

## Short Communication: Sustainability of ecological dimension in peatland management in The Giam Siak Kecil Bukit Batu Landscape, Riau, Indonesia

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Manuscript received: 6 February 2022. Revision accepted: 17 March 2022.

**Abstract.** Zulkarnaini, Sujianto, Wawan. 2022. Short Communication: Sustainability of ecological dimension in peatland management in The Giam Siak Kecil Bukit Batu Landscape, Riau, Indonesia. *Biodiversitas* 23: 1822-1827. The Giam Siak Kecil-Bukit Batu (GSKBB) in Riau Province, Indonesia, is assigned as a biosphere reserve due to its importance in terms of biodiversity conservation and ecosystem services provision, particularly due to the existence of large tracts of peat swamp forest. However, GSKBB landscape is threatened by various anthropogenic activities of using peatland resources because such activities are often carried out in an exploitative and destructive manner. This study aims to analyze the sustainability of the ecological dimension in peatland management in the GSKBB landscape. Methodologically, the design of this research used a mixed approach by combining quantitative and qualitative methods to determine the sustainability of peatland management. Primary data was collected through field observations and in-depth interviews with key informants from the GSKBB Biosphere Reserve management board, local government, private companies, non-governmental organizations (NGOs), and other local stakeholders. Computer programming RAPPEAT was used to analyze the sustainability index. The results of sustainability analysis of the ecological dimension of peatland management in the GSKBB landscape obtained a sustainability index of 46.5% or classified as less sustainable (<50). This value suggests that the condition of the peatland ecosystem is under pressure viewed from the ecological aspect. This is reinforced by the results of field observations which showed that the peatland ecosystem is experiencing damage and quality degradation such as land degradation, illegal logging, and land conversion. Leverage analysis obtained two attributes that are sensitive to the sustainability index of ecological dimension, namely land use (RMS = 3.84) and land conversion (RMS = 3.11). These two attributes indicate that the condition of the peatland ecosystem is strongly influenced by plantation activities in the area.

**Keywords:** Biosphere reserve, ecological sustainability, habitat degradation, peatland management

### INTRODUCTION

Various policies have been made in the context of sustainable peatland management in Indonesia, but these policies have been ineffective in protecting peatlands from destruction. Data shows that of around 14.95 million hectares of peatland, it is estimated that 6.66 million hectares or 44.6% have been degraded (Wahyunto et al. 2013a; 2013b; 2014). Peatland degradation occurs in all regions in Indonesia that have peatland areas, including in Riau Province. Riau is a province in Sumatra Island that has the largest peatland area with 3.89 million hectares out of 6.49 million hectares of the total peatland area on the island.

Among 3.89 million hectares of peatland in Riau, it is estimated that degraded peatlands reach 2.31 million hectares or 59.54% of the total peatlands in the province (Masganti et al. 2014). About 27% of the peatland area in Riau, or equating to 45% of degraded peatlands, have been used by the community for the cultivation of plantation crops, food crops, and horticultural crops (Wahyunto and

Dariah 2013; Wahyunto et al. 2014). Of the 934,130 ha of the degraded peatlands that have not been utilized, about 585,217 ha have the potential to be developed for plantation, food and horticultural crops based on the thickness of the peat.

In Riau Province, there is a protected and preserved peatland area, namely the Giam Siak Kecil Bukit Batu Biosphere Reserve (GSKBB). This biosphere reserve encompasses two districts (Bengkalis and Siak) and one municipality (Dumai City) with two rivers flowing in the area, namely Bukit Batu and Siak Kecil. The core area of the GSKBB Biosphere Reserve is an essential habitat of biodiversity of peat swamp forest, including the Sumatran tiger (*Panthera tigris sumatrae* Lyon) as key animals (Riau KSDA Unit 2001, Riau BBKSDA 2011). Most of the core area and buffer zone of the GSKBB Biosphere Reserve are peat ecosystems with peat domes of more than 6 m deep (Azra'ie et al. 2011). This area is also one of eight peat swamp forest blocks in Riau and is considered a High Conservation Value Forest (Jarvie et al. 2003).

