International Annals of Science
ISSN: 2456-7132
Volume 12, Issue 1, pp. 22-30, 2022
DOI: https://doi.org/10.21467/ias.12.1.22-30

RESEARCH ARTICLE

Composition of Mangroves and Mangrove Associates in Barangay Ata-Atahon, Nasipit, Agusan del Norte, Philippines

Cresencio C. Cabuga Jr.[1*], Aldrin B. Lopez[2], Neprissa E. Cuarteron[3], Nñeka Jean A. Pangapalan[4]

[1]Senior High School Department, Del Pilar National High School, Cabadbaran City, Agusan del Norte, Philippines
[2]Senior High School Department, University of San Jose Ricoletos, Cebu City, Philippines
[3]Languages and Social Science Department, North Eastern Mindanao State University (NEMSU), Cantillan Campus, Surigao del Sur, Philippines
[4]Senior High School, Department of Education, San Jose National High School, Surigao Del Sur, Philippines

[*]Corresponding Author
Received: 11 March 2022 / Revised: 17 October 2022 / Accepted: 26 October 2022 / Published: 19 November 2022

ABSTRACT

Mangroves are essential components of the coastal biome and have an extremely productive ecosystem. It provides benefits for both the environment and humans. Valuation of the diversity and species composition plays a crucial role in the conservation and protection. This study aimed to assess the composition of mangroves and mangrove associates in Barangay Ata-Atahon, Nasipit, Agusan del Norte, Philippines. Three sampling stations were established with a 50-meter interval in every station. Transect lines of 50 meters were laid perpendicular to the shoreline. The results show that 19 species of mangroves and 5 mangrove associates were recorded. *Ceriops decandra* was found to be the dominant species with 303 individuals and constituting 36% of the entire mangroves population. While *Camptostemon philippinensis, Rhizophora apiculata, Rhizophora mucronata* had the lowest number of individuals and made up a combination of 5%. In mangrove associates, *Avicennia rumphiana* made up 47% of the population and was followed by *Avicennia marina* (40%). This implied that the study area is less diverse based on the observed species when compared to the 46-mangrove species found in the Philippines alone. Necessarily, reforestation and conservation efforts must be attained to fill the gaps between the community and mangrove sustainability. Thus, determining the species diversity and composition measures ecological status. Mitigations and ecological management must be enacted by the locality to further conserve the mangrove ecosystem.

Keywords: Biodiversity, Mangroves, Caraga Region.

1 Introduction

Mangroves are known as the most productive ecosystems. It is geographically situated in the intertidal zones among tropics and subtropics region [1]. Characteristically as woody shrubs or trees found in coastal saline or brackish water. They are called halophytes, or salt-tolerant trees, and are used to harsh coastal conditions. These species are found explicitly on tropical and subtropical coasts of 30 to 50 mangrove species in the Philippines [2]. Globally, mangrove biodiversity is highest in the Indo-Malay Philippine Archipelago, with between 36 and 46 of the 70 known mangrove species occurring in this region [3]. Mangrove forests are highly productive ecosystems with a rate of primary equal to those of tropical humid evergreen forest. It also plays a crucial role in both human and animal sustainability [4]. The mangrove trees are ecologically significant as it offers a home for different species such as phytoplankton, zooplankton, and fish. These invertebrates feed on decomposed leaves, rubble, plankton, and small animals [5]. The trees also produce large amounts of leaf litter and are decomposed by fungi and bacteria. Also serve as a food source for

marine life. Mangroves' habitats are also associated with water purification as it is related to the accumulation of algae, bacteria, and filter-feeding animals.

Also, it works as an essential role in removing excess nutrients from the water [6]. Large amounts of carbon are tied up both in mangrove tree forests and in their fertile soils. Hence, mangroves are often critical for the long-term storage of carbon in their biomass and soil [7]. Further, it plays a significant role in protecting shorelines from damaging storms and typhoon winds, waves, and floods. In the natural environment, mangroves are capable of lowering storm surge height and of dampening the waves. The use of mangroves in coastal areas ensures to play a critical role in reducing wind or swell waves, thus reducing erosion [8]. As the mangrove's ecosystem function, a crucial role in our ecosystem, their diversity in a specific region is essential.

