ASSESSMENT OF MANGROVE DAMAGES WITHIN THE RECLAMATION AREA IN CORON, PALAWAN

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EXECUTIVE SUMMARY

Mangroves provide many ecosystem goods and services to coastal communities. They serve as nursery ground for many marine creatures, a habitat for animals, a defense against severe winds and storm surges during typhoons, and a reservoir for atmospheric carbon that is stored. However, despite the benefits they provide, these coastal resources have been in decline over the years, mostly as a result of their conversion to other land uses such as land reclamation for housing and commercial establishment.

One of the remaining mangroves in the country is in Coron, Palawan. The area has one of the longest shorelines and the largest intact mangrove forest in the country that serves as habitat for endemic and threatened Philippine mangroves and wildlife fauna.

This report is in response to the request of DENR PENRO Palawan to conduct an assessment and valuation of the damages to a mangrove stand in Coron, Palawan. An on-going reclamation project in the area has included some mangrove trees to be cut and reclaim the area they occupy.

The study aims to assess and value the damages owing to reclamation, including the stumpage and carbon sequestration lost as well as the assessment of habitat loss. The mangrove stand adjacent to the recent reclamation was used as a proxy for the mangrove lost to reclamation. Standard field methods were used to characterize the adjacent mangrove stand's composition, diversity, and structure and assess their present condition. The field survey was done in November 2022.

Analysis of the adjacent mangrove stand, reveals that the mangrove ecosystem in Poblacion V in Coron, Palawan, is a mixed forest ecosystem composed of true mangroves and mangrove associates or beach species. A total of 10 species belonging to 6 families were recorded, with the Rhizophoraceae family being the most represented. The mean DBH and height of trees range from 6.40 to 29 cm and 3 to 5 m, respectively. *Rhizophora apiculata* is the most dominant species, followed by *Rhizophora mucronata*. *Aegiceras floridum* is nearly threatened under the IUCN Red List and DENR DAO 2017–11; hence, there is an urgent need to conserve them.The biomass carbon stock of the mangrove study sites ranged from 69.3 MgC/ha to 348.2 MgC/ha, or a mean of 203.9 MgC/ha.

Based on satellite image time-series analysis, the mangrove cover in the area was reduced from 1.40 ha in July 2019 to 0.34 ha in November 2021, or a reduction of some 1.06 ha. Based on field measurements of adjacent mangrove, the mean stumpage or volume of wood in the area is 617.20 m^3/ha. With the computed stumpage value of Php 1,300.00/m^3, the total value of stumpage lost to reclamation is estimated at PHP 883,092.11.

Furthermore, using the literature value of the annual carbon sequestration rate of 14.7 tCO_2/ha, and a market price per ton of CO_2 of 11 US dollars, the total value of carbon sequestration lost is about PHP 161,700.00 for the next 20 years.

This assessment has demonstrated that the Poblacion V, Coron Palawan mangrove area, is an important habitat that has been damaged by reclamation activities. This mangrove area also supports the growth and development of a number of species that are considered globally and nationally threatened by extinction due to anthropogenic causes, among many other causes. It also stores a considerable stock of carbon from the biomass of its mangrove trees. Therefore, it should be of highest importance to preserve the remaining resources, such as mangroves and seagrass.

The monetary values of the mangrove ecosystem goods and services (i.e. stumpage and carbon sequestration) lost to reclamation are initial estimates but can be used as a basis to guide the DENR management in refining the monetary value of the mangrove damage. These monetary estimates do not include the value of the mangrove biodiversity lost due to reclamation.

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INTRODUCTION

Mangrove ecosystem provides a variety of ecosystem services (ES), including the provision of foods, goods, and habitat for species that are commercially important (Mukherjee et al., 2014), coastal protection (Alongi, 2008), and cultural services. Through carbon sequestration, they also play a crucial role in reducing the effects of climate change (Duarte et al., 2005; McLeod et al., 2011).

