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Spatial Multi Criteria Analysis using Ecological and Socioeconomical Aspect to Propose the Buffer Zones of Sembilang National Park (SNP) - Indonesia

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ABSTRACT

The successful determination of buffer zone played the main role in the implementation of sustainable development in the National Parks. However, the buffer zone of Sembilang National Park (SNP) in Banyuasin Regency, South Sumatera, Indonesia was not well proposed due to the complex conflict of interest and the fragmentation area. The present study aims to propose the most appropriate criteria in determining the SNP buffer zone using the overlay technique between the ecological and socio-economic aspects. The analysis was conducted using Quantum Geographical Information System (QGIS) using a limited rational model to produce an output in the form of a boundary based on the provided function. The results showed that the proposed SNP buffer zone covering an area of 175,327.2 hectares which consisted of the forest mosaics, the agricultural land, the area of the settlement, the mixed gardens, the open land, the community villages, the oil palm plantations, and the other types of land use. Based on the land ownership status, the SNP buffer zone is approximately 131,037.75 hectares where the rest area of 44,289.45 hectares was owned by the community which has a regulation to use the land. The further analysis proved that the state-owned forest is the best area as the SNP buffer zone. By combining the ecological and socioeconomic aspects, the buffer zone was determined properly without ignoring the sustainability and socio-economic aspects. As the boundary, the distinctive ecosystem (peat dome) and the small unit of land use were found to separate the buffer zone and another part of SNP.

Key words : *Sembilang National Park, Buffer zones, Analytical Network Process, Ecological – Socio-economical Aspects*

Introduction

The buffer zones are designed to protect and conserve the biodiversity, the environment, and natural resources of forest or any other protected area (McGray, 2008). In simple words, the buffer zones are a specific place which can be legally used by the communities near the protected area to support

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their life without entering the core of forest and national park which are regulated as the protected area. According to EbregtandDe Greve (2000),the buffer zone is a periphery area of a protected region managed with the aim to boost the positive impact of conservation on the surrounding communities, and conversely reduce the negative effects of any thoseactivities conducted by neighborhood. Indonesian Law Number 5 of 1967 about the conservation of natural resources and the ecosystems define the buffer zone as a specific region bordering to the reserve area. In addition, Indonesian Government Regulation Number 68 of 1998 regulated the buffer zone as an area ofprotecting the corefrom the outside and within the region. Based on the definition above, the buffer zone defined as the area which aimed to protect the core of protected region/park/forest/area from the possibility changes because of the direct impact of human activities, preventing the conflicts and providing space for seasonal movements or wildlife migration (United National Educational, Scientific, and Cultural Organization, 1974).

The buffer zones were designed to serve two purposes: the annex of core habitat areas and the social buffers, which both were used in providing goods and services to human and ecosystem (Jotikapukana *et al*., 2010). Thus, the position of buffer zone are the extension of conservation area and the integration between the conservation region and the residents (Martino, 2001). The process of determining buffer zone should consider the ecological, economic, and socio-cultural aspects of the community (Bismark and Sawitri, 2006). The size and shape of the buffer zone also depends on the specific location,the socio-economic conditions and the threats on the core area.There is no explicit definition of sustainability in the buffer zones but in fact, the buffer zone was built to maintain the sustainabily of the core of protected area (Bibby *et al.*, 2000). Furthermore, several criteria used to determine the buffer zones are such as the protected habitat including the area of their ecosystem, the area of indigenous people, ecological landscape, land cover, slope steppness and height, area conditions, and ecological landscape (Semlitsch, 1998; WWF Indonesia, 1996).

In South Sumatera, Indonesia, Sembilang National Park (SNP) is a natural conservation area, located in the wetlands area and dominated by mangrove forest, freshwater, and peat swamp forests. SNPhas the largest mangrove ecosystem inWestern Indonesia (Sarno et al., 2017), with 21 major species which were protected due to its important function in the ecosystem. The SNP is also known as the transition zone for the migration bird which move from north part of the earth to south part of the earth during the cold season. However, the area of mangrove forest area in SNP shrunk from 91,679 ha in 2003 to 83,447 ha in 2009 due ot the antrophogenic activities and the infrastructure development (Blue Ventures, 2020). In fact, the information about the buffer zone is unknown, the information about which area legally used is limited, and the process of land utilization is nonstandarized (Indica *et al*., 2011). Therefore, the determination of buffer zone must be discovered before the further development of conservation program. The available information and proper approach should be considered to provide the closest of real condition of SNP to determine the buffer zone.

The administration of SNP is managed by the Berbak-Sembilang National Park Office of the Ministry of Environment and Forestry Republic of Indonesia.The designation of SNP as a Biosphere Reserve at the 30th session, on the International Coordinating Council of Man and Biosphere Program (ICC-MAB) in Palembang, South Sumatra, 2018, confirmed the existence of the park as an important habitat for Sumatran tigers, elephants, and mangrove forests. Therefore, management concept should harmonize the need for a sustainable biodiversity-socio-economic conservation and sufficient logistical support, with the protected areas as the core zone, while the cultivation regions are the buffers.Based on the above conditions, the delineation of buffer zone has a very important function, in reducing conflict and improving the population welfare around the SNP. Therefore, the present research aims to determine the SNP buffer zone indicators, for clear delineation and acceptance by all parties.

