The status of mangroves in Panguil Bay, Philippines

[1]Wilson C. Nabua, [2]Alita T. Roxas, [3]Wilfredo H. Uy

[1] Northwestern Mindanao State College of Science and Technology, Tangub City, Philippines; [2] Mindanao State University-Iligan Institute of Technology, Iligan City, Philippines; [3] Mindanao State University at Naawan Campus, Naawaan, Misamis Oriental, Philippines. Corresponding author: W. C. Nabua, wilsonabua@gmail.com

Abstract. This study aimed to determine the past and present status of mangroves in Panguil Bay, Philippines. This study utilized a descriptive research design to assess the community structure of the three areas considered in this study and these are the municipalities of Tubod and Kolambugan in Lanao del Norte and Tangub City in Misamis Occidental. Both quantitative and qualitative methods were used in this study. For quantitative research, an assessment of the community structure of mangroves was done. On the other hand, to enhance the discussion, the qualitative research method employed oral history to determine the status of mangroves 30 to 40 years ago. Line transects plot sampling was employed in the identification of mangroves, including their richness and abundance. Results revealed that within 50 years from 1956, DENR in 2015 estimated a 50% reduction in the area of mangroves in Panguil Bay. Due to the serious implementation of the rehabilitation programs, the reduction of the mangrove areas was down to 21.59% and 10.59% in Lanao del Norte and Misamis Occidental, respectively. Mangroves have regained their abundance through rehabilitation efforts under the Upland Development Program (UDP) and National Greening Program (NGP). There were twenty-seven (27) mangrove species identified in Panguil Bay under the thirteen families and Tangub City has the most number of species with twenty-two (22) while Tubod has only eight (8). The Philippines has 39 species of true mangroves, and 20, or 51.28% are found in Panguil Bay. The mangrove areas in the three locations were fragmented but mangroves in Tangub City were more diverse and had a higher rate of regeneration compared to other areas.

Key Words: abundance, diversity, mangrove assessment, mangrove status, Panguil Bay.

Introduction. Mangrove forests provide a living to the community as a source of wood and other estuarine products (Ajonina 2011; Cañizares & Seronay 2015; Venturillo 2016). They protect people from harm due to the attack of waves, typhoons, and soil erosions (Baleta & Casalamitao 2016). As the years went by, forest areas were becoming thinner by natural and anthropogenic factors. The latter is the most evident factor as manifested by a significant increase in population (Chu & Karr 2017; Ritchie & Roser 2021). The degradation of natural resources has somehow improved the living condition of the people but posed a threat to the environment (Do & Thuy 2022). Mangrove forests had been very thick several decades ago. However, due to an increase in population, people exploited the mangrove resources as their source of livelihood and other economic-related activities (Sandilyan & Kathiresan 2012). People utilize the plants and animals and unknowingly they already exploited the resources depriving future generations to use them at an optimum level. They may be unaware that mangroves shelter coastlines and estuaries. One of the significant reasons for the degradation of mangrove habitats may be the people's lack of knowledge about the value of its services (Nyangoko et al 2021). This may be the reason why environmental degradation becomes a perennial issue in every country, particularly developing nations.

Giri et al (2011) reported that in the 118 countries and regions in the world, mangroves constituted a total area of 37,760 km^2. Three to five decades ago, the area declined at a rate of 5,000 hectares per year due to the establishment of fishponds as government initiatives (Long et al 2014; Primavera et al 2014). The destruction of mangrove forests escalated as people utilized some resources of mangroves through the cutting of trees for building houses and making charcoal (Aye et al 2019; Dahdouh-Guebas et al 2020) and agriculture and urbanization (Bhattarai & Giri 2011). Moreover, natural calamities have also caused the shrinkage of mangrove areas (Asbridge et al 2015; Buitre et al 2019). In effect, several species of mangroves were gone and some are already at the stage of extinction. This alarms the government so that it advocates initiatives of healing the environment through tree growing. The government intervened through the formulation of policies to protect the ecosystems from continuous degradation.

Like the other places in the country, Panguil Bay in Mindanao, Philippines has also experienced the denudation of mangrove forests. Moreover, the incoming infrastructure development, particularly the establishment of the Panguil Bay Bridge (PBB) connecting the municipality of Tubod in Lanao del Norte and the City of Tangub in Misamis Occidental, can also affect some of the species of mangroves and fish products in the area but has a strong effect on the economy in the area. More than a decade ago, Roxas et al (2009) reported that in Panguil Bay, there were 21 and 15 species of true and associated mangroves, respectively. In 2009, the communities were the recipients of the rehabilitation programs of mangroves under the Upland Development Program (UDP) of the Department of Environment and Natural Resources (DENR), followed by the National Greening Program (NGP) in 2012-2017 (DENR R10 report). For several years now, the bay is believed to be different already. Since there were already interventions in the previous years, the study sites had already mixed types of mangroves; the naturally grown and replanted. This study then assesses the status of mangroves as a basis for the formulation of appropriate policies.

