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Status of Mangrove Ecosystems in Selected Coastal Municipalities In Zambales, Philippines

ANNIE MELINDA PAZ-ALBERTO
ORCID NO. 0000-0002-2828-432X
anniealberto@clsu.edu.ph
melindapaz@gmail.com
Central Luzon State University
Nueva Ecija, Philippines

KATHRINA M. MAPANAO
ORCID NO. 0000-0002-5234-656X
mapanao.kathrina@gmail.com
Central Luzon State University
Nueva Ecija, Philippines

DARYL A. JUGANAS
ORCID NO. 0000-0003-0298-1095
daryljuganas@gmail.com
Central Luzon State University
Nueva Ecija, Philippines

ABSTRACT

Eleven species of true mangroves species were observed in selected study sites of Sta. Cruz, Candelaria, Masinloc and Palauig, Zambales. All the mangrove species belong to Division *Tracheophyta* and Class *Magnoliopsida* except for *Nypa fruticans* is under Class *Liliopsida*. The mangrove species are under eight orders, nine families, and ten genera. Results revealed that *Rhizophora mucronata* dominated all study sites. The mangrove ecosystems of the four selected municipalities in Zambales exhibited very low diversity. All the species of mangrove observed were evaluated as Least Concerned (LC) species except for *Aegiceras floridum*, which is in the Near Threatened (NT) category. All the mangroves observed in selected study sites in Zambales were in decreasing population trend except for *Nypa fruticans*. The condition of the mangrove ecosystems in Palauig is excellent due to the excellent crown cover and regeneration of the mangrove trees and the undisturbed condition of the mangrove trees. Furthermore, the mangroves conditions in the municipalities of Sta. Cruz and Masinloc are good, while in Candelaria are in fair condition. The sources of environmental degradation that could affect the mangrove ecosystems are sedimentation/siltation, quarrying, dynamite fishing, mine tailings, soil erosion, environmental aesthetic degradation, eutrophication, oil spill, mine drainage pollution, solid wastes, and tourism.

Keywords: Mangrove ecosystems, Conservation Status, Diversity Index, Importance Value Index, environmental degradation

INTRODUCTION

Mangroves are salt-tolerant flowering plants of tropical and subtropical sheltered coastlines. They have been variously described as coastal woodland, tidal forest, and mangrove forest (Marine Ecology Fiji, 2020). They grow well in places where freshwater mixes with seawater and where sediment is composed of accumulated mud deposits (FAO, 2007). The term *mangrove* may have been derived from a combination of the Malay word *manggi-manggi*, for a type of mangrove tree, and the Arabic *el gurm*, for the same, as *mang-gurm*. As a word, it can be used to refer to a species, plant, forest, or community (Peter & Sivasothi, 2001). Mangroves have a high potential to get acclimatized to environmental conditions. (Murugan & Anandhi, 2017).

Mangrove forests are among the most productive and biologically important ecosystems of the world because they provide important and unique ecosystem goods and services to human society and coastal and marine systems (Giri et al., 2010). It is considered as the best form of coastal bioshield since mangrove forests help to reduce the devastating impact of cyclonic storms, hurricanes, and tsunami on human lives and properties (Danielsen et al., 2005; Kumar et al., 2014; Murugan & Anandhi, 2017; Selvam, 2005). It also avoids or reduces soil erosion. It enhances fishery productivity of the adjacent coastal waters by acting as a nursery ground for commercial and non-commercial fish, shellfish, prawns, and crabs. They are also rich in biodiversity by providing habitats for wildlife (Kumar et al., 2014; FAO, 2007).

However, the world's mangroves are struggling. Mangroves are losing their habitats as their waters diverted and the intertidal zone extensively developed for agriculture or aquaculture and generally dried up. Large tracts have been converted to rice fields, fish and shrimp ponds, industrial and land development, and other non-forest uses. Mangrove areas are also over-exploited for fuelwood and charcoal-making. In overpopulated and acute fuelwood deficit areas, even small branches were historically harvested for furniture and other economic uses.