The GSKBB Biosphere Reserve is one of 11 biosphere reserves in Indonesia. This biosphere reserve was established in 2009 as a result of collaboration between the Indonesian Institute of Sciences (LIPI), the Ministry of Forestry through the BBKSDA Riau, the Riau Provincial Government and the private sector (i.e. PT. Sinar Mas Forestry). This area was assigned as a biosphere reserve through the *Man And Biosphere* (MAB) Program-UNESCO on 26 May 2009, and was inaugurated by the Minister of Forestry on 1 July 2009. The total area of the GSKBB Biosphere Reserve is 705,270 ha, consisting of core zone (conservation area) of 178,722 ha, buffer zone (plantation forest) of 222,426 ha, and transitional zone (cultivation area) of 304,123 ha. As a tropical peat swamp forest ecosystem, this reserve plays an important role in regulating the ecological systems of peat swamp. Each element of the sub-system in the peat swamp ecosystem interacts to form a life cycle process including biogeochemical cycles, food chains, hydrological dynamics and water quality, and habitat areas for various species of flora and fauna (Barchia 2006). Thus, the existence of peatlands and their ecosystems in the GSKBB Biosphere Reserve has a positive impact on the socio-economic conditions of local communities.

However, various anthropogenic activities have caused deforestation and degradation of the peat swamp ecosystem in GSKBB Biosphere Reserve. The clearing of peat swamp forest is done through logging, mainly illegally, to obtain forest timber because access to peat forest stands is relatively easy. Forest clearing is then followed by further degradation through the creation of canals to drain the water, burning the remaining vegetation, land encroachment and pollution of rivers and lakes (Sutikno et al. 2018). Such disturbances result in forest fires, loss of people's livelihoods and destruction flora and fauna habitat. The worst peatland fires in the GSKBB Landscape, which are included in the Peat Hydrological Unit (KHG) of the Rokan River-Siak Kecil River, Bengkalis District, occurred five years in a row, namely 2011, 2012, 2013, 2014, and 2015. According to NASA Active Fire data, half of the fire hot spots in Riau Province occur in protected areas, such as the GSKBB Biosphere Reserve, and about 38 percent of the fires in Riau Province are located on peatlands that are rich in carbon stocks and can release greenhouse gases into the atmosphere which further trigger global climate change.

The utilization of natural resources on peatland in the GSKBB Biosphere Reserve becomes a concern because it is often carried out in an exploitative and destructive manner. The activities include land conversion into agricultural, plantation and forestry land, as well as settlements that are mostly carried out by the community and companies. During 2010-2014, the area of monoculture plantations (oil palm and rubber) increased from 667.76 Ha to 1,198.73 Ha and mixed gardens also increased from 3,674.48 Ha to 6,580.02 Ha (Rushayati et al. 2014). This land conversion continues to happen today, and is suspected to be the main trigger of massive forest and land fires every year.

Peatland fires in the GSKBB Biosphere Reserve occur in the same area from year to year. The dominant factor causing the occurrence of peatland fires is the destruction of the hydrological conditions of the area (Sutikno et al. 2018). These fires occur not only on land managed by the company, but also on community plantations. Data shows that during 2012-2016 the number of fire hotspots detected was 9,215 in which 4,714 hotspots occurred on transition zones, 3,504 on buffer zones, and 999 on core zones. The irony is that hotspots do not only appear in transition and buffer zones, but also in core zones which is a protected areas.

The devastating condition of tropical peatlands in the GSKBB Biosphere Reserve should receive serious attention from various stakeholders (Qomar 2018). This is because not only humans which are threatened from the destruction of peatlands in this area, but also the entire flora and fauna. Therefore, this study aimed to analyze the sustainability of the ecological dimension in peatland management in the Giam Siak Kecil Bukit Batu Landscape.