Materials and Methods

The study was carried out in 14 villages in Banyuasin district, namely Sungsang I, Sungsang II, Sungsang III, Sungsang IV, Marga Sungsang, Tanah Pilih, Tabala Jaya, Jatisari, Majuria, Karang Sari, Mekar Sari, Sri Agung and SumberRejeki, Purwodadi, and 4 villages in Musi Banyuasindistrict, namely Perumpung Raya, Karang Makmur, Karang Agung and Muara Medak. The detail mapping of studylocations is

presented in Figure 1.

To determine the buffer zone of Sembilang National Park, the ecological and socio-economical approaches were used. The ecological aspects consist of biodiversity using land cover approach, ecosystem types, primary forest vegetations, and the existence of protected species. The socio-economic aspects consist of the population characteristics (area, community groups, livelihoods, education level, business diversification) and land use.

To support the mapping and data of this research, several tools such as the materials used as the basis for ecological data collection are Global Positioning System (GPS), Drone, land cover maps from the Ministry of Environment and Forestry Republic Indonesia in 2020, peat maps from the Peat Restoration Agency Republic Indonesia in 2020 and the administrative maps of Banyuasin districts and Musi Banyuasin districts were used. The primary data collection was carried out in January - June 2020 using purposive sampling method by making 10 x 10 m plots for mangrove forests. In swamp forest and peatlands, the plots were measured with a size of 20 m x 20 m (400 m^2) to identify the tree phases, 2 m x 2 m (4 m^2) for the seedling phase, 5 m x 5 m (25 m^2) for the sapling phase, and 10 mx 10 m for the pole phase.The primary data on socioeconomic aspects were obtained through the interviews and distributing questionnaires to the community in all 18 villages with total of 235 respondents participated and randomly selected.

After obtaining the primary data, the analysis method used in delineating the SNP buffer zone was the overlay technique using a limited rational model to produce an output in the form of a boundary. The data obtained in the field observation were processed and analyzed using the Quantum-Geographical Information System (QGIS). Several previous studies have shown that there are no truly suitable criteria for all buffer zones (Abdullah, *et al.*, 2013; Borgström *et al.*, 2012; Defries, 2007; Martino, 2001), therefore, this present research could contribute the criteria for proposing the buffer zone.

Results

The Determination of Buffer Zone of Sembilang National Park (SNP) Based on Ecological Aspects

Buffer zone based on biodiversity using land cover approach

Biodiversity of SNP become the first parameter to determine the buffer zones because the biodiversity is the important aspect to be well maintained in the SNP (Sala 2000; Jetz *et al.*, 2007; Rittenhouse, 2012). However, the biodiversity becomes the most threatned aspect affected by the change of land use in the SNP (Seki *et al.*, 2017). The determination of

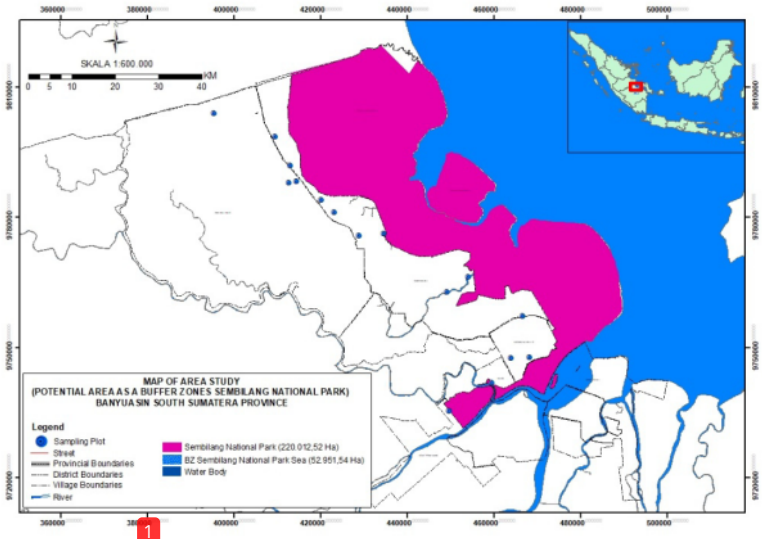

Fig. 1. The map of studied area in Sembilang National Park, South Sumatera-Indonesia. The blue dots represent the location of studied area

biodiversity was conducted by analyzing the land cover condition in the SNP in recent years compared to the land cover reported in 2010 (10 years ago). The details of land conver in 2010 and 2020 was presented in Figure 2.

In the period of 10 years,the land cover of SNP changes significantly where the primary swamp forest area and mangrove area become the most massive land change. The primary swamp forest losses 145,224.02 ha in 2010 to 10,249.03 ha in 2020 or losing approximately 92.94% of the land cover in the period of last 10 years. The mangrove area decreased from 101,569.65 ha in 2010 to 75,440.53 ha in 2020 or losing approximately 25.72% in last 10 years. The main convertion was made by the increase of residences area and monoculture plantation. The size of residences area increased six times larger in last 10 years from738.73 ha in 2010 to 4,574.36 ha in 2020. On the other hand, the monoculture plantations of acacia plant and paddy field have increased from 13,691.28 ha in 2010 to 65,016.01 ha in 2020 for acacia plantation, and 18,831.36 ha in 2010 to 28,599.52 ha in 2020 for paddy field.

