COMPOSITION AND DIVERSITY OF MANGROVE SPECIES ON DINAGAT ISLAND, PHILIPPINES

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Abstract: Executive Order No. 63 of June 25, 1914 and Proclamation No. 391 signed by President Manuel L. Quezon in March 13, 1939, serves as legal basis in declaring Dinagat Island as Mineral Reservation Area. The study is aimed at assessing the composition and diversity of Mangrove species on Dinagat Island, Philippines. Maximum of 15 Plots were laid at 300 m apart. Plants inside the quadrat were identified, then counted accordingly. Plants with diameter breast height (DBH) of 1 cm and above were measured. Result shows, 17 mangrove species classified into 13 families and 15 genera, 10 classified as true mangrove and 7 as associate mangrove species. The most represented Genus was *Rhizophora*. Rhizophoraceae as the most represented family for true mangrove and Orchidaceae for associate's mangrove species. The species diversity value was low (1.3 – 1.6). Mangrove forest was dominated by trees with a DBH ranges 1 to 10 cm (69%) and 31% for more than 10 cm. Average basal area of 31 m^2/ha. Total height ranges from 3 to 8 m with an average crown diameter of 3 m. The dominant species were *Sonneratia ovata* Backer, *Rhizophora apiculata* Blume, *Avicennia officinalis* L., and *Rhizophora mucronata* Lam. Areas with existing mining operation have lower species diversity. The low species diversity of Mangrove forest on Dinagat Island need immediate attention on behalf of the government, private sectors, mining companies and the community for its protection and conservation, for the people on the island depend on fishing as their major source of income.

Keywords: Dinagat Island, diversity, dominant species, forest structure, species composition

Introduction:

Mangrove forests play a key role in the conservation of tropical and subtropical coastlines. The unique ecosystem serves as natural bridges that link the marine and terrestrial environments (Aksornkoae et al. 1992; Doydee and Buot 2010). Mangroves also provide important indirect services such as shoreline stability and water quality (Buot 1994; Janssen and Padilla 1999; Anongponyoskun and Doydee 2006). These ecosystems have high impact on the carbon budget of the tropical and global coastal zones (Bouillon et al. 2008), as it sequesters up to 25.5 million tonnes of carbon per year (Ong 1993), and provides more than 10% of essential organic carbon for the global oceans (Dittmar et al. 2006).

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However, based on Food and Agriculture Organization of the United Nations (FAO 2007), the total area covered by mangroves throughout the world has declined from 18.8 million hectares (ha) in 1980 to 15.2 million ha in 2005, with less than 7% being protected (Giri et al. 2010). In the Philippines area covered by mangrove it dwindled from an estimated 500,000 ha in 1918 (Primavera 2000) to 117,700 hectares in 1995 (DENR 1995). The largest remaining mangrove areas were located in the south of the Philippine archipelago: Mindanao and Samar, and in the west on Palawan.

Destruction of mangrove was common throughout Southeast Asian countries including Thailand (Field 1996; Macintosh et al. 2002; Ashton et al. 2003). Mangroves were already critically endangered or on the brink of extinction in 26 of the 120 countries in where they exist (FAO 2003). It was estimated that 26% of mangrove forests worldwide were degraded due to overexploitation for fuelwood and timber production (Valiela and Bowen 2001). Demographic increase, urban sprawl, expansion of industrial activities, natural resources prospecting and exploitation, have caused mangrove disappearance at an alarming rate (Duke et al. 2007). Similarly, clearing of mangroves for shrimp culture contributes 38% of global mangrove loss, with other aquaculture accounting for another 14% (Ellison 2008).

The Philippine Biodiversity Conservation Priority-setting Program (PBCPP) spearheaded in 2001 by Department of Environment and Natural Resources (DENR) and conservation groups, identified the province of Dinagat Island which had previously been under the province of Surigao del Norte as an extremely and highly-critical terrestrial conservation priority. The rich biodiversity of Dinagat Island and the ecological stability of its forests were constantly under pressure and weakened by mining, kaingin and illegal commercial logging (Haribon 2004). Dinagat Island is the third largest Island in the Mindanao biogeographic sub-region (Fig. 1). It is located north from the northeastern Mindanao and is home to several interesting species of flora and fauna including Odonata (Villanueva 2009).