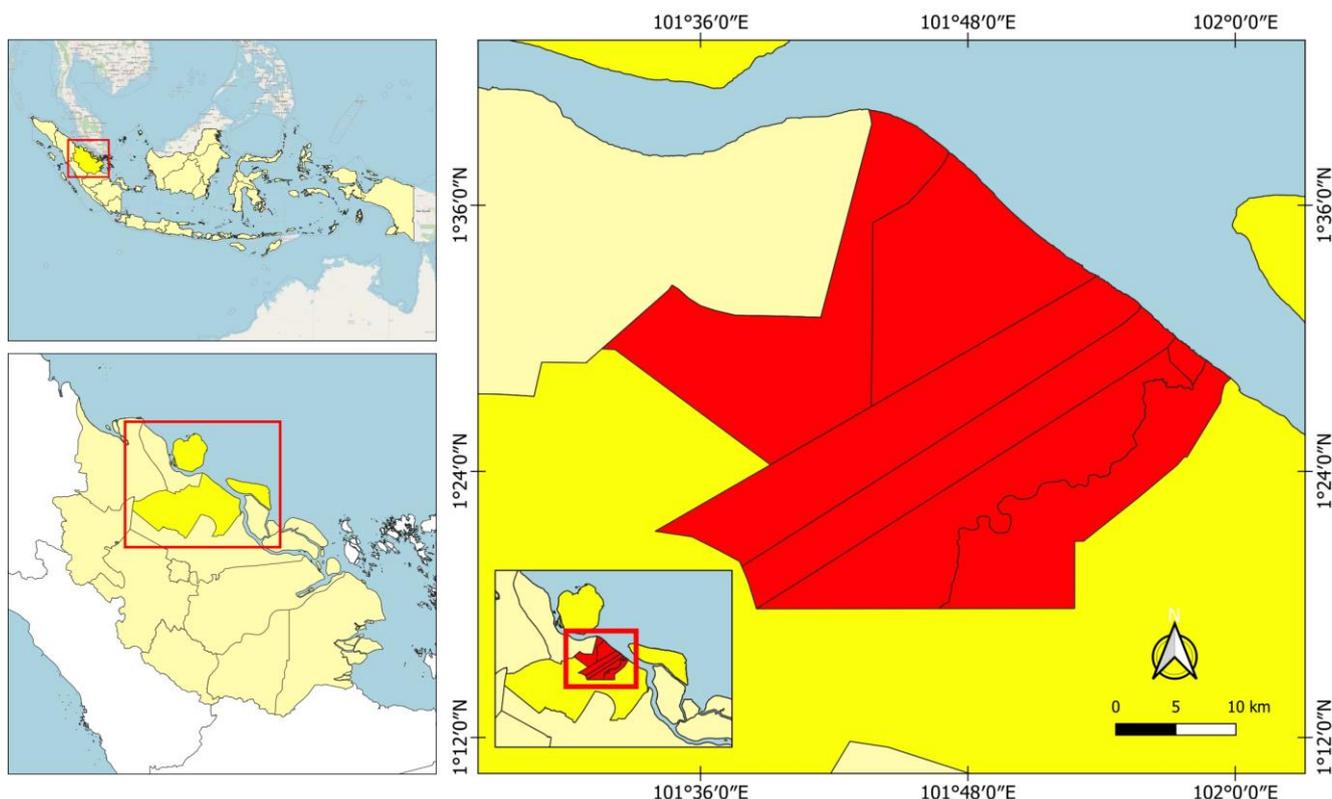
## MATERIALS AND METHODS

### Study area and period

The research location was in the Giam Siak Kecil – Bukit Batu landscape, administratively located in Bukit Batu Subdistrict, Bengkalis District, Riau Province, Indonesia between April 2020 and December 2021. Data collection was conducted in seven villages, namely Tanjung Leban Village, Tenggayun Village, Api-api Village, Temiang Village, Sepahat Village, Parit I Api-api Village, and Sukajadi Village. The selection of the seven villages by considering the characteristics of the area that has clear boundaries with all existing physical components and the similarity of local rules owned by the community and applied in the area. The map of the research area can be seen in Figure 1.

### Data collection procedure

Methodologically, the design of this research used a mixed approach by combining quantitative and qualitative methods. The initial stage of this research was carried out to take a comprehensive picture of the situation and problems, especially regarding the people living in peatlands in the GSKBB landscape, then formulated a model design based on these conditions. The main aspect to focus on was identifying or mapping community interactions with peatlands and the key elements/factors that influence them. Then this was followed by identifying the needs of local communities according to their priority scale. Primary data was collected through field observations and in-depth interviews with informants from the GSKBB Biosphere Reserve Management Coordinating Board, Local Government, Sinarmas Forestry (SMF), Non-Governmental Organizations (NGOs), and other local stakeholders.



