

# The Carrying Capacity of Ecosystem Services of Mangrove Angke Kapuk Area, Jakarta Bay

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## The Carrying Capacity of Ecosystem Services of Mangrove Angke Kapuk Area, Jakarta Bay

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**Abstract.** Mangrove ecosystems have an important role and provide ecosystem services that support the surrounding life, but their existence gets to experience pressure and degradation continuously. This study aims to analyze the ecosystem services carrying capacity of Angke Kapuk Mangrove (MAK) Jakarta Bay. The carrying capacity of the MAK ecosystem area was analyzed by examining the condition of ecosystem services and the carrying capacity of the protected function of the MAK and surrounding ecosystems. The condition of ecosystem services refers to the carrying capacity (D3TLH) map of the Muara Angke Kapuk mangrove ecosystem Area, Jakarta Bay, P3EJawa KLHK, while the carrying capacity of the protected function refers to the 2014 Ministry of Environment (KLH) D3TLH Guidelines and remote sensing and GIS techniques. MAK ecosystem areas are mostly in the low ecosystem services category. The results of the analysis show that the carrying capacity of the protected area of MAK ecosystem in Penjaringan District is 0.32, which means the carrying capacity of the protected function of the region is categorized damaged. These results provide an overview of the challenges and threats that occur in the MAK ecosystem area so that it requires attention and strategic efforts in maintaining the sustainability of ecosystem services.

### 1. Introduction

Ecosystem services are very interesting studies because it can illustrate the relationship between ecosystems with human well-being. Decreased biodiversity of an ecosystem will negatively impact ecosystem services [1]. The condition of ecosystem services can be seen by evaluating the carrying capacity of the environment in the region. Carrying capacity of the environment is the ability of the environment to support the lives of living things and maintain the balance [2]. The carrying capacity of the environment needs to be considered and mandated by Law no.32 of 2009 concerning management and protection of the environment that needs to be applied in the planning and utilization of natural



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resources and the environment. One effort to overview the carrying capacity of the environment is to examine the existence of an ecosystem in supporting the lives of humans and other creatures that are closely related to their ecosystem services. Ecosystems provide many ecosystem services to humans, and their changes affect the existence of ecosystem services and ultimately, human well-being [3]. Understanding of the functions and services of ecosystems on human well-being is very important in sustainable development [4]. The contribution of ecosystems to human well-being even though it has been recognized, ecosystems face challenges in development efforts to be able to meet the needs of their ecosystem services while the ecosystem can be maintained.

Coastal areas such as the MAK area Jakarta Bay and the surrounding areas continue to experience environmental pressure. The pressure increased due to an increasing number of socio-economic factors such as population and infrastructure development. The pressure will potentially increase the complexity of the problem and impact on the carrying capacity of ecosystem services in the region. Jakarta with a population of more than 9.5 million people is a core urban area (core area) of an agglomeration system of the Jabodetabek punjur (Jakarta, Bogor, Depok, Tangerang, Bekasi, Puncak, dan Cianjur) region with a total population of 30.1 million in 2013. Jabodetabek punjur area is an urban area determined as a national strategic area in accordance with the provisions of Perpres No. 54 of 2008 [5].

Coastal ecosystems such as the MAK ecosystem still have several benefits and services for human life, such as protecting the coast from sea waves and preventing seawater intrusion, as well as for recreation and ecotourism. The potential threat of ecosystem degradation such as mangroves is greater in areas close to the center of economic activity [6]. The coastal region is the center of economic activity and development and a rapid increase in population. Exploitation and pressure on ecosystems will continuously have an impact on the carrying capacity of ecosystem services needed by the community. The carrying capacity of the protection function is essential to know because it is related to the sustainability and availability of ecosystem services. Ecosystem services are strongly linked to ecosystems in providing benefits to the well-being of the community [7]. An assessment of the carrying capacity of protected functions can support better planning, and optimize appropriate policies in reducing the threat of coastal development and can be useful in ecosystem management strategies. This study aims to examine the carrying capacity of ecosystem services and the protection function of the MAK ecosystem area, Jakarta Bay.

## 2. Method

### 2.1 Research Location

The study was conducted in the MAK ecosystem area at Penjaringan District, Jakarta Bay, DKI Jakarta Province with a coordinate of 6°05'20"-6°07'40" LS and 106°43'00"-106°48'00" East BT as shown in Figure 1.



Figure 1. Study sites (Citra SPOT 6)

## 2.2 Data sources and tools

The data used are SPOT 6 2016 satellite image data from the National Aeronautics and Space Institute (LAPAN) that have been corrected geometrically and radiometrically, Indonesian Earth Map (RBI) 1 : 25,000 Penjaringan District, North Jakarta, Carrying Capacity and Capacity Map (DT3LH) of Muara Angke, P3EJawa KLHK scale of 1: 50,000. Field observations and interviews were conducted with related parties such as Conservation and Natural Resources Office (BKSDA) DKI Jakarta, Angke Kapuk Protection Forest (HLAK) and Nature Tourism Park (TWA). Other data obtained from the results of research, reports, and other related data.

