SPECIES DIVERSITY ON SANDBAR PRESENT IN ESTUARINE ECOSYSTEM OF AGUSAN RIVER, PHILIPPINES: ITS THREAT, MANAGEMENT, AND CONSERVATION

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ABSTRACT. *Estuary is a unique ecosystem due to the gradients of ecological conditions from riverine to marine. In some cases, there is sandbar in an estuary which rarely gets attention in scientific activities and conservation management. At the mouth of the Agusan River, the Philippines, where freshwater from the Agusan River and saltwater from Butuan Bay converge, lies one of Mindanao's most significant estuaries with the presence of sandbar. The aim of this study is to identify all the available species (flora, fauna, and fungi) in the sandbar located in an estuary along the Agusan River and know the possible threats happening on the sandbar. The study used a descriptive method to examine many viewpoints and discover connections between the complex relationships among species on the sandbar. We utilized diversity parameters formulated as Shannon's diversity, richness, evenness, and dominance indices. The results showed that the sandbar had Shannon's diversity index of 1.231 featuring a low diversity level due to anthropogenic activities such as water pollution and habitat fragmentation that can negatively affect the species in the sandbar. Based on the International Union for Conservation of Nature, it appeared that species present in the sampling area were categorized under Vulnerable (VU), Near Threatened (NT), and Least Concern (LC). This meant that some of the species in the sampling area may be gone for approximately 10 years from now if not given proper attention and care. We strongly suggest strengthening the conservation and management plan like continuous mangrove planting and security provided by the Local Government Unit of the place. This study concluded that the place should undergo a more thorough evaluation to come up with better management and conservation planning.*

Keywords: Biodiversity, Diversity Index, Estuarine, Sandbar, Management, Conservation

I. INTRODUCTION

Estuaries encompass gradients of ecological conditions from riverine to marine. During high catchment flows or floods, an estuary can become a river mouth with no seawater entering the formerly estuarine area. On the other hand, when there is little or no fluvial input, an estuary can be isolated from the sea by a sandbar and become fresh or even hypersaline [1]; modified by van Niekerk and Turpie 2012). The sandbar's main function is to limit the water exchange between the estuary and the open sea [2].

Estuaries are subject to a variety of stresses, and it is becoming more and more clear how they are responding to climate change. Estuaries' capacity to provide essential ecosystem services decreases as their health declines. Estuaries exhibit a wide array of human impacts that can compromise their ecological integrity mainly because of rapid population growth and uncontrolled development in many coastal regions worldwide. Long-term environmental problems plaguing estuaries require remedial actions to improve the viability and health of these valuable coastal systems. Detailed examination of the effects of pollution inputs, the loss and alteration of estuarine habitat, and the role of other anthropogenic stress indicate that water quality in estuaries, particularly urbanized systems, is often compromised by the overloading of nutrients and organic matter, the influx of pathogens, and the accumulation of chemical contaminants. In addition, the destruction of fringing wetlands and the loss and alteration of estuarine habitats usually degrade biotic communities. Estuaries are characterized by high population densities of microbes, plankton, benthic flora and fauna, and nekton; however, these organisms tend to be highly vulnerable to human activities in coastal watersheds and adjoining embayment. Trends suggest that by 2025 estuaries will be most significantly impacted by habitat and alteration associated with the burgeoning coastal population, which is expected to approach six billion people. Habitat destruction has far-reaching ecological consequences, modifying the structure, function, and controls of estuarine ecosystems and contributing to the decline of biodiversity [3].

The impact of these stresses on estuaries and the areas that call for intervention has been clearly highlighted by research on estuaries. Future estuarine research will be necessary to support collaborative governance and the implementation of the Ecological Reserve and Estuary Management Plans [4]. Numerous difficulties must be overcome to effectively manage anthropogenic activities that put stress on estuarine biodiversity. Several problems are general to many estuaries, while others are site-specific, such as the various environmental and socioeconomic objectives and competing views and priorities. An evaluation of known human activities in and around the site for their potential to endanger the designated habitats and species features should be done as part of the preparation of the management scheme. This assessment also helps to identify the management authorities' necessary actions to reduce or remove pressures and threats [5].