Processes of erosion and sedimentation, which occur naturally along the coastline, were strongly amplified by mining activities (Fernandez et al. 2006). Sediments are carriers of trace metals in the hydrological cycle and because metals are partitioned in the surrounding waters, they reflect the quality of the aquatic system in particular (Attri and Kerkar 2011). The metal and metalloid release into the environment from mining represents a major threat to mangrove biodiversity and also for human health (Marchand et al. 2012). In contrast with organic pollutants, metals cannot be biologically or chemically degraded, and thus may either accumulate locally or be transported over long distances.

If the destruction of mangrove forest in Dinagat Island continues, these forests might be reduced to relic patches too small to support the diversity of organisms that depend on them (Barbier 2007). Sustainability of natural resources is always intimately linked to ecology, as each management system interferes with the forest structures and processes (Schmidt 1982).

Knowing the exact plant species composition of mangroves is an important prerequisite to understand the aspects of structure and function, as well as biogeographical affinities and their conservation and management (Jayatissa et al. 2002); Wang et al. 2003).

The study is aimed at assessing the composition, diversity, structure, dominance and threats/disturbance on Mangrove species of Dinagat Island, Philippines.

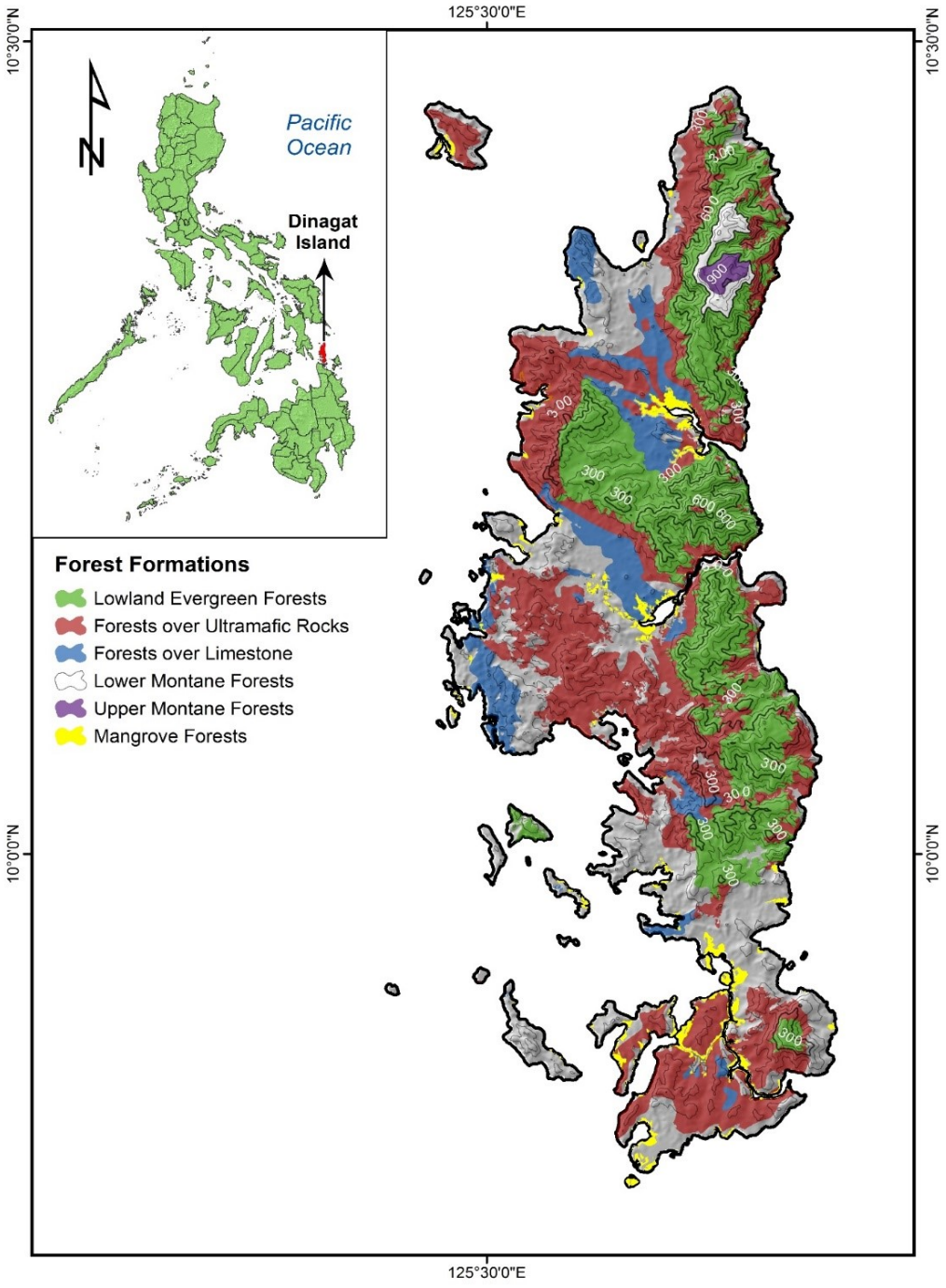
Materials and methods:

