Formulating the Direction of Community Land Use to Support the Conservation of Javanese Gibbon (*Hylobates moloch*) Habitat at Petungkriyono, Central Java

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Abstract. - The Petungkriyono forest is one of the few remnant tropical forests on the island of Java, particularly in Central Java. This forest is known for its high conservation value due to its abundance of biodiversity, particularly the endangered Javan gibbon or Owa Jawa (*Hylobates moloch*). The Petungkriyono people, on the other hand, rely on upland agriculture and cultivation on steep slopes as a means of subsistence, which poses a threat to the Petungkriyono forest. This paper aims to formulate the direction of the community land use at the habitat of Javanese gibbon at Petungkriyono. The method used the Spatial Multi-Criteria Analysis (SMCA). SMCA was applied to create the initial model of the zoning description of sustainable land use in Petungkriyono. The SMCA analysis process includes goal setting and conceptualization, data collection, analysis, field ground checks, and Focus Group Discussions (FGD) with the community and related parties. The result showed that considering the massive changes of land use at Petungkriyono almost 70% of the area is formulated for perservation and protection to support the conservation of Javan gibbon.

1 Introduction

Petungkriyono forest, located in the district of Pekalongan, Central Java province is the remaining tropical forest at Java island, especially in Central Java [1;2; 3]. It is said to own high conservation areas including 108 tree species from 88 genus and 43 families[1]. More than 30 species of epiphyte from 7 families are staying in this forest [2]. The most important thing is that this forest is the habitat of Owa Jawa or Javan gibbon / silvery gibbon (*Hylobates moloch*), an endemic primate of Java island [3; 4]. The Javan gibbon has been protected since 1931 through Wild Animal Protection Regulation No. 266 which was strengthened by Law No. 5 of 1990 and Minister of Forestry Decree 10 June 1991 No. 301/Kpts-II/1991, however the natural population is considered decreasing. Javan gibbon has most recently been assessed for the IUCN Red List of Threatened Species and listed as endangered under criteria A4cd.

In the perspective of State Forests, Petungkriyono Forest is included in the Doro Forest Management Unit (BKPH) Section, East Pekalongan Forest Management Unit (KPH) which has an area of 5,189,507 ha, consisting of Limited Production Forest with Pine Tree Plants and Other Natural Timber Forest or forest nature

which functions as a Limited Protected Forest (HLT) for the Hydrological Protection function. The protected forest has an area of 1,931.90 ha (Decree of the Minister of Forestry Number: 359/Menhut.II/2004 dated 1 October 2004). The Petungkriyono protected forest functions as a Limited Protection Forest. The Petungkriyono protected forest is still a relatively well-maintained primary forest, with tropical rain forest vegetation types.

In the perspective of the administrative area, the area is within a certain administrative area. In this context, Petungkriyono Forest is a forest located in the administrative area of Petungkriyono District. Sixty-four percent of the Petungkriyono District area is in the form of State Forest which is currently managed by Perhutani. In fact, there are villages with very dominant forest areas such as in Curugmuncar Village where 80% of the area is forest area. Economically, the community has some dependence on the forest area in their area. Petungkriyono community utilizes the forest by cultivating grasses, harvesting coffee under forest stand, tapping pinus latex, coffee planting and vegetable planting [5]. One of the developing economic potentials in the Petungkriyono region is upland farming which is being developed in several villages [5]. If this intensive farming continues, there will be a risk of land expansion due to the growing needs of the community. In addition, the erosion and depletion of soil nutrients that will occur

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are also higher on land with steep slopes. On the other hand, there is potential for production forests in the form of *Pinus merkusii*, Sengon and Aren (*Arenga pinnata*) which are cultivated on community-owned lands. Based on the study of [6], it is possible that the Petungkriyono mixed forest has a significant potential for reducing the effects of climate change by sequestering carbon due to its carbon stocks capacity up to 1,769,390.46 Mg. Moreover, [7] conducted a study to calculate the total economic value of Petungkriyono forest and found that the entire economic value of water value, landslide prevention structures, and carbon sequestration is IDR.163.065.858.080, and the Extended Benefit Cost Ratio in Petungkriyono is 281.35%. However, based on the outcome, it is believed that the Pekalongan local administration will be highly motivated to protect the survival of the Petungkriyono forest.

The problem that needs to be answered is how to maintain the biodiversity of the Petungkriyono forest especially in conserving the Javan gibbon, but the community also has a sustainable livelihood. To obtain that vision, the community should utilize it in a sustainable way. The aim of this paper is to formulate a direction of the community land use at Petungkriyono to support the habitat of Javan gibbon. A zoning map of community sustainable land use will be made for Petungkriyono.

