



RESEARCH PAPER

OPEN ACCESS

Analysis of the uniqueness of physical form of the teluk kelumpang nature reserve which have high potential of biodiversity based on the satellite imagery

Suyanto*¹, Lukito Andi Widyarto², Nikmat Hakim Passaribu³, Ujang Acep³, Suriansyah³

¹*Faculty of Forestry, University of Lambung Mangkurat (ULM), Banjarbaru city, South Kalimantan, Indonesia.*

²*Head of Natural Resource Conservation Center, Banjarbaru, Indonesia*

³*Expert Staffs of Natural Resource Conservation Center, Banjarbaru, Indonesia*

Article published on June 23, 2017

Key words: Nature reserve, Physical form, Wildlife habitat

Abstract

Indonesia has established natural reserve areas, one of which is the Teluk Kelumpang Nature Reserve (TKNR) located in Kotabaru Regency, South Kalimantan with an area of about 28,437,612 ha. TKNR region in which there is a potential biodiversity of biotic natural resources that is high, while the authenticity of its habitat in the form of mangrove plants are still well preserved. The potential for biodiversity is the pride of the people of South Kalimantan and a national and international responsibility. The purpose of this study is to analyze the uniqueness of the physical form of TKNR region, to cause the area of this nature reserve for 37 years the authenticity of the condition of its habitat is still well preserved regardless of the excellent management conducted by the authority of Natural Resource Conservation Center of South Kalimantan. The method used is to examine secondary data, field surveys and integrated with remote sensing satellite imagery. The results show that The uniqueness of its physical form is composed of tidal plains, many natural river tributaries encircle Kelumpang Gulf, growing mangrove vegetation, its compact formation grows along the coast of Kelumpang Gulf forming a green belt, access road to this area is very limited, far from human activity, Its tributaries are rarely used by local populations, the water conditions are calm, isolated, mud deposits formed overgrown by mangrove vegetation in groups resembling small islands add to the uniqueness, become a heaven for the endemic variety of Kalimantan animals.

*Corresponding Author: Suyanto ✉ suyanto_mp@yahoo.com

Introduction

In the framework of sustainable management of forest resources, Indonesia has made the arrangement of forest areas by determining forest areas in accordance with its function (Muladi, 1999). The area is one of them is a conservation forest area, in addition to protected forest areas, and production forest areas. The conservation area is an area in which there is a variety of wildlife, then the ecosystem acts as a buffer of life with the potential of biodiversity is invaluable. The potential of biodiversity is a national pride as a wealth that must be preserved existence and sustainability as national responsibility for all people of Indonesia as well as international responsibility.

In Law no. 5 of 1990 on the Conservation of Biological Natural Resources and Ecosystems states that Nature Reserve is part of conservation area which because of its natural condition has peculiarity of plants, animal, and ecosystem or certain ecosystem which need to be protected and its development take place naturally. In nature reserves can be carried out activities for the benefit of research and development, science, education and other activities that support cultivation. In other words, the area of the nature reserve is the location of flora and fauna reserves that are not intended for commercial or tourism places, but must be protected the existence of flora, fauna, and ecosystems in order to develop naturally and is expected to be utilized for the benefit in the future.

Indonesia already has a high supply of biodiversity resources, because it has many areas of Nature Reserve. Based on the records until 2008, Indonesia has a reserve area of 237 locations with a total area of about 4.7 million ha. Nevertheless, the potential for biodiversity of natural resources in general tends to decrease, both from the number of species and the number of individuals. This depends on the supply of food sources, water sources, and changes in habitat as a shelter, and breeding grounds.

The main factors considered to affect the changes in food sources, water sources and habitats, namely: human activities in addition to natural disasters.

Human activities are the highest contributing factor to the destruction and loss of wildlife habitat such as: illegal logging, mining, plantation, agriculture and land fires and forest fires that threaten the authenticity of wildlife habitats.