Study area

The study was conducted in the mangrove forest of Dinagat Island (Fig. 1). The mangrove forest appears in patches. Larger

patches were found in the municipality of Loreto, Libjo, Dinagat, Cagdianao and Basilisa which serve as the study site. Within the mangrove areas the Municipality of Dinagat has no mining operation; there upland areas are not disturbed by any mining companies.

Figure no. 1 Location of study site in the Philippines and forest formation on Dinagat Island

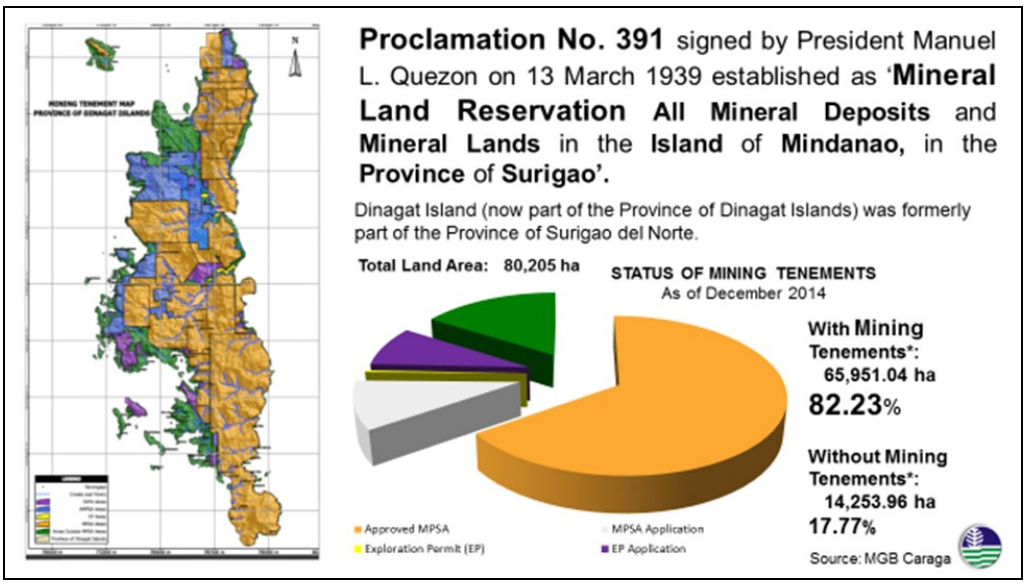


The Province of Dinagat Island lies east-southeast of the southern end of Leyte and directly north of the Surigao Peninsula of Northern Mindanao. Zoogeographically, Dinagat Island was thought to have formed part of a land bridge between Northern Mindanao and Eastern Visayas (Leyte, Samar and Bohol) in the late Pleistocene epoch (Leviton 1963). Dinagat and Siargao Island were considered the northern extensions of the northeastern mountains of Mindanao, forming an island separate from the remainder of Mindanao during the Pliocene epoch (Dickerson 1928; Taylor 1934; Heaney 1986).

The Province of Dinagat Island consisting of seven municipalities with a total land area of 80,205 hectares, almost 80 percent of which 62,544 hectares were classified as forestland, while the remaining 17,661 hectares were alienable and disposable land (NSO 2010). The Islands feature a total population of 126,803 with an average annual population growth rate (PGR) of 1.72 percent.

Executive Order No. 63 of June 25, 1914 and Proclamation No. 391 signed by President Manuel L. Quezon in March 13, 1939, serves as legal basis in declaring the Island of Mindanao as Mineral Land Reservation including all Mineral Deposits and Mineral lands in the Province of Surigao. By virtue of this Proclamation the entire island of Dinagat which is now the Province of Dinagat Islands as well as some portions of Surigao Del Norte was declared as Surigao Mineral Reservation Area. Based on this existing policy, Dinagat Island was utilized mainly for Mineral Production (DENR 2014) (Fig. 2). Most of the forest areas were destructed or damaged by mining activities than kaingin. There were 19 mining companies operating in the province. Gold, silver, nickel, copper, chromite, limestone and silica were mined throughout the region.