Material and Method

Study areas and sampling sites. The study was conducted in Panguil Bay, the Philippines, particularly in the City of Tangub in Misamis Occidental and the municipalities of Kolambugan and Tubod in Lanao del Norte (Figure 1). Panguil Bay is about 41 kilometers long and has an area of 18,000 hectares with a coastline of 112 kilometers. At its narrowest point between Tangub and Tubod, the bay is 1.7 kilometers wide, while it is 11.5 kilometers wide at the bay's mouth. The mangroves that were assessed were both natural and second-growth. Figures 2 and 3 are the sampling sites showing barangays, the transects and sampling points in Tangub City, and the municipalities of Tubod and Kolambugan, respectively. The assessment of community structure of mangroves was done on January to February 2020.

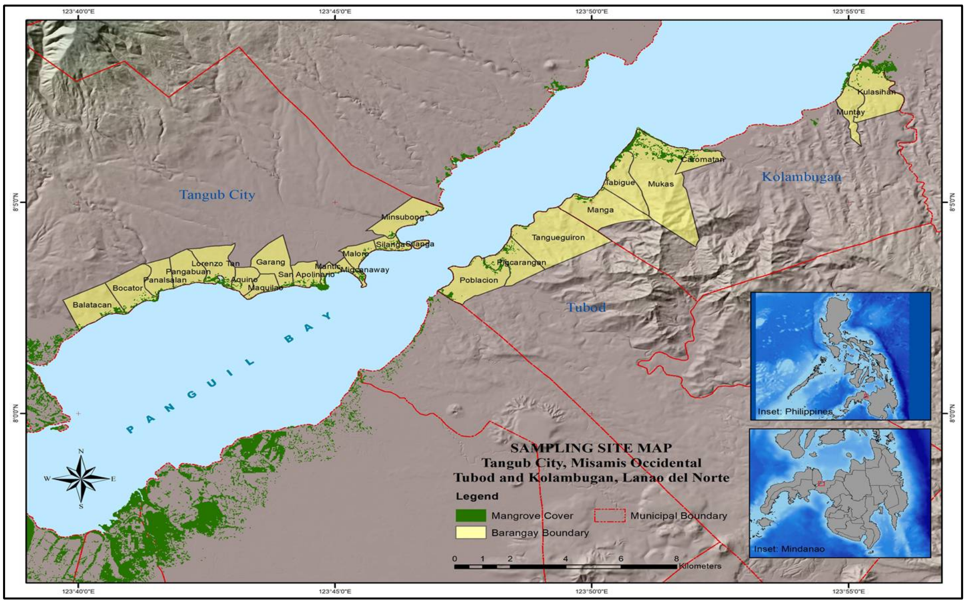

Figure1. Map showing the study sites: Tangub City, Tubod, and Kolambugan in Lanao del Norte.

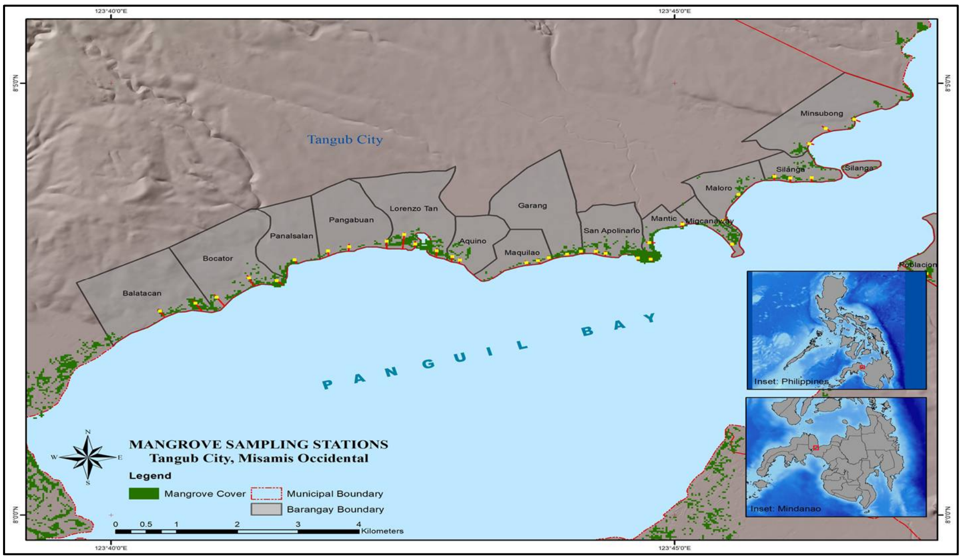

Figure 2. Sampling sites in Tangub City.