The Teluk Kelumpang Nature Reserve area (TKNR) is one of 237 locations of nature reserves in Indonesia. Based on the results of the map digitization Appendix to the Decree of the Minister of Forestry Number: 435/Menhut-II/2009 dated July 23, 2009 on the Appointment of South Kalimantan Province Forest Area and the boundary (Director of Inauguration and Stewardship of Forest Areas Number: S.467/Kuh-2/2014 dated 19 June 2014, TKNR area is ± 28,437,612 ha.

Based on the result of research (BKSDA, 2016) that the potency of diversity of flora and fauna is still high enough, while the authenticity of its habitat in the form of mangrove plant is still well preserved, from the existing area only about 20% has been disturbed, especially in land for plantation and dry land farms and very little (3%) mangrove plants that turned into swamp bushes due to fish farming activities.

Based on the description there is something of interest to be analyzed, that since the TKNR area was appointed in 1979 and designated as a nature reserve area until now for 37 years the authenticity of the condition of the habitat is still well preserved, on the case of the nature reserve in other places have experienced degradation. There are several approaches for the purpose of the analysis, including a secondary data approach, a field survey that is integrated with a remote sensing approach to satellite imagery.

Material and methods

Study Site

The Teluk Kelumpang Nature Reserve Area (TKNR) astronomically located at 2°50'15"- 3°39'54" S and 116°06'03"- 116°09'35" E, or geographically TKNR is in the coastal region Kelumpang Gulf and a number of islands in it, namely: Pulau Suren, Tanah Merah Island and Kaluang Island.

Administrative TKNR is located in 4 sub-districts, namely Kelumpang Hulu, Kelumpang Tengah,

Kelumpang Selatan, and Kelumpang Barat, Kotabaru Regency of South Kalimantan Province.

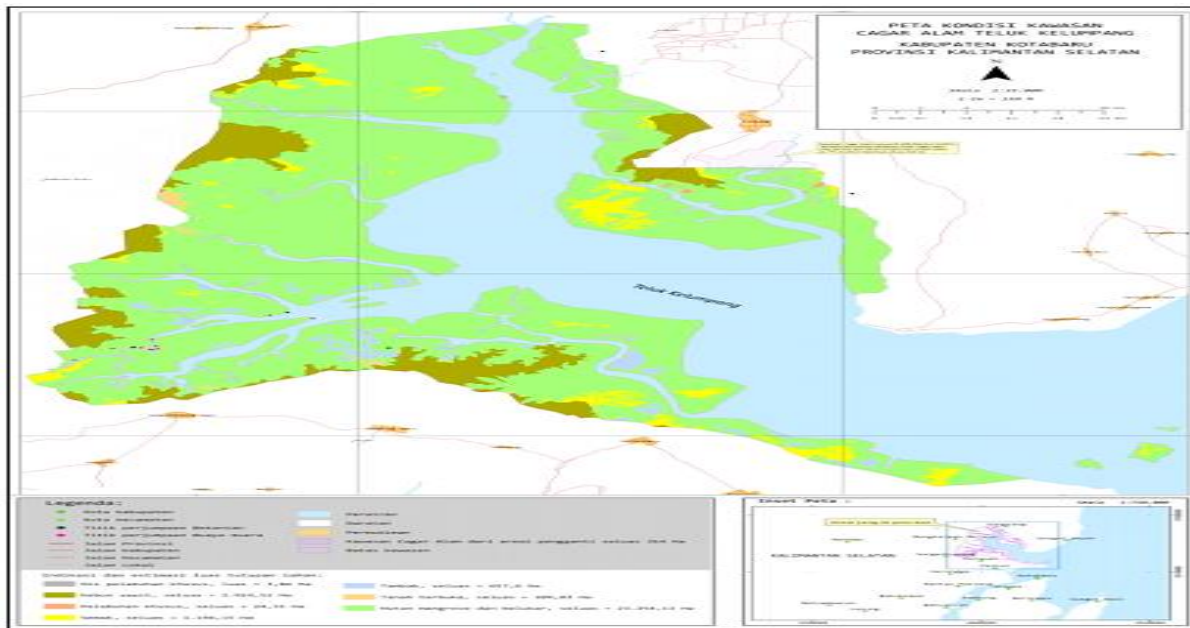


Fig. 1. Map of Teluk Kelumpang Nature Reserve (TKNR)

Based on the technical area of conservation area management, TKNR region located in the management area of Resort TKNR Area, Conservation Section Area III Natural Resource Conservation Center of South Kalimantan which is located in Geronggang Village, Kelumpang Tengah District, Kotabaru Regency. The total area of TKNR is approximately 28,437,612 ha. This research was conducted in March 2017.

