

Assessment of the Status of Mangrove Stands in Illana Bay, Zamboanga Del Sur, Mindanao, Philippines

Lasagas R.¹ and Yagos R.^{1,2}

¹*School of Agriculture, Forestry and Environmental Studies, JH Cerilles State College, Mati, San Miguel, Zamboanga del Sur*

²*School of Graduate Studies, JH Cerilles State College, Mati, San Miguel, Zamboanga del Sur*

(Received 8 June, 2025; Accepted 23 July, 2025)

ABSTRACT

Mangrove forests are vital coastal ecosystems that provide nursery grounds for marine life, protect shorelines, and support biodiversity. Currently, it is threatened by climate change and destructive human activities such as deforestation and fishpond conversion. The study aims to assess the status of the mangrove stand to determine its density, basal area, regeneration species, crown cover, height, canopy cover, relative dominance, and diversity. The transect plot technique was used in this study. A total of 17 mangrove species belonging to 8 families were recorded in the mangrove forest of seven (7) municipalities in Illana Bay, Zamboanga del Sur, with 12 species found within transect plots and 5 species outside. The largest number of species was family Rhizophoraceae, comprising 5 species, and the least were Palmae, Combretaceae, and Acanthaceae, with 1 species, respectively. The municipality of *Dimataling* has the most expansive mangrove forest area among the seven coastal municipalities. On the other hand, the municipality of *Tabina* registered the highest total basal area with a value of 2,900.36 m² per hectare, with a corresponding density of 1,280 per hectare, respectively. The mangrove forest in seven (7) municipalities of *Illana Bay* was in good condition based on the average of crown cover, height, and regeneration species, except the municipality of *San Pablo*, with excellent condition.

Key words: Crown cover, Basal area, Regeneration species, Diversity, Mangrove stand, Coastal Area

Introduction

Mangrove is a type of forest growing along tidal mudflats and along shallow water coastal areas extending inland along rivers, streams, and tributaries where the water is generally brackish. Its trees dominate the mangrove ecosystem as the primary producer, interacting with associated aquatic fauna and physical factors of the coastal environment. It also provides nursery grounds for fish, prawns, and crabs, and supports fisheries production in coastal waters. It also served as a good nursery because it provided hiding places for young animals (Ellison,

2008; Martinez *et al.*, 2018). The arched-shaped roots of the *Rhizophora* species or Bakauan mangroves and the finger-like roots of *Avicennia* or Piapi species are good examples.

Mangroves provide other benefits to man. They protect the environment by protecting coastal areas and communities from storm surges, waves, tidal currents, and typhoons. The crown and stem of mangroves serve as physical barriers. Their specialized roots strap and hold sediments and siltation from the upland. Further, mangroves promote clear water and the growth of corals and sea grass (Alongi, 2008a). Despite its good reputation, the eco-

system faces a very alarming condition.

Climate change is one of the many environmental issues that humanity is facing at a global level, and whose adverse impacts are very alarming. The Philippines is not exempt from the impacts of climate change, especially on its coastal ecosystems. The Philippines has estimated mangrove forests of about 356,000 ha, with a recent decadal deforestation rate of 0.5% (Gevaña *et al.*, 2018). Mangrove ecosystem in the Philippines, one of the mega diverse countries in the world, constantly faces threats due to human activities and other environmental problems (Van Lavieren *et al.*, 2012). The decline of mangrove cover is due to the destruction of mangrove habitat for fishponds, the cutting of mangrove trees for charcoal, and source of building materials (Primavera *et al.*, 2004).

Assessment of mangrove species plays a vital role in ecosystem protection and conservation, particularly in Illana Bay in Zamboanga del Sur. Illana Bay is one of the single biggest marine resources in Southern Philippines. Its coastal area covers 501,000 hectares, including an estimated 4,000-hectare mangrove forest. But decades of abuse had caused the degradation of Illana Bay's marine ecosystem. Local governments also focused more on upland development and turned a blind eye to the dying bay. There was mass destruction of mangrove forests and sea

grass in the eighties as residents considered them a nuisance and unnecessary growth. Instead, they set up fishponds and cut down mangroves to be sold as firewood. Dynamite, cyanide, trawl, and other forms of illegal fishing destroyed coral reefs that gave life to the very creatures people depended on for a living. Upland and lowland degradation also contributed to the silt that eventually covered the coastline and devastated the natural reef cover in the bay. Marine products were so depleted that fisher folk had to travel outside the bay for their catch.

