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Relationship Between Mangrove Condition and Socio-economic Livelihoods of Fishermen Traps in Central Tapanuli

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Abstract*— Central Tapanuli Regency is a region that has significant potential in the fisheries sector, mainly traditional fisheries, due to its extensive mangrove ecosystem and lengthy coastline. Mangroves are essential for the livelihood of local fishing, as they protect the marine environment and serve as a barrier against coastal erosion. The mangrove ecosystem in Central Tapanuli Regency is experiencing increased pressure due to land conversion, illicit logging, and other human activities, as research surveys indicate. This pressure has a negative impact on the productivity of catches and the welfare of fishermen. This risk is undoubtedly a significant concern; the ecological value of the mangrove ecosystem may be diminished, resulting in a decrease in the catch of local trap fishermen. Consequently, this research is necessary for the local government to reference when developing mangrove management strategies. This investigation aimed to assess the state of the mangrove ecosystem in Tapian Nauli Bay and the correlation between mangrove conditions and the socio-economic status of crab trawl fishermen. The investigation was conducted in Central Tapanuli, specifically in Tapian Nauli Bay. Surveys and interviews with respondents were implemented to accumulate data. Descriptive and correlational analyses are implemented. The results of this study indicated that 60% of the mangroves in Tapian Nauli Bay were in excellent condition, while only 30-40% were in poor condition. The income of bubu fishermen is significantly influenced by the presence of mangroves, as the catches they capture increase, thereby improving their livelihoods.

Keywords—Central Tapanuli Regency, Mangrove, Tapian Nauli Bay, Traps Fisher's.

I. INTRODUCTION

The fisheries sector, mainly traditional fisheries, is up-and-coming in Central Tapanuli Regency due to its extensive mangrove ecosystem and lengthy littoral. Mangroves are crucial in the economic livelihoods of local fishers, as they serve as coastal abrasion barriers and marine habitat protectors. This ecosystem's sustainability is paramount to trapping fishermen, who depend on mangroves as their primary fishing grounds. Nevertheless, fish productivity and fishermen's well-being are adversely affected by the increasing pressure on mangrove ecosystems due to land conversion, illegal forestry, and other human activities [1].

The condition of the mangrove ecosystem is inextricably linked to the sustainability of trap fishers' socio-economic existence. The primary source of livelihood for fishers is the habitat provided by healthy and sustainable mangroves, which are home to a variety of fish, crustaceans, and other biota. Consequently, it is imperative to comprehend the correlation between fishers' socio-economic status and mangroves' conditions to develop sustainable management policies [2].

Mangrove forests are crucial in coastal ecosystems such as Central Tapanuli and North Sumatra. In addition to safeguarding shorelines, these forests also serve as a source of income for fishery communities that rely on marine resources. In Central Tapanuli, a significant number of fishermen employ conventional fishing equipment, including Bubu. Nevertheless, the socio-economic well-being of fishermen may be impacted by human activities, including deforestation and land conversion for aquaculture, which pose an escalating threat to the condition of mangrove forests.

Although the significance of mangroves in sustaining the livelihoods of fishermen has been acknowledged, numerous mangrove areas in Central Tapanuli Regency are in a state of degradation. The productivity of bubu fishers, who depend on these ecosystems to capture crustaceans, fish, and other species, can be adversely affected by this damage. The primary concern is the impact of changes in mangrove ecosystem conditions on the socio-economic livelihoods of trap fishers. Furthermore, the absence of empirical data regarding the direct and indirect effects of mangrove degradation on the welfare of fishers complicates the development of effective management strategies.

Mangroves are multifunctional ecosystems crucial for maintaining local livelihoods and economies, providing various ecosystem services and resources [3]. Mangroves

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serve as a feeding, nursery, and spawning habitat for various aquatic organisms, making them one of the buffer systems [4]. This condition suggests that the mangrove ecosystem may contribute to habitat devastation, resulting in the extinction of various flora and fauna species that rely on mangrove ecosystems. Human intervention, which involves the conversion of mangrove land into ponds, settlements, industries, and other structures, is a cause and effect in addition to the harm caused by natural factors [5].

