Indonesian Journal of Earth and Human

Carrying Capacity of Protection Function of Tuntang Watershed

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ABSTRACT

Watershed is the unity of space or ecosystem contained within it components of abiotic (soil, water, air), biotic (human vegetation, animals, living organisms), and human activities that interrelate and interact with one another. Tuntang Watershed is one of the nation's priority watersheds, according to data issued by KLHK (Ministry of Environment and Forestry), in 108 priority watersheds, which have enormous water availability. The increasing population has environmental (ecological) and spatial consequences. The spatial result is the growing demand for space for human activities. Paying attention to the environment's carrying capacity is the key to realizing a comfortable and sustainable living space that supports the resident's activities in meeting their living needs without causing damage. Seeing the relationship between the provision of space and the carrying capacity of the protection function of an area and the entry of the Tuntang watershed into the KLHK's priority, this study will examine the carrying capacity function of the protection function of the Tuntang watershed. The method used in this study is data interpretation and analysis of CCPF (Carrying Capacity of Protective Function) values. The researchers displayed the results as a table of DDL values for each Tuntang watershed sub-watershed, land use changes in the sub-watersheds, and the significant CCPF values. The shift in value increased in the Rawapening Sub-watershed, which was 0,51 to 0,63. There was no change in the CCPF (Carrying Capacity of Protective Function) value of the Blorong and Tuntang sub-watersheds. Meanwhile, the Bancak, Senjoyo, Temuireng, and Tuk Bening Sub-watersheds experienced a decrease in CCPF (Carrying Capacity of Protective Function) values.

Keywords: *Supportability, Protection Function, Tuntang Watershed*

Received: August 20, 2024, revised: November 29, 2024, accepted: Desember 1, 2024

Citation: Rafidah, Z., Arifin, S.M., Zahrany, F., Syahbananto, G., Fariz, T.R., Jabbar, A. (2024) Carrying Capacity of Protection Function of Tuntang Watershed. Indonesian Journal of Earth and Human, 1(2), 76-83

1. INTRODUCTION

Watershed is the unity of space or ecosystem contained within it components of abiotic (soil, water, air), biotic (human vegetation, animals, living organisms), and human activities that interrelate and interact with one another. In addition, watersheds comprise three sections: upstream, middle, and downstream. The upstream part serves as the river's water source, while the downstream part functions as the end of the river flow before it finally reaches the sea. (Putri et al., 2023). The sustainability of a watershed means that it must pay attention to the role of every biotic, abiotic, and human component and each part's role in the watershed (Syaferi et al., 2019). Various factors, including topography, vegetation, and human factors, influence the existence of a watershed. Changes in the function of each of these factors mean that there has been a disturbance in rainwater catchment, water catchment, and storage, which impacts fluctuations in river discharge. The fluctuation of river discharges is a condition where discharges in the dry and rainy seasons have a huge difference (Arthur, 2019). BPDAS (River Basin Management Center) is a management agency that coordinates every factor in the watershed because watershed management cannot be done based on administrative boundaries but on ecoregions.

Tuntang watershed is one of the nation's priority watersheds. From data issued by KLHK (Ministry of Environment and Forestry) in 108 priority watersheds, it has an enormous water availability (Farras, 2022). Geographically, the Tuntang watershed spans an area of 130,036,886 hectares, divided into eight sub-watersheds: Jajar Upstream Sub-watershed (32,745,154 ha), Rawapening Sub-watershed (27,434,393 ha), Tuntang Downstream Sub-watershed (17,788,318 ha), Bancak Sub-watershed (13,862,643 ha), Tuk Bening Upstream Sub-watershed (13,193,241 ha), Senjoyo Sub-watershed (12,400,263 ha), Temuireng Sub-watershed (10,309,329 ha), and Blorong Sub-watershed (2,303,545 ha).

The increasing population has environmental (ecological) and spatial consequences. The spatial consequence is the growing demand for space for human activities. Meanwhile, the ecological impacts that arise are in the form of exploitation of regional resources and changing the use of non-awakened land into an awakened land. The needs for land, water, goods, and everything else are going up, so it takes calculations of the carrying capacity of its environment (Fathurrohmah et al., 2022). Carrying capacity is seen as more helpful in determining the number of humans that can be accommodated in an area. In short, the concept of carrying capacity can be limited to the ability to support human life, namely to meet the needs of human life. Resources, climate, and other physical conditions solely determine part of the land's carrying capacity for the population. Another influencing factor is how to organize the population to utilize these resources.