The mangrove assessment was conducted across various municipalities in Illana Bay, including Tukuran, Labangan, Pagadian City, Dumalinao, San Pablo, Dimataling, and Tabina, Zamboanga del Sur. Prior to the assessment, the team reviewed the transect plot technique to standardize the approach for evaluating the mangroves in the region. The assessment aimed to determine the current condition of the mangrove forest, focusing on factors such as density, basal area, regeneration species, crown cover, height, canopy cover, and the relative dominance and diversity of species. The study aims to raise awareness among coastal communities about climate change and its potential impacts on both their livelihoods and the mangroves. Additionally, the findings will inform policymakers in developing



Fig. 1. Specific Location of Sampling Sites

coastal management strategies for the protection, conservation, and sustainable use of mangrove resources in the municipalities bordering Illana Bay.

Materials and Methods

Research Setting

The study was conducted in the coastal waters of seven (7) municipalities along Illana Bay namely; Tukuran, Labangan, Pagadian, Dumalinao, San Pablo, Tabina and Dimataling, Zamboanga del Sur (Figure 1).

Research Procedure

Mangrove Assessment

The mangrove community within each municipality was assessed through standard methods, specifically the methodology described in the technical bulletin on detailed assessment as provided by the Biodiversity Management Bureau (BMB), DENR Central Office.

With a 100-meter transect line, a station is being established perpendicular to the shoreline, beginning at where the mangrove habitat starts, and ending where the habitat extends.

A series of 10m x 10m quadrates was established along the transect line and consistent throughout the survey, with 10-meter intervals between the quadrates. With the strip transect, a number of trees were counted, height and crown estimated, and the diameter of every mature tree per species was measured. Within the quadrates, smaller quadrates of 1 m x 1 m were also established to count the number of regenerations (seedlings/saplings). The locations of transects and sampling plots were marked using

Global Positioning System (GPS).

Analysis of the assessment results was done using the methods as adopted and provided by the BMB per Technical Bulletin No. 5 "Guidelines on the Assessment of Coastal and Marine Ecosystems".

In the analysis, it is significant to determine the percent crown cover, regeneration per square meter, and the average height. The aforementioned parameters are measured through the following standard equations:

$$\text{*Percent Crown Cover} = \frac{\text{Total Crown Cover of all trees}}{\text{Total Area sampled}}$$

$$\text{*Regeneration per m}^2 = \frac{\text{Total regeneration count}}{\text{Total No. of regeneration plots}}$$

$$\text{*Average Height} = \frac{\text{Total Height of all Trees Recorded}}{\text{Total number of all trees recorded}}$$

The condition of the mangrove habitat is classified into four categories: *excellent*, *good*, *fair*, and *poor*. The table below shows the criteria of the mangrove area with their corresponding conditions:

The area as a representation for mangrove assessment was 10% of the total area. Observations on the

Table 2. Mangrove Diversity Index Scale

Relative Values Fernando, <i>et al.</i> , 1998	Shannon (H') Index
Very High	3.5 and above
High	3.0 – 3.49
Moderate	2.5 – 2.99
Low	2.0 – 2.49
Very Low	1.9 and below

Table 1. Criteria on determining the condition of mangrove habitat

Condition	Criteria
Excellent	76% and above in % crown cover 1 regeneration per m ² Above 5 m in average tree height Undisturbed to negligible disturbance
Good	51-75% crown cover <1 – 0.76 regeneration per m ² <3 m – 2m in average tree height Slight disturbance and few cuttings
Fair	26 - 50% crown cover 0.50 - .75 regeneration per m ² <2m in average tree height Moderate disturbance and noticeable cuttings
Poor	0-25% crown cover <0.50 regeneration per m ² <2m in average tree height Heavy disturbance/cuttings/pollution, rampant, conversion to other uses, nearly destroyed

number of trees, average height, crown cover, and species, including the number of regeneration plots and faunas, were undertaken in the survey.

Results and Discussion

A total of 17 mangrove species, or 48.57% of the total number of mangrove species in the Philippines, belonging to 8 families, were recorded in the mangrove forest of seven Municipalities in Illana Bay, Zamboanga del Sur (Table 3). Among the 17, 12 species were found within the transect plots and 5 species outside. The largest number of species per family was Rhizophoraceae, comprising 5 species, followed by Avicenniaceae, Sonneratiaceae, Meliaceae, and Myrsinaceae with 3 and 2 species, respectively. The other 3 families, namely: Palmae, Combretaceae and Acanthaceae, registered 1 species each. The list of all the mangrove species identified in the mangrove forest of seven (7) municipalities in Illana Bay is shown in Table 3 with the corresponding local names.