**Figure 1.** Map of the study area in the Giam Siak Kecil Bukit Batu (GSKBB) Biosphere Reserve in Riau Province, Indonesia

### Data analysis

To determine the sustainability of peatland management, computer programming RAPPEAT was used. The aim is to obtain ecological sustainability in peatland management in the GSKBB landscape. The sustainability analysis using the Rapfish was carried out through several stages as follows: (i) Determination of sustainable attributes of peatland management which includes five dimensions, namely ecological, economic, social, institutional, and technological; (ii) Scoring each attribute on an ordinal scale based on the sustainability criteria of each dimension; (iii) Inputting the value of the assessment results of each attribute into the software; (iv) Preparation of index and sustainability status of peatland management.

The ecological aspects of sustainability consisted of five attributes, namely: (i) land conversion, (ii) land conservation, (iii) soil fertility level, (iv) land use, and (v) land use for tourism areas. Each attribute in each dimension was given a score based on the scientific judgment of the scorer. The score ranged from 0; 1; 2 or depending on the state of each attribute, which was interpreted from bad to good. The score results for each indicator were analyzed multi-dimensionally to determine sustainable levels into

three, namely good, medium and bad points. The definitive score was the mode value, which was analyzed to determine the points that reflect the position of the sustainability indicators of the management that affect sustainability with the MDS statistical ordinance technique. The estimated score for each dimension was expressed on a bad (0%) scale to good (100%). The category of the management sustainability index value for each dimension can be seen in Table 1. Through the MDS method, the position of a continuous point can be visualized through the horizontal and vertical axes.

**Table 1.** Category of sustainability in ecological aspect in peatland management

Index value	Category
0.00-25.00	Bad (unsustainable)
25.01-50.00	Less (less sustainable)
50.01-75.00	Sufficiently (sufficiently sustainable)
75.01-100.00	Good (very sustainable)

## RESULTS AND DISCUSSION

The sustainability status of the ecological dimension in peatland management policies in the GSKBB Biosphere Reserve consisted of five attributes, namely land conversion, land conservation, soil fertility level, land use and utilization of the area for tourism. The results of the ecological dimension sustainability analysis (RAPPEAT) obtained a sustainability index of 46.5% or classified as less sustainable (<50) (Figure 2). This value implies that the peatland ecosystem is under pressure viewed from the ecological aspect. This is strengthened by field observations that showed the peatland ecosystem was experiencing disturbances such as land degradation, illegal logging, and land conversion.

In addition to obtaining a sustainability index, RAPPEAT analysis also produces output in the form of leverage of attributes. Leverage analysis aims to see particular attributes that have a significant influence on the sustainability index value of the ecological dimension. Based on the leverage analysis, two attributes that are sensitive to the sustainability index value of the ecological dimension are obtained, namely land use (RMS = 3.84) and land conversion (RMS = 3.11). These two attributes suggest that the condition of the peat swamp ecosystem is strongly influenced by plantation activities. Kavanagh and Pitcher (2004) stated that the RMS value indicates the magnitude of the role of each attribute on the sensitivity of sustainability status. In other words, the higher the RMS value, the greater the influence of these attributes on sustainability sensitivity.

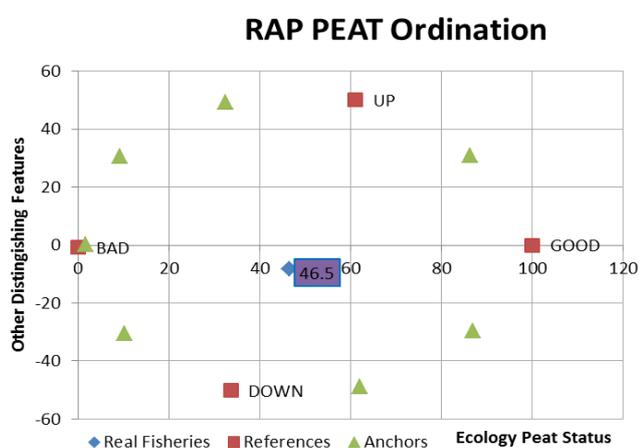
Figure 3 shows that the attributes of land use and land conversion have high sensitivity to the sustainability of the ecological dimension of peatland in the GSKBB Biosphere Reserve. This is caused by the destruction of peatlands driven by the use and conversion of land for plantation activities. The existence of peatlands in Riau Province in general and the GSKBB Landscape in particular has recently begun to become a global environmental issue (Sutikno et al. 2018). This is due to the occurrence of

various forms of degradation or destruction to peatlands which have an impact on a local scale and globally and not only in the short term, but also in the long term. Peatland degradation can be interpreted as a change in natural characteristics that reduces the ability of peatland to provide various ecological functions, such as regulating water and storing carbon (Bassi et al. 2020).