The field observations were conducted to see which vegetation was mostly reduced in number during last 10 years. In the mangrove forest, the dominant logged vegetations were *Avicennia sp*, *Rhizophora sp*, *Bruguierasp*, *Sonneratiasp*, *Xylocarpus sp*, *Ceriops tagal* and *Nypa fruticans*. In the primary swamp forest, the diversity of vegetation was relatively high where most of the native vegetation such as Jelutung Rawa (*Dyera* sp.), Ramin (*Gonystylus* sp), Kempas (*Kompassiamalaccensis*), Punak (*Tetramerista* sp.), Perepat (*Combretocarpus* sp,) Pulai Rawa (*Alstonia pneumatophore*), Terentang (*Campnosperms* sp.)., Bungur (*Lagerstroemia speciosa*), Nyatoh (*Palaquium* spp.), Meranti Rawa (*Shoreapaucifilora*), Meranti (*Shorea* sp.), Balam (*Palaquiumburckii*) and Rengas (*Melanorrhoeawalichii*) still exsist during the massive land change in the last 10 years

The major change of land use was the planting of monoculture plantation and this fact made the diversity was low. The *Acacia mangium*, oil palm (*Elaeis sp.*) and paddy rice (*Oryza sativa*) become the dominant change of land use replacing the mangrove and other native vegetations. Figure 4 showed the monoculture plantation of Acacia, Oil Palm and

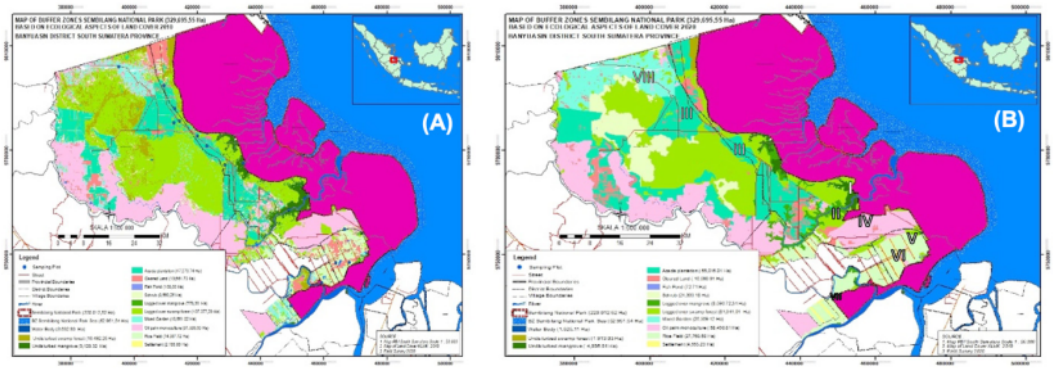

Fig. 2. The land covers of SNP observed in 2010 (a) and 2020 (b). The major change was in the area marked with roman number. The field observations were presented in Figure 3-5

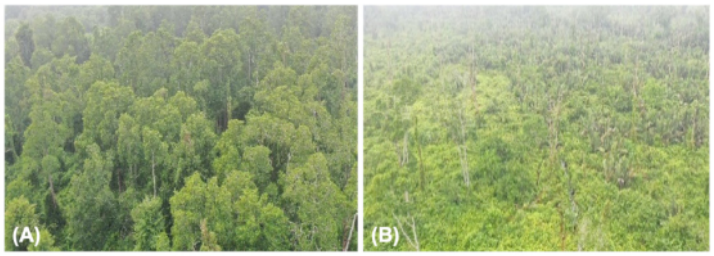

Fig. 3. Mangrove Forest (A)and Logged over Mangrove (B)in SNP Buffer Zones. The detail location of the observed area was shown in Figure 2 (B) marked as I and II.

Rice Field found during the field observation.

In the seattlement area, some open area had a higher diversity compared to the monoculture plantation. The communities planted some essential vegetations which can be consumed and had high price in the market such as Coconut tree (*Cocos nucifera*), Palm Oil (*Elaeissp*), Pinang (*Arecacatechu*), Kapuk Randu (*Ceiba pentandra*), Sengon, (*Albiziasp*), Jambu Air (*Syzygiumaqueum*), Nangka (*Artocarpus heterophyllus*), Rambutan (*Nephelium sp*), Manggos (*Mangifera indica*) and Sukun (*Artocarpus altilis*). Figure 5 showed the multiculture of plantation which planted by the local communities in several villages near SNP.

Buffer zone based on typical ecosystems

Figure 6 showed the characteristics of typical ecosystem in the SNP. The peat area is found as the dominant typical ecosystems which formed by a geographical process caused by deposition and transportation phase. (Sukarman, 2015). As the downstream area, Sembilang National Park is the estuary habitat where there were 70 large rivers and small rivers reported flowing through Sembilang National Park (The Office of Berbak Sembilang National Park, 2020). The largest river in the core of park wasAir Sembilang river which has a length of about 70 kilometer and the longest river passed the national park is Air Lalan river which had 186 kilometers long. However, the river was not fully located in the SNP where some river only ended in SNP before entering to the ocean. Several rivers channel watered from the rainfed freshwater swamps and peat swamp forests far inland in a pinnate pattern to the coastal areas of the national park. The rivers contribute to the formation of estuarine habitats includes Benu river, Terusanluar river, Terusandalam river, Tiram river, Peldes river, Deling kecil river, Deling Besar river, Buayabesar river, Buayakecil river, Ngirawan river, Simpang Hajimani river, Bakorendo river, Siapokecil river, Siapobesar river, Distributors Simpang river, Simpangalangan river, Agas river, Benawang river, Bogem river, Sembilang river, Simpangsatu river, Tanjung tutu river, Batang river, Tenggorak river, Dinding river, Solok buntu river, Snail river, Barong besar river, Barong kecil river, Apung river, Bungin river, Calik river and Banyuasin river (South Sumatera Natural Resources Conservation Center, 2020). The blue line in Figure 6 represents the position of river located in Sembilang national park.