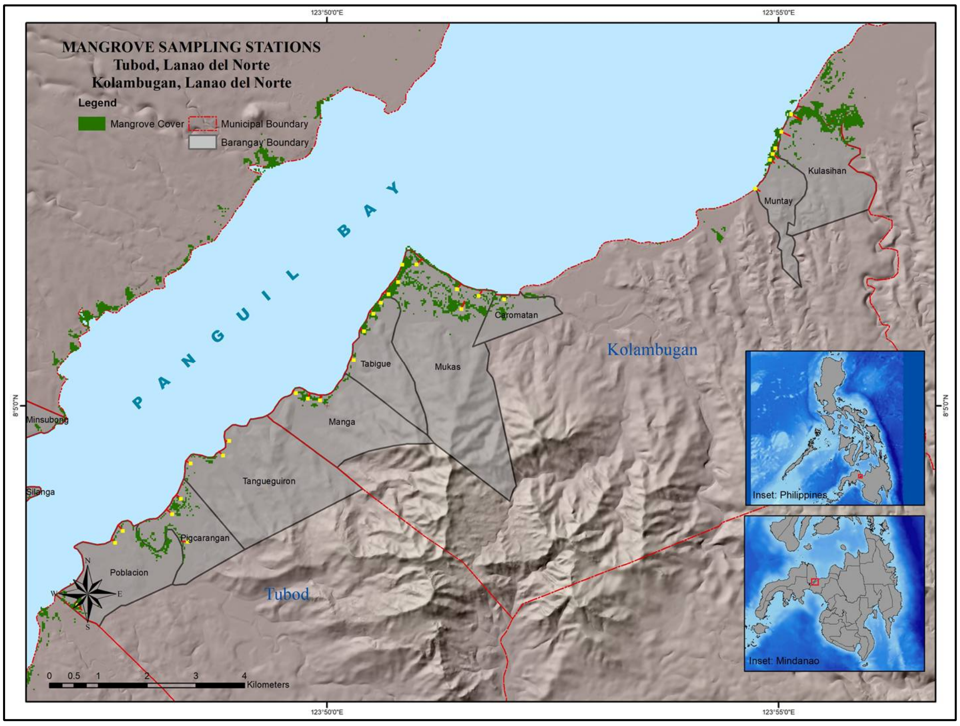

Figure 3. Sampling sites in Kolambugan and Tubod, Lanao del Norte.

Informants of the study. To determine the status of mangroves through oral history, the researchers conducted key informant interviews among old folks who have been residents in the areas for more than 30 years. One old informant was identified through the recommendation of the Barangay Chairmen. These informants should have observed the changes in the mangrove environment and described the situation of mangroves more than 30 years ago to the present. Oral history can inform the researchers and the reading public what mangroves were like at different times, and in this specific case, from 30 years ago to the present time. As Ranjan (2012) stated, oral history is an emerging discipline that is very useful for the present and future generations. The information obtained from the oral history was good support to the secondary data from the DENR and the data derived from the actual assessment of the community structure of the mangroves.

Aside from the old residents in the area, the Barangay chairs and councilors, officers of the different associations, employees of non-government organizations

(NGOs), and DENR personnel also served as key informants of the study. The interviews with the informants were conducted on June to November 2020, during the pandemic period. Health protocols were strictly followed during the interviews.

Method of data collection. Sampling stations were established in each barangay that formed part of the study areas. For each station, 100 meters long transect lines were laid perpendicular to the shoreline. For the sampling of mangroves, the field researcher set up a 10 x 10 m plot with an interval of 20 meters for every plot to facilitate inventory. Inside the plot, the researcher identified and counted the mangroves. Each mangrove within the plots was characterized as a seedling, sapling, and mature tree based on the definition of English et al (1997) and Deguit et al (2004). On the regeneration of mangroves, one 5 x 5 and three 1 x 1 m subplot for saplings and seedlings counting, respectively, was established.

The mangroves were identified *in situ* and classified taxonomically. The mangrove species were determined using the field guide manual to Philippine mangroves by Primavera (2004) and the field guide to the identification of some mangrove plant species in the Philippines by Melana et al (2000). The mangroves in the study sites were both naturally grown and replanted as rehabilitation of mangrove forests was implemented in these sites.

Data processing and analysis

Diversity indices. This study used the Shannon-Wiener diversity index which was calculated using the Paleontological Statistical Software Package (PAST) developed by Hammer et al (2001):

$$H' = -\Sigma p_i \times \ln(p_i)$$

where: H' = diversity index;

p_i = the proportion of the entire community made up of species *i*.

Species richness. In this study, the species richness was simply counting the number of different kinds of species present in a particular area.

Vegetation analysis. The vegetation analysis was measured using the following parameters: frequency of occurrence, relative frequency, relative density, relative basal area, dominance (rank), and importance value (Nabua et al 2020).

Regeneration potential. The percent composition of trees, saplings, and seedlings is measured by the following formulae:

$$\text{\% of trees} = \frac{\text{Number of individual trees per plot}}{\text{Total no. of ind. trees, seedlings, saplings}} \times 100$$

$$\text{\% of seedlings} = \frac{\text{Number of individual seedlings per plot}}{\text{Total no. of ind. trees, seedlings, saplings}} \times 100$$

$$\text{\% of saplings} = \frac{\text{Number of individual saplings per plot}}{\text{Total no. of ind. trees, seedlings, saplings}} \times 100$$

Results and Discussion

The past and present status of mangroves in Panguil Bay. The DENR report shows that mangrove areas s in Region X have continually decreased since 1956 from 8,186.07 hectares to 5,994.99 hectares in 2010 which further went down to 5,216.9 hectares in 2015 (DENR 2018). In the whole country, DENR (2018) reported that there were 346,423 hectares of mangrove already degraded of which 1,297 from Region X, and need restoration to bring back their productivity. The decline was due to unabated deforestation which current rate ranges from 2,000 to 3,000 hectares per year (Tacio 2012).

