Natural Regrowth of Mangrove Five Years After a Large-Scale Disturbance

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Abstract

Haiyan, the strongest typhoon on landfall damaged mangrove covers resulting to uprooting, cutting off trunks, total defoliation and eventually death. After five years, Cancabato Bay were monitored for mangal succession and natural regrowth. Basal area was computed using diameter by breast height to estimate recovery. New species reappeared compared to the baseline study of GIZ (2014). Mangroves manifested regrowth and should be given time for natural regeneration and colonization. Natural succession patterns should be considered in human-assisted rehabilitation after disturbance.

Keywords: ecological succession, succession patterns, large-scale disturbance, human-assisted rehabilitation

Introduction

For decades, Philippine mangrove cover declined from 400,000-500,000 hectares/year and 120,000 hectares/year in 1994, attributed to unsustainable human-induced practices- aquaculture, land conversion, and settlements (Canopio et al., 2021; Primavera & Esteban, 2008; Garcia et al., 2014). As anthropogenic pressures proliferate, typhoons also contribute to mangrove decline (Hakim et al., 2017; Long et al., 2016; Primavera et al., 2016). Mangroves became an interest in climate change as a sustainable mitigating solution.

Mangroves are the coastal defense against typhoon, wave surges, and storm impacts (Primavera et al., 2016; McIvor et al., 2012). Synergism of anthropogenic and natural pressures is least understood on ecosystems and recovery, whether natural, human facilitated or combinations are dearth in literature. Nevertheless, mangrove protection by the Department of Environment and Natural Resources (DENR) recorded an increase of 247,362 hectares in 2007 (Garcia et al., 2013).

On November 8, 2013, the strongest typhoon on landfall, Haiyan generated strong winds and storm surges, causing

Materials and Methods
Study Site
Four permanent transect lines were laid in Brgy. Alimasag, Tacloban City, is part of the Kataisan Point, a tapering piece of land extension from mainland Leyte Island distending to Cancabato Bay and Leyte Gulf. This area is at the tip of Tacloban City DZR Airport, impending the construction of the Causeway Project embankment. During Haiyan, this area was totally obliterated, generating 7m+ surges.

Figure1. Research Locale (A)The four permanent transect lines established in the sampling sites were labeled S1, S2, S3, and S4, respectively. (B) A map of Tacloban City, emphasizing the sampling site, encircled its exact position and proximities from water bodies. (C) A table was inserted to stress the GPS coordinates of the sampling sites.

total devastation in Tacloban City (NDRRMC, 2013; Matillano, 2016). Haiyan damaged coastal greenbelts, uprooting large trees and breaking off main trunks, which created total defoliation and death among mangroves. The Philippine government provides PHP 167.86B Haiyan Rehabilitation Fund (Villamayor et al., 2016), including PHP 38M allocation of the DENR for mangrove planting alone (r8.denr.gov.ph).

Mangrove survived along San Juanico Strait, Anibong Bay, and Cancabato Bay exhibiting regeneration (Matillano et al., 2018; Matillano et al., 2020). GIZ (2014) monitored surviving mangrove patches along Brgy. Cabalawan and Brgy. Alimasag withstanding the super typhoon and manifested regrowth even without restoration.

Monitoring recovery and regrowth, comparing from the baseline study, offers succession outlooks on ecosystem recovery. Mangroves respond to stress differently (Primavera et al., 2016), and human-assisted rehabilitation should pattern natural succession frameworks. Mangroves recover after disturbance depending upon the magnitude of damage (Primavera et al., 2016).

Methods
Four 50-meter transect lines were laid in the four identified sites (Figure 1), setting two transect lines in seaward and landward zones. A 10x10 m observational quadrat was also established every 10 m on both sides of the transect line. A total of 40 quadrats were covered for the actual observation sites. The sampling site identification was based on the extent of mangrove cover, access to the area, and land ownership delineation.

Species Identification
The taxonomic key found in the Field Guide to Philippine Mangroves by Primavera, 2009 was the basis for the identification. Photo documentation was confirmed by the Department of Environment and Natural Resources (DENR).

Computing the Basal Area
The diameter of surviving mangrove's trunks was measured for the computation of basal area by Diameter at Breast Height (DBH). Basal area is needed to determine forest stand density to estimate mangrove recovery. Seedlings were not included in the computation.

Results and Discussions

As a basis for the re-emergence of mangrove species after Haiyan, GIZ (2014) data served as the baseline for surviving species list. They became a source of comparison of new species, which will be identified in this study. In 2014, 8 species of mangroves were identified compared to 22 species in this study. No other references are available after Haiyan, as most of the literature talks about the socio-political perspectives of rehabilitation (Matillano, 2016; Daga, 2019).

Table 1. Comparison of mangrove and mangrove associate species found in 2014 and 2019

Mangrove Species	GIZ, 2014	This Study, 2019
Acanthus ilicifolius		√
Acanthus volubilis		√
Aegiceras corniculatum	√	√
Aegiceras floridum		√
Avicennia marina	√	√
Avicennia rumphiana		√
Breyia vitis ideae		√
Bruigera cylindrica		√
Bruigera gymnorrhiza	√	√
Ceriops decandra	√	√
Ceriops tagal		√
Lumnitzera littorea		√
Lumitzera racemosa		√
Nypa fruticans		√
Pemphis acidula		√
Rhizophora apiculata	√	√
Rhizophora mucronata	√	√
Rhizophora stylosa		√
Scyphiphora hydrophyllacea	√	√
Sonneratia alba	√	√
Sonneratia caseoralis		√
Xylocarpus granatum		√