Figure no. 2 Status and coverage of mining operation in Dinagat Island (Mines and Geosciences Bureau, Caraga 2014)



Data collection
Establishment of sampling plots

Plots were established in 5 identified mangrove forests of Dinagat Island. A minimum of 3 plots were established at 300 m apart. The plot size was 20 m x 10 m. However, the assignment and establishment of plots depend on the accessibility of the site. Generally, 20 meters is the longest distance that can be accurately surveyed in a dense forest (Dallmeier 1992).

Mangrove species Identification

Voucher specimens for every individual of the species within the plot were collected and tagged. The collected specimens were brought to the metallophytes laboratory of the Department of Forest Biological Sciences, College of Forestry and Natural Resources, University of the Philippines Los Baños Laguna (UPLB) for proper identification. The identification of sample specimens was undergone by means of manuals, Herbarium comparison, Co - digital flora of the Philippines, on line literature and also through the expertise of Dr. Edwino S. Fernando.

Measurement of trees

Trees with diameter of 1 cm and above were measured in terms of their diameter breast height (DBH), total height and crown (height and width). The measurement of DBH was done with the use of diameter tape for larger trees and tree caliper for smaller trees. For the total height of the trees the measurement was made by using an Abney hand level. Related to the crown height and width, their measurement was done through estimation. The tree height and DBH were categorized into different classes such as: 1-10 cm, 10-20 cm, 20 -30 cm, 40 – 50 cm, 50 cm and above (Lulekal et al. 2008). Basal area was calculated by means of the formula: $BA = 0.7854\ (d)^2$ where d is diameter at breast height in meters (Department of Environment and Natural Resources formula). Plant Density was a count of the number of individuals of a species within the quadrat.

Threats and disturbance on Dinagat Island

In this study the Identification and quantification of anthropogenic threats against biodiversity in the site were determined through direct observation and by interviewing randomly selected respondents. There were 50 people interviewed per municipality as respondents.

Data Analysis
Diversity of species

Species diversity were computed and interpreted by using the Shannon Diversity Index. The computations were performed by using Multi Variant Statistical Package (MVSP) software. The Multi - Variant Statistical Package (MVSP) software was used to compute the Shannon Diversity Index (H') of all sample sites by entering their respective tree species and their corresponding density values as well as total number of tree individuals in each sample plot.

Species density, dominance, frequency and importance value

All recorded data was stored in a Microsoft Excel database and analyzed quantitatively by using Microsoft Excel statistics. Vegetation analysis was performed using the formula of density, relative density, dominance or basal area, relative dominance, frequency, relative frequency and the Importance Value Index (IVI). The ecological importance of each species in relation to the total forest community was calculated by summing its relative density, relative dominance and relative frequency (Curtis and McIntosh 1951).

Threats and disturbance on Dinagat Island

These determined threats and disturbances serve as potential hindrance to the existence and survival of vulnerable native tree species in the island. All data collected were tabulated and analyzed based on frequency and its percentage equivalent. The disturbance or threats per municipality were ranked based the number of frequency.

The scoring system for the disturbance indicators utilized in this study is similar to the model presented by the National Park Conservation Association (NPCA) in their annual assessment of the National Parks of the United States (Nations 2004). Each indicator is assigned a score from 0–3 based on the evaluator's interpretation of the extent and severity of the variable being considered. A score of 0 means no human impact/ karst disturbance. If disturbance is apparent, then the evaluator must judge if the impact is catastrophic (rating = 3), severe and widespread (rating = 2), or localized and not severe (rating = 1) (Beynen and Townsend 2005). Once all the indicators have been scored, scores can be summed. This total is then divided by the highest possible score to attain a value between 0 and 1. The higher the value, i.e., the closer the number is to 1, the greater the degree of disturbance. Five categories have been created and range from 0.8–1.0 (highly disturbed) to 0.0–0.19 (pristine).

Correlation between species diversity and site disturbance

To examine the relationship between diversity (i.e. Shannon Diversity Index, H') and site disturbances in mangrove forest habitat type, linear regressions were used to test a simple correlative relationship (West et al. 2007). The measure of correlation between two variables is called the coefficient of correlation and calculated in different ways, the most usual measure is the Pearson coefficient, it is the covariance of the two variable divided by the product of their variance, it is scaled between 1 (for a perfect positive correlation) to -1 (for a perfect negative correlation), 0 would be complete randomness. When one variable increases and the other increases as well, then these two variables are said to be positively correlated. The other way round when a variable increases and the other decreases then these two variables are negatively correlated. Pearson's r = .804 indicates a strong positive relationship (Hertzog 2015). The computation of Pearson r correlation was made in the Microsoft Excel.

