Integrating Economic Value of Environmental Services and Carbon Stock: A Case Study from Bogani Nani Wartabone National Park

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Abstract. As a conservation area, national parks play essential roles in environmental services provision and have the potential to support the REDD+ program. This study aims to estimate appropriate incentives for national parks based on carbon units by integrating the economic value of environmental services and carbon stock provided by the lowland dry forest ecosystem in Bogani Nani Wartabone National Park (BNWNP) consisted of North Sulawesi and Gorontalo areas. Carbon stock was estimated by establishing sample plots, including five carbon pools. While the economic valuation of environmental services includes biodiversity using the market approach, ecotourism using the zonal travel cost method, and water service using simulation water regulation services method and market approach. The total ecosystem carbon stock in BNWNP is estimated at 73.67 Mton. Meanwhile, the estimation of the economic value of environmental services is about IDR 70.57 trillion. Based on these results, the appropriate carbon values are IDR 683,308 and IDR 1,304,238 per ton carbon for the lowland dry forest ecosystem in Gorontalo and North Sulawesi areas. This result indicates that given its essential environmental services, the incentive for protecting national parks may exceed the carbon value used in result-based payment scheme in REDD+ initiatives that have been implemented.

1. Introduction
The national park is a conservation area that functions for biodiversity conservation and providing environmental services. Sustainable utilization is also allowed in this area. Ecosystem services become a popular concept in natural resources management since it promotes ecosystem benefits to human life, including ecological benefits, and social and economic benefits [1]. Several studies mentioned that the quality of ecosystem services is influenced by land-use type, in which the
change may lead to the decrease in services received by beneficiaries [2,3]. Therefore, protecting the national park area is essential to maintain these benefits.

In general, ecosystem services schemes implemented in Indonesia are mainly from water services and carbon [4]. However, carbon-based environmental services utilization in national parks has not been implemented yet. Result-based payment for emission reduction in the land sector is usually only from avoided deforestation and forest degradation. Meanwhile, deforestation and degradation rate within national parks tend to be lower compared to other forest areas. It has been known that REDD+ (Reducing Emissions from Deforestation and Forest Degradation) promotes the role of conservation as a mitigation action to reduce greenhouse gas emissions. Moreover, non-carbon benefits also need to be included in program development and activities implementation associated with the REDD+ initiative [5]. This can be a recognition of the role of national parks in ecosystem and biodiversity conservation.

Considering these essential values and potential, integrating environmental services values and the amount of carbon stock based on national parks’ ecosystem type is essential. This study aims to estimate appropriate incentives for national parks in protecting natural resources and ecological functions in the climate mitigation program under the REDD+ initiative. The previous study related to this integration has been done in 4 national parks in Java and Kalimantan islands [6]. This research used Bogani Nani Wartabone national park as a case study, representing the lowland dry forest ecosystem in the Sulawesi region. The variation of study areas is essential because each national park has unique ecosystem characteristics that may influence the values of environmental services. Although the REDD+ scheme at the global level is still measured based on the current emission level compared to historical emission, the result of this study is expected to provide an alternative method to determine appropriate incentives to improve the management of national parks and support Indonesia’s emission reduction target achievement.

2. Method
Carbon stock measurement was conducted by establishing 36 permanent sample plots in lowland dry forest ecosystem in BNWNP, which consists of North Sulawesi and Gorontalo areas, including disturbed and undisturbed forests. The plots are circular with a radius of 10 m. The data collected from 5 carbon pools. Aboveground biomass was estimated using an allometric equation from Chave et al. (2005) [7], while litter, dead organic matter, and soil data were collected by taking samples in the field. These samples were further analyzed in the laboratory to estimate the dry weight and % organic content. Below-ground biomass was estimated using a root shoot ratio value of 0.37 from IPCC 2006. The biomass was converted to carbon using a carbon fraction of 0.47 [8].