## 2.3 Methodology

The carrying capacity of ecosystem services and the protection function of the MAK ecosystem on the north coast of Jakarta is assessed in terms of the North Jakarta Penjaringan District in the Jakarta Bay. Analysis of the carrying capacity of ecosystem services used D3TLH maps of Muara Angke Kapuk area of Jakarta Bay. The protection function used the carrying capacity index of the protection function and the protection coefficient refers to the guidelines for determining the carrying capacity and capacity of the Ministry of Environment in 2014 [2], RBI map scale 1: 25,000 from BIG, and the classification of the quality of the carrying capacity of the protected function refers to Irawan [8] as well as data and map processing using remote sensing software and GIS.

Carrying capacity of the protected area ecosystem function in the MAK obtained from land cover map produce from the visual interpretation of SPOT 6 satellite images. The carrying capacity of the protected function was also analyzed from the distribution of the Subdistrict in the Penjaringan District. The carrying capacity of the protected function was then used to analyze the MAK ecosystem area.

The carrying capacity of the protection function was calculated by using the following equation [2]:

$$DDL = \frac{\sum(Lgl1.\alpha1 + Lgl2.\alpha2 + Lgl3.\alpha3)}{LW}$$

DDL = carrying capacity of the protected function Lgl1 = land use area type 1 (ha)

LW = area (ha)

$\alpha1$  = protection coefficient for land use

Carrying capacity y of the protection function (DDL) has a range of values between 0 (minimum) to 1 (maximum), the closer it is to 1, the better the protection function that exists in the area. The quality classification carrying capacity of the protected function consists of value 0 - 0.20 (very damaged), value of 0.21 - 0.40 (damaged), value of 0.41 - 0.60 (medium), value of 0.61 - 0.80 (good), value of 0.81 - 1 (very good) [8].

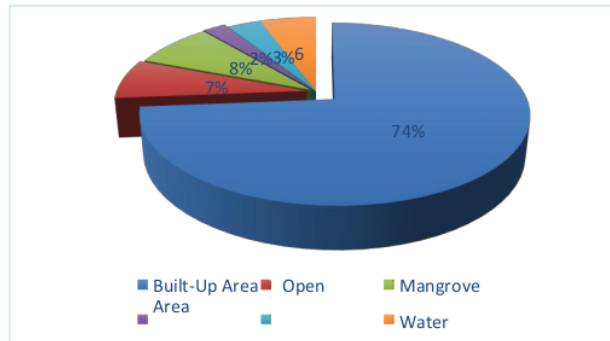
## 3. Result and discussion

### 3.1. The Condition of the north coast of Jakarta

The MAK ecosystem is located in the northern coastal region of Jakarta and directly borders with Jakarta Bay. Jakarta Bay also still has marine and coastal resources both along the northern coastline of Jakarta and the Thousand Islands of Jakarta [9] and including the MAK ecosystem area. The area is included in the North Jakarta Penjaringan District starting from Kapuk Muara Subdistrict to Kamal Muara Subdistrict and Angke river estuary at the western end of Pluit Subdistrict. Population and development activities are growing rapidly with a number of supporting facilities such as ports and trade centers. The north coast region has the potential to be developed, but the rapid development of coastal urban areas in addition to having a positive impact on economic development can also lead to environmental problems [5].



Land use in Penjaringan District, North Jakarta consists of built-up areas, open areas, mangrove forests, swamps, ponds, and water bodies, as shown in Figure 2. The MAK ecosystem area has a strategic position between residential and business centers of the densely populated city of North Jakarta and dynamic development activities. The mangrove ecosystems exists in the north coast of Jakarta, but its area has decreased from 1,165.33 ha in 1980 to 165.28 ha in 2016 [10]. Mangrove ecosystems are one of the most threatened coastal ecosystems in the world due to continues pressure and degradation, and their area has declined over the last few decades [11, 12].



**Figure 2.** Land Use Area of the MAK Ecosystem Penjaringan District

### 3.2. Carrying capacity of the environment

An assessment of the carrying capacity of the environment was obtained through evaluating the carrying capacity of its protection functions as presented in Table 1.