There were only 4 mangrove species common in the seven municipalities of Illana Bay (Table 4), namely: *Rhizophora apiculata* (Bakauan Lalaki), *Avicennia officinalis* (Piapi), *Avicennia marina*, and *Sonneratia alba* (Pagatpat). These species, known for their adaptability to coastal environments, were the primary mangrove species observed in the region (Primavera *et al.*, 2004). The municipality of Dimataling has the most expansive mangrove forest

area among the seven coastal municipalities assessed under Illana Bay, but a large portion of its mangrove forest was converted to fishponds, and some of them have been abandoned. This conversion of mangrove areas to aquaculture is consistent with trends observed in other coastal regions, where mangrove forests are often cleared for commercial purposes, particularly for fish farming (Alongi, 2002).

Most of the remaining mangrove forest of each municipality was mostly long, narrow strips found along the shoreline and riverbanks, left by the coastal residents to protect the inner portion that was cleared for aquaculture. Such land-use practices highlight the tension between conservation and livelihood needs in coastal areas (Barbier, 2011). There are some areas inside that were rehabilitated by fisher folk/people's organizations, particularly in the municipality of San Pablo, Dimataling, and Tabina, and minimal cutting of trees and branches was observed during the assessment.

The assessment of mangrove forests in the municipalities of Illana Bay revealed significant variations in basal area, density, and regeneration. As shown in Figure 2, the Municipality of Tabina registered the highest total basal area with a value of 2,900.36 m² per hectare with a corresponding density of 1,280.00 per hectare followed by the municipality of Tukuran and Dumalinao with a total basal area of 2,775.05 m² and 2,190.71 m² with density value of 1,394.32 and 2,465.30 per hectare respec-

Table 3. List of mangrove species recorded in the 7 Municipalities of Ilana Bay, Zamboanga del Sur

Family	Common Name	Scientific Name
Rhizophoraceae	Bakauan lalaki	<i>Rhizophora apiculata</i>
	Bakauan babae	<i>Rhizophora mucronata</i>
	Tangal/Tungog	<i>Ceriops tagal</i>
	Pototan/Langarai	<i>Ceriops decandra</i>
	Langarai	<i>Bruguiera parviflora</i>
Avicenniaceae	Piapi	<i>Avicennia officinalis</i>
	Bungalon	<i>Avicennia marina</i>
	Piapi	<i>Avicennia alba</i>
Sonneratiaceae	Pagatpat	<i>Sonneratia alba</i>
	Pagatpat/Pedada	<i>Sonneratia caseolaris</i>
Meliaceae	Tabigi	<i>Xylocarpus granatum</i>
		<i>Xylocarpus mollocensis</i>
Palmae	Nipa	<i>Nypa fruticans</i>
Myrsinaceae	Saging-saging	<i>Aegeceras floridum</i>
	Sagin-saging	<i>Aegeceras corniculatum</i>
Combretaceae	Talisay	<i>Terminalia cattapa</i>
Acanthaceae	Lagiwliw	<i>Acanthus ebracteatus</i>

tively. The least was the municipality of *Pagadian* with a total basal area of 1,453.32 m² per hectare, with a density value of 2,167.80 per hectare. *Sonneratia alba* (Pagatpat), *Rhizophora apiculata* (Bakauan Lalaki), *Avicennia marina* (Piapi), and *Avicennia officinalis* (Piapi) are the most dominant species in seven municipalities in Illana Bay. In terms of regeneration species, the municipality of San Pablo registered the highest number of Seedlings and Saplings, recorded with a total of 1,839.03 pcs per hectare, and the lowest was the municipality of Tabina with a total of 328 pcs per hectare. These findings suggest that Tabina, despite having the highest basal area, faces challenges in mangrove regeneration, potentially limiting its long-term mangrove ecosystem health. The observed variations in basal area and regeneration reflect the need for site-specific management strategies to enhance mangrove restoration and conservation efforts in the region (Gevaña *et al.*, 2018; Hidayah *et al.*, 2024; Polidoro *et al.*, 2010; Sagala *et al.*, 2024).