The economic valuation of environmental services includes biodiversity, water service and ecotourism. Biodiversity services, which consist of flora and fauna were valued by using market approach based on wood volume and wildlife population data. The valuation of water service in Bogani Nani Wartabone National Park was conducted by calculating water debit using the Simulation Water Regulation Services (SWAT) method and calculating the economic value of water using market approach. While the assessment of ecotourism service was carried out using Travel Cost Method approach. In this study, Zonal Travel Cost Method (ZTCM) was used.

The integration of environmental services into the carbon stock was formulated as follows:

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C = \frac{\text{TEV}}{\text{Carbon Stock}} \times \frac{\text{TEV}}{\text{Carbon Stock}} \text{ (IDR/tonC)}
\]

Notes:
- \( C \) Value = Ecosystem Carbon Value (IDR/tonC)
- TEV = Total economic value of environmental services (IDR)
- Carbon Stock = Total ecosystem carbon stock (ton)
3. Results and discussion

3.1. Total ecosystem carbon stock

The highest carbon stock in the lowland dry forest ecosystem in BNWNP is in the undisturbed forest in Gorontalo, with 421.80 tons/ha. This is higher than the total carbon stock of the undisturbed ecosystem in North Sulawesi, 220.64 tons/ha. The difference is caused by the variation of tree composition and tree density in both areas. The density of vegetation diameter > 5cm in the Gorontalo area is 521 individuals/ha, while the North Sulawesi area is 450 individuals/ha. Meanwhile, in disturbed lowland dry forest ecosystems, the total carbon stock in the North Sulawesi area is 112.29 ton/ha, higher than in the Gorontalo area, which is 91.84 tons/ha (Figure 1).

![Figure 1. Carbon stock of lowland dry forest ecosystem based on 5 carbon pools.](image)

Above-ground carbon has the highest contribution compared to other carbon pools in all sites, except in disturbed areas in North Sulawesi. Above-ground carbon contributes to 65%, 53% and 50% of the total carbon stock in the undisturbed and disturbed forest in Gorontalo, and the undisturbed forest in North Sulawesi. Meanwhile, dead organic matter has the highest contribution (50%) of the total carbon stock in the disturbed area in North Sulawesi. The lowest contribution in the total carbon stock in all sites is from litter.

Total ecosystem carbon stock was calculated by multiplying C stock/ha by the total area of each ecosystem condition. Combining these values, this research estimated that the total carbon stock of the dry lowland ecosystem in BNWNP is about 73.76 Mton (Table 1).

| Location       | Ecosystem condition | Area (ha) | Total C stock (Mton) |
|----------------|---------------------|-----------|----------------------|
| Gorontalo      | Undisturbed         | 96,989.06 | 40.91                |
|                | Disturbed           | 1,758.85  | 0.16                 |
|                | Total               |           | 41.07                |
| North Sulawesi | Undisturbed         | 144,136.45| 31.08                |
|                | Disturbed           | 7,051.44  | 0.79                 |
|                | Total               |           | 32.59                |
3.2. Economic valuation of environmental services

The study results show that Bogani Nani Wartabone National Park has great potential for environmental services from biodiversity, water, and ecotourism. Flora has the highest economic value in both North Sulawesi and Gorontalo areas. Economic valuation of flora in this study is limited to tree level and not included seedling to pole levels. We used wood volume to estimate the economic value based on market survey on timber price in these areas. The second highest economic values in both areas is from water service. Potential water debit in BNWNP is around 16,800 – 18,071 m$^3$/ha/year, and it has been utilized by local communities living surrounding national park area. Fauna in Gorontalo area has much higher value, because this area has larger population of Maleo (*Macrocephalon maleo*) and Anoa (*Bubalus depressicornis*) which have high economic value. Meanwhile, ecotourism has the lowest economic value in both areas.