This study aimed to assess the present condition of mangrove ecosystems in selected coastal municipalities of Zambales. Specifically, the objectives were to identify different mangrove species observed in the mangrove ecosystems, to determine the diversity index value of the mangrove ecosystems, to determine the conservation status of the mangrove species and the condition of the mangrove ecosystems, and to determine the levels and impacts of environmental degradation present in the selected coastal ecosystems in Zambales.

OBJECTIVES OF THE STUDY

This study was conducted to assess the present condition of the mangrove ecosystems in the selected coastal municipalities in Zambales, Philippines. The results of this study would be relevant to the local communities and barangays of the coastal municipalities of Zambales for they will be able to know the present status of the mangrove ecosystems and the sources of problems that could affect these resources in their areas in order for them to plan and prioritize their development activities for the conservation and protection of their mangrove ecosystems.

MATERIALS AND METHODS

Location of the Study Sites

Four sampling stations were established in each of the mangrove ecosystems. Twelve mangrove ecosystems in Sta. Cruz, four in Candelaria, 28 in Masinloc, and 28 in Palauig were assessed and studied. The location of the sampling sites was randomly selected using GPS (Global Positioning System) device.

Table 1

Location of the study sites established for the biodiversity assessment of mangrove ecosystems in Zambales, Philippines.

Site	City/Municipality	No. of Barangay Covered	Number of Mangrove Ecosystems	Ecosystem
1	Sta. Cruz, Zambales	3	12	Mangrove Ecosystem
2	Candelaria, Zambales	1	4	Mangrove Ecosystem
3	Masinloc, Zambales	7	28	Mangrove Ecosystem
4	Palauig, Zambales	7	28	Mangrove Ecosystem

Identification and Collection of Mangroves

A random sampling of different species of mangroves was done. Nine quadrats were laid in each station measuring 10m by 12m. All trees (growing with heights > 3m) enclosed within the 10m x 12m plot were identified and counted, and their percentage crown cover was estimated. The percentage crown cover was obtained following the equation below. The estimated crown cover was analyzed based on the criteria and condition (Table 2).

$$\text{Percentage Crown Cover} = \frac{\text{total crown cover}}{\text{total area sampled}} \times 100$$

Table 2

Habitat criteria rating for mangroves

CONDITION	CRITERIA
Excellent	76% and above in % crown cover; 1 regeneration per m^2 above 5m in average tree height; undisturbed to negligible disturbance
Good	51%-75% crown cover; <1-0.76 regeneration per m^2 <5m-3m average of trees; slight disturbance and few cuttings
Fair	26%-50% crown cover; <0.50-0.75 regeneration per m^2 <3m-2m average of trees; moderate disturbance and noticeable cuttings
Poor	0%-25% crown cover; <0.50 regeneration per m^2 <2m average of trees; heavy disturbance/cutting/pollution rampant conservation to other uses, nearly destroyed

Ecological Measurements

The relative density, relative dominance, relative frequency, and Importance Value Index values for each species were tabulated and analyzed. The dominance indices and their corresponding formulas to derive the importance value index (IVI) were based on Brower (1989) as cited by Fernando et al. (1998), and Paz-Alberto (2005) are provided below:

$$\text{Relative Density} = \frac{\text{Density of a species}}{\text{Total densities of all species}} \times 100$$

$$\text{Relative Dominance} = \frac{\text{Dominance of a species}}{\text{Total dominances of all species}} \times 100$$

$$\text{Relative Frequency} = \frac{\text{Frequency of a species}}{\text{Total of frequencies}} \times 100$$

Importance Value (IV) = Relative Density + Relative Dominance + Relative Frequency

Diversity Index

The diversity index value was calculated using the Shannon - Wiener Diversity Index (H') formula (Smith and Smith, 1998), which is shown below:

$$\text{Shannon Diversity Index: } H' = \sum_{i=1}^{s} (pi*\ln(pi))$$

Where H' = Shannon index of diversity, pi = proportion of species from the total species, S= numbers of species encountered, ln = naperian logarithm or natural logarithm, ∑ = sum from species 1 to species S.