Results and discussion:

Mangrove forest
Dinagat mangrove (no mining)

Dinagat mangrove site located in the Municipality of Dinagat, (1105538 N; 786117 E) with no disturbance from any mining company, has a total of 10 mangrove species categorized into 8 families and 9 genera. The site has the highest number of species compared to other mangrove sites. Based on Shannon index of diversity, the site has a diversity of H = 1.60, with a relative value of low species diversity (MacDonald 2003). The structure of the forest is dominated by small trees with an average DBH of 10 cm, height of 5 m, crown diameter of 4 m and average basal area of 50.4 m^2/ha, larger and denser among mangrove sites (Figs. 3a, 3b). The dominant species regarding relative frequency, dominance, density, and importance value are *Avicennia officinalis* L., *Rhizophora apiculata* Blume, *Rhizophora mucronata* Lam, *Sonneratia ovata* Backer, *Dolichandrone spathacea* (L. f.) K. Schum and *Xylocarpus granatum* J. Koenig.

Figure no. 3 Habitat of Mangrove forest in Dinagat Island: a. Mangrove forest in the Municipality of Loreto; b. Mangrove forest in the Municipality of Dinagat

a

b

Cagdianao mangrove site

Cagdianao mangrove sites located in the Municipality of Cagdianao (1099124 N; 790191 E) with an existing nickel mining company operating on the upper elevation, has a total of 6 mangrove species categorized into 5 families and 5 genera. It is the lowest in number of species among study sites. Based on Shannon index of diversity the site has a diversity of H = 1.40, with a relative value of very low species diversity

(MacDonald 2003). The structure of the forest is dominated by a very small size trees with an average DBH of 6 cm, height of 5 m, crown diameter of 3 m and average basal area of 25.6 m^2/ha. The dominant species considering relative frequency, dominance, density and importance value are *Avicennia officinalis* L., *Rhizophora apiculata* Blume, *Rhizophora mucronata* Lam, *Sonneratia ovata* Backer and *Dolichandrone spathacea* (L. f.) K. Schum., similar with Dinagat mangrove sites.

Basilisa mangrove site

Basilisa mangrove sites located in the Municipality of Basilisa (1113569 N; 784791 E) with an existing nickel mining company operating on the upper elevation, has a total of 9 mangrove species categorized into 8 families and 8 genera. The number of species is larger as compared to other mangrove sites featuring mining operation, but lower in number with Dinagat mangrove site.

Based on Shannon index of diversity the site has a diversity of H = 1.5, with a relative value of low species diversity (MacDonald 2003), but higher than Cagdianao. The structure of the forest is dominated by small size trees with an average DBH of 6 cm, height of 7 m, crown diameter of 3 m and average basal area of 21 m^2/ha. The dominant species in terms of relative frequency, dominance, density, and importance value are *Avicennia officinalis* L., *Rhizophora apiculata* Blume, *Rhizophora mucronata* Lam, *Sonneratia ovata* Backer, *Dolichandrone spathacea* (L. f.) K. Schum. and *Lumnitzera littorea* (Jack) Voigt, similar with Cagdianao mangrove sites.

Llamera Gaas inlet, River Mangrove site

Mangrove site in Llamera Gaas in Let River located in the Municpality of Libjo (10.13963 N; 125.54962 E) with an existing nickel mining company operating on the upper elevation, has a total of 8 mangrove species categorized into 7 families and 7 genera. Based on Shannon index of diversity the site has a diversity of H = 1.40 with a relative value of very low species diversity (MacDonald 2003), similar to Cagdianao but lower in Basilisa and Dinagat mangrove sites. The structure of the forest is dominated by small size trees with an average DBH of 8 cm, uniform Height of 6 m, crown diameter of 2 m and average basal area of 35 m^2/ha. The dominant species in terms of relative frequency, dominance, density, and importance value are *Avicennia officinalis* L., *Rhizophora apiculata* Blume, *Rhizophora mucronata* Lam, *Sonneratia ovata* Backer, and *Xylocarpus granatum* J. Koenig. The presence of *Xylocarpus granatum* J. Koenig as one of the dominant species in Llamera Gaas Inlet river mangrove site makes them distinct from other mangrove sites. The species are also recorded in Dinagat mangrove sites but they are not dominating.