The mangrove forest in the seven municipalities of Illana Bay was in good condition based on the average crown cover and regeneration species. Crown cover, an essential indicator of forest health, was found to be robust across the region, indicating that the mangrove forests are actively contributing to ecosystem functions such as coastal protection, carbon sequestration, and habitat for biodiversity (FAO and UNEP, 2020). Additionally, the presence of sufficient regeneration species, particularly seedlings and saplings, suggests that the mangrove eco-

system is regenerating and has the potential for long-term sustainability (Alongi, 2008b). However, the average height of the mangrove trees across all municipalities was greater than 5 meters, which is typically indicative of an older, more mature forest. This may reflect the lack of younger, fast-growing trees, which are essential for maintaining forest resilience, especially in the face of environmental stressors like climate change (Alongi, 2002, 2008a; Polidoro *et al.*, 2010).

These findings suggest that while the mangrove forests in Illana Bay are in good overall condition, the absence of younger trees could signal a potential gap in the natural regeneration process. Therefore, future management efforts should focus on enhancing regeneration and promoting the growth of younger mangrove trees to ensure the continued ecological health of the area (Agaloos, 1994; Primavera, 2002; Sagala *et al.*, 2024). This can be achieved through active restoration programs, such as planting initiatives and protecting areas from further anthropogenic disturbance (Barbier *et al.*, 2008).

Canopy cover plays an important role in the amount of sunlight that penetrates the forest floor. Of all seven municipalities, the municipality of Dumalinao was observed with high density, followed by the municipalities of Tukuran and San Pablo, respectively (Figure 2). The estimation affirmed that the municipality of Dumalinao has a high number of individuals of mangrove trees. It was also recorded that the municipality of Dumalinao obtained a high species density. Tabina

Table 4. Occurrence of mangrove species in the transect plots of seven (7) Municipalities in Illana bay, Zamboanga del sur

No.	Species	Municipalities						
		Tukuran	Labangan	Pagadian City	Dumalinao	San Pablo	Dimataling	Tabina
1	<i>Rhizophora apiculata</i>	x	x	x	x	x	x	x
2	<i>Rhizophora mucronata</i>	x	x	x	x	x	x	-
3	<i>Ceriops tagal</i>	x	-	-	x	x	-	-
4	<i>Ceriops decandra</i>	-	-	-	x	x	-	-
5	<i>Bruguiera parviflora</i>	-	x	-	-	-	-	-
6	<i>Avicennia officinalis</i>	x	x	x	x	x	x	x
7	<i>Avicennia marina</i>	x	x	x	x	x	x	x
8	<i>Avicennia alba</i>	x	x	x	x	x	x	-
9	<i>Sonneratia alba</i>	x	x	x	x	x	x	x
10	<i>Sonneratia caseolaris</i>	x	-	-	x	x	-	-
11	<i>Xylocarpus granatum</i>	-	x	-	-	x	x	-
12	<i>Aegiceras floridum</i>	x	x	x	x	x	x	-
	Total	9	9	7	10	11	8	4

registered the highest total average of canopy cover within the 7 coastal mangrove areas, with a total value of 63.68 % which is interpreted as good condition. With these results, it can be interpreted that the area still has an intact mangrove population density but needs close monitoring and should be provided with a systematic rehabilitation plan for further improvements.

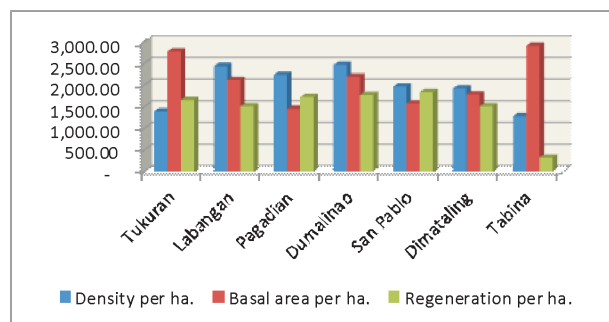


Fig. 2. Status of Mangrove structure in the seven (7) municipalities of Illana Bay, Zamboanga del Sur

The findings from the assessment of canopy cover and mangrove tree density across the seven

municipalities provide valuable insights into the health and sustainability of coastal mangrove ecosystems. Notably, the municipality of Dumalinao exhibited a high density of mangrove trees, which is indicative of a robust ecological framework supporting biodiversity. This observation aligns with previous studies that emphasize the correlation between tree density and ecological health in mangrove forests (Choudhary *et al.*, 2024).