A multidimensional biodiversity index for national application alarmed us to the lack of urgent action to reverse biodiversity loss is partly due to the complex nature of biodiversity as a feature of our planet [6]. Subsequently, policymakers receive an often-confusing variety of narratives on why biodiversity matters, which makes it difficult to link biodiversity and risk to the attainment of sustainable development. In the context of the Philippines [7], it is stated that the scientific references behind the various biodiversity areas within the country, as well as the status of their conservation, remain lacking and thus require continuous effort. The shortcomings of the available data should not be a reason for postponing action on

conservation, but perhaps instead encourage better prioritization and focus. The inadequacies also reflect the necessity of being adaptable in approaching biodiversity management and protection.

One of the most important estuaries in the Philippines is the mouth of the Agusan River, Mindanao. The influx of freshwater from the Agusan River meets the seawater of Butuan Bay where *Johnius borneensis* (locally known as "guama") is one of the most abundant and important food fish in the Agusan River estuary [8]. A deeper comprehension of the richness of species is found in the Agusan River mouth and on the sandbar that borders Butuan Bay, particularly in the Municipality of Magallanes. It is helpful in calculating their biodiversity index and further establishing management plans that take these migration patterns into account, a problem that is crucial for both ecosystems. It revealed that the municipality of Magallanes has the lowest number of mangrove species due to many anthropogenic disturbances [9].

Sheltered waters of healthy estuaries are home to rich and diverse communities where marine, aquatic, and terrestrial flora and fauna mix and interact [10]. The objective of this study was to investigate the flora and fauna diversity on sandbar present in the estuarine ecosystem of the Agusan River. It is expected the result of this study might inform people of the importance of estuaries in maintaining ecological balance.

2. MATERIALS AND METHODS

Study Area and Period

The study was located at a sandbar in an estuary along Agusan River with the coordinates of 9°00'52.1"N 125°30'33.3"E near Barangay Lumbocan, Butuan City bounded to the land of the Municipality of Magallanes, Agusan del Norte.

Research Design

This study used a descriptive research approach which entails gathering and analyzing quantitative data for a study [11]. This sought to describe the status of an identified species available on the sandbar present in the estuary along the Agusan River. Descriptive method research takes advantage of the potential benefits of quantitative methods, enabling researchers to examine many viewpoints and discover connections between the complex relationships among species on the sandbar situated in an estuary.

Data Collection Procedure

We used a 10x10 meter sampling transect at a specific area of the sandbar in the estuary along the Agusan River that was randomly chosen based on its categories. Random sampling was used because it allows us to easily determine the composition of all species available in the sandbar. Typically, a specified number of transects of a particular size are put in a habitat of interest, and the species found inside those transects are identified and documented [12]. We randomly measured three transects ten meters apart. The sampling sites were determined randomly using wooden sticks and straw thread. We classified the sampling sites based on hydrological conditions: (i) areas without surface water; and (2) areas with surface water.

After doing all the preliminary measures, we then identified if there were contributing factors affecting the biodiversity of the area. The researchers were assisted by the field guides in locating the sampling sites and in identifying each species with reference from the Taxonomic Key Manual for correctness and accuracy. To investigate the potential causes of protection success, we explored using socio-environmental diagnosis and management protocols, inventories of local and planted species, data and photographic records, mapping, and other information [13]. Semi-structured stakeholder interviews, fishermen's observations, and document analysis were used to gather the data for this study.

Data Analysis

We used the diversity index as a mathematical measure of species diversity in each community and was based on the species richness (number of species present) and species abundance (the number of individuals per species) [14]. One of the referred-to family of heterogeneity indices is the Shannon diversity index. Although they rely on the relative distribution of individual species, these indices do not specifically take taxa richness into account. Shannon's information formula, $H' = C\Sigma\ p\ i\ \log2\ p\ i$, is found to be linearly related to evenness and to the log2 of the number of species [15]. Shannon's Diversity Index and equitability were then classified into low, medium, or high diversity of organisms.