Despite the benefits they offer, these coastal resources have declined globally, primarily as a result of their conversion to other land uses (Duarte et al., 2013). As mangrove ecosystems deteriorate, CO_2 emissions may return to the atmosphere and contribute to global warming (Pendleton et al., 2012). Protecting these coastal resources can significantly lower greenhouse gas emissions and improve carbon sinks (Duarte et al., 2013).

This study report is prepared by DENR-ERDB for DENR-CENRO Coron in response to their request for assessment and valuation of damage to the mangroves of Brgy. Poblacion V, Coron Palawan that were reclaimed adjacent to the reclamation in the area. The study aims to accomplish the following objectives:

1. To assess the damages to mangrove within the reclamation area in Brgy. Poblacion V, Coron, Palawan; and

2. To estimate the monetary value of assessed damages to Coron mangroves.

METHODS

A. Study site

The study site is located adjacent to the reclamation area in Barangay Poblacion V in the municipality of Coron, Palawan (Fig.1). The site is 371 km from Manila and is geographically located at approximately 12◦00'N 120◦12'E. Coron is the third-largest island in the Calamian Islands in northern Palawan in the Philippines. The municipality of Coron is under climatic Type I which has two pronounced seasons, dry from November to April and wet during the rest of the year. Moreover, the annual average rainfall is 198 millimeters (7.80 inches) (PAGASA, 2022).

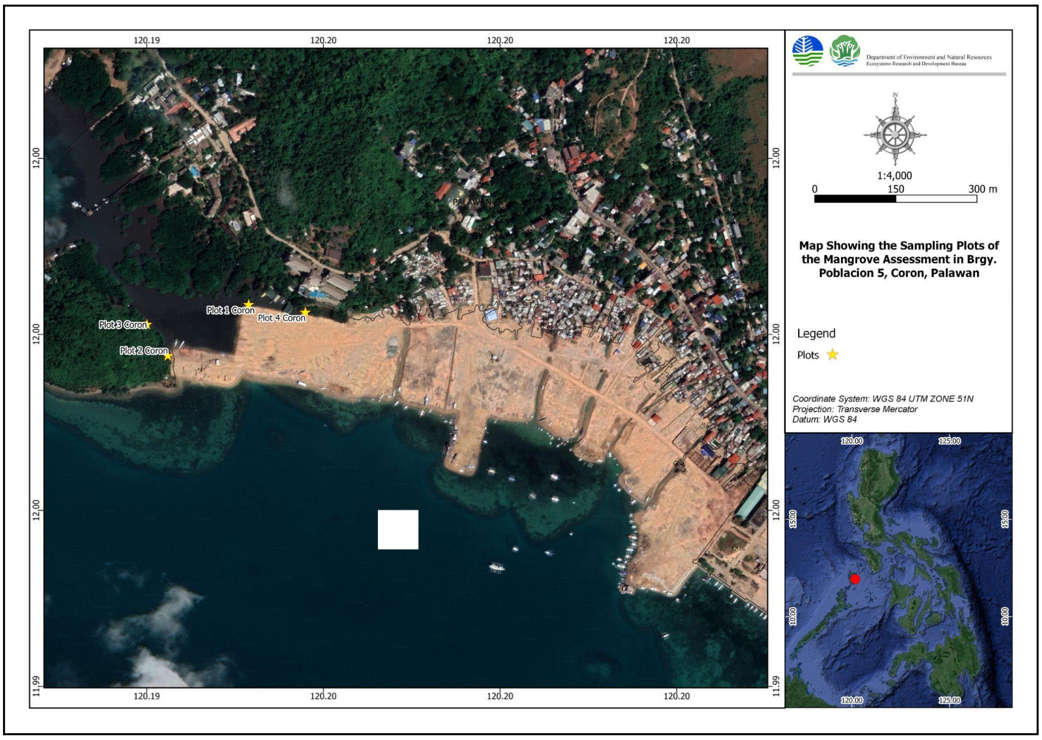

Figure 1. Sampling points of the Mangrove Assessment in Coron, Palawan

B. Vegetation Assessment of Mangrove

To assess the damage to mangroves that were lost to reclamation, the adjacent intact mangrove stand was used as proxy. Quadrat Sampling Technique was used to sample the mangrove vegetation.

