeier, W. H., & Smith, D. D. (1978). *Predicting rainfall erosion losses: a guide to conservation planning* (Issue 537). Department of Agriculture, Science and Education Administration.