Materials

The materials needed in the study include land cover map of TKNR and Topographic map/Rupa Bumi Indonesia (RBI of 1: 50,000 scale) as the base map. ALOS Satellite Imagery of South Kalimantan with a spatial resolution of 2.5 m, which is obtained from the Provincial Forestry Office of South Kalimantan. We also used land satellite imagery TM 7 (2015).

We used a set of computers for assisting spatial analysis and mapping using Geographical Information System (GIS), Hand Compass, Global Positioning System (GPS), Shuunto Clinometer, Altimeter and field notes.

Data collection and analysis

Spatial analysis method used is to examine the protection block area, then make the process of matching, which is comparing the field condition data presented in maps with the criteria of the protected area reserve blocks. Field condition data is known by doing field inspection activity directly. Adjustment process is done in stages starting from specific criteria to general criteria. Preparation of area management blocks is based on the suitability of area potential and criteria of protection blocks.

The data collected consist of primary data and secondary data. Secondary data is data collected by literature search, library, either in the form of activity report result and research result related to potency of TKNR area, while primary data is data and information collected in field by direct observation in TKNR area. Preparation of protection blocks under Article 7 and Article 11 of the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number: P.76/Menlhk-Sekretariat/2015 on Criteria of Nature Reserve Blocks. Spatial data collected based on criteria on protection blocks such as Table. 1

Results and discussion

Regional Status

The status of the Teluk Kelumpang Nature Reserve area (TKNR) was initiated in 1979 by the Sub-Center for Protection and Nature Conservation by

designating the Teluk Kelumpang, Selat Laut and Selat sebuku as the Nature Reserve area and received approval from the Head of the Provincial Forestry Service of South Kalimantan and Brigade Planology III of Forestry, Banjarbaru.

Table 1. Spatial Data Collected Under Criterion of Protection Block.

Criterion P.76	Data Collected	Explanation
The Original Ecosystem	Land cover map of the relevant area	Land cover conditions of primary and secondary mangrove forests with true mangrove vegetation
Concentrations of major plants/animals	Coordinate of wildlife encounter (distribution) and tree density	The coordinates of wildlife encounter represent the concentration of the existence of the main plant/animal with high phn density
Natural phenomenon/geology	Coordinate or delineation area of natural phenomena/geology unique	There is a unique natural/geological phenomenon
Migrant wildlife stop area	Coordinate or delineation of migrant animal shelter area	Migrant animal shelter area is an area that must be protected
Human Threats	Road network maps, river networks for transportation infrastructure, and residential maps around the area	The higher the accessibility, the higher the threat to the region

In 1980, the Sub-Directorate of Protected Forest and Nature Reserve conducted a potential survey on the forest groups of Teluk Kelumpang, Selat Laut and Selat Sebuku. In 1981, the ideas and proposals of Teluk Kelumpang, Selat Laut and Selat Sebuku as Nature Reserves gained support from the Government of the First Level Region of South Kalimantan through the Governor's Recommendation Letter No. 522/780/EK dated May 7, 1981. In 1981, The Decree of the Minister of Agriculture No. 827/Kpts/Um /9/1981 on the Appointment of Mangrove Groups Teluk Kelumpang, Selat Laut and Selat Sebuku covering ± 66,650 ha as forest area with Nature Reserve function.

The period of 1982/1983 and 1983/1984 carried out the boundary arrangement of the Mangrove Forest Group of Teluk Kelumpang, Selat Laut, and Selat Sebuku of 66,650 ha as forest area with Nature Reserve function as stated in the boundaries News on December 2, 1983 and 16 June 1984 passed by the Minister of Forestry dated October 12, 1987.