2 Material and Methods

Spatial Multi-Criteria Analysis (SMCA) was used to make a basic model for a zoning description of sustainable land use in Petungkriyono District. The principle of this analysis is to combine several aspects into one with predetermined weighting between aspects [8]. The principle of this analysis is to use a limited rational model to produce an output in the form of a block direction map according to its function (functional area). The SMCA analysis process includes goal setting and conceptualization, data collection, SMCA analysis, field ground checks, and Focus Group Discussions (FGD) with the community and related parties. In the initial process, the first step is determining the focus or purpose of the analysis and to look at the potential for land cover management in Petungkriyono District. At this stage, the aspects and criteria that will be used in the SMCA analysis are also determined. Aspects to be used include ecological and socio-economic-cultural aspects. These two aspects were chosen because the direction map that will be made does not only concern ecological aspects, but will also take into account the socio-economic-cultural conditions in Petungkriyono District. Each aspect is given a value or score according to the magnitude of the influence on sustainable land use models including agroforestry, intensive farming, protected zones, and others. Ecological aspects as well as socio-economic and cultural aspects are prepared using several related criteria. For ecological aspects, the criteria used include land/area conditions, the presence of water sources, topographical conditions, and

biodiversity conditions. For the socio-economic and cultural aspects, the criteria used include accessibility, housing, economy, and culture. Then, each of these criteria is implemented into one or more variables that can describe the conditions of the related criteria. The list of variables used in this activity can be seen in the Table 1. Each of these variables is deducted based on the boundaries of the Petungkriyono District. Each variable is classified with class weights one through five. The greater the weight value indicates the more important the area is to be protected. Determination of the weighting classification is carried out semi-experimentally adjusting the range of values obtained by each variable. However, for land cover and area function/status variables, the classification is based on the classification from the Ministry of Environment and Forestry. Each variable is then overlaid according to its aspect with equal weight considerations to obtain a map of aspects of ecological sensitivity and social, cultural, and cultural sensitivity. To make an indicative model of land use in Petungkriyono, the ecological sensitivity aspect is given a weight of 60%, while the social, cultural and cultural sensitivity aspect is given a weight of 40%. The weight determination is based on the assumption that ecological considerations have a larger portion in determining sustainable land use zoning. Verification and validation were carried out through ground check and focus group discussions. FGD was carried out to determine the aspirations of Petungkriyono community regarding their future land use. While ground check was carried out by stratified samplings and survey. Survey points were chosen randomly for each SMCA class namely at Tlogopakis, Tlogohendro, Yosorejo and Kayupuring. Vegetation condition, biodiversity, slopes and other ecological aspects were checked. As for survey, were conducted to give an overview of the actual socio economy and cultural condition.

Tabel 1. List of variables used for SMCA Analysis

Aspect	Criteria	Variable	Raw Data	Source
Ecology	Land condition	Land cover	Land cover and land use map 2019	MoEF
		Status/land function	Forest area map 2017	MoEF
		NDVI	Sentinel-2	European Space Agency
	Water source	Distance from river	Rupa Bumi Indonesia (RBI) map	Geospatial Information Agency, RI
	Biodiversity	Distance from important animal	Owa Jawa observation data	SwaraOwa
	Topography	Altitude	DEMNAS	Geospatial Information Agency, RI
		Slopes	DEMNAS	Geospatial Information Agency, RI

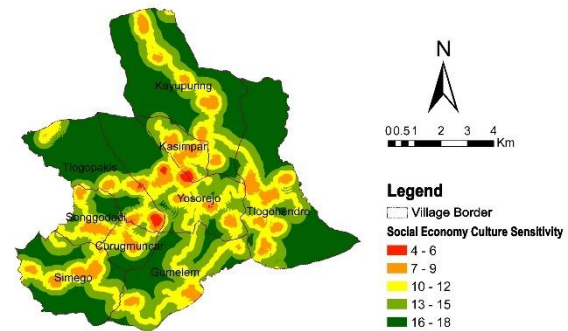|				
Social, economy and culture	Accessibility	Distant from the road	RBI map	Geospatial Information Agency, RI
	Settlements	Distance from settlements	RBI map	Geospatial Information Agency, RI
	Economy	Distance from tourist spots	Field survey 2021, Google Maps	RELUNG
	Cultural	Distance from cultural sites	Field survey 2021, Google Maps	RELUNG