Tapian Nauli Bay, Central Tapanuli Regency, is one of the regions with mangrove forests, with a mangrove thickness of 70,571 m. Degradation harms the mangrove ecosystem in the Small Island Park MPA area. The activities of residents have also posed a hazard to Central Tapanuli.

As indicated by the survey, the mangrove ecosystem is at risk due to the diversion of land functions and the cutting down of mangrove trees for building materials and structures. This peril is undoubtedly a significant concern. The illegal clearance of mangrove forests threatens numerous sectors due to the potential for developing intricate environmental and ecosystem issues. These conditions can affect the components, including benthos and plankton, susceptible to environmental fluctuations. Assume that the presence of trophic animals is disrupted. In that event, the ecological value of the mangrove ecosystem may be diminished, leading to a decrease in the value of the environment, a decline in the number of fish caught, and a reduction in the income of small-scale fishermen in the local coastal region. Most fishermen in the coastal area of Tapian Nauli Bay employ bubu fishing gear. The haul and livelihood of bubu fishermen will be affected if the conversion of mangrove forests persists. Previous research has demonstrated a robust correlation between mangrove forests and fish resources. Specifically, the sustainability of fish resources is contingent upon the sustainability of mangrove ecosystems and the relationship between changes in mangrove areas and fish production. The linear positive relationship between fish production changes and mangrove areas is evident.

The mangrove ecosystem of Central Tapanuli Regency has been the subject of numerous previous studies, including the status and distribution of mangroves in the conservation area [6], mangrove vegetation study in the mangrove ecosystem [7], [8] mangrove health assessment [9], and the distribution and abundance of mangrove species seedlings in the intertidal zone. The distribution, health, and variation of mangrove growth were the sole focus of previous research patterns. Therefore, the information is restricted to mangroves' distribution, variations, and development. Nevertheless, research has yet to examine the correlation between local fishermen's socio-economic livelihoods and the mangroves' conditions. Therefore, there is a lack of information regarding the relationship between the issue of mangrove clearance and the livelihoods of local fishermen, even though mangroves are a critical ecosystem that serves as a habitat for biota such as crabs and a fishing area for fishermen who employ Bubu fishing gear.

Consequently, this investigation is deemed crucial to ascertain the relationship between mangrove forests' condition and bubu fishermen's circumstances in Central Tapanuli. This will enable the identification of the most effective solution to ensure the welfare of the fishing community and the preservation of a sustainable mangrove ecosystem. This research endeavors to evaluate the state of the mangrove ecosystem in Central Tapanuli Regency and to establish a correlation between the socio-economic circumstances of Bubu fishermen and the condition of the mangrove ecosystem.

Consequently, this research is deemed crucial to ascertain the relationship between the condition of trap fishermen in Central Tapanuli and the condition of mangrove forests and identify the most effective solution. This research aims to evaluate the state of mangrove ecosystems in Central Tapanuli Regency and establish a correlation between trap fishers' socio-economic livelihoods and the condition of mangrove ecosystems.

II. METHOD

This research was conducted in July 2024, focusing on Mela 1 Village, Central Tapanuli Regency, North Sumatra. The selection and determination of this area was chosen because the dominant fishermen use traps and fishing gear to catch fish, and the location of the mangrove forest is quite extensive.

Data were gathered from both primary and secondary sources. Data on the status and distribution of mangroves in Central Tapanuli Regency, economic data of Central Tapanuli fishermen, data on the condition of the mangrove coastal environment, correlation of mangrove clearing with fishing activities and resource utilization in mangrove ecosystems, and income of fishermen were all collected as primary data. The area and density of mangroves in Central Tapanuli, economic statistics on Central Tapanuli fishermen, fishermen's harvest production, and satellite mapping to monitor land change were collected as secondary data.

The purposive sampling method was employed to identify respondents by the researcher's criteria, and a direct survey of fishermen directly associated with mangroves was used for data collection. In this instance, the respondents were fishermen, coastal communities adjacent to mangroves, and district administrations related to mangroves, specifically the Central Tapanuli Regency Marine and Fisheries Service and Tapanuli Tengah fishermen groups. The information was acquired through the use of interview techniques.