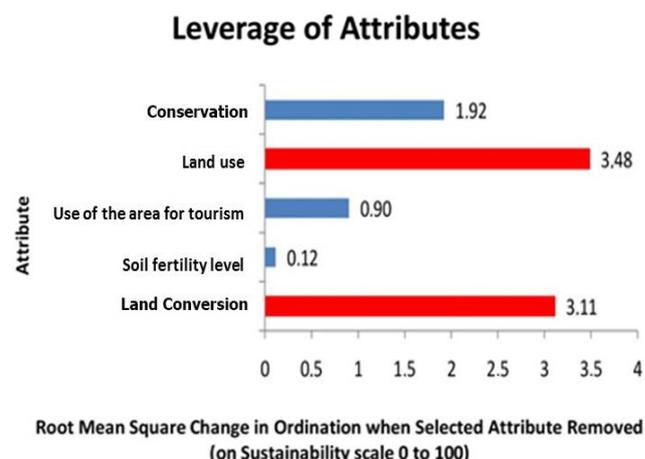
The current dynamics of peat fires are a consequence of the abundance of fuels and sources of fire (Whitefield et al. 2011). When landscape-scale forest clearing and peat drainage are combined with the widespread use of fire, the inevitable result is an increase in uncontrolled fires (Wildayana 2017). Deforested and drained peatlands are at the highest level of fire risk because the dry surface of drained peatlands is highly flammable, placing them at a significant risk level from intentional and unintentional burning.

Fire can be used as a cheap, fast and effective tool to clear large forest areas but it can also be sustained in peat swamp forest. If forest vegetation burns once, it will undergo secondary succession and return to closed forests (Yuliani et al. 2019). In reality, however, deadwood left over from the first fire will increase the likelihood of a second fire, putting the ecosystem on a path to flammable organic materials with very little chance of forest recovery and a high risk of further fires.

Although the most severe fires in recent years can be attributed to drought triggered by the El Nino climate anomaly (Page 2016), abnormal weather conditions are not a prerequisite for peat fires. In fact, fires are now a regular occurrence every dry season, despite the short dry season (Guha and Chakrabarti 2019), and are more a result of rapid land-use change than climate variability. The dynamics of these new fires mean that peat fires in Indonesia can no longer be considered occasional events. In every fire season, there are intensive environmental concerns with major implications for greenhouse gas emissions, air quality, human health, local livelihoods and regional economies (Tanneberger et al. 2020).



**Figure 2.** Sustainability index of ecological dimension of Giam Siak Kecil Bukit Batu (GSKBB) Biosphere Reserve, Riau, Indonesia



**Figure 3.** The leverage of each attribute of the ecological dimension of Giam Siak Kecil Bukit Batu (GSKBB) Biosphere Reserve expressed in RMS Value

Many actors play a role in the dynamics of fires, ranging from large plantation companies to small farmers, from policymakers at the national level to local communities in the regions (Noor 2016). However, as the remaining peat swamp forest continues to decline over the years and with the increased risk and severity of peat fires, all actors need to be involved in extinguishing efforts and, most importantly, fire prevention. Much efforts to be done to prevent these peatland fires, especially to support smallholders who often have no other method than burning to clear land for planting.

Based on the results of this study, in an effort to improve the sustainability status of the ecological dimension, it is necessary to seriously consider the sensitive attributes mentioned above. However, it is also necessary to pay attention to other attributes such as conservation activities and land use for tourism areas. Moreover, recently the village government is also been actively developing tourism activities such as peat and mangrove arboretums. The big task ahead is the need for efforts to increase public awareness of the importance of conservation functions in an area that will be able to maintain ecological and economic functions for the local community. According to Sulistyorini (2018), the education and income level have highly affected the willingness to conserve mangrove areas. Achieving this balance between ecological and economic functions makes the management of the peat ecosystem in the area optimal and sustainable.