To measure species' evenness, we also counted the number of terrestrial plants and animals for each species. Species richness is the first parameter to be considered when evaluating biodiversity. The first step is always to determine how many taxa are present in the sample under consideration. The biodiversity index was analyzed to determine its relationship to the two component parts of richness, evenness, and dominance [16]. The Shannon Diversity Index, Species Richness, Dominance, and Evenness were the sole metrics calculated using the Paleontological Statistical Software Package (PAST).

We monitored the status of fauna and flora of the sampling area to determine the population abundance and distribution, then identified and prioritized the factors which may impact the abundance and distribution of general threats [17]. We interviewed residents in the area for some changes observed within a period to be recorded for future use and to address the issues being recognized.

3. RESULTS AND DISCUSSION

Species Composition

The entire variety of species found in a particular biome or ecosystem is known as species composition [18]. Across the sampled sites, a total of 9 species of flora were recorded with 8 species able to be identified while the other one was unknown. Moreover, 6 species of fauna were also recorded with 5 identified and the remaining one was unknown. Another species of fungus was also recorded and identified as observed on the three sites in the sandbar along the Agusan River.

The goal of biological classification in this study, also known as taxonomy, is to organize and condense the enormous diversity of life into coherent groups of organisms called

taxa, each of which has a name that is generally recognized and whose members share key characteristics [19]. This can make use of the different knowledge of shared biological characteristics of taxa by integrating heterogeneous, character-based data in a phylogenetic framework through the process of biological classification. Classifications are frequently categorized as either phylogenetic or evolutionary, mostly based on whether they reject paraphyletic groups. With the use of taxonomy, the identification of all species in different taxon levels had been very useful in determining how widely diverse the sandbar was. Tables 1 and 2 show the taxonomy of species and number of individuals for plants and animals found within the three-sampling area in the sandbar in Agusan River.

Table 1. List of plant species recorded in the sandbar along the Agusan River

Family	Species	Local Name	No. of Individuals	IUCN Status
Rhizophoraceae	*apiculata*	Baklaw	23	Least Concern
Malvaceae	*riliaceus*	Lalaki Anagdong	3	Least Concern
Combretaceae	*catappa*	Talisay (Tavola)	2	Least Concern
Araceae	*oblongifolia*	Bagon-bagon	25	Least Concern
Lythraceae	*alba*	Pagatpat	1	Least Concern
Euphorbiaceae	*agallocha*	Piapi	6	Least Concern
Rhizophoraceae	*mucronata*	Bakhaw	25	Least Concern
Aracaceae	*fruticans*	Nipa Palm	20	Least Concern
Unknown	*Unknown*	Sampinit	5	Unknown
		Total	**110**	

Table 1 shows the nine plant species in three sampling areas which belong to 7 families and 8 genera with a total of 110 individuals. It indicates that the sandbar situated in an estuary along the Agusan River is considered significant when it comes to having diverse species of plants. Significantly, this taxonomy of species on kingdom Plantae helped the researchers to identify the possible available plant species present in the sandbar. Using this taxonomic nomenclature, researchers would be able to understand more how wide the scope of organisms could get in the hierarchical system.

Human well-being depends on plants, which also supply vital ecosystem services that are fundamental parts of natural capital. They offer essential solutions to some of the world's biggest problems, including bioenergy, human and animal health, nutrition, microbial resistance, industrial biotechnology, and synthetic biology. They supply food, medicine, fiber, fuel, and building materials, as well as a wide range of other benefits to society [20] showed a standardized DNA fragment for barcoding to identify taxon, which has demonstrated a potential in offering a useful, uniform, species-level identification tool for ecological research, life history evaluations, and forensic investigations, and this method has been frequently used ever since its debut in 2003.

Table 2 shows five 6 species recorded in the three sampled sites which belong to 5 families and 5 genera with a total of 1,444 individuals. Based on these results, the fauna can be considered as significantly diverse in the sandbar.

Table 2. List of animal species recorded in the sandbar along the Agusan River.