Descriptive statistical analysis is employed in the initial research objective, while regression and multivariate analysis are used in the second. An overview of the socio-economic data of fishermen and the conditions of the mangroves in Central Tapanuli Regency was provided by descriptive statistical analysis. In the interim, regression analysis established the correlation between the socio-economic variables of fishermen (income, education, and resource access) and the conditions of the mangroves. The factors contributing to variations in mangrove conditions can be ascertained

through this analysis. In the interim, multivariate analysis was implemented to investigate the correlation between the socio-economic variables of different fishers and their impact on mangrove conditions.

II. Result and Discussion

1. Mangrove Forest's Ecological State

Central Tapanuli and Sibolga Mangrove forests are dispersed along river estuaries, harbors, and coastlines. These mangroves, an essential habitat for various marine fauna, such as shrimp, crabs, and fish, provide natural littoral protection from abrasion and erosion. Mangrove forests are a collection of diverse vegetation, such as palms, shrubs, vines, and ferns, that coexist in tidally inundated land and near river openings. Other organisms that inhabit mangrove forests depend on mangrove vegetation. Central Tapanuli Regency encompasses 6,931 hectares of mangrove forests, while the regional water area spans approximately 1,011 hectares. The canopy cover is classified as "good" and ranges from 60%. Data indicates that 30-40% of the current mangrove forest area in Central Tapanuli Regency, particularly in Tapian Nauli Bay, has been damaged or destroyed.

The coastal environment in Central Tapanuli consists of various ecosystems, including a mangrove forest ecosystem composed of multiple communities around Tapian Nauli Bay. The mangrove forest community located in Tapian Nauli Bay is composed of mangrove species (*Rhizophora mucronata*), Avicennia officinalis (*Rhizophora apiculata*), and (*Rhizophora stylos*) (**Figure 1)**.

Unfortunately, however, mangrove forests in this region have been damaged by several factors, including:

1) Land Clearing and Conversion: Numerous mangrove forests are cleared to facilitate the construction of plantations, reservoirs, or settlements. Consequently, the extent of mangrove forests has considerably diminished.
2) Resource Exploitation: The degradation of these forests is also exacerbated by the logging of mangroves for firewood or construction materials. Furthermore, the mangrove ecosystem is also impacted by environmentally hostile fishing activities, such as using destructive fishing gear.
3) Pollution results from the improper treatment of domestic and industrial refuse discharged into rivers and seas. This pollution is detrimental to the quality of water and mangrove ecosystems.

Figure 1. Mangrove condition in Tapian Nauli Bay

According to Figure 1, the mangroves in Tapian Nauli Bay, Central Tapanuli Regency, are generally in good condition. This condition is supported by fishermen continuing to engage in shrimp fishing activities near the mangroves, and the results are promising. Nevertheless, there are specific regions where mangroves are harmed due to human activities, such as fishing, mining, and residential expansion. The exploitation of fishing activities, the need for basic materials, and the increasing number of people each year are all potential causes of this damage. The area or vegetation of mangroves in Tapian Nuali Bay, in particular, and Central Tapanuli Regency, in general, will be damaged and reduced in area if this persists and is left without excellent and sustainable management in the future, according to [10], if this continues and is left without excellent and sustainable management in the future, the area or vegetation of mangroves in Tapian Nuali Bay, in particular, and Central Tapanuli Regency, in general, will be damaged and reduced in area.

2. Relationship between the condition of mangrove ecosystems and the socio-economic livelihoods of trap fishers

According to the findings of field observations conducted through interviews with respondents from Bubu fishing gear, coastal communities, and the government, they have a relatively consistent perspective on the advantages of mangrove ecosystems in their respective lives. The mangroves surrounding Tapian Nauli Bay are essential to the Bubu fishermen's catch, as they typically capture mangrove crabs and crustaceans near the mangrove area. The economic conditions of the bubu fishermen are extremely closely correlated with the existence and condition of mangroves, as evidenced by the correlation value (r) of 0.95, nearly equal to 1. Consequently, the relationship is extremely close. This relationship is possible because fishermen's catches, typically crab and crab species, are associated with mangroves. Therefore, the existence of both species will be abundant if the mangroves are in excellent condition. The condition of the mangroves significantly influences the quantity of capture that fishermen acquire. A substantial catch will enhance fishermen's income or economy.