The GSKBB Biosphere Reserve is an essential natural wealth of Riau Province and has become an international concern. Unlike other biosphere reserves in Indonesia, the uniqueness of this biosphere reserve is the number of springs which are very important to maintain the balance of water volume. As a tropical peat swamp forest ecosystem, this biosphere reserve plays an important role in delivering various ecosystem services. Each subsystem element in a peat swamp ecosystem interacts to form a life cycle process which includes biogeochemical cycles, food chains, hydrological dynamics and water quality, including habitat for various flora and fauna.

The GSKBB Biosphere Reserve has designated as a conservation area with the consideration that this area has unique characteristics. Among the peculiarities that exist in reserve are lowland rain forest and peat swamp forest with high biodiversity and become the habitats for various types of rare and endangered species and serve as supporting life systems for the living organisms including humans living in the nearby area. The eastern part of this reserve has a dome that is shallower at the edges. This dome is very important for water reservoirs (aquifers), especially during the dry season because the ability of peatlands to absorb water is highly affected by their thickness, quality and density (Haris et al. 2012).

Another uniqueness of this biosphere reserve is the vast expanse of a hydrological system that is integrated with lakes and rivers. The river in this area has black water, typical of the peat swamp ecosystem. Besides rivers, there are also several lakes, including Kemenyan Lake, Nyiur Lake, Terentang Lake, and Nine Lakes. The most common

types of flora are rasau (*Pandanus helicopus*) and daffodils (*Crinum asiaticum*) which can be found along rivers. Rasau and daffodils thrive so that they cover the river. The dense coverage of these plants makes access to the area very difficult.

In addition, in the GSKBB Biosphere Reserve live hundreds of species of animals and plants that are very valuable. Some of them are protected under CITES, IUCN and Indonesian laws. According to LIPI (2011) research, there are at least 189 plant species from 113 families and 59 genera. These species include tiger orchid (*Grammatophyllum speciosum*), Dara-dara (*Knema* sp.), Mengris (*Kompassia malaccensis*), Nepenthes (*Nepenthes* spp.), Suntain (*Palaquium leiocarpum*). There are also Meranti (*Shorea teysmanniana*), Punak (*Tetramerista glabra*), Ramin (*Gonystylus bancanus*), and Durian (*Durio carinatus*). Here also consisted 46 species of mammals, 159 species of birds, 30 species of fish, 11 species of reptiles and 162 species of moths. Some of them are Sun Bear (*Helarctos malayanus*), Tapir (*Tapirus indicus*), Sumatran Elephant (*Elephas maximus*), and Sumatran Tiger (*Panthera tigris sumatrae*). There are also highly protected species, namely the Butung hornbill (*Buceros bicornis*), Arowana fish (*Scleropages formosus*), and Estuary crocodile (*Crocodilus porosus*).

This area is also a habitat for various types of fauna such as insects, birds, reptiles, and primates. Various types of butterflies and dragonflies will accompany the tourists' journey, colorful butterflies and dragonflies will fly along the river. Types of *Graphium doson* butterflies can be found in groups on the banks of rivers, they eat the carcasses of other living things found on the banks of the river. The hornbill (*Rhyticeros corrugatus*) is an icon or prima donna of its own. Its large body size with a white beak when it is young and orange when it is an adult, plus a very distinctive and unique voice, makes this bird often a target for hunting.

The problems that are often faced in the management of The GSKBB Biosphere Reserve until now include weak socialization and unclear territorial boundaries, area encroachment, forest and land fires, illegal logging, the limited human resources for protecting the landscape, the utilization of environmental services has not been optimal, and habitat degradation. In conclusion, the condition of the GSKBB landscape has decreased in quantity and quality which will reduce its ecological and economic functions (Bappeda Riau, 2015). The lack of attention and ecosystem management activities carried out by the government and NGOs, and the excessive use of resources by companies and communities are very dangerous for the sustainability of ecosystems in supporting people's lives

## ACKNOWLEDGEMENTS

The authors would like to thank the Coordinating Board for the Management of the Giam Siak Kecil Bukit Batu Biosphere Reserve, Riau Province, Indonesia, and other related parties who have supported this research activity to be carried out properly.

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