Table 1 shows that after 59 years, more than 50% of the mangrove areas had decreased in the two provinces of Lanao del Norte and Misamis Occidental. In Lanao del Norte alone, the area had decreased by 56.4% per Google imagery. However, the actual mangrove cover was 3,937.37 hectares of which 71.47% was converted to agricultural land and fish farms. In Misamis Occidental, only 45% of mangrove areas remained based on Google imagery. As of 2017, the DENR report shows that there were more or less 440 hectares rehabilitated in the two provinces in Panguil Bay which made a reduction of mangrove area in Lanao del Norte and Misamis Occidental down to 21.59% and 10.59%, respectively. This can be considered a significant improvement in the mangrove areas in Panguil Bay from 1956. The full cooperation of the agencies involved coupled with the active implementation of the rehabilitation program of the government made the mangrove forest in Panguil Bay increase its size, gradually restoring the 1956 condition. The rehabilitation performance in Panguil Bay could also have a significant contribution to the reduction of the country's mangrove situation. Long et al (2014) estimated the Philippine mangrove area to have decreased by approximately half (51.8%) from 1918 to 2010. Although, it would be impossible to fully restore the situation of mangrove areas half a century ago due to urbanization, and agri-fishery production, at least the unutilized denuded areas would be restored.

The results indicate that the present situation of mangroves in Panguil Bay is already at an alarming stage. Anthropogenic deeds were pointed out as causes of degradation which are aggravated by the lack of planning and monitoring by the concerned agencies. In fact, several researchers averred that increasing population and development within the coastal area (Carter et al 2015) and the conversion of mangrove forests to fish farms and agricultural zones (Polidoro et al 2010; Thomas et al 2017) have caused fast degradation. Moreover, 90% of stem mortality is caused by cutting (Walters 2005; Nguyen et al 2015).

The data were confirmed with the narrations of the old residents in the area. During the 1970s, a big portion of their respective barangays was covered with true and associated mangroves. Due to the influx of migrants from the upland areas coupled with the rising population, the people preferred to build houses in the mangrove areas. Some hectares of mangrove areas were developed into fishponds (particularly in Tangub City) and residential areas. As the population grew, the demand for housing increased thus cutting of trees continued and this was until such time that the number of mangrove trees became inadequate to cover the strong waves brought about by the monsoons. Another informant narrated that in the 1970s, houses constructed in the mangrove areas were devastated by the strong waves which forced the people to evacuate to higher areas. Soils were eroded and the bay became wider.

A 67-year-old teacher-retiree narrated that when she was still 15 years old, their barangay was still full of mangroves. As the population increased, mangroves were cut for construction, and the repair of small houses, particularly using these as posts (*haligi*), flooring, and roofing. People continued to use mangroves unabated because there was no strict policy yet to prohibit the cutting of trees. However, somewhere in the year 2000, the rehabilitation of mangrove areas through planting started. All the old residents who were among the key informants had more or less the same line of experience. Residents had been constructing houses in the mangrove swamps making some areas congested which continued unabated until such time that the government made some policies on the conservation of mangroves. The government implemented the UDP and NGP to rehabilitate the mangrove areas. The mangrove-tree growing activities were supported by municipal/city ordinances.

Table 1

Profile of mangroves in Misamis Occidental and Lanao del Norte in Panguil Bay based on DENR (2018)

Location	*Mangrove cover (NAMRIA 1956) (ha)*	*Existing mangrove stand based on Google Imagery (2015) (ha)*	*Mangrove area under rehabilitation projects, as of 2017 (ha)*	*Mangrove area converted to other land use, as of 2017 (ha)*	*Remaining mangrove area for Dev't as of 2017 (ha)*	*Total actual mangrove cover, as of 2017 (ha)*	*Percent reduction (1956-2017/ 1956) *100*
Lanao del Norte**	5,021.39	2,089.29	1,123.00	2,814.37	6.27	3,937.37	21.59
Misamis Occidental*	3,435.20	1,558.91	496.00	2,575.88	22.71	3,071.88	10.59

Source: Department of Environment and Natural Resources, Cagayan de Oro City as of 2018; total includes all municipalities under the province.

Species composition. A total of 27 mangrove species were identified under the thirteen families in the three study sites (Table 2). Tangub City has the most species with 22 while Tubod has only 8. The results revealed that each sampling area has unique species that cannot be found in other areas. As such, among the 22 species in Tangub, *Aegiceras corniculatum* was only found in Brgy Garang, *Scyphiphora hydrophyllacea* in Aquino, *Dolichandrone spathacea* in Silanga while the *Bruguiera sexangula*, *Afzelia rhomboidea* and *Heritiera littoralis* were found in Brgy. Lorenzo Tan. In Kolambugan, Acanthaceae species were only found in Brgy Karomatan while *Aegiceras corniculatum*, *Bruguiera cylindrica* and *Ceriops decandra* were found in Brgy. Manga and *Lumnitzera racemosa* which is known as Kulasi was found only in Brgy. Kulasihan.