A total of four (4) circular plots of 7-m radius (154 m^2) were established at an interval of 10–20m. These plots were used for trees with a diameter at breast height (dbh) of > 5 cm. The geographic coordinates of each plot were determined using a handheld GPS receiver. For each circular plot with a 7-m radius, all vegetation within each duly designated plot was measured, identified, and counted. Height and dbh were measured for species with at least a 5 cm diameter. The count and

DBH collected in the field will be used to calculate tree density and basal area. Tree saplings were also recorded for analysis. Other species seen were documented. The data were analyzed in terms of abundance, dominance, and diversity.

The sample plots established in mangroves are shown in Table 1.

Table 1. Coordinates of the sampling plots in the study area

Plots	Longitude	Latitude
Plot 1	120.193731	12.000503
Plot 2	120.192358	11.999634
Plot 3	120.192003	12.000166
Plot 4	120.194695	12.000372

C. Damage Assessment

Due to difficulty in determining the monetary value of the damage, only the area, stumpage and carbon sequestration losses attributed to the reclamation were included in the assessment.

1. Mangrove Area Lost to Reclamation

The extent of the mangrove cover was computed by digitizing the Google Earth Image of the site. The July 2019 and November 2021 images were used to compute the changes in mangrove in the area during the period.

2. Stumpage Lost to Reclamation

Stumpage is a payment for the right to harvest standing wood calculated as a unit value per stump (Daniels, 2011).

The variables in the computation of stumpage value of mangrove timber were adapted to the study of Vista et al. (2016) on Cost and return for mangrove related products.

Volume of stumpage of each tree was computed by multiplying the basal area of each tree with its height. The total volume per plot was computed as well as average volume of the total plots established.

The Stumpage Value of Mangrove Timber was computed using the formula below.

= (Volume * Unit Price of similar good) + transport cost – harvesting cost

= (Volume* Php 1,861.67/m^3) + Php 72.48 – Php 549.02

Note. Volume V (m^3) = BA.H.ff

where: BA = basal area (m^2)

H = height (m)

ff = form factor (average 0.65)

3. Carbon Sequestration Lost to Reclamation

Published allometric equations for aboveground and belowground biomass of mangroves from Southeast Asian countries were used to calculate the tree biomass (Table 2). The tree biomass data were computed from DBH values of each tree and converted to its C equivalent using C fraction value (47% for AGB and 39% for BGB) based on Kauffman and Donato (2012).