As the wetland area, SNP had several Peat Hydrological Unit (PHU) as the water trap which included to the part area of SNP or having a direct affect to the hydrology of SNP. The PHU Air Ngirawan - Air Sembilang was the largest PHU in the part of SNP which had approximately 56,145.80 Ha followed by PHU Air Hitam Laut - Air Buntu Kecil (41,537.96 Ha) and PHU Air Sembilang - Air Bungin (21,801.45 Ha). Two neighborhood PHU was

Fig. 4. Acacia Plantation (A), Oil Palm Plantation (B) and Rice Fields (C) cultivated in SNP. The detail location was shown in Figure 2 (B) marked as III, IV, and V.

Fig. 5. The high diversity of vegetation found in the seattlement area of Jatisari Village (A), Purwodadi Village (B) and Medak Village (C). The detail location of this observed area was shown in Figure 2 (B) marked as VI, VII and VIII.

Air Lalan - Air Sembilang (16,306.36 ha) and PHU Air Merang - Air Ngirawan (60,165.28 ha) which were not part of SNP, but they provided an effect to the hydrology of SNP. The largest PHU located near SNP was PHU Air Lalan - Air Merang (63,415.18 Ha), but it did not provide any significant effect to the SNP. The detail location of PHU was shown in Figure 6.

The management of PHU was important since the peatlands tend to burn easily especially in dry season because the peat contained the high organic matter which was imflammable. The high organic matter made the properties of peat were irreversible dryness, high porosity, and low vertical hydraulic conductivity which make the peat was hard to be wet after it get dried. Furthermore the incidenct of peat fire in PHU gave the direct impact to the environment, ecology, and socio-economical aspects of SNP. With the characteristics of the peat, the buffer zones management with peat is a mandatory since the peat dome is a unit of hydrology. Therefore, managing peat in one hydrological unit is important in maintaining moisture of peat which further used to prevent the fire on the peat land and save the ecology of SNP.

Buffer zone based on the existence of primary forest

Figure 7 showed that the primary forest in the border of SNP was relatively small where only 20,224.4 ha of primary forest existed. The swamp forest and small vegetation can be only found as the potential buffer zone along the SNP border which potentially separate the SNP with the industrial plantation and community land (Figure 8A). However, the separation forest can be only found aroung the upper Sembilang river, whereas on the Purwodadi village, there are no swamp forests or mangrove forests due to the massive fragmentation land developed by private sectors or communities (Figure 8B).

The dominant cause of degradation in protected areas was because of massive human population growth and intensifying land use around protected areas (Brashares *et al.*, 2001, DeFries *et al.*, 2004, Hansen *et al.*, 2011). Those are the impact on transmigration of communities from the city and the impact of infrastructure development. Thus, the existence of primary forest outside the area of SNP is important to design the buffer zone based on the presence of primary forest. The small amount of vegetation as the buffer zone separated the SNP and communities land potentially become degrade the SNP and initiate the conflict. It was getting worst since the alternative road was developed in the area of SNP which should be protected. The presence of road has provided a significant transformation where some parts of SNP have been converted to community agricultural land with a tidal irrigation network.

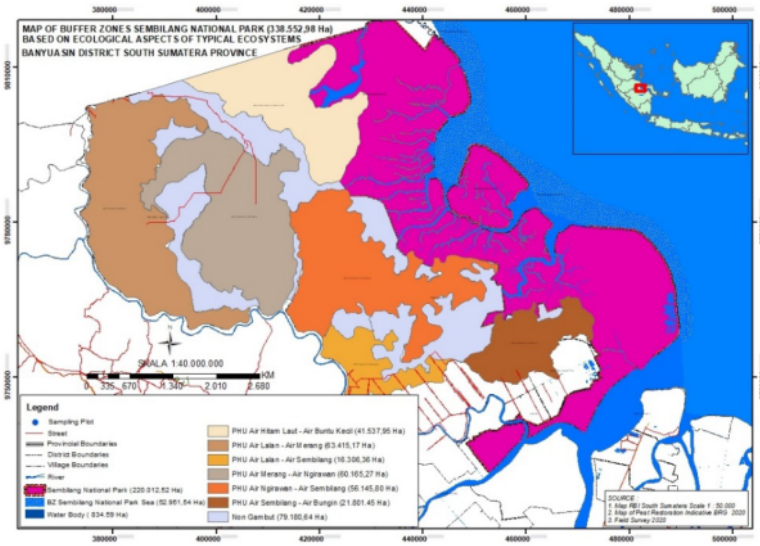

Fig. 6. The typical ecosystem of SNP dominated by peat and indicated by Peat Hydrological Unit.