Thus, the diversity of the mangroves produces significantly both in humans and the environment. Each species performs an indispensable function regardless as they are a small or large system [9]. Species composition is similarly essential, especially when seeking how an ecosystem works and how different vital organisms are to an environment [10]. A pressing matter continues to arise, the Indo-Malay Philippine Archipelago has one of the highest rates of mangrove area loss globally, with an estimated 30% reduction in mangrove area since 1980. Mangroves in this region were threatened by clearing for the creation of shrimp and fishponds. Approximately half of the 279,000 hectares of mangroves in the Philippines lost from 1951 to 1988 were developed into fish/shrimp culture ponds. The species of *C. philippinensis* (listed as endangered) has an estimated 1,200 or fewer individuals remaining due to the extensive removal of mangrove areas for both aquaculture and fuelwood within its range [3]. The massive decline of the mangrove areas continues to occur. The International Union for Conservation of Nature (IUCN) Red List of Threatened Species has listed several species of mangroves as vulnerable and endangered. Thus, the study aims to assess the species composition of mangroves in Barangay Ata-Atahon, Nasipit, Agusan del Norte, Philippines. And further, it is vital to conserve and protect the remaining trees in the area. Lastly, this evaluation also targets spreading awareness of the current situation of the mangrove forests in the area and advocating replanting and rehabilitation of the floral community.

2 Research Methodology

2.1 Description of the Area

The study was conducted in April 2021 in Barangay Ata-Atahon, in the town of Nasipit, in the province of Agusan del Norte, Caraga Region in Mindanao, Philippines (Fig. 1). It is located (8°59'N 125°20'E). Accordingly, 1,232 hectares of Mangrove forests are found in the province of Agusan del Norte [11].

Figure 1: *Map of the study area, Barangay Ata-Atahon, Nasipit, Agusan Del Norte, Philippines.*

2.2 Species Identification

The mangroves and mangrove associates were identified as on-site and classified taxonomically. A digital camera was used to document the plant samples. The field guide manual obtained from the Philippine Mangroves was used to determine the mangrove species [12].

2.3 Establishment of Line Transects and Plot Sampling

Three sampling sites (S1, S2, and S3) were established in the area with a 50-meter interval in every station. The corresponding transects lines ranging 50 meters were laid perpendicular to the shoreline. Inside, the area was divided into two sides, the mangroves inside each division were then identified and counted.

2.4 Status Determination of Mangrove and Mangroves Associates

The IUCN Red List of Threatened Species by IUCN, 2019 [13] was used to determine the status of the species of mangroves and its associates. It is the comprehensive and globally used for the inventory of the conservation status among of the plant and animal species. The IUCN Red List is recognized as the most authoritative guide to the rank of biological diversity. The IUCN Red List Categories (Table 1) define the extinction risk of species assessed. Nine categories extend from NE (Not Evaluated) to EX (Extinct).

Table 1: *Categories of the IUCN Red List of Threatened Species of the status of plant and animal species (2019).*

Categories	Description
Not Evaluated (NE)	Has not yet been evaluated against the criteria
Data Deficient (DD)	There is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status
Least Concern (LC)	Evaluated against the criteria and does not qualify for Critically Endangered, endangered, Vulnerable or Near Threatened
Near Threatened (NT)	Evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.
Vulnerable (VU)	30% extinction risk based on exceeding a threshold of population decline
Endangered (EN)	50% extinction risk based on exceeding a threshold of population decline
Critically Endangered (CR)	80% extinction risk based on exceeding a threshold of population decline
Extinct in the Wild (EW)	Known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range
Extinct (EX)	no reasonable doubt that the last individual has died

3 Results and Discussion

A total of 1,175 individuals composed of 19 species of mangroves and 5 species of mangrove associates were documented (Table 2). Specifically, 848 individuals of mangroves were observed, and these are classified into 13 families namely: Acanthaceae, Pteridaceae, Myrsinaceae, Avicenniaceae, Rhizophoraceae, Bombacaceae, Euphorbiaceae, Combretaceae, Myrtaceae, Rubiaceae, Sterculiaceae, Arecaceae, and Sonneratiaceae. Indeed, C. decandra, from the family Rhizophoraceae, was noted to have the highest number recorded, thus examined having 303 individuals and accounting for 36% of the overall mangroves' population. The plant species is currently classified as Near Threatened on the IUCN Red List of Threatened Species (2019), suggesting that this species is decreasing in number despite it having the highest number of individuals in this area. Subsequently, mangroves associates were also recorded and A. rumphiana has the highest individuals (152) followed by A. marina (132), N. fruticans (33), A. alba (9) and S. alba (1) and accounting to 327 individuals.