Table 2. Biomass allometric equations and wood density value used in the study

Species	Aboveground	Belowground[+]	References for aboveground biomass equations	Wood Density (g cm^{-3})
Aegiceras floridum	Biomass (kg) = $0.251*\square*D^{2.46}$	Biomass (kg) = $0.199*\square^{0.899}D^{2.22}$	Komiyama *et al.* (2005)	0.71[a]
Bruguiera gymnorrhiza	Biomass (kg) = $0.186 D^{2.31}$	Biomass (kg) = $0.199*\square^{0.899}D^{2.22}$	Clough and Scott (1989)	0.85[b]
B. parviflora	Biomass (kg) = $0.168D^{2.42}$	Biomass (kg) = $0.199*\square^{0.899}D^{2.22}$	Clough and Scott (1989)	0.89[b]
B. sexangula	Biomass (kg) = $0.168D^{2.42}$	Biomass (kg) = $0.199*\square^{0.899}D^{2.22}$	Clough and Scott (1989)	0.87[b]
Camptostemon philippinense	Biomass (kg) = $0.251*\square*D^{2.46}$	Biomass (kg) = $0.199*\square^{0.899}D^{2.22}$	Komiyama *et al.* (2005)	0.71[a]
Ceriops tagal	Biomass (kg) = $0.251*\square*D^{2.46}$	Biomass (kg) = $0.199*\square^{0.899}D^{2.22}$	Komiyama *et al.* (2005)	0.89[b]
Cocos nucifera	Biomass (kg) = $0.7854*D^2*H*\square*1.6$	Biomass (kg) $=0.7845*D^2*H*\square*1.6*0.04$ (Zamora 1999)	Brown (1997); Zamora (1999)	0.25[c]
Heritiera littoralis	Biomass (kg) = $0.251*\square*D^{2.46}$	Biomass (kg) = $0.199*\square^{0.899}D^{2.22}$	Komiyama *et al.* (2005)	0..84[a]
Lumnitzera racemosa	Biomass (kg) = $0.251*\square*D^{2.46}$	Biomass (kg) = $0.199*\square^{0.899}D^{2.22}$	Komiyama *et al.* (2005)	0.71[a]
Rhizophora apiculata	Biomass (kg) = $0.235D^{2.42}$ + Biomass$_{stilt}$ (kg) = $0.0209D^{2.55}$	Biomass (kg) = $0.199*\square^{0.899}D^{2.22}$	Ong et al. (2004)	1.04[b]
R. mucronata	Biomass (kg) = $0.235D^{2.42}$ + Biomass$_{stilt}$ (kg) = $0.0209D^{2.55}$	Biomass (kg) = $0.199*\square^{0.899}D^{2.22}$	Ong et al. (2004)	0.98[b]
R. stylosa	Biomass (kg) = $0.235D^{2.42}$ + Biomass$_{stilt}$ (kg) = $0.0209D^{2.55}$	Biomass (kg) = $0.199*\square^{0.899}D^{2.22}$	Ong et al. (2004)	0.98[b]
Sonneratia alba	Biomass (kg) = $0.251*\square*D^{2.46}$	Biomass (kg) = $0.199*\square^{0.899}D^{2.22}$	Komiyama *et al.* (2005)	0.83[b]
Xylocarpus moluccensis	Biomass (kg) = $0.251*\square*D^{2.46}$	Biomass (kg) = $0.199*\square^{0.899}D^{2.22}$	Komiyama *et al.* (2005)	0.66[b]
X. granatum	Biomass (kg) = $0.251*\square*D^{2.46}$	Biomass (kg) = $0.199*\square^{0.899}D^{2.22}$	Komiyama *et al.* (2005)	0.66[b]

[a]Howard *et al.*, 2014 [b]Brown and Fisher, 1920 [c]Brown 1997; Zamora, 1999 [+]Equations from Komiyama et al. (2005) unless stated otherwise

Mangrove carbon sequestration of 14.7 tonne CO_2/ha/year were taken from Castillo & Breva (2012)

Total Price of Carbon Sequestration Lost = Total Sequestration (tCO_2/year) * Price per ton

RESULTS AND DISCUSSION

A portion of the reclamation area was once covered by mangroves. The area is covered with mangrove and beach strand vegetation with seagrass beds. The common plants recorded are *Rhizophora apiculata* and *Rhizophora mucronata*. A total of 10 species belonging to 6 families were recorded in the area and the recorded species of *Aegiceras floridum* is nearly threatened under the IUCN Red List and DENR DAO 2017-11 hence, there is an urgent need to conserve them.

The analysis of the tree flora of the study showed that the families of Rhizophoraceae are the most represented, followed by Acanthaceae and Combretaceae, which recorded the highest number of species. Indeed, the presence of the Rhizophoraceae, Acanthaceae and Combretaceae are generally represented by species of tree is a characteristic common to all mangrove forests (Feller, 2018), as shown in Figure 2.