Figure 2. Socio-eco-culture sensitivity map at Petungkriyono

3 Results and Discussions

The ecological variables (land cover, status/land function, NDVI, distance from river, distance from important animal/key species/ altitude and slopes) were overlayed to create an ecological sensitivity map. The aspects of ecological sensitivity map resulted in the scores of 12-32 which were then classified into 5 classes. From the ecological sensitivity, more than 50% of Petungkriyono sub district with ecological score 5 were at Kayu Puring village. Most of Owa Jawa were seen at this village. The location of Kayu Puring is very close to forest proximity. It means that there is an urgent need for further arrangements of sustainable land use at Petungkriyono.
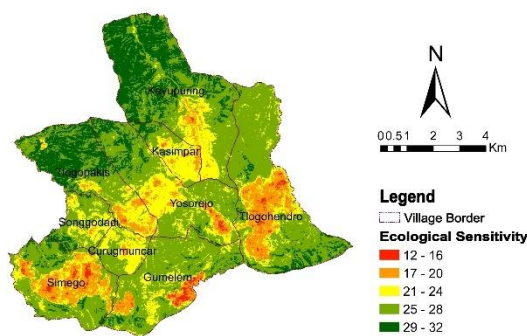

Figure 1. Ecological sensitivity map at Petungkriyono, the higher scores showed the higher urgency for protection

Four variables such as distance from the road, distance from settlements, distance from tourist spot and distance from cultural sites were overlayed to create socio-eco-culture sensitivity map. This map resulted in score 4-17 and those were classified into 5 classes. As for socio-eco-culture sensitivity, 44.1 % of Petungkriyono has score of 2 meaning that arrangement for sustainable land use is needed. The map of socio-eco-culture sensitivity of Petungkriyono is presented in Figure 2.

To create the initial model of land use zoning at Petungkriyono, we overlayed the two maps with consideration of 60% ecological sensitivity and 40% socio-eco-cultural map. Keeping the forest cover is a priority because the purpose of zoning map is to support the conservation of Owa Jawa habitat at Petungkriyono. Consequently, the focal point lies on the ecological dimension. Then, we classified 5 classes of land use including : business as usual (BAU), utilization, limited utilization, protection and preservation.

Business as usual showed vital locations for community with degraded ecological condition. In this class, people is free to utilize the land. Utilization class is directed for usage with no negative massive impact. Basically, utilization area consists of settlements, local government offices and roads. Limited utilization is directed for usage with small scale impact to environment. In this category, cultivation is authorized with certain limitations, such as soil and water conservation buildings. For example, for agriculture, it is mandatory to use terraces so that hydrological functions are maintained. Apart from that, this category is also urged to conduct planting with agroforestry method. Protection is directed for area with good vegetation cover condition. In this area, restoration and rehabilitation is needed when the vegetation is degrading. This category also emphasizes the cultivation of food trees for Javan Gibbons. If dryland farming continues to be practiced in this region, it is imperative that it be oriented towards the implementation of agroforestry planting techniques, with the ultimate goal of restoring the area to its original forested state in the future. Community are able to utilize the natural resources in this area without disturbing the biophysical and ecological function. Preservation areas were directed for limited utilization such as research, education and environmental services. From the initial indicative zoning map before groundceck, limited utilization area was the largest (36.7%) at Petungkriyono followed by protection (29.4%), utilization (24.2%) , BAU (6.5%) and preservation (3.2%).

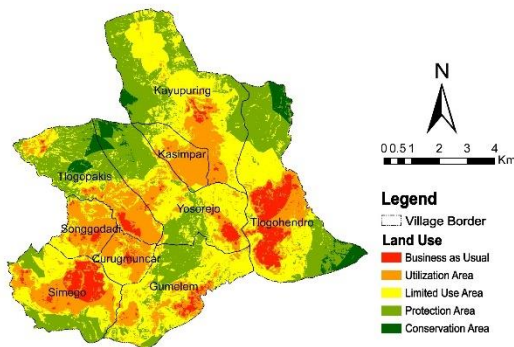The initial indicative zoning map before groundcheck is presented in Figure 3.

