Evaluation of blocking area management based on ecological and socio-economic sensitivity mapping in Sermo Wildlife Sanctuary, Kulon Progo, Yogyakarta

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Abstract. Sermo Wildlife Sanctuary (SWS) is a nature reserve area located in Kulon Progo, Yogyakarta that has a unique diversity of plant and animal species. SWS was established in 2014 with a total of 184,99 ha area based on the Decree of the Ministry of Forestry No. 3112/Menhut-VII/KUH/2014. The area management in SWS is managed by a blocking system that since 2016 has not been evaluated. This study aims to evaluate the blocking area in SWS based on the current ecological and socio-economic sensitivity in SWS. We carried out Spatial Multi Criteria Analysis (SMCA) that used scores and weights to each ecological and socio-economic criterion and sub-criteria. For the ecological sensitivity, four criteria were used such as slope, land cover, canopy density, and the potential presence of protected wildlife. While for the socio-economic sensitivity, four criteria were used such as accessibility, tourism area, built facilities, and water-use infrastructure. In addition, participatory mapping was carried out to map the activities from the local communities inside the SWS. Based on the results, we propose a larger special block and rehabilitation block than before in 2016, because there was expansion in the built facilities and open area inside the SWS.

Keywords: ecological sensitivity, socio-economic sensitivity, blocking management, Sermo Wildlife Sanctuary, wildlife.

1. Introduction

Sermo Wildlife Sanctuary (SWS) is a nature reserve area located in Kulon Progo, Yogyakarta that has a unique diversity of plant and animal species. SWS was established in 2014 located in Kulon Progo, Yogyakarta with a total of 184,99 ha area based on the Decree of the Ministry of Forestry No. SK. 3112/Menhut-VII/KUH/2014. Before being appointed as a protected forest, SWS was a production forest area so that is dominantly covered by a single species (i.e., monoculture). According to the flora inventory in 2015, SWS is mainly occupied by several commercial trees, such as teak (Tectona grandis), eucalyptus (Melaleuca leucadendron), acacia (Acacia auriculiormis), pine (Pinus merkusii), and mahogany (Swietenia macrophylla). In addition, SWS is located in a mountainous topography of the Menoreh Mountains area. The ecosystem of SWS is a typical low land forest ecosystem at an altitude between 70-100 meters above sea level. To date, the forest ecosystem of SWS has supported the hydrological function of the Sermo Reservoir and becomes habitat of various flora and fauna, also becomes a limited tourism area [2].

Besides having unique biodiversity, the SWS area has a close relationship with the community from the surrounding villages. It should be mentioned that the SWS area was a production forest that was managed with intercropping systems involving local communities to plant crops in between the main tree commodity [2]. Thus, the local communities have relied on the forest resources inside the SWS such as collecting firewood, utilizing cattle-feed grass,
the garbage, and tourism [2]. In addition, several public facilities have been built inside the SWS before it was appointed as a protected area, such as roads, offices, and parking areas. The existence of socio-economic activities in the SWS area may affect the ecological condition of the area and threaten the existing biodiversity.

The management of protected area should accommodate the ecology and socio-economic conditions [12]. A blocking management area, as a main spatial planning strategy, must include the ecological sensitivity for the protection area purpose. The more sensitive the ecological aspect of an area within the SWS area, the higher the need for the area to be protected as a core blocking. Meanwhile, the socio-economic sensitivity assessment can be used to determine the importance of the SWS area in the socio-economic perspective of the community. The more sensitive the socio-economic aspects of an area within the SWS area, the higher the need for the area to be managed with community involvement as a utilization block.

However, finding a balance between ecological and socio-economical perspectives in blocking area management is not easy. Conflicts in the protected forest area management often arise because the managers only focus on the importance of ecological preservation and ignore socio-cultural aspects of the local communities around the area [13]. In addition, the interaction between the public and the forest area is a dynamic process that keeps changing in time due to many factors, e.g., regional plan. Since 2016, the blocking system in SWS has not been evaluated and possibly does not update with the current situations. For this reason, this study aims to evaluate the blocking area in SWS based on the current ecological and socio-economy sensitivity in SWS. The results of this study are expected to support the managers of SWS to take actions related to the change of ecological and socio-economic situation in SWS.