Table 2

Mangroves and mangrove associates distribution in Panguil Bay

Family name	*Species*		*Distribution*		
	Scientific name	*Common name*	*Tangub*	*Tubod*	*Kolam bugan*
	True mangroves				
Primulaceae	*Aegiceras corniculatum*	Saging-saging	+		+
Acanthaceae	*Avicennia alba*	Bulangon-puti, Piapi Laki	+	+	+
	Avicennia marina	Bungalon, Piapi Baye	+	+	+
	Avicennia officinalis	Api api	+		
	Avicennia rumphiana	Api api	+	+	+
Rhizophoraceae	*Bruguiera cylindrica*	Pototan-lalaki			+
	Bruguiera gymnorrhiza	Pototan	+		+
	Bruguiera sexangula	Pototan, Busain	+		
	Rhizophora apiculata	Bakhaw-lalaki	+	+	+
	Rhizophora mucronata	Bakhaw-babae	+	+	+
	Rhizophora stylosa	Bakhaw-bato	+		+
	Ceriops decandra	Malatangal			+
Combretaceae	*Lumnitzera littorea*	Kulasi	+		
	Lumnitera racemosa	Kulasi			+
	Terminalia catappa	Dalisai	+		
Lythraceae	*Sonneratia alba*	Pagatpat	+	+	+
	Sonneratia caseolaris	Pedada	+	+	+
Rubiaceae	*Scyphiphora hydrophyllacea*	Nilad	+		+
Meliaceae	*Xylocarpus granatum*	Tabigi	+		
	Xylocarpus moluccensis	Piag-ao	+		
Arecaceae	*Nypa fruticans*	Nipa	+	+	+
	Mangrove associates				
Acanthaceae	*Acanthus ebracteatus*	Tigbau	+		+
	Acanthus volubilis	Tigbau			+
Bignoniaceae	*Dolichandrone spathacea*	Tui	+		+
Euphorbiaceae	*Excoecaria agallocha*	Buta-buta			+
Malvaceae	*Heritiera littoralis*	Dungon	+		
Fabaceae	*Afzelia rhomboidea*	Ipil, Taal	+		

Avicennia alba, *Avicennia marina*, *Avicennia rumphiana*, *Rhizophora apiculata*, *Rhizophora mucronata*, *Sonneratia alba*, *Sonneratia caseolaris* and *Nypa fruticans* were widely distributed in the three sampling sites. These species might be a generalist or could tolerate a wide range of environmental conditions. The distribution of these species in the two sampling sites might be because of the common characteristics of its environment, utilization practices of the community, and intervention of LGU. Some species were area-specific in which its distribution was limited to specific sampling sites such as *Bruguiera cylindrica*, *Ceriops decandra*, *Acanthus volubilis*, *Excoecaria agallocha* which were distributed only in the Kolambugan sampling site and *Bruguiera sexangula*, *Xylocarpus granatum*, *Xylocarpus moluccensis*, *Heritiera littoralis*, *Afzelia rhomboidea*, and *Terminalia cattappa* which were specific in Tangub area. The majority of the mangrove species and its associate species were widely distributed in the Tangub area.

In the three study sites, the number of true mangroves identified was only 20. This covers only 51.28% of the 39 true mangroves in the Philippines (Primavera 2004). The study of Roxas et al (2009) showed that there were 21 true mangroves in Panguil Bay. The difference could be due to the coverage of this study which was limited to only three municipalities/cities in the bay as well as to the time frame of the study. With the passage of 12 years, there is the likelihood that environmental stress reduced the number of true mangroves. The number of true mangroves in Panguil Bay was lower than the number found in Puerto Princesa Bay which was reported to have 27 true mangroves (Dangan-Galon et al 2016), Davao Oriental with 31 true mangroves (Pototan et al 2017), higher than in Davao del Sur with only 12 species (Jumawan et al 2015).

Diversity indices. As a whole, Tangub City had the most number of species compared to Kolambugan and Tubod. The overall diversity status of mangroves in the three study areas based on Shannon's index was considered generally low (Table 3). Tangub mangroves (H' = 2.17) were considered to be more diverse compared to Kolambugan mangroves (H' = 1.86) and Tubod (H' = 1.63). This could be attributed to the uneven distribution of individuals or lack of species variations (Kovacs et al 2011; Abino et al 2014; Patindol & Casas 2019). Thus, the species in the three areas are prone to extinction (Asuk et al 2018).

Table 3

Diversity of mangroves species in the three areas

Diversity parameter	*Panguil Bay*		
	Tangub	*Tubod*	*Kolambugan*
Number of species (a)	22	8	19
Shannon's index	2.17	1.63	1.86

Vegetation analysis. Table 4 presents the frequency, density, basal area, relative values and importance values of mangrove species in Tangub City. The results revealed that *Avicennia marina* and *Sonneratia alba* appeared more frequent with frequency values of 47.37 and 58.77%, respectively. While species *Bruguiera gymnorrhiza*, *Dolichandrone spathacea*, *Afzelia rhomboidea*, *Lumnitzera littorea*, *and Scyphiphora hydrophyllacea* occurred only in less than one percent. As to the species with high density, *A. marina*, *S. alba*, and *Lumnitzera littorea* topped the list with 335.76, 295.67, and 250 individuals per hectare. On the other hand, *S. alba*, *A. marina*, and *A. alba* had the highest basal area with 110,479.47 cm^2, 87,675.47 cm^2, and 31,456.03 cm^2, respectively. Most of these species were already big, and old.

The top 5 species based on importance values were *Sonneratia alba*, *Avicennia marina*, *Sonneratia caseolaris*, *Avicennia alba*, and *Xylocarpus granatum.* The least dominant were the genera *Scyphiphora*, *Dolichandrone*, *Bruguiera*, and *Afzelia.* This implies that these less dominant species are becoming extinct in the area, and need to be protected.