Table 2: *Mangroves and mangrove associates recorded in Barangay Ata-Atahon, Nasipit, Agusan del Norte.*

Mangrove Species	**Family**	**Local Name**	**No. of Individuals**
Acanthus ilicifolius	Acanthaceae	Lagiwliw, Ragoyroy	156
Aegiceras corniculatum	Myrsinaceae	Saging-Saging,	3
Aegiceras floridum		Tinduk-tindukan	67
Acrostichum aureum	Pteridaceae	*Unavailable	5
Acrostichum speciosum		Palaypay	94
Camptostemon philippinensis	Bombacaceae	Gapas-Gapas	1
Avicennia officinalis	Avicenniaceae	Miapi, Apia-Apia, Bungalon	51
Bruguiera sexangula	Rhizophoraceae	Pototan	3
Ceriops decandra		Baras-Baras	303
Kandelia candel		*Unavailable	109
Ceriops tagal		Tungog, tangal	26
Rhizophora apiculata		Bakhaw lalaki	1
Rhizophora mucronata		Bakhaw babae	1
Excoecaria agallocha	Euphorbiaceae	Lipata, Buta-Buta	2
Heritiera littoralis	Sterculiaceae	Dungon	8
Lumnitzera littorea	Combretaceae	Tabao, Culasi	4
Lumnitzera racemosa		*Unavailable	3
Osbornia octodonta	Myrtaceae	Tawalis, Bunot-Bunot	3
Scyphiphora hydrophyllacea	Rubiaceae	Nilad	8
Mangrove Associates	Avicenniaceae		
Avicennia alba		Ani-Ani	9
Avicennia marina		*Unavailable	132
Avicennia rumphiana		*Unavailable	152
Nypa fruticans	Arecaceae	Nipa, Sasa	**33**
Sonneratia alba	Sonneratiaceae	Pagatpat	**1**
Total			**1,175**

Note: *Local name unavailable

Nevertheless, A. ilicifolius from the family Acanthaceae followed with 156 individuals, nearly half of the population of the species C. decandra. Besides, C. candel with (109), A. speciosum (94), A. floridum (67), and A. officinalis (51). The abundance of these mangrove species often associated with the soil type in the area (Fig. 2). These types of mangroves usually grow on muddy freshwater in which salinity never exceeds that of normal seawater. The species were recognized to acclimate to oxygen-poor environments and nutrient-rich muddy substrates that endure salinity variations [14, 15]. As evidence, soil sampling techniques have come to the most efficient way to investigate its correlation among species growth and development [16, 17]. Also, geographic settings such as climate, substrate type, and nutrients availability have a significant role in the distribution of mangroves community. Nonetheless, among of soil pH, salinity, and organic matter cause substantial differences of mangrove forests. Indeed, study shows that diversification of soil contents changes the species composition, vegetation, and structure of mangrove forests [18]. Moreover, the Philippines had known to be covered by 400,000–500,000 hectares of mangroves in 1920 but it dropped

to 120,000 hectares in 1994 [19, 20, 21]. The declined forests were associated to conversion to agriculture, salt ponds, industry, settlements, and overexploitation by coastal dwellers [12].