Comparing with other research that relate to this topic, there is lack of research that discuss the evaluation of blocking system management in protected area which refers to the socio-economic sensitivity. Whereas the existence of community component is very influential on the blocking system management in protected area. So, this study aims to complete discussion about the assessment for evaluating blocking system of the sensitivity in protected area that refers to the socio-economic aspects along with considering the ecological aspects.

2. Methodology

2.1. Study Area

This research is located in Sermo Wildlife Sanctuary (SWS), Kulon Progo, Yogyakarta. Geographically, SWS is located between 7°47'00” to 7°50'00” South Latitude and 110°00'00” to 110°09'30” East Longitude. Administratively, SWS is located in Hargowilis Village in Kokap sub-district and Karangsari Village in Pengasih sub-district.

2.2. Methods

2.2.1. Data Collection

Data collection was carried out by both secondary data and primary data. For the ecological aspect, the spatial data collected such as slope, land cover, canopy density, and the potential presence of protected wildlife such as barking deer (*Muntiacus muntjac*), bido-snake eagle (*Spilornis cheela*), and Javanese lathe (*Centropus nigrorufus*). Meanwhile, for the socio-economic aspect, the spatial data collected such as accessibility, tourism area, built facilities, and water use infrastructure in the SWS area. In addition, direct observations in the field were carried out to validate the resulting map [14].

The slope used in this study was generated from DEM SRTM that was acquired from the USGS website. The land cover map and the distribution of the protected wildlife were obtained from the Nature Resources Conservation Agency (BKSDA) Yogyakarta. The canopy density map was derived from the Sentinel 2A satellite imagery with the acquisition date in
2021, which was downloaded via the USGS website. Then, field work was conducted to validate the resulting canopy density map using a stratified random sampling method at 28 plot points that were randomly selected over the SWS area. We used an eyepiece tube technique that was conducted on a circular plot with a diameter of 22.6 m i.e., protocol sampling (see Figure 1) [8]. In addition, we also collected vegetation data using nested sampling (Figure 2) to determine the diversity of flora species based on differences in canopy density [10]. For the socio-economic aspects, we carried out a field survey to map the distribution of the tourism locations and conducted a participatory mapping using 2D scaled mapping technique with relevant stakeholders such as the BKSDA Yogyakarta, PDAM Tirta Binangun Kulon Progo, and the local village officials in Hargowilis and Karangsari [11].

\[\text{Figure 1. Design plot of protocol sampling}\]

\[\text{Figure 2. Design plot of nested sampling}\]

2.2.2. Data Analysis

The Spatial Multi Criteria Analysis (SMCA) was used to analyse ecological sensitivity and socio-economic sensitivity in the SWS area. This method uses a weighted score assessment based on criteria and sub-criteria [4]. For the ecological sensitivity, four criteria were used such as slope, land cover, canopy density, and the potential presence of protected wildlife. While for the socio-economic sensitivity, four criteria were used such as accessibility, tourism area, built facilities, and water use infrastructure. Table 1 and Table 2 show the weights and scores used for each criterion and sub-criteria. Ecological sensitivity has a weight of 0.6, larger than the socio-economic that is weighted of 0.4 since the SWS is a protected area so that the main purpose is to preserve ecological functions [3].

In addition to the SMCA, the resulting canopy density map has been tested the accuracy using the confusion matrix. We used the limit of 75% accuracy in order to be able to use the processed canopy density map [7]. We also carried out a vegetation analysis to observe the forest density, dominance, and frequency using the Shannon Wiener diversity index [10].