Despite the promising results regarding mangrove density and canopy cover, the findings also underscore the need for ongoing monitoring and a systematic rehabilitation plan. While Dumalinao shows a healthy mangrove population, it is crucial to recognize that mangrove ecosystems are vulnerable to environmental changes and human impacts (Alongi, 2002). The implementation of a structured rehabilitation plan will not only enhance the resilience of these ecosystems but also ensure their long-term sustainability.

The regeneration count for seedlings and saplings was calculated using the formula described in the methodology. Planted seedlings by the fisher folks/

Table 5. Condition of Mangroves in 7 Municipalities under Illana Bay, Zamboanga del Sur.

Barangay	Percent Crown Cover (%)	Average Height (meters)	Regeneration Per squaremeter	Condition
Tukuran	59.25 (Good)	7.60 (Excellent)	0.72 (Good)	Good
Labangan	36.52 (Fair)	5.09 (Excellent)	0.98 (Good)	Good
Pagadian City	35.88 (Fair)	5.27 (Excellent)	0.78 (Good)	Good
Dumalinao	61.23 (Good)	6.69 (Excellent)	0.85 (Good)	Good
San Pablo	36.41 (Fair)	7.45 (Excellent)	1.04 (Excellent)	Excellent
Diamtaling	35.71 (Fair)	6.69 (Excellent)	0.77 (Good)	Good
Tabina	63.68 (Good)	9.20 (Excellent)	0.47 (Poor)	Good

Table 6. Relative Dominance of Mangrove Species in the Coastal areas of Illana bay Zamboanga del Sur

Family Name	Scientific Name	Relative Dominance						
		Tukuran	Labangan	Pagadian	Dumalinao	San Pablo	Diamtaling	Tabina
Avicenniaceae	<i>Avicennia marina</i>	18.15	81.72	66.58	30.59	32.21	8.42	2.44
Avicenniaceae	<i>Avicennia officinalis</i>	0.19	4.79	1.03	4.49	10.16	0.71	0.16
Avicenniaceae	<i>Avicennia alba</i>	0.23	9.79	18.39	50.42	6.64	0.29	-
Rhizophoraceae	<i>Rhizophora apiculata</i>	0.65	0.79	6.30	6.78	5.63	21.88	36.35
Rhizophoraceae	<i>Rhizophora mucronata</i>	0.01	0.63	0.35	3.94	18.12	8.92	-
Sonneratiaceae	<i>Sonneratia alba</i>	16.53	1.81	6.47	1.14	10.99	59.66	61.05
Sonneratiaceae	<i>Sonneratia caseolaris</i>	49.07	-	-	1.80	8.64	-	-
Myrsinaceae	<i>Aegiceras floridum</i>	15.07	0.45	0.88	0.59	5.55	0.08	-
Rhizophoraceae	<i>Ceriops tagal</i>	0.09	-	-	0.14	0.19	-	-
Meliaceae	<i>Xylocarpus granatum</i>	-	0.01	-	-	0.38	0.04	-
Rhizophoraceae	<i>Bruguiera parviflora</i>	-	0.01	-	-	-	-	-
Rhizophoraceae	<i>Cereops decandra</i>	-	-	-	0.12	-	-	-
Myrsinaceae	<i>Aegiceras corniculatum</i>	-	-	-	-	1.49	-	-

people's organization in barangay were not included and only natural seedlings/saplings are recorded below the mangrove tree species. Figure 3 shows the regeneration per square meter (m^2) and estimated height of mangrove trees. The results of the study revealed that mangrove species in Tabina were observed the tallest among other areas followed by the coastal areas of Tukuran and San Pablo and it is all represented with a *S. alba* showing how acclimated it is in its environment.

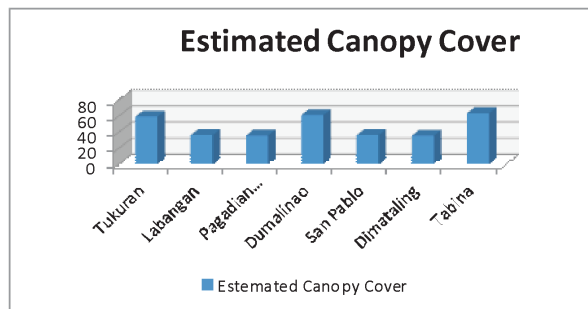


Fig. 3. Estimated Canopy Cover in all sampling stations in 7 municipalities of Illana Bay, Zamboanga del Sur.