Based on the Decree of the Minister of Forestry Number: 329/Kpts-II/1987 dated October 14, 1987 concerning determination of Mangrove Forest Group

of Teluk Kelumpang, Selat Laut, and Selat Sebuku of 66, 650 ha as a Nature Reserve. In 2009, the Minister of Forestry Decree No. 435/Menhut-II/2009 dated July 23, 2009 on Appointment of Forest Area of South Kalimantan Province. Based on the result of map digitization of Appendix to the Minister of Forestry Decree, the area of Teluk Kelumpang Nature Reserve (TKNR) is ± 28,437,612 ha. Then the year 2014 has been done outside boundaries of forest areas and in 2015 has been made the boundaries news of Function Area Forest of TKNR.

Ecosystem Type

The area of Teluk Kelumpang Nature Reserve (TKNR) is a presentation of mangrove forest ecosystem type in South Kalimantan Province. Mangrove plants have a combination of characteristics of plants that live on land and in the sea. Mangroves generally have a root system that appears on the surface to form the root of the breath. Such rooting systems become a way of adaptation of mangrove plants to less or no oxygenated soil conditions. Mangroves grow and flourish along the coast from the sides of the island which is protected by wind, or behind coral reefs on sheltered island beaches.

Various types of mangroves grown on the shoreline and sprouted in the sea water region, is a typical ecosystem because it survives in two transition regions between land and sea, while other plants are not able to survive. Mangrove area is a specific ecosystem, located in coastal areas that are protected from the waves or waves are relatively small, influenced by tidal sea water and freshwater input

from the mainland. Mangrove area as a system, this area is influenced by the energy of sunlight, rain, river flow along with sedimentation and cations from the mainland and removing inorganic or organic materials through various ways, so that mangrove conducts internal activities in the ecosystem to maintain and develop themselves (Marsono and Setyono, 1993).

Table 2. Land Cover Condition of Teluk Kelumpang Nature Reserve.

No.	Land cover	Area (ha)	Percentage (%)
1	Bushes swamp	938.013	3.33
2	Water bodies	299.320	1.06
3	Bushes	1,450.913	5.15
4	Palm plantations	2,927.975	10.38
5	Settlements	190.315	0.67
6	Fishery ponds	407.742	1.45
7	Dryland farming	147.809	0.52
8	Mining	170.757	0.61
9	Open ground	7.595	0.03
10	Dry land farms with shrubs	1,008.257	3.58
11	Primary mangrove forest	8,407.565	29.81
12	Secondary mangrove forest	12,243.622	43.42
Total		28,199.883	100.00

Source: result of image interpretation using land satellite imagery TM 7 of 2015.

The ecosystem of mangrove forest is also specific from the aspect of the constituent vegetation type is almost uniform, flat titled and no layers and always green, due to the influence of tidal pools, the level of acidity and salinity of sea water. Large salinity changes, muddy waters and anaerobic conditions result in only certain trees capable of growing and breeding, so the number of species is small.

The mangrove forest of TKNR as an ecosystem has many ecological functions, such as: maintaining the ecosystem balance of coastal waters, protecting abrasion or coastal erosion, curbing seawater intrusion, retaining wind, holding and depositing mud and filtering marine food sources, as the habitat of various types of shrimp, fish and other marine biota, as well as the habitat of animals such as birds, mammals and reptiles.

Land cover

Based on satellite image interpretation and field observation, the mangrove forest condition of TKNR is still relatively good with percentage of 77.62%, the area has been mildly degraded with 5.15% shrub cover condition, the area is degraded with the condition of the cover In the form of dry land agriculture, 4.13% open land and 4.13% of open land, while the areas that have experienced severe degradation with cover conditions such as plantations, settlements, ponds and mines 13.11%, as shown in Table 2.

Biotic Potential

The area of TKNR is a forest region with its function as a conservation of wildlife habitat, whether protected or not yet protected by law. The mangrove forest conservation of TKNR area is intended to be utilized for the benefit of science, education and other

activities that support cultivation in accordance with the mandate of Law no. 5 of 1990 on the Conservation of Natural Resources and Its Ecosystems.