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Table 1. The weights and scores for each criterion and sub-criteria for the ecological sensitivity in Sermo Wildlife Sanctuary

| Criteria                  | Weight | Sub-criteria                        | References | Score |
|---------------------------|--------|-------------------------------------|------------|-------|
| Slope                     | 0.6    | >40% (very steep)                   |            | 3     |
|                           |        | >15% - 40% (steep)                  | [6]        | 2     |
|                           |        | 0-15% (flat to moderate slope)      |            | 1     |
|                           |        | Forest                              |            | 3     |
| Land Cover                |        | Grassland, shrub                    | [3]        | 2     |
|                           |        | Open area                           |            | 1     |
|                           | 0.6    | Dense                               |            | 3     |
|                           |        | (70-100% and 0.42 ≤ NDVI ≤ 1)       |            |       |
| Canopy Density            |        | Moderate                            | [1] and [5]| 2     |
|                           |        | (50 – <70% and 0.32 ≤ NDVI ≤ 0.42)  |            |       |
|                           |        | Sparse                              |            | 1     |
|                           |        | (<50% and -1 ≤ NDVI ≤ 0.32)         |            |       |
| Potential Presence of    |        | Available                           | [6]        | 3     |
| Protected Wildlife        |        | Unavailable                         |            | 1     |

Table 2. The weights and scores for each criterion and sub-criteria for the socio-economic sensitivity in Sermo Wildlife Sanctuary

| Criteria                  | Weight | Sub-criteria | References | Score |
|---------------------------|--------|--------------|------------|-------|
| Road Accessibility        | 0.4    | 0-25 m       | [3]        | 3     |
|                           |        | 25-50 m      |            | 2     |
|                           |        | >50 m        |            | 1     |
|                           |        | 0-25 m       |            | 3     |
| Built Facilities          |        | 25-50 m      | [3]        | 2     |
|                           |        | >50 m        |            | 1     |
|                           |        | 0-25 m       |            | 3     |
| Tourism Potential         |        | 25-50 m      | [9]        | 2     |
|                           |        | >50 m        |            | 1     |
| Water Utilization (Pipeline) |        | 0-25 m      | [3]        | 3     |
|                           |        | 25-50 m      |            | 2     |
|                           |        | >50 m        |            | 1     |
Furthermore, an assessment of sensitivity analysis of the SWS area was classified into 3 classes such as low sensitivity (i.e., with a score range 4-6), moderate sensitivity (i.e., with a score range 7-9), and high sensitivity (i.e., with a score range 10-12). Then, the proposed blocking management area was determined based on the key determination table (see Table 3) which correlated the ecological sensitivity and socio-economic sensitivity of the SWS area. Then, block evaluation was carried out by comparing the resulting blocks with the blocking system in 2016.

Table 3. A key determination to determine the blocking area management based on the ecological and socio-economic sensitivity [3]

| Criteria          | Ecological Sensitivity |
|-------------------|------------------------|
|                   | High                   | Moderate               | Low                     |
| Socio-economic    |                        |                        |                         |
| Sensitivity       | High                   | Rehabilitation         | Utilization             | Special/Religion, Culture, or History |
|                   | Moderate               | Rehabilitation         | Protection              | Special/Religion, Culture, or History |
|                   | Low                    | Protection             | Protection              | Protection                     |
3. Results and Discussion

3.1. Ecological Sensitivity Area in the Sermo Wildlife Sanctuary

Based on the SMCA, it was observed that the areas of high ecological sensitivity are widely distributed across the SWS area. This area is characterized by forest land cover, steep slopes, dense canopy density, and locations of the protected wildlife encountered in SWS. While for the areas with a moderate level of ecological sensitivity are typically a forest with medium canopy density, flat to relatively steep slopes, and less potential for encounters of protected wildlife. These high and moderate ecological sensitivity have occupied most of the SWS area, indicating the importance of the SWS area to be preserved (Figure 3). However, it was observed that the high and moderate ecological sensitivity areas are fragmented by the roads that stretch in the middle of the SWS area. This is a warning sign of a high threat to the ecological aspect in SWS.

![Ecological Sensitivity Map in the Sermo Wildlife Sanctuary](image)

**Figure 3.** Ecological sensitivity map in the Sermo Wildlife Sanctuary
3.2. Socio-economic Sensitivity Area in the Sermo Wildlife Sanctuary

Based on the SMCA, it was observed that the areas of high socio-economic sensitivity are scattered over the SWS area, with a smaller area compared to the moderate and low levels of socio-economic sensitivity (Figure 4). The areas of high socio-economic sensitivity are characterized by good accessibility of roads, building public facilities, limited tourism activities, and existing waterpipes for water infrastructure in the Sermo Reservoir. Meanwhile, the areas with a low level of socio-economic sensitivity are characterized by very little human intervention which is typically far from road access, no public facilities buildings, and covered by a dense forest.