Sources and Levels of Impacts on the Environmental Degradation of the Coastal Ecosystems of Sta. Cruz, Candelaria, Masinloc and Palauig

To assess the present condition of the forest ecosystem, the checklist developed by Paz-Alberto (2005), which pertains to the sources and level of impacts on environmental degradation in the aquatic ecosystem, was utilized. The sources of the environmental degradation indicated in the checklist were rated using values 1-4 by selected barangay officials, employees of LGUs, other employees from government agencies such as CENRO, MENRO, BFAR-TOSFMW, PAMB, and researchers from CLSU to determine the present condition of the mangrove ecosystem. Four levels of impacts in each source of environmental degradation were used. For each level, a value is assigned. The level of impact was estimated based on the percentage of impact/damage in the study area.

Table 3

The corresponding values of damage and level of impacts on environmental degradation of the forest ecosystem

VALUE	IMPACT LEVEL	IMPACT ESTIMATE (%)
1	No Significant Impact	0 – 5
2	Small Impact	6 – 25
3	Moderate Impact	26 – 49
4	Major Impact	50 and above

The means of the answers of the respondents were computed. The sum of the answers for each level was divided by the total number of respondents. A scale was used to interpret the scores in the level of impacts on the environmental degradation of any ecosystem (Table 4).

Table 4

The scale number to interpret the scores in the level of impacts on the environmental degradation of any ecosystem

SCALE	IMPACT LEVEL
1.01 – 1.75	No Significant Impact
1.76 – 2.50	Small Impact
2.51 – 3.25	Moderate Impact
3.26 – 4.00	Major Impact

RESULTS AND DISCUSSION

Eleven (11) species of true mangroves species were observed in selected sites of Sta. Cruz, Candelaria, Masinloc and Palauig, Zambales. The true mangroves are as follows: *Excoecaria agallocha* L., *Osbornia octodonta* F.Muell., *Heritiera littoralis* Aiton., *Sonneratia alba* Sm., *Rhizophora mucronata* Lam., *Nypa fruticans* Wurmb, *Rhizophora apiculata* Blume, *Avicennia marina* (Forsk.) Vierh, *Bruguiera cylindrica* (L.) Blume, *Xylocarpus moluccensis* (Lam.) M.Roem., and *Aegiceras floridum* Roem. & Schult. (Table 3). All the species belong to Division *Tracheophyta* and Class *Magnoliopsida* except for *Nypa fruticans* under Class *Liliopsida*. The species are under eight orders, nine families and ten genera. Among the 11 mangrove species identified, species of *Rhizophora mucronata* dominated all the study sites, followed by *Rhizophora apiculata* and *Sonneratia alba* (Table 3). This is because they grow best where sediment is composed of accumulated deposits of mud, sandy shores, and coral terraces (Numbere, 2018). The seaward areas are mostly inhabited by *Rhizophora sp*. (Jalonen et al., 2009).

Table 5

Distribution of mangroves in selected municipalities of Zambales

Species Name	Total # of individuals	Sta. Cruz (Site1)	Candelaria (Site2)	Masinloc (Site3)	Palauig (Site4)
Exoecaria agallocha	50	Present (+)	Present (+)	Absent (-)	Absent (-)
Osbornia octodonta	54	Present (+)	Present (+)	Present (+)	Present (+)
Heritiera littoralis	1	Present (+)	Absent (-)	Absent (-)	Absent (-)
Sonneratia alba	359	Present (+)	Present (+)	Present (+)	Present (+)
Nypa fruticans	64	Present (+)	Absent (-)	Absent (-)	Absent (-)
Rhizophora apiculata	756	Present (+)	Present (+)	Present (+)	Present (+)
Aegiceras floridum	2	Present (+)	Absent (-)	Absent (-)	Absent (-)
Rhizophora mucronata	1093	Present (+)	Present (+)	Present (+)	Present (+)
Bruguiera cylindrica	11	Present (+)	Present (+)	Absent (-)	Absent (-)
Xylocarpus moluccensis	4	Present (+)	Absent (-)	Absent (-)	Absent (-)
Avicennia marina	124	Present (+)	Present (+)	Present (+)	Present (+)

Ecological Parameters of Mangroves

Table 6 shows the ecological parameters of mangroves surveyed in the four study sites in Zambales. The highest importance value index in Sta. Cruz, Zambales was obtained by *Sonneratia alba* with 62.29% IVI. This was followed by *Exoecaria agallocha* with an IVI of 42.23% and *Nypa fruticans* with 38 % value for IVI, and the lowest value was obtained by *Avicennia marina* with an IVI of 6.01%.