Figure 2. Sampling plots for the mangrove assessment (Photo: MMBernales)

The biomass Carbon stock of the mangrove study sites ranged from 69.3 MgC/ha to 348.2 MgC/ha or a mean of 203.9 MgC/ha.


a
b
c
d

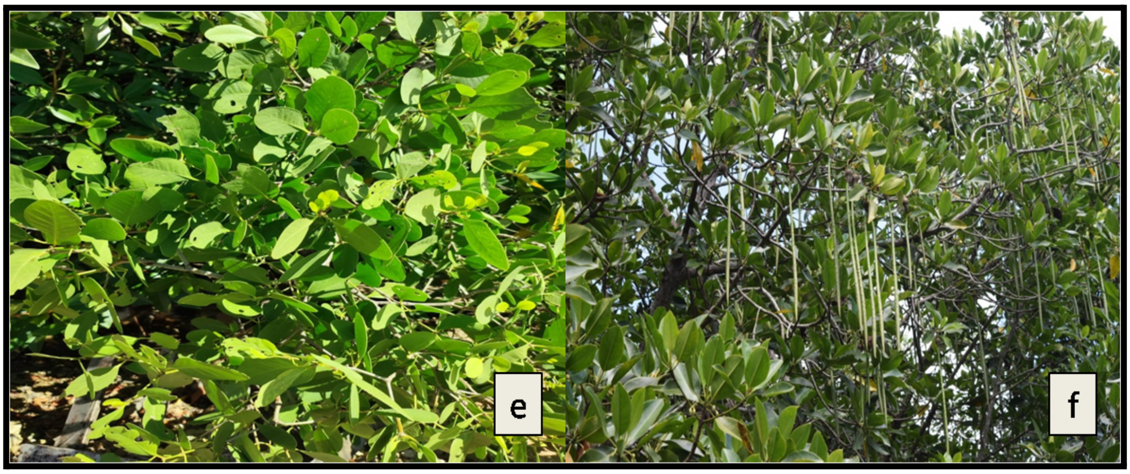
e
f

Figure 3. Species recorded in the sampling plots (a) *Rhizophora apiculata* (b) *Xylocarpus granatum* (c) *Osbornia octodonta* (d) *Avicennia marina* (e) *Sonneratia alba* (f) *Rhizophora mucronata* (g)*Lumnitzera littorea* (h) *Bruguiera cylindrica* (i) *Avicennia officinalis* (j)*Aegiceras floridum*

A. Area Lost to Reclamation

In July 2019, the mangrove cover lost to reclamation was estimated to be 1.40 hectares. However, only 0.34 hectares of mangrove cover remained, which was taken in November 2021, barely two years later (Figure 4).