![Socio-economic sensitivity map in the Sermo Wildlife Sanctuary](image)

**Figure 4.** Socio-economic sensitivity map in the Sermo Wildlife Sanctuary

3.3. Evaluation of the Blocking Management Area

By using the determination key, we proposed four types of management blocks in the SWS (see Table 4 and Figure 5). The blocking management areas include protection blocks, utilization blocks, rehabilitation blocks, and special blocks. The protection blocks are areas designated to preserve the biodiversity, the utilization blocks are the area designated to be commercially used as a tourism area, the rehabilitation blocks are the area designated to be rehabilitated due to the ecological importance but the conditions are threatened, the special blocks are the area which has been built for the public facilities. We proposed a larger protection blocks than the other three blocks, while the utilization block is the smallest area. Compared to the blocking system in 2016, there is an increase in the area of rehabilitation and special blocks, and at the same time a decrease in the area of protection and utilization blocks.

We proposed larger protection block since we found that the SWS area is the habitat of several protected animals such as barking deer (*Muntiacus muntjac*), bido-snake eagle (*Spilornis cheela*), and Javanese lathe (*Centropus nigrorufus*). The area designated as rehabilitation blocks is damaged areas and requires ecosystem restoration activities. This area
is typically prone to erosion on steep slopes and is mainly occupied by bare land. The utilization block has the potential to be developed as limited natural tourism, such as Quarry Parking, the area around Batu Tumpang and Puncak Bukit Gemulung, Gemulung intersection, also the gazebo area. The special block areas are the buildings belonging to the BKSDA Yogyakarta such as a guard post located at Gemulung intersection, a tourist retribution post and the Sermo Guest House owned by Government of Tourism Yogyakarta, also the Sermo reservoir monitoring unit and office owned by PDAM Tirta Binangun Kulon Progo.

Figure 5. The proposed blocking management area map based on the ecological and socio-economic sensitivity in Sermo Wildlife Sanctuary

Table 4. Comparison between the proposed blocking management area based on the sensitivity analysis and the existing blocking from 2016.

| Blocking system | 2016 Area (Ha) | Percentage (%) | 2021 Area (Ha) | Percentage (%) |
|-----------------|----------------|----------------|----------------|----------------|
| Protection      | 145.138        | 78.457         | 141.56         | 76.523         |
| Rehabilitation  | 27             | 14.595         | 29.91          | 16.168         |
| Utilization     | 7.052          | 3.812          | 6.83           | 3.692          |
| Special         | 5.8            | 3.135          | 6.69           | 3.616          |
| Total           | 184.99         | 100            | 184.99         | 100            |
4. Conclusion

The results of our study show that the Sermo Wildlife Sanctuary (SWS) has a larger area that is prioritized for protection activities than the socio-economic activities. This is due to the conditions that the SWS areas are mostly characterized by a dense forest cover where several protected animals can be found such as barking deer (Muntiacus muntjac), bido-snake eagle (Spilornis cheela), and Javanese lathe (Centropus nigrorufus). In addition, the SWS area is mostly occupied by steep topography that is prone to soil erosion. The socio-economic sensitivity areas are relatively scattered across the SWS area, but it is connected by roads that have fragmented the forest area. Finally, we proposed new blocking systems that are different from the existing blocking system in SWS that was established in 2016. We proposed increasing special and rehabilitation blocks and at the same time a decrease in the area of utilization and protection blocks. The proposed new blocking system is protection block with an area of 141.56 ha, rehabilitation block with an area of 29.91 ha, utilization block with an area of 6.83 ha, and special block with an area of 6.69 ha. However, it should be noted that this analysis is merely based on spatial analysis. A change in the blocking system should be coordinated and agreed upon with other stakeholders.

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