The different species of mangroves prefer different types of substrates, and knowledge of the substrate type at the site will help determine which species are needed. *Sonneratia alba* grows along seashores of sandy, rocky or muddy soils and coral reef terraces (Cordova et al., 2017) and does not tolerate wide fluctuations in salt concentration (Lemmens et al., 2012). Among the four municipalities, Sta. Cruz coastline is most famous for its gravelly sandy beaches and coral reef terraces, and this is an ideal substrate in the planting of *Sonneratia alba*.

Furthermore, the highest IVI recorded in the municipality of Candelaria in Zambales was obtained by *Rhizophora mucronata* with an IVI of 81.73%, followed by *Sonneratia alba* with 81.02% IVI and *Avicennia marina* with an IVI of 39.18%, and the lowest computed IVI was attained by *Osbornia octodonta*. In Masinloc, the highest IVI recorded was *Rhizophora apiculata* with a value index of 118.99%, followed by *Sonneratia alba* with 58.09% and *Osbornia octodonta* with a value index of 42.63%, while the lowest value index was obtained by *Rhizophora mucronata* with an IVI of 42.42%. Moreover, the highest importance value index recorded in Palauig, Zambales was attained by *Rhizophora mucronata* with 124.09%, followed by *Rhizophora apiculata* with 83.29% and 47.66% for *Sonneratia alba*, while the lowest IVI of mangrove species was obtained by *Osbornia octodonta* with 11.58% IVI.

Since the mangrove ecosystem in Zambales has been affected by anthropogenic activities such as tourism, quarrying, mine drainage pollution, and conversion into fishponds, mangrove ecosystems are one of the most threatened ecosystems on earth. The degraded mangrove ecosystems in the area were undergoing rehabilitation. *Rhizophora sp.* is one of the recommended mangrove species to be planted in the degraded areas. It is frequently used for rehabilitation programs (Basyun et al., 2018; Iftekhar, 2008). *Rhizophora sp.* plays an important role in the intertidal zones to prevent soil erosion (Eganathan et al., 2001). In Zambales, the Bureau of Fisheries and Aquatic Resources (BFAR) leads community-based mangrove restoration activities in the four municipalities of Zambales, and the mangrove assessment was regularly conducted by the Department of Environmental and Natural Resources (DENR).

Table 6

Ecological Parameters of Mangroves in Sta. Cruz, Candelaria, Masinloc and Palauig