Among the mangrove species, *Avicennia marina* is a dominant species in three (3) coastal areas in Illana Bay; Labangan, Pagadian and San Pablo while in Dimataling and Tabina, the dominant species were *Sonneratia alba*. On the other hand, *Avicennia alba* and *Sonneratia caseolaris* were the dominant mangrove species in Dumalinao and Tukuran respectively (Table 6).

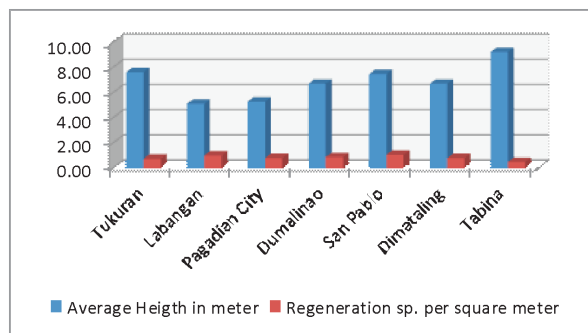


Fig. 4. Average Height and Regeneration of Mangrove Species in the Coastal areas of Illana Bay Zamboanga del Sur

The sampled mangrove areas in Illana Bay showed a very low to low diversity ranging from 1.16 to 2.08 (Table 7) based on the Shannon-Weiner Index of Diversity (H') and relative values by Fernando (1998). This also takes into account the low

Table 7. Diversity of Mangrove Species in the Coastal areas of Illana Bay Zamboanga del Sur

Coastal Municipalities in Illana Bay	Diversity Value
Tukuran	1.65
Labangan	1.41
Pagadian	1.66
Dumalinao	1.99
San Pablo	2.08
Dimataling	1.64
Tabina	1.16

number of species and low number of individuals recorded. It also shows that the mangrove forest is dominated by few species. With these results, this can be interpreted that the area is in need of close monitoring and be provided with a systematic rehabilitation plan for more improvements.

Conclusion

In conclusion, the mangrove assessment in seven (7) Municipalities in Illana Bay revealed low to very low species diversity. A total of 17 mangrove species belonging to 8 families were recorded with 12 species found within transect plots and 5 species outside. The most number of species was family Rhizophoraceae comprising 5 species, and the least were Palmae, Combretaceae, and Acanthaceae with 1 species, respectively. The municipality of Dimataling has the most expansive mangrove forest area among the seven coastal municipalities. On the other hand the municipality of Tabina was registered the highest total basal area with a value of 2,900.36 m^2 per hectare with a corresponding density of 1,280.00 per hectare respectively. The mangrove forest in seven (7) municipalities of Illana Bay was in good condition based on the average of crown cover, height, and regeneration species except the municipality of San Pablo with excellent condition. Conservation efforts should be exerted to increase species diversity of mangroves. Hence, we recommend immediate rehabilitation, protection and conservation measures of the mangrove ecosystem in Illana Bay due to increasing anthropogenic activities and environmental problems observed in the area. An Information Education Campaign (IEC) should be considered to raise awareness in the communities residing near their mangrove forest.

Acknowledgements

The researchers would like to acknowledge the JH

Cerilles State College for the support throughout the study. Further, the researchers are grateful for the support of the local government of seven municipalities along Illana Bay namely; Tukuran, Labangan, Pagadian, Dumalinao, San Pablo, Tabina and Dimataling, Zamboanga del Sur, headed by its Mayor through the Office of Municipal Agriculture, and Municipal Environment and Natural Resources. Also, to the assistance rendered by Renolfo S. Lasagas and Ronie B. Salinas as Technical Diver and Edna Mayordo as Diver Aide field technicians of the Department of Environmental and Natural Resources (DENR-CENRO) Guipos, Zamboanga del Sur during field sampling.

Conflict of Interest

The authors declare no conflict of interest for this study.