Table 1 shows that fourteen additional (14) mangrove species were added to the list of species present on the premise of the GIZ (2014) study. The mangrove species are *Acanthus ilicifolius*, *Acanthus volubilis*, *Aegiceras floridum*, *Avicennia rumphiana*, *Breyia vitis ideae*, *Bruigera cylindrical*, *Ceriops tagal*, *Lumnitzera littorea*, *Lumnitzera racemosa*, *Pemphis acidula*, *Rhizophora stylosa*, *Sonneratia alba* and *Xylocarpus granatum*. The emergence or reemergence of mangrove species after a large-scale disturbance may increase species richness as an attribute of an ecological succession of biological communities (Chang & Turner, 2019). Depending upon the severity of the disturbance, succession is site specific depending upon ecological conditions contingent on the disturbance intensity, site conditions, competition, and demographic trade-offs (Chang et al., 2019; Fischer et al.,

2019). Though the data is limited to increased species richness and recovery of mangrove species after Haiyan, a manifestation of succession is already in its primary stage. It is a challenge for researchers to persistently monitor ecosystems' coping mechanisms in order to establish patterns and drivers of ecological succession.

Table 2. Comparison basal area occupied mangrove and mangrove associates in GIZ, 2014 and this study 2019

Mangrove Species	Basal Area GIZ, 2014 m²/ha	Basal Area This Study, 2019 m²/ha
Acanthus ilicifolius		
Acanthus volubilis		
Aegiceras corniculatum	0.016	3.41
Aegiceras floridum		38.27
Avicennia marina	0.077	93.71
Avicennia rumphiana		6.22
Breyia vitis ideae		
Bruigera cylindrica		1.37
Bruigera gymnorrhiza	0.023	2.55
Ceriops decandra	0.017	14.46
Ceriops tagal		4.5
Lumnitzera littorea		2.61
Lumitzera racemosa		2.56
Nypa fruticans		
Pemphis acidula		0.51
Rhizophora apiculata	0.029	11.33
Rhizophora mucronata	0.025	30.85
Rhizophora stylosa		30.52
Sonneratia alba	0.016	105.7
Sonneratia caseoralis		8.12
Scyphiphora hydrophyllacea	0.129	1.43
Xylocarpus granatum		3.45
Total	0.332	361.57

🟩 Creepers　　🟨 Juvenile

The basal area occupied by surviving mangroves after super typhoon Haiyan GIZ (2014) and this study was compared to indicate recovery after five years. In Brgy. Alimasag, a total of .332 m²/ha were recorded occupied by mangroves indicating regrowth one year after the super typhoon. Resprouting from defoliation, stumps, and fallen trunks with sprouting meristems were included in the sampling. Otherwise, shoots were not included and considered dead if the trunk was cut, fallen, and uprooted but with no signs of sprouting. As there are no follow-up studies on the status of mangroves, monitoring their conditions entails ecological succession.

After five years, the basal area occupied by mangroves had reached 361.57 m²/ha, dominated by *S. alba*, *A. marina*, *A. floridum*, *R. mucronata*, and *R. stylosa*. Compared with
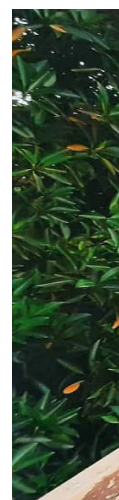
GIZ's (2014) study, mangrove density flourished, indicating natural regeneration without human-assisted intervention. Much is attributed to S. alba, from 0.016 m²/ha in 2014 to 105.7 m²/ha in 2019, indicating slow sprouting after one year, with few mangrove stands exhibiting regeneration. After five years, more mangrove trees had shown regrowth, including large trees, stumps cut, and trunks fell had already displayed recovery. Most of the mangroves did not show an indication of regrowth in 2014 but exhibited recovery after five years.

Similar to A. marina, 0.077 m²/ha in 2014 to 93.71 m²/ha in 2019, had shown natural recovery indicating a high increase in basal area. Though regrowth was not immediate, natural recovery patterns allow previously thriving species to regenerate and restore themselves, if not the same systems as before, may mirror natural succession mechanisms that may be recovering to their original system or, maybe, deviate into a new one.

Much is attributed to A. floridum, which did not manifest regrowth one year after Haiyan but flourished after five years. This implies the dawdling recovery of A. floridum compared to other mangrove species. If there would be stands of A. floridum before the disturbance, leaving defoliated trunks, cut, and fallen stumps should be given time to recover and resprout in their means prior to human-assisted rehabilitation efforts. Mangrove planting after Haiyan was so rampant as Philippine Government allocated many funds for mangrove planting in the pretense of restoration efforts. Without considering the natural succession patterns and replacing natural thriving species after disturbance, human-assisted restoration efforts may divert functional systems that had been established prior to the disturbance.

Conclusion

After five years, mangroves reappeared: *Acanthus ilicifolius, Acanthus volubilis, Aegiceras floridum, Avicennia rumphiana, Breyia vitis ideae, Bruigera cylindrica, Ceripos tagal, Lumnitzera littorea, Lumnitze raracemosa, Pemphis acidula, Rhizophora stylosa, Sonneratia alba* and *Xylocarpus granatum* that were not identified in the study of GIZ (2014). S. alba, A. marina, and *A. floridum* have the highest basal area signifying natural regeneration among defoliated stands, cut, fallen, and uprooted trunks five years after Haiyan. Mangroves should be given time for regrowth and establish natural regeneration and colonization. Natural succession patterns should be considered in human-assisted rehabilitation after disturbance.

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Natural Regrowth of Mangrove Five Years

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