Buffer zone based on the existence of protected species

The other approach to determine the buffer zone of the Sembilang National Park (SNP) was using the tracking of some protected species. As mention before, the aims of buffer zone were to create the boundary between the protected area and the community land which most activities happened. By tracking the existence of protected species, the buffer zone would meet the minimum criteria to separate the community with the native species which should be well maintained to meet the sustainability (Shafer, 1999; Thiolay, 2007). In addition, the buffer zones served the dual purpose of expanding the area of core habitat, and 'socio buffers' to provide goods and services to humans (MacKinnon *et al.*, 1986) including the SNP is one of the conservation areas which is the habitat of Sumatran tigers (*Panthera tigris Sumatrae*) and Elephants (*Elephas maximussumatranus* Temminck). Therefore, knowing the existence of protected animals is important. Based on the results of field observations and interviews with the community, the existence of important animals outside the SNP was presented in Figure 9.

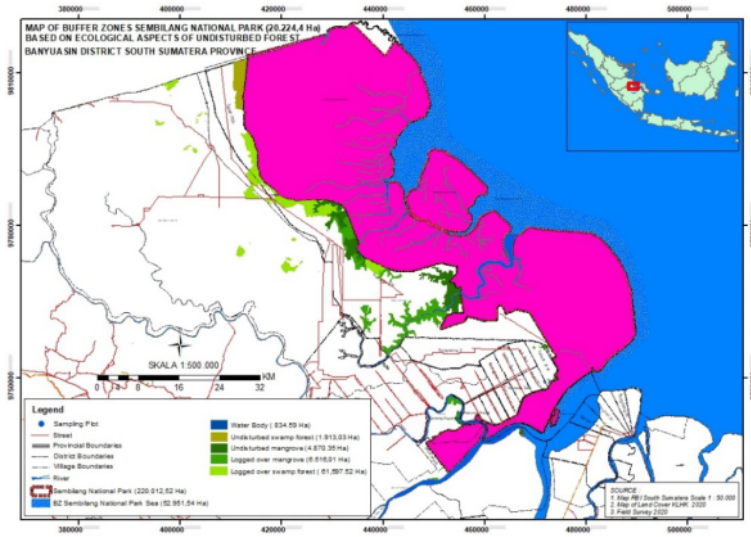

Fig. 7. The existence of the primary forest as the potential buffer zone between the community land and Sembilang National Park (SNP)

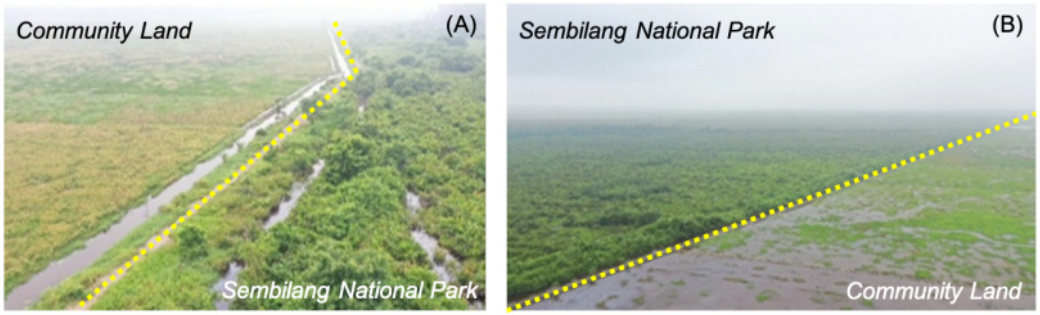

Fig. 8. The vegetation separated the community land and Sembilang National Park. Yellow line as the embankment boundary of SNP. (A) Small amount of land cover of vegetation; (B) No vegetation separated the SNP and community land

The fieldobservation found many traces of protected animals such as Sumatran tiger, sun bears, and elephant. The tiger tracks were often found at the border area of Sembilang National Park and the production forest of PT. Tripupajaya and PT. Sumber Hijau Permai Companies. Figure 10 presented that the most distant Sumatran tigers tracks were found at about 12.5 km from the outer edge of SNP where specifically located around Pancoran Hamlet village and Muara Medak Village confirmed by the found of footprint (Figure 10A). In the recent years, the elephanthas been also detected in the outside of SNP area within a radius of 5 km from the outer edge of SNP near the private company of PT Tripupajaya and the Perumpung Raya Karang Agung Ilir village (Figure 10B). The private company of Raja Palma which have a concession area near SNP reported that the elephant was suspected crossing the area of production plantation and it was more intense in last six months. The presence of wild species in the community area potentially endangered both community and the species since the animal could attack the society in the village, and the community would start to do defensive by hunting the animal which entered the community area. The conflict between the wildlife animal and local community have happened in Karang Agung Ilir and Lalan sub-district which initiated by the destruction of community corps. Moreover, there was a local community was died because of attacked by