Species Name	Basal Area station	Dominance	Relative Dominance	Density	Relative Density	# of Quadrats where sp. Occurred	Frequency	Relative Frequency	IVI
Sta. Cruz, Zambales (site1)									
Exoecaria agallocha	0.030428431	0.063473332	6.34733322	0.149533	14.95327	9	1	20.93023	42.23083681
Osbornia octodonta	0.011470668	0.023927672	2.39276719	0.124611	12.46106	7	0.77777778	16.27907	31.13289614
Herriera littoralis	0.114403489	0.238644269	23.8644269	0.003115	0.311526	1	0.11111111	2.325581	26.5015348
Sonneratia alba	0.042281072	0.088197796	8.81977963	0.302181	30.21807	10	1.11111111	23.25581	62.29366211
Rhizophora mucronata	0.066027926	0.137733442	13.7733442	0.168224	16.82243	1	0.11111111	2.325581	32.92135546
Nypa fruticans	0.012449717	0.025969957	2.59699566	0.199377	19.93769	7	0.77777778	16.27907	38.81376014
Rhizophora apiculata	0.053226594	0.111030019	11.1030019	0.009346	0.934579	1	0.11111111	2.325581	14.36316276
Avicennia marina	0.016170104	0.033730639	3.37306388	0.003115	0.311526	1	0.11111111	2.325581	6.010171752
Bruguiera cylindrica	0.020559133	0.042886098	4.28860979	0.021807	2.180685	1	0.11111111	2.325581	8.794876539
Xylocarpus moluccensis	0.062153839	0.129652143	12.9652143	0.012461	1.246106	3	0.33333333	6.976744	21.18806438
Aegiceras floridum	0.050935829	0.106251512	10.6251512	0.006231	0.623053	2	0.22222222	4.651163	15.89936696
Candelaria, Zambales (site2)									
Rhizophora apiculata	0.058878204	0.210949791	21.0949791	0.19883	19.88304	3	0.33333333	13.04348	54.02149835
Sonneratia alba	0.061198895	0.219264403	21.9264403	0.28655	28.65497	7	0.77777778	30.43478	81.01619365
Avicennia marina	0.049376569	0.176907179	17.6907179	0.040936	4.093567	4	0.44444444	17.3913	39.17558946
Rhizophora mucronata	0.051545055	0.184676465	18.4676465	0.415205	41.52047	5	0.55555556	21.73913	81.72724478
Osbornia octodonta	0.014452031	0.051778972	5.17789724	0.023392	2.339181	1	0.11111111	4.347826	11.86490462
Bruguiera cylindrica	0.018393494	0.06590051	6.59005104	0.023392	2.339181	1	0.11111111	4.347826	13.27705841
Masinloc, Zambales (site3)									
Rhizophora apiculata	0.041579235	0.108189113	10.8189113	0.654405	65.44046	50	5.55555556	42.73504	118.9944187
Rhizophora mucronata	0.056142112	0.146081701	14.6081701	0.095837	9.583737	16	1.77777778	13.67521	37.86712043
Avicennia marina	0.059523791	0.154880822	15.4880822	0.081317	8.131655	22	2.44444444	18.80342	42.42315643
Sonneratia alba	0.083026136	0.216033894	21.6033894	0.159729	15.97289	24	2.66666667	20.51282	58.08910436
Osbornia octodonta	0.14404868	0.374814471	37.4814471	0.008712	0.871249	5	0.55555556	4.273504	42.62620012
Palauig, Zambales (site4)									
Rhizophora apiculata	0.062355283	0.196180754	19.6180754	0.443425	44.34251	29	3.222222	19.33333	83.29391635
Rhizophora mucronata	0.055164593	0.17355757	17.355757	0.474006	47.40061	89	9.888889	59.33333	124.0897019
Sonneratia alba	0.099907823	0.31432769	31.432769	0.04893	4.892966	17	1.888889	11.33333	47.65906874
Avicennia marina	0.066056906	0.207826715	20.7826715	0.03262	3.261978	14	1.555556	9.333333	33.37798237
Osbornia octodonta	0.034361472	0.108107271	10.8107271	0.001019	0.101937	1	0.111111	0.666667	11.57933056

Diversity of Mangrove Ecosystem in the Coastal Ecosystems of Sta. Cruz, Candelaria, Masinloc and Palauig

Table 7 shows the Diversity Index (DI) of mangrove ecosystems in four coastal municipalities in Zambales. Results showed that the highest diversity index was obtained in Sta. Cruz, Zambales with -1.78. This was followed by Candelaria with a diversity index of -1.40 and Masinloc with -1.04. The lowest diversity index was computed in Palauig with -0.98.

Table 7

Computed diversity index of mangrove ecosystems in four coastal municipalities in Zambales

Municipality	Total Number of Species	Diversity Index (DI)
Sta. Cruz	321	-1.78
Candelaria	171	-1.40
Masinloc	1045	-1.04
Palauig	981	-0.98

The mangrove ecosystems in all coastal municipalities exhibited very low diversity, which may be due to a number of localized threats such as human activities present such as tourism, quarrying, dynamite fishing, and mine drainage pollution, which could harm and lessen the diversity of organisms in the mangrove ecosystems (Table 7). The mangrove ecosystems in the areas were severely affected by the mine tailings/drainage pollution, which came from the adjacent mining area. Some mangrove areas were only remnants of the primary mangrove forests due to habitat destruction and are often cleared away to make room for the development of urban and industrial areas, aquaculture, fish ponds, salt pans, etc.