Economic value of all environmental services in North Sulawesi area is IDR 42.5 trillion, while in Gorontalo area is about IDR 28 trillion. The value is higher in North Sulawesi area because total lowland dry ecosystem area is around 151,187.89 ha, larger than in Gorontalo, with ecosystem area of 98,747.91 ha. In total, economic value of environmental services in lowland dry forest ecosystem in BNWNP is about IDR 70.57 trillion. The valuation of environmental services are presented in the following table (Table 2).

| Information                  | North Sulawesi Area | Gorontalo Area | Total (in million IDR) |
|------------------------------|---------------------|----------------|------------------------|
| Biodiversity Valuation       |                     |                |                        |
| Flora Valuation (in million IDR) | 42,077,562          | 27,950,102     | 70,027,664             |
| Fauna Valuation (in million IDR) | 933                | 7,046          | 7,979                  |
| Water Services Valuation     |                     |                |                        |
| Potential debit/ha/year (m$^3$) | 16,800             | 18,071.14      |                        |
| Water Volume/Year(m$^3$)     | 2,539,956,552       | 1,784,487,306.32 |                        |
| Water Valuation (in million IDR) | 431,792            | 107,069        | 528,861                |
| Ecotourism Valuation         |                     |                |                        |
| Ecotourism Value (in million IDR) | 150                | 35             | 185                    |
| Environmental Services Integration |                |                |                        |
| Biodiversity, Water and Ecotourism Services Valuation (in million IDR) | 42,510,438          | 28,064,253     |                        |
| Carbon Stock (Mton C)        | 32.59               | 41.07          |                        |
| **Total Carbon Value (IDR/ton C)** | 1,304,238         | 683,308        |                        |

Economic valuation of environmental services is a challenging measure, because it is strongly related to data availability. Field survey data and secondary data were combined to estimate the economic values of environmental services. However, more data area still required to provide better estimates, such as data on flora and fauna species other than commercial timber trees, birds and mammals that were used in this study. The use of other economic valuation methods is also possible depend on collected data variables. The economic valuation of environmental services in this study is also limited to the lowland dry forest ecosystem. Besides this ecosystem, BNWNP also has lower and upper mountain forest ecosystems. These ecosystem have different characteristics to lowland dry ecosystem. Therefore, it needs to be included to estimate the maximum value of environmental services and carbon stock in BNWNP.
3.3. Carbon value based on total economic value of environmental services

Based on carbon stock estimation and the economic valuation of environmental services, this research estimated that carbon value for lowland dry forest ecosystem in Gorontalo area is about IDR 683,308 and North Sulawesi area is about IDR 1,304,238 per ton carbon. The value is higher in the North Sulawesi area because the total lowland dry ecosystem area is around 151,187.89 ha, more significant than in Gorontalo, with an ecosystem area of 98,747.91 ha. These values are equivalent to USD 45 – 86/ton C, much higher than the price determined by the result-based payment scheme under the REDD+ initiative that has been implemented in Indonesia, which is 5 USD/ton CO$_2$ of the reduced emission [9]. This integration can be used to see the effect of the loss of one carbon unit on environmental services in conservation areas. The loss of one carbon unit is assumed to impact water supply, biodiversity, and ecotourism services and will influence the function and contribution of the national park to the surrounding environment [6].

These results also show that the involvement of national parks in the REDD+ initiative which also promotes the role of conservation can be used as an opportunity to develop an appropriate incentive system for national park management to compensate their efforts in protecting environmental services, and maintaining social and economic functions. However, this needs to be supported by government regulations. There is still policy gap in carbon-based environmental service utilization in national park areas in which national parks are likely to receive small amounts of incentives under the REDD+ due to low deforestation and degradation rate [7]. It is therefore important to promote non-carbon benefits in national parks which are represented by environmental services to be included in the REDD+ scheme.

4. Conclusion

The roles of the national park as a carbon storage and environmental services provider should be recognized. This study indicates that the incentive for protecting national parks may exceed carbon price in a result-based payment scheme in REDD+ initiatives that have been implemented. However, this value may change depending on data updates on variables used in the estimation. Further studies in other ecosystem types in BNWNP are also required to estimate the maximum potential of environmental services and carbon values in the area.

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