Family	Species	Local name	Number of Individuals	IUCN Status
Neritidae	*natalensis*	Bungkaha	335	Near Threatened
Potamididae	*decollata*	Saka-saka	120	Least Concern
Varunidae	*takanoi*	Kamas-kamas (Asianshore crab)	64	Least Concern
Coenobitidae	*clypeatus*	Umang/ Hermit Crab	1	Vulnerable
Pachychilidae	*ater*	Banisil	917	Least Concern
UNKNOWN	UNKNOWN	Spider	7	UNKNOWN
		TOTAL	**1,444**	

The table above presents various animal species that were recorded during the sampling visit. It was found that there were animal species that significantly live along with plants that were also noted. Understanding how interactions among species impact their abundance, behaviors, and genotypes is a key objective in ecology and evolutionary biology [21]. Studies in terrestrial plant-animal interactions have classically focused on direct, pairwise interactions. However, more recently, an understanding of how multispecies interactions drastically modify both the ecological and evolutionary outcomes of interactions in ways that could not be expected from a knowledge of pairwise interactions alone has developed.

It is highlighted a substantial gap in our fundamental understanding of life on Earth by stating that, except for a few taxa that have been widely investigated, the number of species is still strikingly unknown [22]. A quantitative method is used to estimate the number of species in all domains of life present in the sandbar. We report that the number of higher taxa, which is far better known than the total number of species, is substantially associated with taxonomic rank, and that this pattern enables extrapolation of the global number of species for every kingdom of life.

Table 3. Fungi species recorded in the sandbar along Agusan River.

Family	Genus	Species	Local Name	Number of Individuals	IUCN Status
Psathyrellaceae	*Psathyrella*	*Candolleana*	Kaupas	11	Not Evaluated
			Total	**11**	

Table 3 shows one species of fungus was recorded in the three sampling sites with a total of 11 individuals. This shows that living organisms present in the sandbar not only comprise plants and animals but also microorganisms, specifically fungi. Fungi have received little attention. Through mutualisms, fungi have played and continue to play a crucial role in the evolution of terrestrial life, ecosystem

function and the preservation of biodiversity, human progress, and the functioning of the earth system.

Studies of the morphology of species from protistan kingdoms have been used to support the idea that eukaryotic microorganisms have worldwide geographic ranges, which is a considerable shift from the situation with microorganisms [23]. The importance of cultural preservation should be emphasized, as the conservation of these types of organisms is complementary. Collaboration at the local and national levels is necessary to create an inventory, quantify functional responsibilities, and implement conservation [24].

Of all the taxonomical groups, Faunus Ater had the highest number of individuals with an approximate number of 917. It can be found in the area because it thrives in disturbed and artificial habitats. It can also infrequently be found in virgin lowland and montane rainforests, although it typically prefers open, disturbed habitats, such as locations close to human habitation. This kind of species is known to be oviparous and recorded as largely distributed because of its extended free-swimming larval stage. However, this is known to be consumed and sold by humans. The existence of the Faunus ater has a role in the food chain in the sandbar ecosystem. Interaction between this species with other individuals is also reported as prone to indicative attacks by the crabs [25].

Two species of mangroves were recorded to be abundant in the area, namely Rhizophora mucronata with 25 individuals, and R. apiculata with 23 individuals. R. apiculata were found in 2 transects while R. mucronata were only seen in one transect. As observed, these species are also naturally grown on sandbars. Part of the existence of mangrove species is due to the restoration efforts of Barangay and Local Government Unit (LGU) through the planting of Rhizophora spp. seedlings which require proper assessment of hydrological and ecological conditions and the need to be focused on formerly deforested and degraded areas [26]. Meanwhile, the least seen species of flora and fauna in the sampling area were a mangrove species Sonneratia alba, and a crab species Coenobita clypeatus each with one individual. Species like mangroves and crabs have ecological importance. S. alba is one of the most pervasive and salt-tolerant mangrove species which inhibits low intertidal zones of the downstream estuarine system. It reaches an optimal growth in 5-50% seawater [27]. On the other hand, Hunt (2021) mentioned that C. clypeatus is a terrestrial crustacean that can survive several kilometers inland along with its ability to store water in its shells and uses enhanced chemosensory cues to pick gastropods to retrieve intact shells for protection from predators. This species is a generalist scavenger/decomposer of plant and animal matter.