Ecological and Conservation Status of Mangrove Species in the Four Selected Coastal Ecosystems of Zambales

Based on the latest IUCN Red List of Threatened Species (2018), all mangrove species observed were evaluated as Least Concerned (LC) species except for *Aegiceras floridum* with Near Threatened (NT) category. It was also noted that all the observed mangrove trees have decreasing population trend except for *Nypa fruticans* with an unknown IUCN population trend (Table 6). *Aegiceras floridum* is relatively widespread but is uncommon with a low population. The different mangrove species are threatened by the loss of mangrove habitat primarily due to coastal development, converting mangroves into aquaculture. They have decreasing population trend due to human activities and may be due also to climate change and severe weather impacts. Although there is an overall range of decline of population in many areas, they did not reach the threatened category threshold except for the *Aegiceras floridum*.

Table 8

Ecological and conservation status of mangrove species in the four selected coastal ecosystems of Zambales

Scientific Name	Conservation Status and Population Trend	
	IUCN 2018.2 Status	Population Trend
Osbornia octodonta	Least Concern (LC)	Decreasing
Rhizophora mucronata	Least Concern (LC)	Decreasing
Rhizophora apiculata	Least Concern (LC)	Decreasing
Excoecaria agallocha	Least Concern (LC)	Decreasing
Heritiera littoralis	Least Concern (LC)	Decreasing
Avicennia marina	Least Concern (LC)	Decreasing
Nypa fruticans	Least Concern (LC)	Unknown
Sonneratia alba	Least Concern (LC)	Decreasing
Bruguiera cylindrica	Least Concern (LC)	Decreasing
Xylocarpus moluccensis	Least Concern (LC)	Decreasing
Aegiceras floridum	Near Threatened (NT)	Decreasing

Based on the habitat criteria rating of the mangroves, the condition of mangroves was determined using the computation of habitat criteria rating for mangroves (Table 1). Results showed that the condition of mangroves in Palauig, Zambales is excellent (Table 9) due to the excellent crown cover of the mangrove and undisturbed condition of the mangrove trees. This finding is owed by the active movement of the local government of Palauig with the help and cooperation of the local communities in the reforestation of the mangrove ecosystems. They have an annual mangrove tree planting in their municipality. On the other hand, the mangroves in Sta. Cruz and Masinloc are in good condition. According to Deguit et al. (2004), mangroves that are in good condition are those that have slight disturbance and few cuttings. Both the local government units of Sta. Cruz and Masinloc perform annual mangrove tree planting in the mangrove ecosystems in the two municipalities to rehabilitate their mangrove ecosystems. However, the planting sites are usually along the shoreline using species from the genus *Rhizophora* (Salmo & Duke, 2010). The survival rate of this species is low and this may be attributed to wrong species-substrate matching (Salmo, 2015). Lastly, results indicated that the mangrove condition in Candelaria is only fair. Among the four sites surveyed, Candelaria has only one barangay with a mangrove ecosystem. In addition, according to Bantay Dagat in Barangay Uacon, the mangrove ecosystems in the area are severely affected by the mine tailings/drainage pollution which came from the adjacent mining areas and the occurrence of extensive sedimentation in the Uacon Lake. However, the Department of Environment and Natural Resources (DENR), the local government unit of Candelaria, and local communities conducted different activities in the Uacon Lake area to improve the condition of the mangrove ecosystems in Candelaria, such as mangrove tree planting and mangrove assessment.

Table 9

Habitat condition of mangroves in four selected sites in Zambales

MUNICIPALITY	% COVER	CONDITION
Sta. Cruz	57.07	Good
Candelaria	43.39	Fair
Masinloc	61.07	Good
Palauig	85.53	Excellent

Major Sources and Levels of Impacts on the Environmental Degradation in the Coastal Ecosystem Sta. Cruz, Candelaria, Masinloc and Palauig, Zambales

Table 10

Sources and levels of impacts of environmental degradation in the four selected coastal ecosystems of Zambales