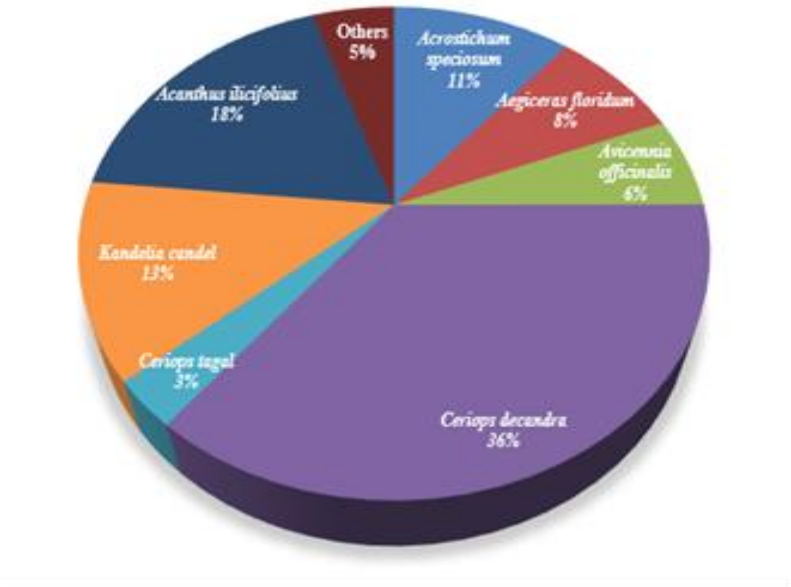

Figure 2: *Percentage of mangroves species in Brgy. Ata-Atahon, Nasipit, Agusan del Norte, Philippines*

On the other hand, *C. philippinensis, R. apiculata,* and *R. mucronata* were listed as having only one individual per species. This is very alarming, especially in the case of *C. philippinensis* as it is currently classified as Endangered' in the IUCN Red List of Threatened Species (2019). Aside from lumber logging of residents, another reason is pointed by Ricklefs [22] to be an invasion of other species in the mangrove habitats causing the decline of mangroves in these areas. The diversity of the mangroves in this area is relatively high compared to other parts of this region due to its geographical location and the soil type, which is favorable to mangroves. Accordingly, the Philippines is considered as one of the top 15 most mangrove-rich countries in the world [23]. Also, it holds at least 50% of the world's approximately 65 mangrove species [12, 24].

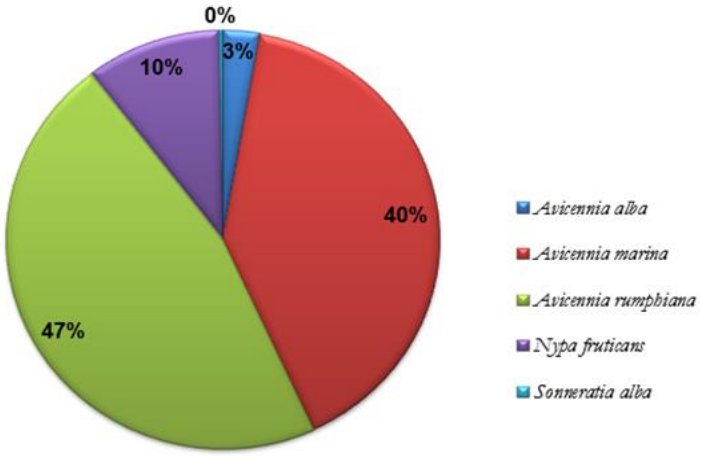

Figure 3: *Percentage of mangrove associates in, Barangay Ata-Atahon, Nasipit, Agusan del Norte, Philippines*

Mangrove diversity is a massive help to the food chain as more diverse mangroves means the variety of home for different organisms [25]. Moreover, it was observed that *A. rumphiana* had the highest number of mangrove associates accounting (47%) of the species recorded (Fig. 3). Accordingly, this type of flora is

mainly found in sandy or firm silt substrate of the mid to high watermark. It is considered among the largest of Acanthaceae family and is endemic to Southeast Asia [25]. Additionally, there is often a lack of baseline information on the status of mangrove forests, which is essential for better conservation planning and mangrove management [26, 27]. This highlights the need for comprehensive assessments and research [28]. In relation, mangroves ecological resources form a vast array from food (59.7%), fuel (51.9%), and fishing materials and construction supplies (44.8%). Recognition that mangroves deliver one or all of these advantages was reported in numerous studies [29, 30, 31, 32, 33]. Among the stated benefits of this ecosystem, locals around the world are known to understand its importance and its impact on their livelihood [34, 35].