The observations of the research team (BKSDA Kalimantan Selatan, 2017) indicate that the tree-level vegetation species that dominate the TKNR area are the mangrove species, including large mangrove leaves (*Rhizophora mucronata*) and small leaf mangroves (*R. apiculata*), then Api-api (*Avicennia marina*), Langadai (*Bruguiera parviflora*), Mirih (*Xylocarpus granatum*), Tingi (*Ceriops sp.*), Nipah (*Nypa fructicans*) and Salak-salak (*Bruguiera sexagula*).

The mangrove forest of TKNR is a habitat of various wildlife species. One of the most important types is Bekantan (*Nasalis larvatus*) which is a protected endemic animal of Kalimantan, due to its endangered status, then the most important reptile species is Buaya Muara (*Crocodylus porosus*). Other protected species are Rusa (*Cervus unicolor*), Kijang (*Muntiacus muntjak*), Pelanduk (*Tragulus javanicus* or *T. napu*) and Landak (*Hystrix brachyura*). Types of mammals found in the region: Monyet Ekor Panjang (*Macaca fascicularis*), Lutung (*Presbytis pyrrhus*) and Bajing (*Callosciurus notatus*).

Birds found in the TKNR area are water bird species. Some of the most important are Bangau Tong-Tong (*Leptoptilos javanicus*) and Kuntul (*Egretta intermecha*). Other protected bird species are Elang Laut Perut Putih (*Haliaeetus leucogaster*), Elang Bondol (*Haliastur Indus*), and Raja Udang (*Pelargopsis capansis*).

Physical condition

Climate in the Teluk Kelumpang Nature Reserve (TKNR) area based on climate data of the last 10 years (2006-2015) obtained from Stagen Meteorology Station, including climate type A region, which is very wet tropical (Schmidt and Ferguson classification). Climatic type of A is characterized by the dominant wet months (> 100 mm) period throughout the year with dry periods (< 60 mm) only about 1-2 months.

The rainy season occurs in November-July, and the dry season occurs in August-October. Type A climates of climate can form unique forest formations and are characteristic of tropical rainforests. Arief (1994) argues that climate differences result in the formation of different forest formations. Characteristics of tropical forests include: always green throughout the year, rich in biological diversity, trees are tightly coated and titanium (Whitmore, 1984; Weidelt, 1995).

The annual rainfall in the TKNR region ranges from 1,853–3,761 mm/year, with an average annual rainfall of 2,545 mm/year. The highest monthly average rainfall in March was 297 mm, and the lowest in September was 138 mm. The highest monthly rainfall of 609 mm occurred in July 2010. The highest incidence of rainfall ever occurred at 186 mm/day on September 2013. The rainfall events > 100 mm/day included in the category of extreme precipitation ever occurred in January, February, March, July, August, September and December 2013.

The number of annual rainy days in the TKNR region ranges from 190 to 306 rd/year, with an average annual rainfall of 240 rd/year. The highest monthly rainy days are highest in January and March (24 rd/month), and the lowest is in September (11 rd/month). The period of the highest monthly rainfall of 30 rd/month occurred in October 2010.

The average monthly air temperature in the TKNR region ranges from 25.6 - 27.8° C. The highest monthly average temperature of 27.8° C occurred in November 2015. The maximum air temperature ranges from 29.4-33.7° C and the minimum air temperature ranges from 21.7 - 24.6° C. The maximum temperature of 33.7° C occurred in October 2015 and a minimum temperature of 21.7° C occurred in July 2011.

Relative air humidity in the TKNR area is relatively high and the pattern is almost the same throughout the year. Average monthly air humidity ranges from 83 to 88%. The highest humidity was 93% in July and August 2010, the lowest humidity 75% in October 2015.

The monthly wind speed in the TKNR region ranges from 2 to 4 Knots, with the most wind direction from the south for 6 months from May to October, the November to April period the wind direction varies from southwest to north. Maximum wind speed occurred at 36 Knots (65 km/h) in April 2014. The condition of gust winds with a speed of < 25 Knots over a 10-year period is most common in January and December.