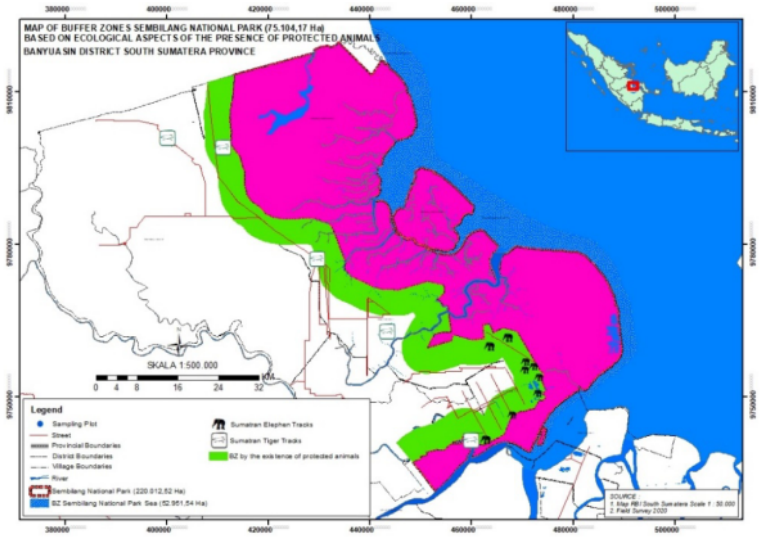

Fig. 9. The track of some protected animals found in the SNP and the area around SNP. Sumatran tiger has been moved to community and private plantation next to SNP which marked with a red arrow (®)

Fig. 10. The footprint of Sumatran tiger found in Sembilang National Park (A) reported by technical regional unit of forest management concession area lalanmendis (*UPT KPH Wilayah II Lalan Medis*) , and footprint of elephant found in Perumpung Raya village

the Sumatran tiger. Thus, the comprehensive study about the buffer zone should be made in detail to protect both community and wildlife animal found in SNP.

The determination of Buffer Zone of Sembilang National Park Based on Sosioeconomical Aspects

Buffer zonebased on the characteristics of society indicators

The society indicator background was obtained using a deep interview 235 respondents who have been randomly selected fromthe resident of villages around Sembilang National Park. From the interview, 11% of respondent were having high education experience (university), 52% have graduated from the high school, and the rest (~37%) only have an education in the level of junior high school and primary school. The number of family was variedwhere 67% of respondent have 3-4 family size, 20% 6-7 family size, and the rest (~13%) has less than 3 family size Based on the length of stay, 89% of community have been seattled in the village for more than 10 years and only 9% was stayed in the village for less than 10 years. The main occupation of community was fisherman (70%) and farmers (30%).

The occupation diversity was low where the most majority of resident were fisherman (~70%) and the rest was farmers. The majority of fisherman was also

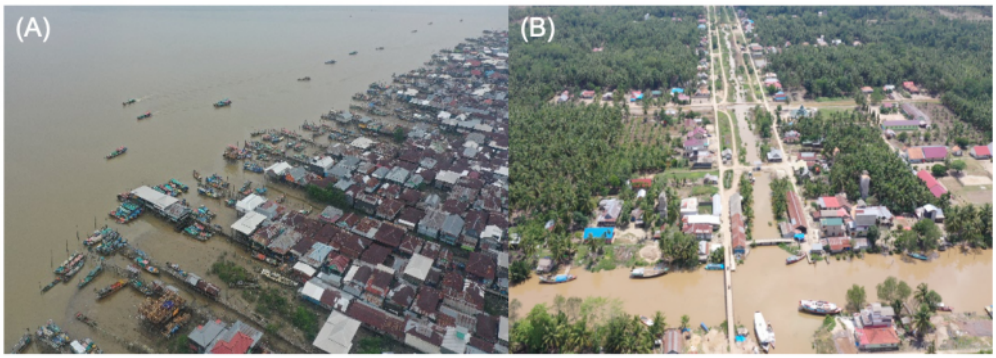

Fig. 11. (A) The community housing as the fisherman builds the house in the riversbank; (B) the farmer community lived in the village near the buffer zone or community land

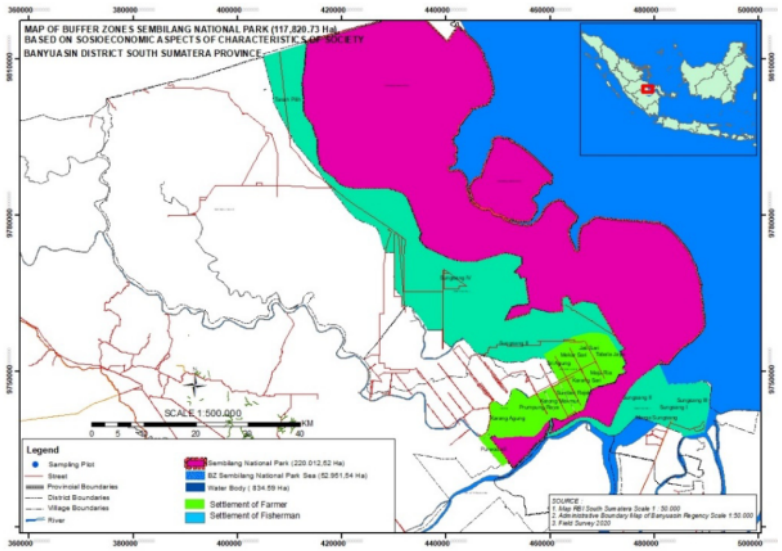

Fig. 12. The detail location of community seattlement near Sembilang National Park

indicated by the high density of residential area near the riversbank (Figure 11A). As comparison, the community who worked as farmers seattled in the community land near their field or plantation where they went for working (Figure 11B). The detail location of the seattlement area of fisherman and farmers was shown in Figure 12. The determination of buffer zone should consider the residential area for achieving the lingkage between the conservation purposes and the resident community's purpose.