Paying attention to the environment's carrying capacity is the key to realizing a comfortable and sustainable living space that supports the activities of residents in meeting their living needs without causing damage (Muta'ali, 2012). Indirectly, evaluating the environment's carrying capacity for protection functions can provide land use direction in an area by paying attention to the characteristics of natural resources; it is essential because it can be used as a measure for sustainable resource management (Sarjanti, 2023). Through the Ministry of Environment and Forestry, the government launched Indonesia Forestry and Other Land Use (FoLU) Net-Sink 2030 regarding water resources management. Minister Siti Nurbaya stated that this relates to managing the threat to the supply and quality of water amidst an increasingly urbanized world, landscape degradation, and challenges posed by climate change. Therefore, Indonesia has made a solid commitment to restoring degraded land; with that statement in mind, the Tuntang watershed goes to the 108th list of watersheds national priorities, and there needs to be a study of the carrying capacity of protective functions on the Tuntang watershed.

2. METHODS

This research takes place in the Tuntang Watershed in Central Java Province. This research uses land cover data. The land cover data used is from 2015 and 2023 . The land cover data for 2015 is secondary in the form of land cover data from the Ministry of Environment and Forestry (KLHK). Researchers constructed the 2023 land cover map by visually and digitally interpreting the 2023 Landsat satellite imagery. A combination of visual and digital interpretation was chosen to obtain a land cover map that is accurate enough but also efficient in terms of time. The selected digital interpretation was multispectral classification with a supervised method. Furthermore, the visual interpretation process is carried out by updating the 2015 land cover map from KLHK based on the appearance of Landsat satellite imagery in 2023; this method has accurate results, especially for distinguishing built-up land that cannot be distinguished through digital interpretation (Yolanda et al., 2023; Fariz & Faniza, 2023; Fariz et al., 2021). After interpreting the land use map, then evaluate the carrying capacity of the watershed protection function with the following formulation:

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

DDL = **daya dukung fungsi lindung**
Lgl_n = **luas guna lahan jenis n (ha)**
LW = **luas wilayah (ha)**
α_n = **koefisien lindung untuk guna lahan n**

Figure 1. The formula for calculating the carrying capacity of the protective function

Table 1. Land use value coefficient

No	Land Use	Coefficient	No	Land Use	Coefficient
1	Nature Reserve	1,00	9	People's Plantation	0,42
2	Wildlife Sanctuary	1,00	10	Rice Fields	0,46
3	Tourist Park	1,00	11	Field / Farm	0, 21
4	Hunting Park	0,82	12	Grassland	0,28
5	Protected Forest	1,00	13	Lake / Pond	0, 98
6	Forest Reserve	0, 61	14	Woody Plants	0,37
7	Production Forest	0, 68	15	Settlements	0,18
8	Large Plantations	0,54	16	Empty Land	0,01

Protected Function Supportability (DDL) analysis was analyzed by matching the DDL values. DDL has a range of values between 0 (minimum) and 1 (maximum). Thus, the closer the value is to 1, the better the protected function of the area and the more the watershed function can accommodate, store, and drain rainfall water to the sea naturally. To determine the range and class of carrying capacity of protected functions, the following formula is used:

Table 2. Protected function carrying capacity category

Range	Classification
0 - 0,20	Very Damaged
0,21 - 0,40	Broken
0, 41 - 0,60	Medium
0, 61 - 0, 80	Good
0, 81 -	Very Good

3. RESULTS AND DISCUSSION

Geographically, Tuntang Watershed is located at the position of 110°18' 26" - 110°51' 01" East and between 6°45' 31" - 7°26' 55" N. Administratively, the Tuntang watershed is located between four regencies and one city. Of the five regions, the largest is Demak Regency with 85,150.17 ha or 39.28% of the total area, followed by Semarang Regency with 65,843.69 ha (30.38%), Grobogan Regency with 55,573.74 ha (25.65%), Salatiga City with 5,703.59 ha (2.64%) and the smallest is Boyolali Regency with 4,461.32 ha (2.05%) (Sriyana, 2011).

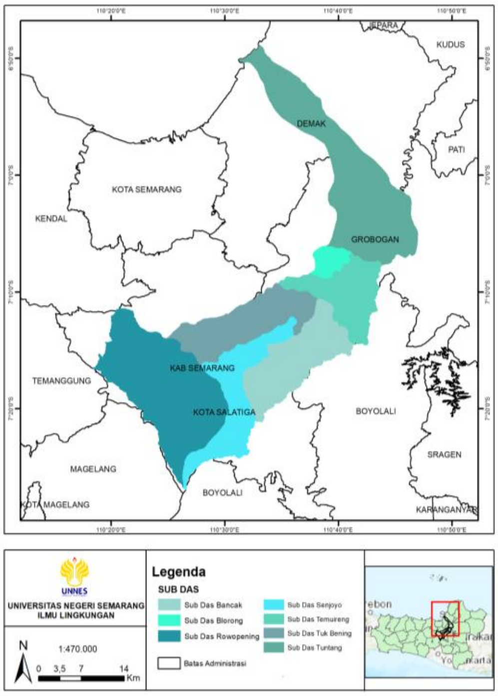

Figure 2. Research Location

Administratively, the upper Tuntang watershed is dominantly located in Semarang Regency. The middle Tuntang watershed is located in the Grobogan Regency, and the downstream Tuntang watershed is located in the Demak Regency. The Tuntang watershed, which has an area of 107,128.76 Ha, is divided into several land use groups (Figure 2).