The geological condition of the TKNR region can be distinguished on the formation of alluvium species of the steps and the Berai formation. Alluvium formation of the steps is the main formation that forms the area, consisting of gravel, sand, silt, clay and mud. The formation consists of a grayish white limestone, lined with a thickness of 20-200 m, inserted a good gray-colored Napal dense (10-15 cm), containing Foraminifera, Plankton and Clay stone.

Soil types are alluvial in predominantly of TKNR region and podzolic areas in dry land areas. Alluvial soil is a recent soil formed from fluvial processes or a combination of alluvial and koluvial processes. According to Soemodihardjo and Soerianegara (1989), in general, the soil in mangrove forest such as in the TKNR region is classified into Halic Hydraquent category, because it is adjacent to sea water, the soil is saturated with water, bulk density is about 0.6, Acidity > 5.5 and high cation exchange capacity.

Podsolcic soil is acidic mineral soil, has undergone advanced development, good drainage, has a thin organic and inorganic horizon above the brightly colored eluviation horizon. Podsolcic soils are formed due to high precipitation and temperature conditions. Yellowish or reddish color, relatively low fertility status due to washing process (Hanifah, 2009).

The TKNR region consists of terrain that is still influenced by tidal sea water and forms a unique landscape. There are many river tributaries that empty into the Kelumpang Gulf.

The arrangement of creeks is evident from satellite imagery, but on the field it is sometimes difficult to tell which ones are upstream and downstream. At the time of the tide, it is not recognizable where the boundaries of its tributaries flow, because the land is very flat.

The streams present within the TKNR region are naturally formed with the river bottom of deep silt. With the existence of its tributaries, it facilitates the mobilization of tide and low tides by bringing sedimentary materials from the sea to be deposited under mangroves.

The TKNR region is unique, so it plays a very important role as wildlife protection, because its compact forms where mangroves grow along the coast of Kelumpang Gulf to the beach. Soemodihardjo and Soerianegara (1989) mentioned that the mangrove community like this is named green belt mangrove.

Access road to this area is very limited, so far from human activities, although there is river transportation, but only limited to the path along the Gulf in order to exit the vessel from a special port of coal owned by PT. Arutmin Indonesia. Its tributaries are rarely used by local people, because besides there is no settlement within the TKNR region as well as the users of the tributaries as a traffic road at risk of failing if it does not take into account the tide of sea water, this area of water is quiet because it is isolated, away from the density of the ship's traffic, so the sedimentation process slimming all the time (Fig. 1).

The formation of delta by mud deposition overgrown by mangrove vegetation groups resembling small islands is a natural process adding to the uniqueness of the TKNR region. Sooner or later these mangrove groups continue to grow and converge into a compact mangrove vegetation. This mangrove habitat is a heaven for breeding endemic Kalimantan species. In general, the spread of wildlife individuals in habitats is clumped, as each individual requires the same environmental factors (Michael, 1994, Umar, 2009).

Economic, Social and Cultural

The development of TKNR conditions is influenced by the surrounding socio-economic conditions. Since being appointed and designated as nature resources conservation with nature reserve function, this region can not be separated from the various obstacles, challenges, disturbances, threats and pressure in its management.

Administratively, the TKNR region is located in 3 sub districts and 11 villages around the area. The total population of the villages is 14,708 people with a density of 7-188 people/Km². The average population growth rate of 3.2% with the highest population growth rate is in Kelumpang Hulu District. The education level of the villagers around the area is relatively low. The average percentage of under-schooled primary school 8.4%, while not attending school 91.6%.

The main source of income for the villagers around the TKNR region comes from agriculture in a broad sense that includes crops such as rice fields and cultivation, plantation and fishery of fish or shrimp ponds. Agriculture is the number one source of livelihood for villages around the region. In some other villages, the main source of livelihoods of the population is service and fishing.

Other sectors that also contribute substantially to the income of the population in a row based on the number of residents are services, trade, handicraft, government and building construction. The existence of coal mining company PT. Arutmin Indonesia Site Senakin and plantation PT. Sinar Mas Resources Tbk is also a source of livelihood for some residents by working as employees for these companies.