Also, the environmental ability of the mangroves supports sustainability towards habitat, feeding, and nursery grounds of numerous aquatic animals. It also acts as a buffer for coastal communities against tsunamis and typhoons [36, 37, 38, 39, 40]. Importantly, this flora community offers food and livelihood among communities where residents are located and support as a sink for carbon absorption [41, 42, 43, 44]. Additionally, this environment adapts and responds to coastal alteration between natural and human-induced activities of changing temporal and spatial season [45]. Residents inhabited the mangrove ecosystem depending on mangrove loggers and timber processors. While collecting fish, invertebrates and shellfish is a form of living [46, 47]. They are the most affected groups by the loss of mangroves. On the other hand, skilled workers and public servants who have low consumption of mangrove ecological services are less affected [48]. Lastly, mitigation and policies shall be enacted to prevent the loss and destruction of this important ecosystem while continuous education among the locals on how to protect and conserve the latter.

Figure 4: *Mangroves species recorded in Barangay Ata-Atahon, Nasipit, Agusan del Norte, Philippines*

A. *Ceriops decandra* **B**. *Aegiceras floridum* **C**. *Heritiera littoralis* **D**. *Rhizophora apiculate* **E**. *Kandelia candel* **F**. *Lumnitzera littorea* **G**. *Lumnitzera racemose* **H**. *Osbornia octodonta* **I.** *Scyphiphora hydrophyllacea* **J**. *Acanthus ilicifolius* **K**. *Ceriops tagal* **L**. *Acrostichum speciosum*

(Note: Image not available: *Aegiceras corniculatum, Acrostichum speciosum, Camptostemon philippinensis, Avicennia officinalis, Bruguiera sexangula, Excoecaria agallocha, Rhizophora mucronate)*

Figure 5: *Mangrove associates recorded in Barangay Ata-Atahon, Nasipit, Agusan del Norte*

A. *Avicennia rumphiana* **B**. *Nypa fruticans* **C**. *Avicennia alba* **D**. *Avicennia marina.*
(Note: Image not available: *Sonneratia alba*)

Nevertheless, 20 species were listed as Least Concern in the IUCN Red List of Threatened Species (2019) implies that these species are not yet subjected to a massive decline in population over the years. Two species namely *A. floridum* and *C. decandra* were classified as Near Threatened, suggesting that these mangroves are declining in number but not in an alarming rate (Fig.4). At the same time, *C. philippinensis* was classified as Endangered and has a 50% extinction risk based on exceeding a threshold of population decline. At the same time, *A. rumphiana* was classified as vulnerable, signifying that this species has a 30% extinction risk based on exceeding a brink of a population drop (Fig. 5). Thus, the present study showed the ecological status of mangroves and mangrove associates. Therefore, the assessment is essential in the effort of conserving and mitigating the mangrove forests.

4 Conclusions

The composition of mangroves and mangrove associates in Barangay Ata-Atahon, Nasipit, Agusan del Norte, Philippines was determined. The result shows a low diversity recorded with only 19 species of mangroves and 5 species of mangrove associates constituting to 1,107 individuals. *C. decandra*, with the local name "Baras-Baras" was the dominant species with an overall number of 303 individuals while listed as nearly threatened. *C. philippinensis* is currently classified as endangered with only one individual recorded and had the same cause of the decline in population as the latter species. *A. rumphiana* and *A. marina* of mangrove associates found the most dominant. The low diversity and the presence of endangered and nearly threatened species in Barangay Ata-Atahon, Nasipit imply the high-risk extinction of some mangrove species if not conserved and managed. Even with the current efforts of restoring and conserving mangrove forests. Planting of seedlings and spreading awareness, mangroves continue to have a high decrease in their population. Thus, pointing out that the cause of the decline of the number is due to habitat shifting and land alteration, logging & wood harvesting.

5 Declarations

5.1 Acknowledgements

Authors are grateful for the support of CENRO-Department of Environment and Natural Resources, Nasipit, Agusan Del Norte for the previous data provided in the study.

5.2 Competing Interests

The authors have no conflicts of interest to declare.

5.3 Publisher's Note

AIJR remains neutral with regard to jurisdiction claims in published maps and institutional affiliations.

How to Cite the Article:

C. C. Cabuga Jr., A. B. Lopez, N. E. Cuarteron, and N. J. A. Pangapalan, "Composition of Mangroves and Mangrove Associates in Barangay Ata Atahon, Nasipit, Agusan del Norte, Philippines", Int. Ann. Sci., vol. 12, no. 1, pp. 22–30, Nov. 2022. https://doi.org/10.21467/ias.12.1.22-30.