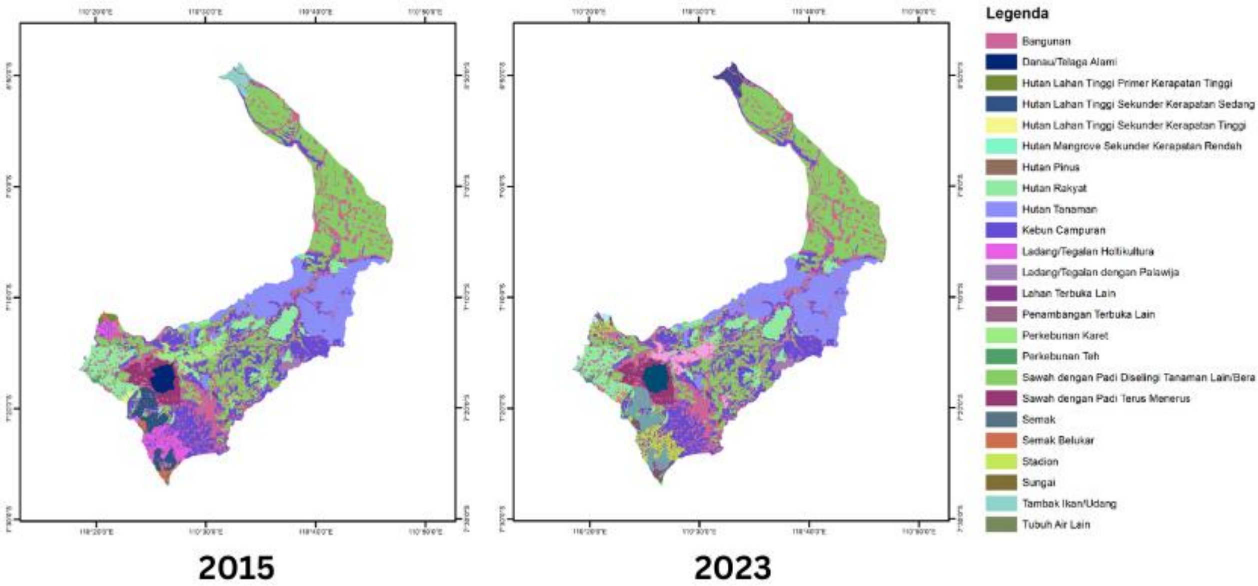

Figure 3. Tuntang Watershed Land Use Map 2015 & 2023

Based on the land use area and the value of the protection coefficient, the carrying capacity of the Tuntang watershed protection function in 2015 and 2023 is obtained as follows:

Table 3. Daya Dukung Fungsi Lindung DAS Tuntang

No	Sub Watershed	DDL	
		2015	**2023**
1	Sub Watershed Bancak	0,54	0,53
2	Sub Watershed Blorong	0,59	0,59
3	Sub Watershed Rawapening	0,52	0,51
4	Sub Watershed Senjoyo	0,46	0,45
5	Sub Watershed Temuireng	0,64	0,63
6	Sub Watershed Tuk Bening	0,58	0,57
7	Sub Watershed Tuntang	0,45	0,45

Based on the analysis results, the carrying capacity of the protected function in each sub-dash shows a value that does not experience significant changes. The carrying capacity value ranged from 0.45 to 0.64 in 2015 and from 0.45 to 0.63 in 2023. This shows that the sub-watershed protection function is dominated by values close to 1, which can be categorized as moderate-good. This is based on the carrying capacity category of protected functions with a value range of 0 (minimum) to 1 (maximum).

Changes in value occurred in the Bancak, Senjoyo, Temuireng, and Tuk Bening sub-watersheds, where the sub-watersheds experienced a decrease in DDL value. The Rawapening sub-watershed part of the upper reaches of The Rawapening sub-watershed occupies the upper reaches of the Tuntang watershed, primarily within the administration of Semarang Regency and a small portion within Salatiga City. The Rawapening sub-watershed falls into the category of watersheds where carrying capacity has been restored (Mardiatno, 2021). Based on the results of extensive data processing in 2015, the smallest allotment area in the Rawapening Sub-watershed area was open land, amounting to 6.32 ha, and the largest allotment area was plantation forest, amounting to 7911.5 ha. In 2023, the same land allotment still holds the smallest and largest land areas: open land remains the smallest allotment at 6.32 ha, while plantation forest has decreased to 7788.7 ha.