Table 4

Frequency, density, basal area and relative values of mangroves in Tangub, January-February 2020

Species name	*Frequency (%)*	*RF*	*Density (ind ha^{-1})*	*RD*	*Basal area (cm^2)*	*RB*	*IV*	*Dom*
Aegiceras corniculatum	9.65	4.49	54.45	3.07	794.02	0.23	7.80	
Avicennia alba	12.28	5.71	109.30	6.17	31,456.03	9.25	21.13	4
Avicennia marina	47.37	22.04	335.76	18.96	87,675.47	25.77	66.77	2
Avicennia officinalis	2.63	1.22	43.57	2.46	14,962.04	4.40	8.08	

Avicennia rumphiana	3.51	1.63	27.86	1.57	8,401.85	2.47	5.68	
Bruguiera cylindrica	6.14	2.86	25.90	1.46	419.61	0.12	4.44	
Bruguiera gymnorrhiza	0.88	0.41	16.67	0.94	43.98	0.01	1.36	
Bruguiera sexangula	4.39	2.04	44.64	2.52	1,024.08	0.30	4.86	
Dolichandrone spathacea	0.88	0.41	25.00	1.41	439.03	0.13	1.95	
Heritiera litoralis	2.63	1.22	45.56	2.57	3,535.06	1.04	4.83	
Afzelia rhomboidea	0.88	0.41	50.00	2.82	548.21	0.16	3.39	
Lumnitzera littorea	0.88	0.41	250.00	14.11	4,885.89	1.44	15.96	
Rhizophora apiculata	7.89	3.67	35.31	1.99	6,092.91	1.79	7.46	
Rhizophora mucronata	8.77	4.08	88.58	5.00	2,509.79	0.74	9.82	
Rhizophora stylosa	4.39	2.04	28.10	1.59	487.49	0.14	3.77	
Scyphiphora hydrophyllacea	0.88	0.41	50.00	2.82	113.10	0.03	3.27	
Sonneratia alba	58.77	27.34	295.67	16.69	110,479.47	32.47	76.51	1
Sonneratia caseolaris	20.18	9.39	126.73	7.16	33,569.92	9.87	26.41	3
Xylocarpus granatum	16.67	7.76	79.46	4.49	24,478.69	7.19	19.44	5
Xylocarpus moluccensis	5.26	2.45	38.69	2.18	8,311.93	2.44	7.07	
Total	214.93	100.00	1771.24	100	340,228.56	100	300.00	

Note: Frequency = frequency of occurrence; RF = relative frequency; RB = relative basal area; RD = relative density; IV = importance value; Dom = dominance (rank). Not all species were included in this table due to non-computation of basal area. Species with less than 5 individual trees in each area were not included.

On the other hand, in Kolambugan area, *Avicennia marina*, and *Sonneratia alba* were the top 2 species that occurred 69.57%, and 51.30%, respectively in all the plots. *Bruguiera cylindrica* and *Lumnitzera racemosa* had the least number of occurrences in all the plots (Table 5). As to the tree density, *Rhizophora mucronata* was the highest with 319.46 trees per hectare, and were found thicker in Barangays Mukas and Tabigue. This was followed by *Avicennia marina*, and *Sonneratia alba.* Most of the time, only *Rhizophora* species were planted during the mangrove rehabilitation due to its availability and accessibility. The DENR also recommended, *Avicennia marina*, and *Sonneratia alba* as propagules in the rehabilitation.

Sonneratia and *Avicenna* species were mostly big and old as manifested by their basal values of more than 200 cm^2 per tree. The top four species based on the importance values were *Avicennia marina*, *Sonneratia alba*, *A. alba*, and *Rhizophora mucronata.* The least dominant were the *Bruguiera cylindrica* and *Lumnitzera racemosa.*

Table 5

Frequency, density, basal area and relative values of mangroves in Kolambugan, Lanao del Norte, January-February 2020

Species name	*Frequency (%)*	*RF*	*Density (ind ha^{-1})*	*RD*	*Basal area (cm^2)*	*RB*	*IV*	*Dom*
Avicennia alba	33.04	14.02	77.08	6.74	369.71	28.59	49.35	3
Avicennia marina	69.57	29.52	191.90	16.77	413.52	31.98	78.27	1
Bruguiera cylindrica	0.87	0.37	7.14	0.62	11.46	0.89	1.88	
Lumnitzera racemosa	0.87	0.37	16.67	1.46	86.66	6.70	8.53	
Rhizophora apiculata	23.48	9.96	142.92	12.49	81.23	6.28	28.73	5
Rhizophora mucronata	36.52	15.50	319.96	27.96	71.63	5.54	49.00	4
Rhizophora stylosa	20.00	8.49	124.23	10.86	58.08	4.49	23.83	
Sonneratia alba	51.30	21.77	264.44	23.11	200.79	15.53	60.41	2
Total	235.65	100	1,144.34	100.00	1,293.08	100.00	300.00	

Note: Frequency = frequency of occurrence; RF = relative frequency; RB = relative basal area; RD = relative density; IV = importance value; Dom = dominance (rank). Not all species were included in this table due to non-computation of basal area. Species with less than 5 individual trees in each area were not included.

In Tubod area, three species frequently occurred and appeared half of all the plots during the assessment period (Table 6). These species were *Sonneratia alba*, *Rhizophora apiculata*, and *Rhizophora mucronata.* Although *Avicennia marina* only appeared at

36.48%, it had the highest density of 615.08 trees per hectare. This is followed by *Rhizophora apiculata* with 350 trees per hectare and *Sonneratia alba* with 266.67 trees.