Sources of Environmental Degradation	Location			
	Sta. Cruz, Zambales	Candelaria, Zambales	Masinloc, Zambales	Palauig, Zambales
1. Sedimentation/ siltation	**2.86**	1.0	1.97	2.65
2. Volcanic eruption/ lahar deposits	1.0	1.0	1.53	2.02
3. Quarrying	2.0	**4.0**	2.03	2.82
4. Dynamite fishing	2.43	**4.0**	**2.52**	**3.27**
5. Mine tailings	**2.9**	**3.2**	2.19	**3.0**
6. Poachers	2.5	1.0	1.79	2.48
7. Encroachment	1.0	2.25	2.09	2.63
8. Toxic chemical hazard	1.0	1.0	2.37	2.16
9. Soil erosion	2.0	**3.0**	2.20	2.94
10. Laundry soap	1.0	1.0	1.63	2.16
11. Environmental aesthetic degradation	**2.67**	**3.0**	2.03	2.69
12. Inorganic fertilizer run-off hazards	1.0	1.0	1.87	2.40
13. Eutrophication	1.0	1.0	**2.64**	**3.56**
14. Organic debris	1.0	1.0	1.65	2.27
15. Oil spill	1.0	1.0	**2.39**	**3.31**
16. Animal wastes	2.0	1.0	1.51	2.40

Table 10 continued.

Sources of Environmental Degradation	Location			
	Sta. Cruz, Zambales	Candelaria, Zambales	Masinloc, Zambales	Palauig, Zambales
17. Mine drainage pollution	**3.2**	**3.2**	**2.38**	**3.06**
18. Desalination	1.0	1.0	2.03	2.60
19. Dredging and filling in water bodies	1.0	1.0	2.07	2.73
20. Solid wastes	**2.71**	2.75	2.15	**3.28**
21. Water oriented disuse hazards	1.0	1.0	2.08	2.77
22. Pond to culture fish	1.0	2.5	2.11	2.90
23. Recreational development	1.0	2.0	1.93	2.63
24. Tourism spot	**3.0**	1.0	2.21	2.94

Table 10 shows the results of the survey of sources and level of impacts on environmental degradation in the coastal ecosystems of Sta. Cruz, Candelaria, Masinloc and Palauig, Zambales.

Results revealed that the major sources of environmental degradation in Sta. Cruz, Zambales are mine drainage pollution and tourism or recreational development while mine tailings, sedimentation/siltation, solid wastes, and environmental, aesthetic degradation had moderate impacts.

Environmental impacts such as biodiversity loss, floods, loss of landscape, soil contamination, waste overflow, deforestation, surface water pollution, disturbance of hydro and geological systems, among others, are caused by mining in Zambales. Mining also posed conflicts on the communities' socio-economic state and impacted the health and wellness of the people (Temper et al., 2015). Moreover, in a study conducted by Bacani et al. (2018), agricultural productivity and food safety were the main concerns affected by mining. Furthermore, in a report published by DENR (2020), mining in Zambales had posed environmental impacts on the communities, farmlands, and water bodies. Likewise, excessive sedimentation caused by mining activities in the area affected the local topography and brought harm to mangrove ecosystems, but also it had great impacts on agriculture and fisheries (Krauss et al., 2008).

However, the sources of environmental degradation in Candelaria, Zambales, which had major impacts on the coastal ecosystems, are quarrying and dynamite fishing. This was followed by mine drainage pollution and mine tailings as well as soil erosion and environmental, aesthetic degradation, which also posed moderate impacts on the coastal ecosystem of Candelaria. West China Min Zambales Ferro-Nickel Plant and Mining Project in Candelaria which conduct quarrying and extract magnetite, black sand, and chromium had caused much destruction in the mountains, watershed, and forests (EPRMP, 2018). These events brought soil erosion, contamination of irrigation waters, river siltation, and flooding, which greatly affected the livelihood of the communities. In view of this, shallow nearshore waters in approximately 10 kilometers of coastline straddling the five coastal barangays were heavily silted. Patches of corals exist in the nearshore area, in widely dispersed distribution, mostly in reef flats that were already heavily degraded due to sedimentation and algal growth (EPRMP, 2018).