Buffer zone based on the land use indicators

As mention in the introduction, the land use and land cover change were one of the major contributors to forest fragmentation and degradation in Sembilang National Park (SNP) (Sahana *et al.*, 2016). The forest cover has massively decreased over the decades through cultivation activities where nearly 140 thousand hectares of forest in SNP and its surroundings have been lost during the last ten years. Theforest fragmentation is the main source of problem where the forest was transformed a small and isolated cluster fragments in response to changes in land use that affect the environment and ecology at a local scale (Sahana *et al.*, 2016). The fragmentation area was easy to be developed as the agriculture, industrial, and resident areas. It was supported by the development of infrastructure such as the road which triggered the people to move to the fragmented area (Tannier, 2012). The mosaic of small forest remnants would suffer significant alteration by edge effects and would lose species (Richard, 1992).

The development of fragmentation area was confirmed by the increase of land use in the buffer zone. There are at least 7 types of land use found around the SNP such asPlantation, Industrial Plantations Forest, Oil Palm Plantations, Village Forests, Business permits for utilization of Non-Timber Forest Products (NTFP), Production Forests, Settlements and Rice Paddy Fields. The high diverse of land use near the buffer zonecould made the determination of buffer zone harder because there would be lots of interests should be considered. It was getting worst since each sector of land use was managed by private and local community which technically different in institutional, funding, and management vision. Each sector determined the buffer zone based on their needs and most of the buffer zone had 500 meters of buffer zone along the boundary of SNP. Figure 13 showed the land use of buffer zone and area near the buffer zone of the SNP.

Discussion

The size of the buffer zone varies and depend on the purpose, land availability, traditional land use sys-

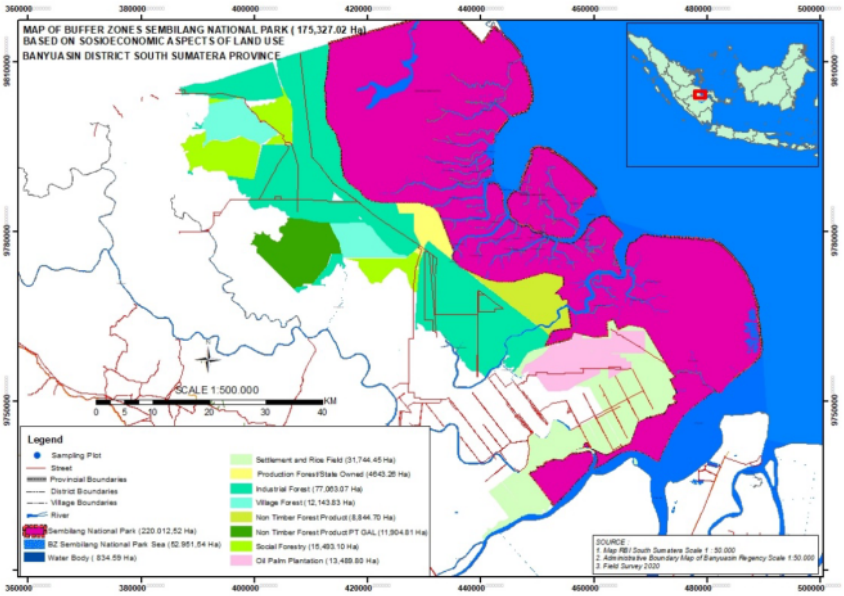

Fig. 13. The land use in the buffer zone of Sembilang National Park

tems, threats and opportunities (Ebregt and Greve, 2000). Each approach proposed the buffer zone to fulfil the requirement. However, the conservation is put as the highest priority to save the ecosystem.The approaches of ecological and socio-economical aspects have determined that there 11 villages included in the buffer zone of Sembilang National Park and consist of 107,050.77 Ha of land. The detail location of village in the buffer zone was shown in Figure 14.

By observing the condition of the SNP buffer zone, the SNP buffer zone consists of the forest mosaics, the agricultural land, settlements, mixed gardens, open land, villages, oil palm plantations and other types of land use. Determining the buffer zone would include all those sectors to form a protective layer and reduce negative external influences. Furthemore, the proposed buffer zone should put the high benefits of the existence of a conservation area for the welfare of local communities.

The existence of the community, community groups and business entities around the SNP must be considered in determining the SNP buffer zone. There are 6 industrial plantation forest companies (PT. Tripupajaya, PT. Sumber Hijau Permai, PT. Rimba Hutani Mas, PT. Rickim Mas Jaya and PT Tiesco), 3 community group business entities that have been granted permits to utilize non-timber forest products (Karang Sari, Muara Medak and Lalan), 2 village forests (HD Muara Merang and HD Kepayang), 2 oil palm plantation companies and 11 villages directly adjacent to SNP. The variety of groups of land users around the SNP makes the goals to be achieved by each party even more diverse. It was supported by the education level found during the interview. Several obligations are attached to each entity, including the obligation to provide space within the concession area for conservation purposes. including any forest utilization business permits for industrial plantations, NTFP, Village Forests and plantations which are located directly adjacent to the SNP is obliged to create a buffer zone of at least 500 m along the area bordering the SNP.