However, *Avicennia rumphiana* dominated all the species in the area with an importance value of 79.10. As manifested by its big basal area of 3,671.17 cm^2, *A. rumphiana* trees were mostly big and old.

Table 6

Frequency, density, basal and relative values of mangroves in Tubod, Lanao del Norte, January-February 2020

Species name	*Frequency (%)*	*RF*	*Density (ind ha⁻¹)*	*RD*	*Basal area (cm^2)*	*RB*	*IV*	*Dom*
Avicennia alba	25.00	10.00	53.17	3.15	474.96	8.76	21.91	
Avicennia marina	37.50	15.00	615.08	36.48	144.10	2.66	54.14	2
Avicennia rumphiana	12.50	5.00	108.33	6.42	3,671.17	67.68	79.10	1
Rhizophora apiculata	50.00	20.00	350.00	20.76	56.24	1.04	41.79	4
Rhizophora mucronata	50.00	20.00	209.52	12.43	73.30	1.35	33.78	5
Sonneratia alba	56.25	22.50	266.67	15.82	352.95	6.51	44.82	3
Sonneratia caseolaris	18.75	7.50	83.33	4.94	651.82	12.02	24.46	
Total	250.00	100.00	1,686.10	100.00	5,424.54	100.00	300.00	

Note: Frequency = frequency of occurrence; RF = relative frequency; RB = relative basal area; RD = relative density; IV = importance value; Dom = dominance (rank). Not all species were included in this table due to non-computation of basal area. Species with less than 5 individual trees in each area were not included.

Figure 4 shows the mean tree density per hectare for the three locations. Results revealed that *Avicennia marina* and *Sonneratia alba* were the most common species that have high density per hectare in the three locations. Among the three locations, Tubod had a comparative advantage in growing *A. marina. Rhizopora apiculata* was also more abundant in Tubod than in other locations. On the other hand, *Rhizophora mucronata* had a higher density in Kolambugan than in the other two areas. Although the three areas have common dominant species and abundant species, they differ in the number of species.

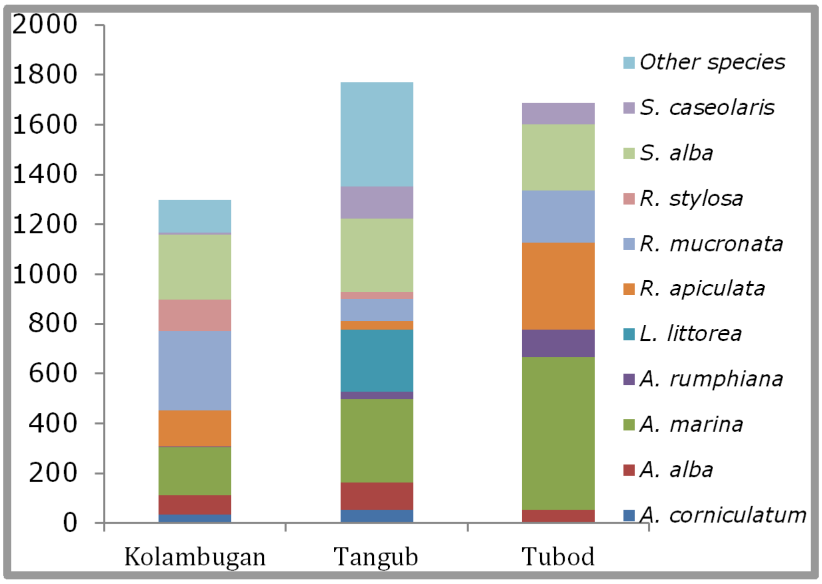

Figure 4. Mean tree density estimated per hectare for the three locations in Panguil Bay from January to February 2020.

Figure 5 shows basal tree estimates per square centimeter in the three areas. The results revealed that *Sonneratia alba* was common in the three areas and had relatively large basal values which connote that most of these trees were already old and big. Among the three locations, Tangub City had relatively bigger trees than Tubod and Kolambugan. These tree species were *Sonneratia alba*, *Avicennia marina*, *Avicennia alba*, *Sonneratia caseolaris*, and *Xylocarpus granatum*.

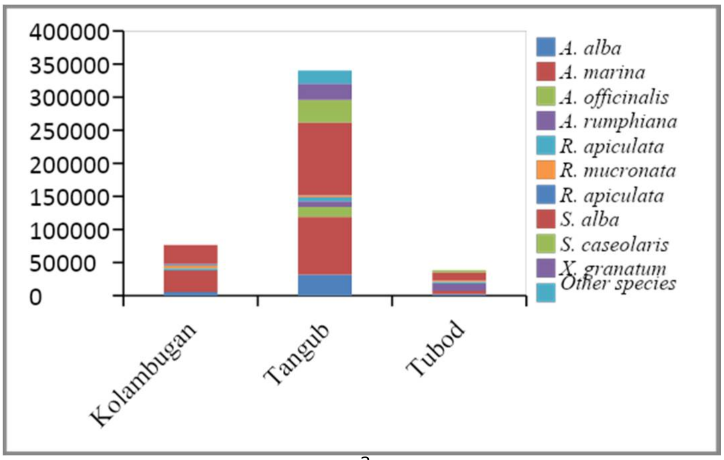

Figure 5. Mean tree basal estimated per cm^2 for the three locations in Panguil Bay from January to February 2020.