Figure 3. Initial indicative zoning map of Petungkriyono (before groundcheck)

After ground check and survey, it showed that agricultural expansion at the four villages were massive during 2019-2023. There were quite a lot the changes of land cover during 2019 and the actual condition. Land openings at steep slopes and high elevations are potential to cause natural disasters. In those areas, agroforestry implementation is needed. The presence of tree canopies and deep rooting systems can reduce the chances of soil erosion which is the main cause of land slides. Trees along border can be implemented for agricultural species which are not shading tolerant. Furthermore, the income from non-timber forest products is not yet guaranteed which is the main cause of the clearing of forest cover for timber and the opening of new agricultural land. In fact, there are many potential non-timber forest product commodities in Petungkriyono namely pine resin, coffee, honey, durian, cloves, cardamon, palm sugar and ginseng. Other than pine resin, coffee, honey and ginseng, other non-timber forest product commodities have not been used and managed optimally by the community. The main problem related to the use of non-timber forest products is the absence of a market chain that benefits the community. Based on the results of discussions with several communities, they got very cheap prices from collectors/middleman. Meanwhile, prices in the downstream market can be worth several times the price they sell. So that in the future it is necessary to carry out special studies related to the market chain for non-timber forest product commodities in Petungkriyono District which are sustainable and benefit the local community.

Non-timber forest products in the form of environmental services have been used and managed by the local community such as water and natural attractions. However, there are still some problems related to these two things. The first is related to water, based on the results of field surveys, several places in Petungkriyono sub district do not have a good supply of water, especially in terms of quality. We predict the amount of erosion caused by clearing of forest cover at certain points as the main cause. Thus, it is very important to replant forest areas that are not forested, land at an altitude of more than 1500 meters above sea level, as well as steep land. Regarding the management of ecotourism, it is necessary to include cultural elements as one of the attractions apart from natural attractions. The most important thing was that during the ground check, several Owa Jawa were observed in Tlogopakis and Tlogohendro villages ; meaning that the ecological dimension needs to be more focussed.

Based on the survey and FGD, it was then decided to adjust the several variables according to the actual conditions in the field. The latest SMCA models were quite different with the initial zoning (Table 2). Table 2 showed that the area of preservation class is increasing 3 higher than the initial while for BAU area is decreasing half from the initial model. Figure 4 showed the final zoning map of Petungkriyono sub district with SMCA after ground check and field survey

Tabel 2. Changes of initial and final SMCA of Petungkriyono

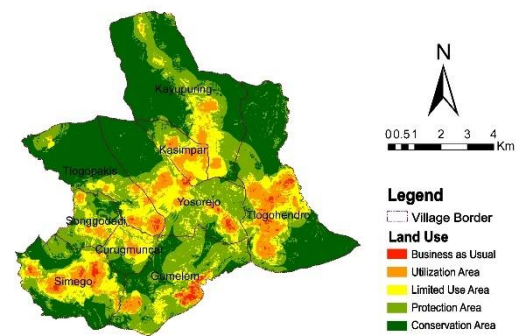| Class	Recommendation	Initial (ha)	Final (ha)
1	Business as usual (BAU)	234.87	99.40
2	Utilization	1199.14	945.43
3	Limited utilization	3242.84	1483.34
4	Protection	2811.11	2472.37
5	Preservation	910.61	3398.03

Figure 4. Final indicative zoning map of Petungkriyono with SMCA (after ground check)

Based on the study of [9], the people in the Petungkriyono area have had a very strong connection with the forest area since its historical history, long before the area was declared as a protected forest area. Indigenous people who adhere to customary rules and norms as agreements that control their daily patterns are one of two major community groups in the area. Traditional knowledge that controls how people interact with and use the environment and its resources [9] is just as important as knowledge about how to live with other

people.As a result, it does not rule out the prospect of expanding the protective area receiving support from Petungkriyono community.

The Petungkriyono regional government has also formed a multi-stakeholder forum consisting of local government, companies, community and village representatives in Petungkriyono as well as NGOs that provide assistance there [10]. This forum has agreed that the Petungkriyono forest must be protected because it is the habitat of the endangered Javan Gibbon.

4 Conclusion

The initial model for zoning is divided into five classes, namely BAU, utilization, limited use, protection, and preservation. Each class has a proportion of area sequentially, namely limited use (36.7%), protection (29.4%), utilization (24.2%), BAU (6.5%), and preservation (3.2%)). The final SMCA models is generally more conservative. The preservation class of the new model has increased by more than three times the area of the first model. Meanwhile, the Business As Usual (BAU) class experienced a decrease in area to less than half of the initial model. The final zoning map of community land use in Petungkriyono including: Business as Usual (99.40 ha), utilization (945.43 ha), limited utilization (1483.34 ha), protection (2472.37 ha) and preservation (3398.03 ha). This zoning map is expected to support the conservation of Owa Jawa habitat.

Acknowledgements

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