References

[1] Y.S. Ho and S.A. Mukul, "Publication Performance and Trends in Mangrove Forests: A Bibliometric Analysis". *Sustainability*, vol.13, no. 12532, 2021. https://doi.org/10.3390/ su132212532.

[2] B.A. Polidoro, K.E. Carpenter, L. Collins, N.C. Duke, A.M. Ellison, "The Loss of Species: Mangrove Extinction Risk and Geographic Areas of Global Concern", vol. 5, issue 4, 2010.

[3] J. Kamaruzaman, "Malaysian Mangrove Forests and their Significance to the Coastal Marine Environment", *Polish Journal of Environmental Studies*, vol. 22, issue 4, pp. 979-1005, 2013.

[4] L. Carugati, B. Gatto, E. Rastelli, M. Lo, M. Caterina, S.D. Greco, "Impact of Mangrove Forests Degradation on Biodiversity and Ecosystem Functioning", *Scientific Reports*, vol. 8, issue 10, 2018.

[5] B.L. Pototan, N.C. Capin, M.R.M. Tinoy, A. Novero, "Diversity of Mangrove Species in Three Municipalities of Davao del Norte, Philippines", *AACL Bioflux*, vol.10, pp. 1569-1580, 2017.

[6] B. Sen, M.T. Alp, F. Sonmez, M. Koçer, O. Canpolat, "Relationship of Algae to Water Pollution and Waste Water Treatment", University of Firat, Faculty of Fisheries Department of Aquatic Basic Sciences Elazığ, Turkey, vol.14, pp. 341-353, 2013.

[7] A. Sekar, K. Kandasamy, V. Gomathi, R. Anburaj, K. Saravanakumar, N. Asmathunisha, S.K. Sahu, V. Shanmugaarasu, "Carbon Sequestration Potential of Mangroves and Their Sediments in Southeast Coast of India", *Proceedings of the International Conference: Meeting on Mangrove Ecology, Functioning and Management*, Galle, Sri Lanka, pp.1-192, 2012

[8] M.D. Spalding, S. Ruffo, C. Lacambra, I. Meliane, L.Z. Hale, C.C. Shepard, M.W. Beck, "The Role of Ecosystems in Coastal Protection: Adapting to Climate Change and Coastal Hazards", *Ocean & Coastal Management*, vol. 90 pp.50-57, 2014.

[9] K. Shah, A.H. Kamal, Z. Rosli, K.R. Hakeem, M.M. Hoque, "Composition and diversity of plants in Sibuti mangrove forest, Sarawak, Malaysia", *Forest Science and Technology*. vol. 12, issue 2, pp.70-76, 2016.

[10] F.J. Brundage, F. May, A, Huth, "Species composition and forest structure explain the temperature sensitivity patterns of productivity in temperate forests", *Biogeosciences*, vol.15, pp.1795-1813, 2018.

[11] Department of Environment and Natural Resources (DENR), "Rules and Regulations for the Issuance of Free Patents to Residential Lands", *DENR Administrative Order No. 2010-12*, 2010.

[12] J.H. Primavera, "Philippine mangroves: status, threats and sustainable development", *In M. Vannucci (Ed.), Mangrove management and conservation*: present and Tokyo, Japan: United Nations University Press, pp.192–207, 2004.

[13] International Union Conservation Network (IUCN), "The IUCN Red List of Threatened Species. Version 2019-1", http://www.iucnredlist.org., 2019.

[14] R.E. Sherman, T.J. Fahey, R.W. Howarth, "Soil-plant interactions in a neotropical mangrove forest: iron, phosphorus and sulfur dynamics", *Oecologia*, vol. 115, pp. 553-563, 1998.

[15] T.O. Ferreira, "Effects of Bioturbation by Root and Crab Activity on Iron and Sulfur Biogeochemistry in Mangrove Substrate", *Geoderma*, vol. 142, pp.36-46, 2007b.

[16] L.L. Eberhardt and J.M. Thomas, "Designing Environmental Field Studies", vol. 61, issue 1, pp. 53-73,1991.

[17] D.J. Pennock, "Designing Field Studies in Soil Science", *Canadian Journal Soil Science*, vol. 84, pp.1–10, 2004.