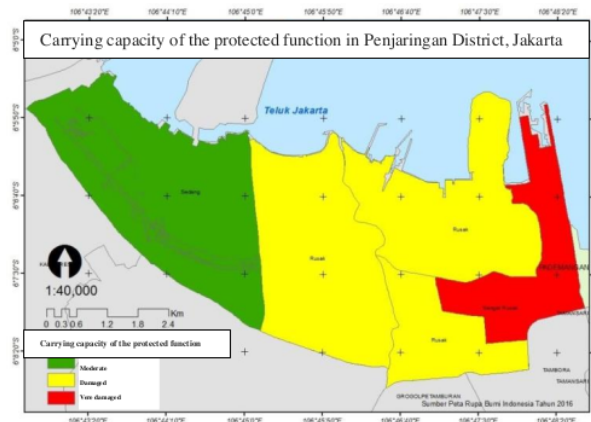
**Tabel 1.** The carrying capacity of the 2016 Penjaringan District protected function

Land Use Area	Area (ha)	$\alpha$	$L \times \alpha$
Built-Up Area	2,688.01	0.18	483.84
Open Area	262.62	0.01	2.63
Mangrove	291.17	1.00	291.17
Swamps	83.71	0.98	82.04
Ponds	121.87	0.98	119.43
Water Bodies	200.19	0.98	196.19
Total	3,647.56		1,175.29
DDL			0.32

The analysis of the carrying capacity of the protected function in Penjaringan District showed a value of 0.32. This value is close to zero, may indicates that Penjaringan District is in a damaged condition. This condition demonstrate the environment imbalance in the area due to the domination of settlements in the area, even though protected areas play a significant role in protecting the environment and supports life in the area. Damage due to land conversion has occurred from the mangrove ecosystem to other land uses such as settlements and business areas. The MAK ecosystem in Penjaringan Subdistrict has experienced major changes, especially since the opening of large-scale ponds, and infrastructure development such as toll roads and settlements [13].

Conversion of land functions from mangrove ecosystems to other uses results a pressure to the ecosystems from an increased development activities both in settlements, business centers, and others. Development activities such as housing, toll road construction, power generation facilities, airport infrastructure, and ponds resulted in mangrove damage in Muara Angke [14]. Land conversion and human activity are the most significant factors causing the degradation of mangrove ecosystems in

Jakarta [10]. The development of the city as the capital and strategic area also triggers an increase in development and human activities that significantly increase the pressure on the carrying capacity of the environment in the economic area of MAK. The city development around the MAK ecosystem area needed to be well controlled as it will impact the carrying capacity of the environment.



**Figure 3.** Carrying capacity of the protected function of Penjaringan District per Sub district in 2016

More detail carrying capacity per subdistrict area, shows that Kamal Muara and Kapuk Muara have moderate carrying capacity (Figure 5). This is due to the two subdistricts are becoming the dominant locations for the MAK ecosystem. The existence of mangrove ecosystems in coastal areas can increase the carrying capacity of its protected function. This condition shows that areas with mangrove ecosystem areas that are still well-maintain will play an important role in increasing the carrying capacity of a region's protected functions.

The low carrying capacity of the protection function will have an impact to the emergence of other environmental problems such as the availability of water and food, tidal flooding, abrasion and pollution because the area is not sufficient to support the survival of life, and this it requires supplies from other places. The area also requires more optimal efforts to maintain and improve the existing ecosystem.

### 3.3. Ecosystem Area of MAK

MAK ecosystem area has potential to increase the carrying capacity of the Penjaringan District area and the north coast of Jakarta. Among the benefits and services of ecosystems are protection of coastal from abrasion and as a place for recreation and tourism. A decrease in the carrying capacity of the environment from the protection function will reduce the availability of ecosystem services, such as the surrounding communities need to pay higher costs for raw water needs, residential areas affected by tidal floods, and the reduced utilization potential that can be obtained from mangrove ecosystem resources such as fisheries. The MAK ecosystem area there, is very valuable and important to be maintained. The extent of mangrove that is maintained will play an important role in determining the diversity of species, allowing mangroves to grow and reduce competition between species with sufficient space, genetic exchange in large populations, and potentially reducing human activity disturbance in utilizing mangrove areas [15].

One of the ways to develop a management strategy that is based on ecosystem sustainability is to evaluate the carrying capacity of the environment. The carrying capacity of the protected function shows that the existence of mangrove ecosystems and other vegetation areas in Penjaringan District is very important potentially can develop in sustainable management. Efforts to conserve and protect the mangrove ecosystem also need to be continued because the MAK ecosystem area still provides ecosystem services and plays an important role in protecting the environment.

## 12 Conclusion

The carrying capacity of the protected area ecosystem function in the MAK area is 0.32, which means the area is in a damaged condition. The condition of the area also shows an environmental imbalance as it is dominated by settlements, even though the protected area plays a very important role in preserving the environment that supports life in the area. The existence of mangrove ecosystems in coastal areas can increase the carrying capacity of its protected function. The existence of mangrove ecosystems and other vegetation areas in Penjaringan District and the north coast of Jakarta is very important and provides a picture of the challenges that occur in the MAK ecosystem area. Therefore, the area needs better attention and strategic efforts to support the sustainability of its ecosystem services. Further research should be done to analyze the carrying capacity of each type of ecosystem service in a more detail and wider scope of areas

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