Communities domiciled around the TKNR region can potentially be a threat, but can also potentially be capital for the protection and security of the region. This depends on the planned area management strategy. As a regional manager, it is imperative to know the social, economic and cultural conditions of the community in and around the forest area.

In fact, these social, economic and cultural data are often considered only supporting data obtained from district and sub district statistics reports.

Conclusion

Based on the above description it can be concluded that the condition of Teluk Kelumpang nature reserve (TKNR) can be said is still good, biotic potential is still high awake its authenticity. The TKNR area is a unique physical form, so it is very good for wildlife protection. The uniqueness of the physical form of TKNR region is composed of tidal plains, many rivers are formed naturally and incorporated into the Gulf of Kelumpang. Much grows of mangrove vegetation that plays an important role as wildlife protection, because of its compact form where mangroves grow along the coast of Kelumpang Gulf to the shoreline forms a unique green belt around the bay of the kelumpang. Access road to this area is very limited, so far from human activity. Its tributaries are rarely used by local people, because they are risky if they do not take into account the tide of sea water. The water condition is quiet because it is isolated, away from the density of the vessel's traffic, so the sedimentation process takes place all the time. The formation of delta by the deposition of mud overgrown by groups of mangrove vegetation resembling small islands is a natural process of adding to the uniqueness of the TKNR region. This mangrove habitat is a heaven for breeding endemic Kalimantan species

Acknowledgement

The authors would like to thank for Ir. Lukito Andi Widyanto, M.P. as the head of Natural Resource Conservation Center, Banjarbaru, Indonesia, which has contributed so much to this article and his staffs: Nikmat Hakim Passaribu, S.P, M. Sc., Ujang Acep, S. Hut, and Suriansyah, S. Hut., who helped activities in the collection and analysis data.

Reference

Arief. 1994. Hutan: Hakekat dan pengaruhnya terhadap lingkungan. Jakarta: Yayasan Obor Indonesia.

- BKSDA Kalimantan Selatan.** 2017. Rancangan Penataan Blok CA Teluk Kelumpang, Selat Laut dan selat sebuku. Balai Konservasi Sumberdaya Alam Kalimantan Selatan, Banjarbaru.
- Hanifah KA.** 2009. Dasar-dasar Ilmu Tanah. Rajawali Pers, Jakarta.
- Marsono D, dan Setyono.** 1993. Pendekatan ekologis rehabilitasi kawasan mangrove. Studi kasus di pantai pemalang. Bulletin instiper. **4(2)**, 57-68.
- Michael PE.** 1994. Metode Ekologi untuk Penyelidikan Ladang dan Laboratorium. Universitas Indonesia. Jakarta
- Moerdiono.** 1990. UU No. 5 Tahun 1990 Tentang Konservasi Sumber Daya Alam Hayati dan Ekosistem. Menteri/Sekretaris negara R.I, Jakarta.
- Muladi.** 1999. Undang-undang Kehutanan no. 41 Tahun 1999 Tentang Kehutanan. Menteri negara Sekretaris Negara Republik Indonesia, Jakarta.
- Rony Irawanto R, Abywijaya dan Mudiana IK, D.** 2017. Kajian pustaka keanekaragaman tumbuhan di Cagar Alam Pulau Sempu, Jawa Timur. Pros Sem Nas Masy Biodiv Indon **3(1)**, 138-146.
- Soemodihardjo S, dan Soerianegara I.** 1989. The Status of Mangrove Forest in Indonesia. Symposium on Mangrove Management: Its Ecological and economic considerations. 73-113. Bogor: SEAMEO – BIOTROP.
- Umar Ruslan M.** 2009. *Penuntun Praktikum Ekologi Umum*. Laboratorium Ilmu Lingkungan Kelautan. Jurusan Biologi, Fakultas Matematika dan Ilmu Pengetahuan Alam. Universitas Hasanuddin. Makassar.
- Weidelt HJ.** 1995, Silvikultur Hutan Alam Tropika (Diterjemahkan oleh: Nunuk Supriyanto), Fakultas Kehutanan UGM, Yogyakarta.
- Whitmore TC.** 1984, Tropical Rain Forest of The Far East (Second Edition), Oxford University Press, Oxford.