By overlaying the buffer zone as function of ecological and socio-economic aspects, the proposed buffer zone was obtained and considered as the most ideal for SNPs with the aim of providing protection and reducing negative effects on SNPs as well as improving the welfare of the community around SNPs. Figure 15 showed that the ecological aspect, land cover indicators and typical ecosystem

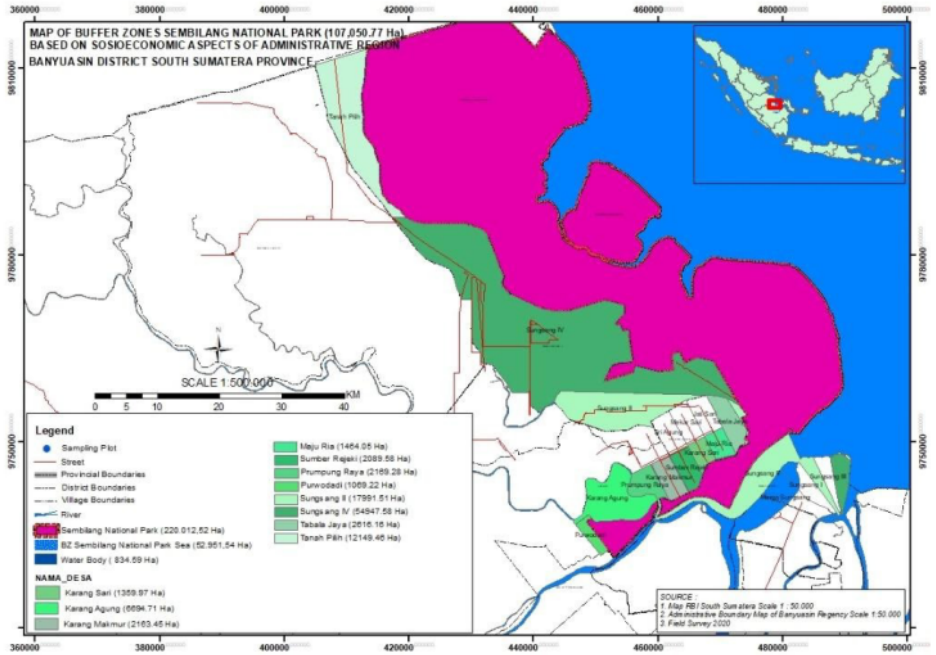

Fig. 14. The location of villages which have a direct boundary with Sembilang National Park

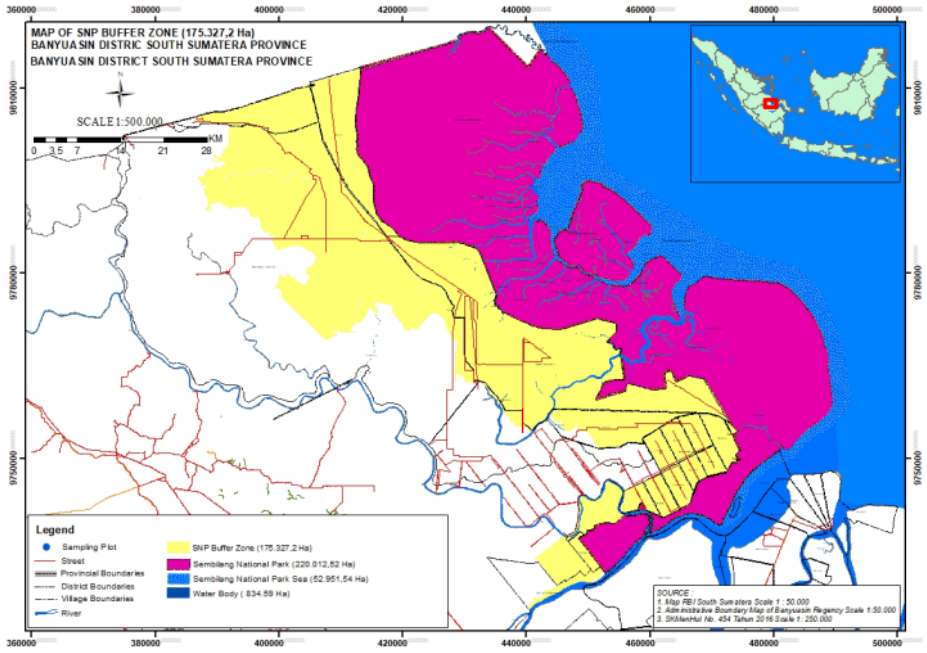

Fig. 15. The proposed buffer zone of Sembilang National Park

indicators (peat domes) become the most priority in determining the buffer zone since those aspects contains the high valuable sector compared to other sectors. The buffer zone areas mostly consist of the primary forest and protected species area to guarantee the sustainable life of wildlife species. Furthermore, the existence of a peat dome has the potential to be an important indicator in determining the SNP buffer zone given its relatively constant condition as a hydrological unit as well as a part that is very prone to fire when the peat is dry / damaged.

In the socioeconomic aspect, the community background was still in consideration where the activity of communities or private sector would be continued without losing their economical aspects. The determination of buffer zone is multidimensional work, especially for conservation and community welfare. Moreover, the approaches using the combination ofecological and socioeconomic aspects was considered as the best way to obtain the win – win solution between the community and the nature.

Conclusion

The buffer zone of Sembilang National Park was conducted using an overlay technique between ecology and socio-economy aspects. The proposed buffer zone covered approximately 175,327.2 hectares which havetwo function: the buffer zone and transition zone. The proposed buffer zone consisted of the mosaic forests, agricultural land, settlements, mixed gardens, open land, villages, oil palm plantations and other types of land use. The diversity of function and land use of the proposed buffer zone provided the win-win solution for communities and wildlife species.

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