Diversity Parameters

Ecology faces a significant issue in figuring out the function of biodiversity in controlling vital ecological processes like productivity. The association between producer diversity and production is favorable because diverse groups may use resources efficiently and extensively and can be more productive [28]. Comprehensive lists of species are regarded as a foundation for systematic revisions and for comparing diversity across taxa, but it is less known that they also offer a way for a statistical sampling of biodiversity databases [29]. It is stated that environmental diversity" refers to any measure of environmental diversity employed as an environmentally based surrogate [30].

Diversity parameters calculated as species richness, dominance, diversity, and evenness of all species in the sandbar of Agusan River is shown in Table 4. Combined across all taxa groups, Quadrat 3 had the highest number of counted individuals among the three-sampling area with 675 individuals. This site was characterized by a coastal area with sandy ground and little surface water where Faunus ater abundantly situated. Conversely, Quadrat 1 had the lowest number of individuals recorded with 232. Anthropogenic disturbances observed in the site included wood sawdust deposits and garbage carried by flood from the mainland. These activities may contribute to the reduction and degradation of habitat. These activities can cause the loss of their habitat and have a significant impact on the abundance and diversity of species [31].

Typically, rare species make a greater contribution to functional diversity than common ones. However, humans have changed the occupancy and abundance patterns of many species-the basis upon which we define "rarity" in this study, the researchers used significantly significant data from the sandbar that is currently protected from any harmful activities caused by different factors to test whether there were rare species that over- contributed to the functional diversity of the place [32].

Table 4. Diversity parameters in term of the number of individuals, species richness, dominance, diversity and evenness of combined flora, fauna, and fungi at each sampling site

Sampling Site	Description	Number of individuals	Species richness	Species diversity	Evenness	Dominance
Quadrat 1	Coastal area	232	13	1.751	0.4431	0.2987
Quadrat 2	Areas without surface water	666	10	1.265	0.3543	0.3664
Quadrat 3	Coastal area	675	19	0.6792	0.1972	0.7143
	Overall	**1,573**	**11**	**1.331**	**0.331**	**0.4598**

Table 4 shows that Quadrat 1 had species richness (S) equivalent to 13 which was the number of species in the quadrat. It has Shannon diversity (H') and evenness (E) indices of 1.751 and 0.4431, respectively indicating a moderate diversity and evenness level according to Moutsambote (2016). It was also observed in the table that this site had a dominance (D) of 0.2987 indicating that there were no dominant species in the site.

Quadrat 2 had a total number of individuals 666 with a species richness of 10, Shannon diversity of 1.265, evenness of 0.3543; and dominance of 0.3664. The data showed a higher number of individuals per species; however, the species diversity was as low as the evenness of the sampled area. According to Shannon diversity index has high values when all species have the same importance, and it has low values when only a few species have strong importance [33]. There were also no dominant species found in Quadrat 2.

Lastly, Quadrat 3 had species richness (S) of 10, Shannon diversity index (H') of 0.6792, evenness (E) of 0.1972; and dominance (D) of 0.7143. It can be observed in the table that among the three quadrats, Quadrat 3 may have the greatest

number of individuals however it had the lowest diversity level and evenness index level. This is likely because of the presence of the dominant species of Faunus ater in the quadrat.

The overall individual recorded from these three Quadrats is 1,573 across all taxonomical groups. The overall Shannon's diversity index is 1.231, indicating a low diversity level [34]. With a lower number of individuals (species abundance) and considerable number of species in an area (species richness), and distribution of organisms per area (evenness), Quadrat 1 is considered more diverse compared with the other sampling sites.

Species diversity

The variety of species present in a region and their relative abundance is referred to as species diversity [35]. The effects of diversity on ecosystem processes might not only be determined by the number of species or genotypes. Recently, attention has been drawn to functional diversity and how it affects ecosystem processes including nutrient cycling and system productivity [36].

The Shannon-Weiner species diversity Index is calculated by taking the number of each species, the proportion of each species of the total number of individuals, and summing the proportion times the natural log of the proportion for each species. The higher the number, the higher is the species diversity [37].