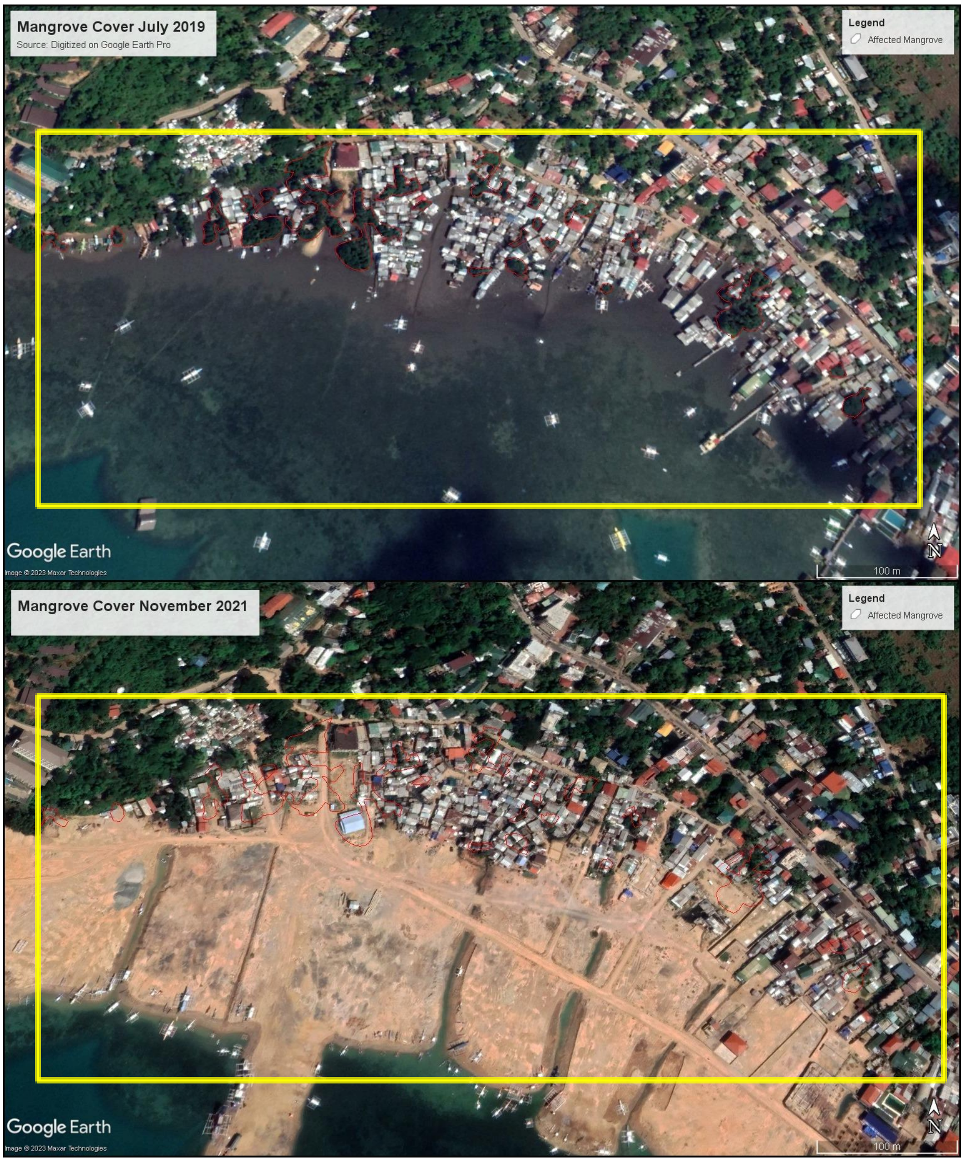

Figure 4. Before and after Google Earth Image of the affected mangrove on reclamation activities in Coron, Palawan

B. Stumpage Lost to Reclamation

The mean DBH and height of mangrove trees in the study site range from 6.40 to 29 cm and 3 to 7 m, respectively. It has been observed that *A. officinalis* and *A. marina* resulted in the species with the highest average DBH among others. In terms of the average height, *A. officinalis*, *S. alba*, and *A. marina* bore the highest among other species that can be found at the study site. *A. officinalis* bore the highest average basal area.

Table 3. Mean DBH, Height and Basal Area of the Species in Coron, Palawan

Species	Mean DBH (cm)	Mean Height (m)	Mean Basal Area
Avicennia officinalis L.	29.00	7.00	0.07
Avicennia marina (Forsk.) Vierh.	22.00	6.00	0.04
Sonneratia alba J. Smith	15.93	6.13	0.02
Rhizophora apiculata Blume	13.83	5.93	0.02
Rhizophora mucronata Lam.	12.56	5.00	0.01
Osbornia octodonta F. Muell.	10.38	4.00	0.01
Xylocarpus granatum Koen.	9.33	5.00	0.01
Bruguiera cylindrica L. (Blume)	8.33	4.00	0.01
Lumnitzera littorea (Jack) Voigt.	8.00	5.00	0.01
Aegiceras floridum Roem. and Schult.	6.40	3.00	0.00

The stumpage value of mangrove timber is computed as follows:

= (Volume * Unit Price of similar good) + transport cost – harvesting cost

= (Volume* Php 1,861.67/m^3) + Php 72.48 – Php 549.02

Volume = (617.20 m^3 * Php 1,861.67/m^3) + Php 72.48 – Php 549.02

= **Php 857,370.98 per hectare**

Table 4. Total price of the stumpage lost

2019 Area (ha)	Volume per hectare	Price per m^3	Total Price
1.063	617.20	Php 1389.13	Php 883,092.11

Based on the computed stumpage value, the total price amounted to PHP 883,092.11. This amount is the total damage brought about by the reclamation activities in the affected 1.063 ha of mangrove stand in Coron, Palawan.