Regeneration potential*.* Among the three areas under study, Tangub City has more percentage composition of seedlings and thus has high regeneration potential compared to the other municipalities (Figure 6). It should be noted, however, that the presence of seedlings and saplings in all municipalities indicates a relatively high potential for recovery if protected properly. This is shown by the more strict implementation of the laws or ordinances related to mangroves.

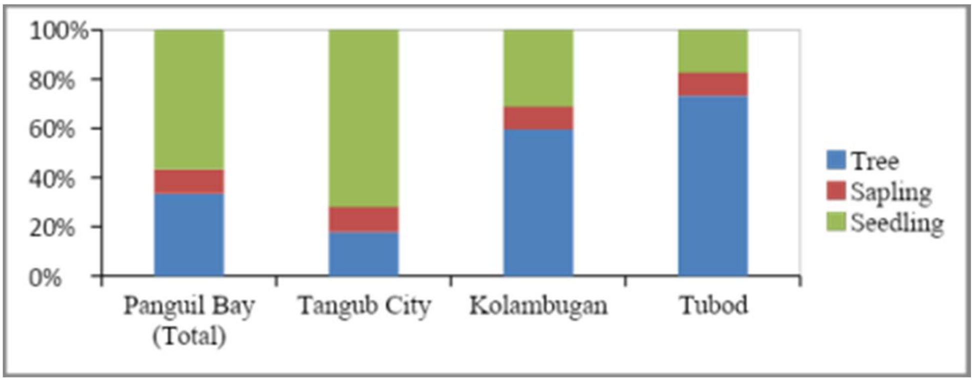

Figure 6. Percent composition of trees, saplings, and seedlings observed in the surveyed plots in Tubod, Lanao del Norte last January-February 2020.

Conclusions and Recommendations. The Department of Environment and Natural Resources reported that mangrove areas in Panguil Bay decreased by more than 50% in 2015 from 1956, more recent estimates also by DENR showed an increase in cover thus reduction was reduced to 20% as of 2017. These may be due to continuing rehabilitation efforts under the Upland Development Program (UDP) and National Greening Program (NGP) which covered approximately 440 hectares.

There were a total of 27 mangrove species identified in Panguil Bay under thirteen families. Tangub City was found to have the most number of species with 22 while Tubod only had eight. There were 20 species of true mangroves in the three areas constituting 46.16% of the total species in the country. The government intervention in planting selected species such as *Rhizophora* and *Avicennia* contributed much to the wide distribution of these species in the three sampling sites. However, some species were area-specific and their distribution was limited to specific sampling sites: *Bruguiera cylindrica*, *Ceriops decandra*, *Acanthus volubilis*, and *Excoecaria agallocha* in Kolambugan and *Bruguiera sexangula*, *Xylocarpus granatum*, *Xylocarpus moluccensis*, *Heritiera littoralis*, *Afzelia rhomboidea* and *Terminalia catappa* in Tangub area.

Sonneratia alba was the most dominant species of mangroves in three areas due to its relatively large trees, high frequency of occurrence, and a high number of trees per hectare. However, the continuous use of mono species in rehabilitation may affect the species variability and diversity in the areas. The mangrove areas in the three locations were fragmented due to anthropogenic activities in the previous years when the implementation of the Forestry Code was not yet strict. The observed high regeneration of mangrove areas was a manifestation of improving mangrove management, constituting:

- the rehabilitation efforts for the mangrove areas should continue to increase the number of areas forested. This would answer the sustainable development goals to minimize the effects of climate change. Moreover, the fishery products within the vicinity of the mangrove ecosystem would increase;
- to make the mangrove areas more diverse, mangrove tree-growing activities shall be sustained. Indigenous species of mangroves shall be planted to increase diversity instead of mainly planting the popular and readily available *Rhizopora*. An ordinance of the municipality specific to the planting of indigenous mangroves including the creation or establishment of a sustainable nursery is further recommended;
- as an implementation of the previous recommendation, each municipality should have at least one mangrove nursery to sustain the rehabilitation efforts. The nursery may be managed by the Fisherfolks' Association, in coordination with the important stakeholders namely; DENR, BFAR, and LGU, and this would be its additional income-generating project;
- the Higher Education Institution located in the study site, in coordination with the DENR's Ecosystems Research and Development Bureau, and BFAR shall formulate and implement research-based technologies/approaches on mangrove field restoration and management, and mangrove resource utilization;
- to enhance the regeneration of mangroves, an ordinance may be formulated to limit anthropogenic activities inside the mangrove areas.

Conflict of interest. The authors declare that there is no conflict of interest.

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Authors:
Wilson C. Nabua, Northwestern Mindanao State College of Science and Technology, Labuyo, Tangub City, Philippines, e-mail: wilsonabua@gmail.com
Alita T. Roxas, Mindanao State University-Iligan Institute of Technology, Iligan City, Philippines, e-mail: alita.roxas@msuiit.g.edu.ph
Wilfredo H. Uy, Mindanao State University at Naawan, Naawan, Misamis Oriental, Philippines, e-mail: wilfredo.uy@msunaawan.edu.ph

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