Table 4 shows that Quadrat 1 has the most diverse species in the sandbar with the value of 1.751 followed by Quadrat 2 with 1.265 and Quadrat 3 with 0.6792 as the least. This explains that among these three quadrats, Quadrat 1 showed different species from different kingdoms based on the level of taxonomy used. The results only show that Quadrat 1 exhibited more variety of species that includes their relative abundance. The data presented can be used as one of the significant factors in the total diversity of species present in the sandbar.

Species Richness

Most of the existing knowledge comes from research that has concentrated on how species richness and, to a lesser extent, functional group richness drive above-ground productivity in addition to other ecosystem processes [38]. Ecosystems are valued largely for the variety of services and functions they offer; hence it is imperative to look at how biodiversity affects many different ecological functions at once.

As mentioned, one element of biodiversity is species richness, or the number of species found in each habitat or another unit [35]. Species richness is simply the number of species in a community. Based on the results, Quadrat 1 consisted of 13 distinct species, Quadrat 2 had 10, and Quadrat 3 had 10 different species. Based on the gathered data, Quadrat 1 shows more species richness compared to other sampling sites. This means that more species are present and living in the said area.

Species richness is the simplest, most intuitive, and most frequently used measure for characterizing the diversity of an assemblage [39]. The intuitive mathematical qualities of species richness are prominent in the first models of community ecology. Thus, species richness becomes one of the metrics for this study that may be employed to measure diversity. This simply implied greater biodiversity in ecosystems, species, and individuals leads to greater stability. Species with high genetic diversity and many populations that are adapted to a wide variety of conditions are more likely to be able to survive and adapt to weather disturbances, disease, and climate change. Greater biodiversity also enriches us with more varieties of foods and medicines.

Species Evenness

Based on the study, there has long been an understanding of the necessity to establish connections between the many characteristics of biotic communities as determinants of ecosystem stability and functioning [40]. The community characteristics of species composition and evenness have been demonstrated to have an impact on ecosystem functioning and are now receiving more attention.

Based on relative abundance, species evenness is a part of species diversity (the number of individuals in a species relative to the total number of individuals in all species within a system). Species evenness is a term used to describe how abundantly different species are distributed throughout a population. When every species in a sample has the same abundance, species evenness is at its maximum level [41]. Higher numbers suggest a more equal distribution of pixels (area) among the various land cover groups. Thus, with a result of 0.4431, Quadrat 1 has the most evenly dispersed species in the sandbar, followed by Quadrat 2 and Quadrat 3 with results of 0.3543 and 0.1972, respectively.

The ecosystem services that were measured were greatly influenced by species evenness and dominant species identity [42]. Evenness consistently improved ecosystem performance, and this effect persisted regardless of the identity of the dominant species. Our findings emphasized the significance of comprehending the numerous community traits that influence ecosystem functioning.

Species Dominance

Species in a community that are more numerous than other species and have corresponding effects on the environment, community diversity, and/or ecosystem function is called Species Dominance [43]. Dominance is one of the determining factors in knowing the totality of a community. In general, alpha diversity indices and dominance indices have a negative correlation (species richness, evenness, diversity). Less diversified are the more dominant communities. Table 4 shows that Quadrat 3 has the most dominant species in the community with a value of 0.7143 which means has the very least diversity. This is followed by Quadrat 2 with a 0.3664 quantity value and Quadrat 1 with 0.2987, the most diverse area among the three.

However, based on the result of Diversity (H') among the three quadrats, Quadrat 1 shows a high diversity value of H'=1.751 among three sampling stations. The area has high diversity since the area was least disturbed compared to the rest of the quadrats as observed during the sampling. Studies have shown, that coastal areas can promote the abundance of plants (both endemic and introduced species) which contributed much to their diversity [44].

Furthermore, the overall diversity was very low, H'=1.231. This could be due to the various habitat fragmentation recorded in the area through anthropogenic activities. The species in the area are moderately distributed with a value of

E=0.331 which indicates that species is not proportionally distributed and there are no dominating species in the area (D=0.4598).