Land conversion from moorland to built-up land is expected in the Rawapening Subwatershed due to the development of transportation routes, activity centers, economic facilities, and land use as cultivation areas (Sadewo, 2022). This is evidenced by the results of the study on existing land cover, where the building area increased from 2015 to 2023, with the initial building area of 5398.2 ha increasing to 5763.6 ha. This is certainly in line with the decrease in the area of plantation forests, which is dominated by mixed gardens or so-called *tegalan*, which have decreased in area as mentioned.

In the Rawapening sub-watershed, the Rawapening site is a natural lake ecosystem that plays a strategic role as a source of fresh water, irrigation, freshwater fisheries, and others (Amalia et al, 2024). Thus, good management is carried out because the area is a water catchment area and is included in the list of critical lakes in Indonesia. However, the upstream Tuntang Subwatershed catchment, namely the Banyubiru area and around Rawapening Lake, has relatively good land cover conditions because there are also PTP coffee plantations. Likewise, the Senjoyo Sub-watershed area, where the Senjoyo Catchment is still relatively good, has dense vegetation in community land and PTP rubber plantations.

Land use and management upstream significantly affect the biophysical condition and quality of the watershed in the middle and lower reaches. The downstream Tuntang sub-watershed, in the Demak regency, is often flooded due to flood submissions from the upper Tuntang. This is due to natural conditions such as high rainfall, critical upstream land that cannot retain rainwater, or the existing weir management that opens the outlet of Rawa Pening Lake (Purwanto, 2014).

In the Tuntang watershed area in the middle part (Tuk Bening, Bancak, and Temuireng sub-watersheds), the dependence on land is heavy, meaning that the agricultural sector is more significant than 70% of the population depends on the agricultural sector. Minor damage occurs in the middle part of the Tuntang Sub-watershed, namely the Kalijambe area and the Bringin Sub-district, where seasonal crops have cleared and cultivated the forest area. Land degradation occurs mainly in the middle of the Tuntang watershed, namely the Blorong Subwatershed and Temuireng Subwatershed in the Kedungjati area. This area is dominated by forest areas that currently have poor land cover. The impact of land degradation in the central part of the Tuntang watershed results in annual flooding in Demak and Grobogan regencies. Meanwhile, in the Bancak Subwatershed/catchment area, land cover is dominated by rice fields and hardwoods such as sengon, mahogany, and teak, whose land cover is still relatively good.

Dryland farming in the Temuireng Sub-watershed tends to be small because dryland farming requires the characteristics of areas with limited water availability. The administrative area of Boyolali Regency is predominantly humid, so there is little potential for dryland agriculture (Nugraheni & Prabowo, 2022). The plantation forest in the Temuireng Sub-watershed is quite large. Therefore, the Temuireng Sub-watershed area is dominated by plantation forests, providing ample supply for the industry.

Downstream of the watershed, built-up areas have increased the fastest, while agricultural areas have decreased as a consequence. These changes can at least reduce the amount of rainwater that seeps as groundwater and increase the amount of water that flows on the surface into floods. Tuntang watershed management is mild, but its problems are severe especially social ones. However, social problems downstream due to low income still need to be solved by implementing watershed management.

Tuntang Sub-Watershed is a sub-watershed that is mainly located in the Demak Regency and the other part in the Grobogan Regency. The Tuntang sub-watershed is located in the last stream or downstream of the Tuntang watershed. In addition, its existence downstream makes the Tuntang sub-watershed a high conservation priority due to coastal erosion or abrasion (Sriyana, 2019). Abrasion occurs downstream of the Tuntang Sub-watershed, resulting in an imbalance in the coastal ecosystem. This can cause ponds, settlements, and mangrove ecosystems to be eroded, submerged, or even lost. High erosion conditions show that the carrying capacity function of the Tuntang watershed, which should be able to accommodate, store, and drain water naturally, needs to run optimally according to its designation.

4. CONCLUSIONS

Tuntang watershed as a whole experienced a decrease in DDL value based on data analysis conducted on each sub-watershed. Temuireng Sub-watershed had the highest DDL value among other Sub-watersheds in 2015 and 2023, which amounted to 0.64 and 0.63. The lowest value is in the Tuntang Sub-watershed, which is 0.45, almost the same in both years of study. Evenly, the decrease and change in DDL value that occurs in each Sub-watershed tends to be almost the same at 0.1. The decrease occurred due to changes in land use in the Tuntang watershed and the times. In addition, this occurs due to increased land use, which has changed from open to developed land.

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