[18] M.D. Hossain and A.A. Nurrudin, "Soil and Mangrove: A Review", *Journal of Environmental Science and Technology*, vol. 9, issue 2, pp. 198-207, 2016.

[19] V.J. Chapman, "Mangrove vegetation", *Journal of Cramer*, New York, p. 477, 1976.

[20] W.H. Brown, F.A. Fischer, "Philippine mangrove swamps". Bulletin No. 17, Bureau of Forestry, Department of Agriculture and Natural Resources, Manila, Philippines, 1918.

[21] J.H. Primavera, "Development and conservation of the Philippine mangroves: institutional issues", *Ecology*, vol. 35, pp. 91–106. 2000.

[22] R.E. Ricklefs and D. Schluter, "Species Diversity in Ecological Communities", Historical and Geographical Perspectives. *University of Chicago Press*, 1993.

[23] J.B. Long and C. Giri, "Mapping the Philippines" *Mangrove Forests Using Landsat Imagery Sensors*, vol. 11, pp. 2972-2981, 2011.

[24] K. Kathiresan and B. Bingham, "Biology of Mangroves and Mangrove Ecosystems", *Advances in Marine Biology*, vol. 40, pp. 81-251, 2001.

[25] M.K. Tan, "Orthoptera in the Mangrove Forests of Singapore", *Nature in Singapore*, vol. 26: pp. 289–300, 2013.

[26] A.C. Ashton, D.J. Macintosh, P.J. Hogarth, "A baseline study of the Diversity and Community Ecology of Crab and Molluscan Macrofauna in the Sematan Mangrove Forest, Sarawak, Malaysia", *Journal of Tropical Ecology*, vol. 19, pp.127–142, 2003.

[27] K. Schmitt, N.C. Duke, "Mangrove management, assessment and monitoring", *Tropical Forestry Handbook*, Chapter 126–1, 2015.

[28] S. Bhatt, D.G. Shah, N. Desai, "The mangrove diversity of Purna Estuary, South Gujarat, India", *Tropical Ecology*, vol. 50, issue 2, pp. 287-293, 2009.

[29] A.M, Dencer-Brown, A.C, Alfaro, S, Milne, "Muddied waters: Perceptions and attitudes towards mangroves and their removal in New Zealand." *Sustainability*, vol. 11, issue 9: 2631. DOI: 10.3390/su11092631.

[30] J.M.D. Quevedo, Y. Uchiyama, R. Kohsaka, "Perceptions of local communities on mangrove forests, their services and management: implications for Eco-DRR and blue carbon management for Eastern Samar, Philippines". *Journal Forestry Research,* vol. 25, issue. 1, pp; 1-11, 2019.

[31] I.F. Setiyaningrum, "Community perceptions on mangrove forest sustainability in Dukuh Bendo, Jatikontal Village, Purwodadi District, Purworejo Regency, Central Java". *IOP Conf Ser: Earth Environ Sci,* vol. 271, issue. 1, 2019.

[32] E. Wahyuni, F. Zulhafandi, J. Hendris, "Detection of community knowledge level of economic, ecological benefits and causes of damage to mangrove forest ecosystems". *IOP Conf Ser: Earth Environ Sci*, vol. 748, issue. 1, no. 012017, 2021.

[33] B.P. Nyangoko, H. Berg, M.M. Mangora, M.S. Shalli, M. Gullstrom, "Community perceptions of climate change and ecosystem-based adaptation in the mangrove ecosystem of the Rufiji Delta, Tanzania". *Clim. Dev*, pp.1–3, 2021.

[34] G. Mikusinski, K Niedzialkowski, "Perceived importance of ecosystem services in the Bialowieza ˙ Forest for local communities – does proximity matter?" *Land Use Pol. 97*, no. 104667, 2020.

[35] B.P. Nyangoko, H. Berg, M.M. Mangora, M. Gullstrom, M.S. Shalli, "Community perceptions of mangrove ecosystem services and their determinants in the Rufiji Delta, Tanzania". *Sustain. Times*, vol. 13, issue. 63. 2021.