Determination of Threats

In this study, visual observations of threats in the three sampling sites were conducted. One observed threat is that humans consume organisms as their primary source of food as well as income. Human activities are disturbing both the structure and functions of ecosystems and altering the native biodiversity that is present in the sandbar [45]. Such disturbances reduced the abundance of some organisms, caused population growth in others, modified the interactions among organisms, and altered the interactions between organisms and their physical and chemical environments [17].

Based on the observations recorded in the sandbar, anthropogenic activities negatively affected the species' breeding viability and abundance. Human activities such as water pollution had led to the species' habitat loss [46]. This pollution could result in bodily deformities and abnormal embryonic formations.

Weather conditions such as typhoons also brought strong winds, floods, and erosion leading to the death of some old and newly planted/born species in the sandbar [47]. High winds dramatically affected plant composition and structure and even caused vegetation to disappear in coastal areas in the place.

Conservation Status

The Local Government Unit (LGU) of Barangay Lumbocan is currently doing its part in mangrove reforestation on riverine sandbars. They limited access to human activities such as hunting for food and clearing agricultural activities while intensifying restoration activities within. The sampling area is considered a sanctuary which is the reason why they assigned a patrol group to check and maintain its cleanliness and reforestation every now and then [48].

Based on the International Union for Conservation of Nature, it appeared that some species present in the sampling area were categorized under Vulnerable (VU), species that possess a very high risk of extinction because of rapid population declines of 30 to more than 50 percent over the previous 10 years (or three generations), a current population size of fewer than 1,000 individuals, or other factors. Near Threatened (NT), species that are close to becoming threatened or may meet the criteria for threatened status soon. Least Concern (LC), is a category containing species that are pervasive and abundant after careful assessment. Hence, in order to conserve species in the sampling area, people must avoid getting organisms solely for the economic purpose for the area is considered prohibited and protected". Moreover, the planting of mangroves and other related activities were also encouraged in the area [49].

Thus, planting mangroves or other vegetation is a significant method of wetland ecological restoration [50]. The ecosystem of the coastal wetland can be successfully restored by this vegetation, which is also vital for sustaining coastal biodiversity, improving the quality of the water, lowering soil salinity, and other factors for the sandbar. This could be restored by strengthening the vegetation in the area [51].

Management

In this study, it had been found that the estuarine along which the sandbar is situated needs to undergo thorough implementation of threat management and conservation. The area lacks resources to address all threats to biodiversity, immediate decisions regarding which dangers to manage are usually needed [52], and comprehensive scientific data on how natural systems respond to threats and management [53].

In a recent study, priority threat management is a decision science approach that brings people together to define and prioritize strategies for managing threats to biodiversity across broad regions [54]. A systematic quantitative approach that engages stakeholders and combines reliable expert knowledge with scientific information can improve threat management prioritization and outcomes.

In response to the data gathered, restoration efforts and additional initiatives like creating a management plan to address illegal visitation of the sandbar should be implemented. Marine and Coastal Management should be given a focus to ensure protection for different species present in the area. It is recommended that agencies involved like the Department of Environment and Natural Resources (DENR) together with the Local Government Unit (LGU) of Barangay Lumbocan should undertake a conservation and management planning exercise for the sandbar present in an estuary along the Agusan River.

4. CONCLUSION

In conclusion, threats to biodiversity and the protection of ecological systems occur both within protected areas such as estuaries, particularly on sandbars. Based on the results, the diversity index level of the sandbar is very low H'=1.23. This is due to habitat fragmentation recorded in the area through anthropogenic activities and natural disasters. However, the restoration efforts and management of the Local Government Unit of Barangay Lumbocan should be strengthened for the improvement of conservation status and to lessen the identified threats which may affect species on the sandbar. The sandbar should undergo a more thorough evaluation for better management and conservation.

5. RECOMMENDATIONS

It is recommended to identify the ecological status of species on sandbars in Agusan River, Mindanao Butuan City, effective management strategies prioritizing recovery funding for nationally listed threatened species, maximize the collaboration of Local Government Units and stakeholders for the conservation of sandbars' biodiversity, assess the management strategies, action plans, and policies to prevent biodiversity loss in sandbar, and emerging strength of strengthening the approach is that it is being adapted to inform other assessments, action plans, and policies at a range of scales for biodiversity.

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