The littoral communities residing near Tapian Nauli Bay are safeguarded from the abrasion and giant waves that can occur on the land. This is due to the presence of mangrove ecosystems. The position of Central Tapanuli, which is directly in front of the Indian Ocean and has the characteristics of quite large waves, can result in large waves and abrasion on the land around the coast. Consequently, the mangroves in the vicinity play a critical role in mitigating surges. Regarding the surrounding government, both villages and districts receive numerous advantages, including the well-maintained waters, the community's stable economy, and the diverse biota surrounding Tapian Nauli Bay, which will augment the government's revenue. Additionally, the government is most optimistic about the potential of the mangrove to serve as a viable marine tourism destination or to provide support for the education and revenue of the local government in the Central Tapanuli and Sibolga regions.

Compared to other ecosystems, the mangrove forest ecosystem is a critical ecological chain for living organisms in the surrounding waters due to its high productivity and high decomposition (decay) of organic matter [11]. The presence of organic matter in mangrove forests serves as a breeding ground and sustenance source for various biota, including shrimp, crabs, and fish. Fish and shrimp production in marine waters significantly influences litter production in mangrove forests. This litter comprises organic debris, including dried leaves, twigs, small branches, bark, flowers, and fruits that have changed color [12].

A mangrove forest is a critical ecosystem on an ecological scale, mainly due to its capacity to maintain the stability of coastal ecosystems. The stability of the mangrove ecosystem will significantly impact the sustainability of coastal regions. Growing on muddy coastlines and river estuaries, mangroves are forest ecosystems with highly unique properties and characteristics. Conversely, the expansion of various other utilization desires is causing this ecosystem to undergo a variety of extremely severe pressures [13].

Fishermen's daily activities are in constant contact with mangrove forest ecosystems, which is why they play a critical role in their lives [14]. Consequently, it is imperative to implement various measures to rehabilitate damaged mangrove forests to ensure that they can once again fulfill their intended functions for the benefit of humanity, particularly seafarers, and to facilitate the growth of coastal regions. The success of mangrove conservation can be contingent upon the involvement of mariners in mangrove rehabilitation and management initiatives [15].

Mangrove ecosystems' physical, ecological, and socio-economic functions are significant for the adjacent communities and coastal and marine ecosystems. Beaches, housing, and other physical structures are safeguarded by mangrove ecosystems, capable of withstanding waves or wind during cyclones [16]. Additionally, mangrove ecosystems provide germplasm, spawning, nurturing, and feeding grounds for various aquatic biota, including fish, prawns, and crabs. From an economic standpoint, mangrove ecosystems can be employed as educational and learning facilities, capture fisheries and aquaculture, and tourist destinations [17].

Nevertheless, mangrove ecosystems have sustained severe damage due to land use changes and over-exploitation. This condition results from a need for more public awareness of the function of mangrove ecosystems, ineffective law enforcement, and high levels of exploitation [18]. The damage has had a negative impact on society and the environment, as evidenced by the following: a decrease in fish catches, disruption of aquaculture activities, freshwater shortages due to seawater intrusion, increased coastal erosion, and damage to residential areas from wind and storms [19].

IV. CONCLUSION

According to the investigation findings, the mangroves in Tapian Nauli Bay, Central Tapanuli Regency, are generally in excellent condition, with a condition score of 60%. The damaged condition is estimated to be between 30% and 40%. The socio-economy of bubu fishermen is closely correlated with mangroves, with a correlation value (r) of 0.95 or nearly 1, indicating a very close relationship. If mangroves serve as a gathering place for fishermen's target species, the harvest and the fishermen's income also increase.

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