[36] G.M. Wagner, F.D. Akwilapo, S. Mrosso, S. Ulomi, R. Masinde, "Assessment of marine biodiversity, ecosystem health, and resource status in mangrove forests in Mnazi Bay Ruvuma Estuary Marine Park". IUCN, UNDP, MPRU, GEF, Nairobi, Kenya. 2004.

[37] D.M. Melana, E.E. Melana, A.M. Mapalo, "Mangroves management and development in the Philippines". *Aquaculture Department, Southeast Asian Fisheries Development Center, Philippines*. 2005.

[38] Food and Agricultural Organization of the United Nations (FAO), "*The world's mangroves 1980 – 2005*". Rome, Italy. 2007.

[39] N.C. Duke, "Mangroves". *Encyclopedia of Earth Sciences Series.* 2011. DOI: 10.1007/978-90-481-2639-2_108.

[40] L.D. Camacho, D.T. Gevaña, L.L. Sabino, C.D. Ruzol, J.E. Garcia, A.C.D. Camacho, T.N. Oo, A.C. Maung, K.G. Saxena, L. Liang, E. Yiu, K. Takeuchi, "Sustainable mangrove rehabilitation: Lessons and insights from community-based management in the Philippines and Myanmar". *APN Sci Bull.* Vol. 10, pp. 18-25. 2020.

[41] B. Satyanarayana, P. Bhanderi, M. Debry, D. Maniatis, F. Foré, D. Badgie, K. Jammeh, T. Vanwing, C. Farcy, N. Koedam, F. Dahdouh-Guebas, "A socio-ecological assessment aiming at improved forest resource management and sustainable ecotourism development in the mangroves of Tanbi Wetland National Park, The Gambia, West Africa". *Ambio.* vol. 41, pp. 513-526. 2012.

[42] M.I. Sawairnathan, N. Halimoon, "Assessment of the local communities' knowledge on mangrove ecology". *Intl J Hum Capital Urban Manage* vol. 2, pp. 125-138. 2017. DOI: 10.22034/ijhcum.2017.02.02.004.

[43] D.T. Gevaña, J.M. Pulhin, M.A. Tapia, "Fostering climate change mitigation through a community-based approach: Carbon stock potential of community-managed mangroves in the Philippines". 2019.

[44] A. Dinilhuda, A.A. Akbar, F. Jumiati, H. Herawati, "Potential of mangrove ecosystem as carbon storage for global warming mitigation". *Biodiversitas*, vol. 21, pp. 5353-5362. 2020.

[45] S. Sannigrahi, Q. Zhang, F. Pilla, P.K. Joshi, B. Basu, S. Keesstra, P.S. Roy, Y. Wang, P.C. Sutton, S. Chakraborti, S.K. Paul, S. Sen, "Responses of ecosystem services to natural and anthropogenic forcings: a spatial regression-based assessment in the world's largest mangrove ecosystem". *Science of The Total Environment*, vol. 715, no. 137004. 2020.

[46] Z. Ermgassen, P.S.E. Mukherjee, N. Worthington, T.A. Acosta, A. Rocha-Araujo, A.R. DaBeitl, C.M. Castellanos-Galindo, G.A. Cunha-Lignon, M. Dahdouh-Guebas, F. Diele, K. Parrett, C.L. Dwyer, P.G. Gair, J.R. Johnson, A.F. Kuguru, B. Savio Lobo, A. Loneragan, N.R. Longley-Wood, K. Mendonça, J.T. Meynecke, J.O. Mandal, R.N. Munga, C.N. Reguero, B.G. Ronnback, P. Thorley, J. Wolff, M. Spalding, "Fishers who rely on mangroves: modelling and mapping the global intensity of mangrove-associated fisheries". *Estuar. Coast Shelf Sci.* vol. 247, no. 106975. 2020.

[47] M. Trevino, P.J. Murillo-Sandoval, "Uneven consequences: gendered impacts of shrimp aquaculture development on mangrove dependent communities". *Ocean Coast Manag.* vol. 210, no. 105688. 2021.

[48] J.M.D. Quevedo, Y. Uchiyama, R. Kohsaka, "Perceptions of local communities on mangrove forests, their services and management: implications for Eco-DRR and blue carbon management for Eastern Samar, Philippines". *J. For. Res.* vol. 25, pp.1–11. 2020. https://doi.org/10.1080/13416979.2019.1696441.