Source of Funding

This study was funded by the J.H. Cerilles State College under the office of the Vice President for Research, Extension and Resource Generation (VPRERG) headed by Dr. Jerry B. Superales. This is an Institutional Research Project of 2021-2023 under the project titled "Assessment on the Status of Mangrove Stand and Coral Reef in Illana Bay through GIS: Its Implications to Coastal Dwellers"

References

- Agaloos, B. 1994. Re-afforestation of mangrove forests in the Republic of the Philippines. *Proceedings of the International Tropical Timber Organization: Development and Dissemination of Reforestation Technique of Mangrove Forest, Japan*, 75-98.
- Alongi, D.M. 2002. Present state and future of the world's mangrove forests. *Environmental Conservation*. 29(3): 331-349. <https://doi.org/10.1017/S0376892902000231>
- Alongi, D.M. 2008a. Mangrove forests: Resilience, protection from tsunamis, and responses to global climate change. *Estuarine, Coastal and Shelf Science*. 76(1): 1-13.
- Alongi, D. M. 2008b. Mangrove forests: Resilience, protection from tsunamis, and responses to global climate change. *Estuarine, Coastal and Shelf Science*. 76(1): 1-13.
- Barbier, E.B., Koch, E.W., Silliman, B.R., Hacker, S.D., Wolanski, E., Primavera, J., Granek, E.F., Polasky, S., Aswani, S., Cramer, L.A., Stoms, D.M., Kennedy, C.J., Bael, D., Kappel, C.V., Perillo, G.M.E. and Reed, D.J. 2008. Coastal Ecosystem-Based Management with Nonlinear Ecological Functions and Values. *Science*. 319(5861): 321-323. <https://doi.org/10.1126/science.1150349>
- Choudhary, B., Dhar, V. and Pawase, A.S. 2024. Blue carbon and the role of mangroves in carbon sequestration: Its mechanisms, estimation, human impacts and conservation strategies for economic incentives. *Journal of Sea Research*. 199: 102504. <https://doi.org/10.1016/j.seares.2024.102504>
- Ellison, A.M. 2008. Managing mangroves with benthic biodiversity in mind: Moving beyond roving banditry. *Journal of Sea Research*. 59(1-2): 2-15.
- FAO and UNEP, 2020. The State of the World's Forests. *Forests, Biodiversity and People*. Rome.
- Fernando, E. 1998. Forest formations and flora of the Philippines: Handout in FBS 21. *College of Forestry and Natural Resources, University of the Philippines at Los Baños (Unpublished)*.
- Gevaña, D.T., Camacho, L.D. and Pulhin, J.M. 2018. Conserving mangroves for their blue carbon: insights and prospects for community-based mangrove management in Southeast Asia. In: C. Makowski and C.W. Finkl (Eds.), *Threats to Mangrove Forests: Hazards, Vulnerability, and Management*, (pp. 579-588). Springer International Publishing. https://doi.org/10.1007/978-3-319-73016-5_26
- Hidayah, Z., As-syakur, A.R. and Rachman, H.A. 2024. Sustainability assessment of mangrove management in Madura Strait, Indonesia: A combined use of the rapid appraisal for mangroves (RAP Mangroves) and the remote sensing approach. *Marine Policy*. <https://doi.org/10.1016/j.marpol.2024.106128>
- Martinez, M., Martinez, M., Buot, I.E. and Buot, I.E. 2018. Mangrove assessment in Manamoc Island for coastal retreat mitigation. *Journal of Marine and Island Cultures*. <https://doi.org/10.21463/jmic.2018.07.1.05>
- Polidoro, B.A., Carpenter, K.E., Collins, L., Duke, N.C., Ellison, A.M., Ellison, J.C., Farnsworth, E.J., Fernando, E.S., Kathiresan, K. and Koedam, N.E. 2010. The loss of species: Mangrove extinction risk and geographic areas of global concern. *PloS One*. 5(4): e10095.
- Primavera, J. 2002. *Management and Conservation of Mangroves in the Philippines*. 8-13.
- Primavera, J.H., Sadaba, R.B., Lebata, M. and Altamirano, J.P. 2004. *Handbook of mangroves in the Philippines*.
- Sagala, P.M., Bhomia, R. and Murdiyarso, D. 2024. Assessment of coastal vulnerability to support mangrove restoration in the northern coast of Java, Indonesia. *Regional Studies in Marine Science*. <https://doi.org/10.1016/j.rsma.2024.103383>
- Van Lavieren, H., Spalding, M., Alongi, D. M., Kainuma, M., Clüsener-Godt, M. and Adeel, Z. 2012. *Securing the future of mangroves*. United Nations University, Institute for Water, Environment and Health