Furthermore, eutrophication, dynamite fishing, oil spill, and mine drainage pollution only posed moderate impacts on the coastal ecosystem of Masinloc, Zambales. The exploitation of marine resources is a critical issue in the municipality of Masinloc and also in the neighboring town, which is the Palauig. The small fishers are often blamed for the degraded state of the coastal areas, mainly because of their use of dynamite, poison, and destructive fishing gear (Cinner, 2009). A significant number of fishers from San Salvador, Masinloc, Zambales, as an example, had once been engaged in illegal fishing methods. They used sodium cyanide and dynamite to catch fish with seemingly no concern for the long-term effects of the practice on the marine resources (Christie et al., 2008). Moreover, a mining company, BCI-Coto in Masinloc is presently operating in the nearby area which exports monthly an average of 1-1/2 million pesos worth of chromite ore, mine from what is known as the biggest deposit of refractory ore in the world (Paz-Alberto et al., 2015; Bridgen & Santillo, 2002). This mining company might be the source of mine drainage pollution in the coastal ecosystems.

While in Palauig, Zambales, eutrophication, dynamite fishing, oil spill, mine drainage pollution, and solid wastes posed major impacts on the coastal ecosystems. In 2007, Primerock/Kao Lee Mining (KLM) operated without the Environmental Compliance Certificate, and the operation of the mining in the town affected the irreversible damage to the environment and also resulted in fish kills and the decrease of farmers' harvest (senate.gov.ph). Moreover, with the decline of production in the capture of fish and the decreasing available land and inland waters, the government promoted mariculture to address the issue of food security. However, the presence of mariculture in the town had a great impact on the quality of the seawater for mariculture use floating fish cage structures where artificial feeds and bread are fed to the cultured fish. (Vera, 2004) Fishermen were worried over the risk of a fish kill event that may happen in the municipal waters of Palauig due to unconsumed feeds and excretory wastes from fish cages that have the potential to enrich coastal ecosystems that could lead to eutrophication (Dauda et al., 2019).

The sources of environmental degradation observed in the coastal ecosystems of Sta. Cruz Candelaria, Masinloc and Palauig, Zambales may threaten the flora and fauna in the mangrove ecosystems, which may eventually cause wildlife extinction, loss of biodiversity, hazards to endangered and endemic species, long term environmental losses, impairment of the quality of surface waters, social conflicts, loss of irreplaceable resources and long term environmental and economic loss.

CONCLUSIONS

Only a few species of mangroves that belong to nine families were observed in the four coastal municipalities of Zambales i.e., eleven species in Sta. Cruz, six species in Candelaria, five species in Masinloc, and five species in Palauig. The mangrove ecosystems exhibited low to very low diversity. The majority of the observed mangrove trees are Least Concerned (LC) and have decreasing population. The condition of mangroves in Palauig, Zambales is excellent, while the mangroves in Sta. Cruz and Masinloc are in good condition, while Candelaria has a fair condition. The sources of environmental degradation which posed major impacts on the mangrove ecosystems are tourism, quarrying, dynamite fishing, and mine drainage pollution, which could harm and lessen the diversity of organisms in the mangrove ecosystem leading to biodiversity loss, impairment of the quality of surface waters, loss of irreplaceable resources and long term environmental and economic loss.

RECOMMENDATIONS

Protection and proper management of existing mangrove ecosystems that serve as a shield to local communities and their valuable assets against coastal hazards are highly recommended in the four coastal municipalities of Zambales. Rehabilitation of existing degraded mangrove ecosystems and planting mangrove trees in degraded mangrove areas must be done extensively. It must coordinate with the Department of Environment and Natural Resources in the proper and appropriate mangrove species to be planted. Local communities should be involved in the management and protection of the mangrove ecosystems to have responsibilities and important roles in protecting and maintaining them over the long term. Development of ordinances/policies on coastal resources protection and management must be conducted by the local communities together with the coastal barangays and local government units. Efforts should be further made by every stakeholder to raise awareness and transfer such technologies such as the distribution of IEC materials and the conduct of seminars and trainings to protect the coastal resources. The information generated from this study must be promoted to serve as a guide for conservation activities and management strategies for the remaining mangrove ecosystems.

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