C. Carbon Sequestration Lost to Reclamation

According to Castillo and Breva (2012), the annual total sequestration rate is calculated to be 14.7 tCO_2/ha. In the market, the price per ton of CO_2 is 11 US dollars. In a 20 year projection, the total price of carbon sequestration lost is about Php 161, 700.00.

Table 5. 20-year projection of the monetary value of the carbon sequestration lost

Year	Total Sequestration (tCO_2/ha/year)	Area Lost to Reclamation (hectare)	Price/ton CO_2(Php)	Total Price (Php)
2022	14.7	1.06 ha	550 (11 USD)	Php 8,085.00
2023	14.7	1.06 ha	550 (11 USD)	Php 8,085.00
2024	14.7	1.06 ha	550 (11 USD)	Php 8,085.00
2025	14.7	1.06 ha	550 (11 USD)	Php 8,085.00
2026	14.7	1.06 ha	550 (11 USD)	Php 8,085.00
2027	14.7	1.06 ha	550 (11 USD)	Php 8,085.00
2028	14.7	1.06 ha	550 (11 USD)	Php 8,085.00
2029	14.7	1.06 ha	550 (11 USD)	Php 8,085.00
2030	14.7	1.06 ha	550 (11 USD)	Php 8,085.00
2031	14.7	1.06 ha	550 (11 USD)	Php 8,085.00
2032	14.7	1.06 ha	550 (11 USD)	Php 8,085.00
2033	14.7	1.06 ha	550 (11 USD)	Php 8,085.00
2034	14.7	1.06 ha	550 (11 USD)	Php 8,085.00
2035	14.7	1.06 ha	550 (11 USD)	Php 8,085.00
2036	14.7	1.06 ha	550 (11 USD)	Php 8,085.00
2037	14.7	1.06 ha	550 (11 USD)	Php 8,085.00
2038	14.7	1.06 ha	550 (11 USD)	Php 8,085.00
2039	14.7	1.06 ha	550 (11 USD)	Php 8,085.00
2040	14.7	1.06 ha	550 (11 USD)	Php 8,085.00
2041	14.7	1.06 ha	550 (11 USD)	Php 8,085.00
TOTAL			Php 161, 700.00	

D. Other habitat lost to Reclamation (Seagrass and Fauna)

During the assessment,the team observed that the greater damage caused by the reclamation occurs in the seagrass ecosystem. The presence of dried leaves of *Enhalus acoroides* (**Fig. 5**) might suggest that the reclamation site was once dominated by this species. The said species is one of the pioneer species of seagrass. They are marine angiosperms that serve as carbon sinks, enhance water quality, provide habitat and food, and serve as biological indicators. This observation was supported by the study of ERDB in 2018 wherein one of sampling plots of the study is situated in the reclamation area. Based on the ERDB study, the eelgrass was also dominant in the area in terms of cover. The seagrass beds in the area were relatively more pristine than in any other seagrass area in Coron, Palawan. The presence of intact mangrove vegetation at the former site may have influenced better growth of the nearby seagrass by reducing sediment and nutrient influx.

Figure 5. Seagrass area damaged by the reclamation in Coron, Palawan

The attributes of the marine and coastal habitats create connected ecosystems that call for an integrated management strategy. If sustainable management initiatives aren't successfully executed, the IP community's proximity to the area may act as a founder population that will soon grow and increase dependence on the coastal resources. Due to their proximity to habitations and the reclamation work done by the LGU, the seagrass beds in the area can be regarded as "disturbed." Nevertheless, equal emphasis should be paid to the protection of the two ecosystems (seagrass and mangrove).

CONCLUSION AND RECOMMENDATION

This study has shown that a total of 1.06 hectares of mangroves were damaged based on analyses of satellite images. This 1-ha mangrove stand lost to reclamation has an estimated monetary value of Php 883,092.11 worth of stumpage and Php 161, 000.00 worth of yearly carbon sequestration function.

These values exclude the monetary value of the biodiversity lost which was not estimated in this study due to technical limitations. These estimates are preliminaries but can be used by the DENR management as a basis to refine the monetary value of the mangrove damage.

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