Loreto Mangrove site

Loreto Mangrove site is located in the Municipality of Loreto (0785694 N; 115174632 E) with an existing nickel and Chromite mining company operating on the upper elevation, has a total of 7 mangrove species categorized into 6 families and 6 genera. Based on Shannon index of diversity the site has a diversity of H = 1.30 with a relative value of very low species diversity (MacDonald 2003). The site has the lowest in species diversity together with Llamera Gaas Inlet River and Cagdianao mangrove sites. The structure of the forest are dominated by small size trees with an average DBH of 6 cm, uniform height of 5 m, crown diameter of 3 m and average basal area of 18 m^2/ha. Apart from lower species diversity, the site also considered as the smallest in basal area of coverage among mangrove sites. The dominant species in terms of relative frequency, dominance, density, and importance value are *Avicennia officinalis* L., *Rhizophora apiculata* Blume, *Rhizophora mucronata*

Lam, and *Sonneratia ovata* Backer (see Figs. 3a, 3b).

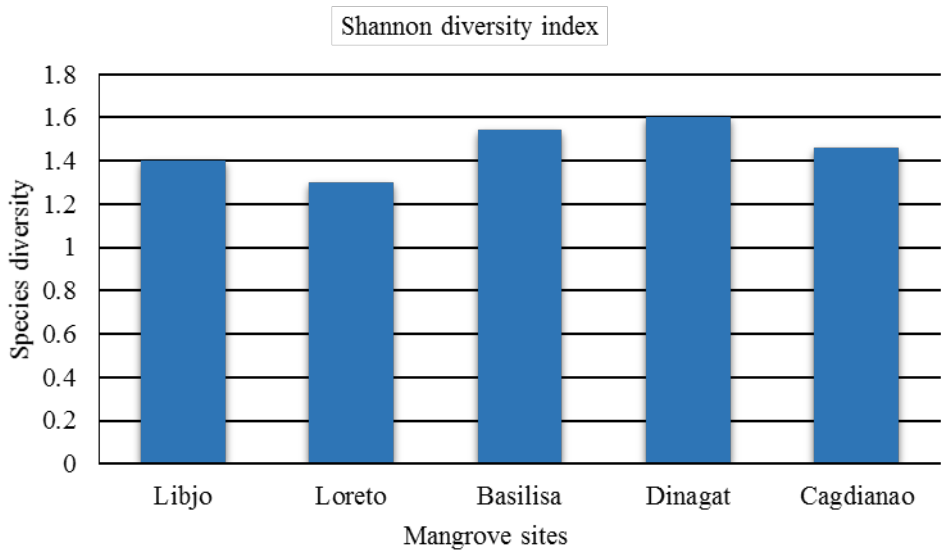
Species composition and diversity of Dinagat Island

The mangrove Forest of Dinagat Island is dominated by 17 plant species classified into 13 families and 15 genera from the 15 sampling plots. Out of the 17 total species, 10 species are classified as true mangrove and 7 species classified as associate mangrove species. The most represented Genus is Rhizophora, and for the family is Rhizophoraceae for true mangrove species, and Orchidaceae for associate's species (Tab. 1, Annexes). True mangrove species are those species that grow in the mangrove habitat only, while those not restricted to this habitat are mangrove associates (Lugo and Snedekar 1974; FAO 2007).

The number of true mangrove species is equivalent to only 26% from the total record of the Philippines, respectively a number of 39 species. (Fernando and Pancho 1980). The result is equivalent in number to the study of Cañizares and Seronay (2016), recorded 10 mangrove species in barangay Imelda of the municipality of Tubajon, Dinagat Island and equivalent only to 71% of the species recorded in Negros Island, respectively 14 species (Calumpong 1994).

Based on Shannon diversity index, the species diversity in the site ranges from 1.3 – 1.6, with a relative value of very low (MacDonald 2003). The mangrove forest of Loreto and Libjo has the lowest species diversity value of 1.3., while the Municipality of Dinagat records a higher value, of 1.6 (Fig. 4). Species diversity is a community attribute related to stability, productivity and trophic structure (McIntosh 1967; McNaughton 1977; Tilman 1996), as well as migration (Wisheu and Keddy 1996; Caley and Schluter 1997; Colwell and Lees 2000). An area with high species diversity engenders a more stable and productive ecosystem. The result of the study implies that Dinagat Island has an unstable and degraded mangrove ecosystem (Marchand et al. 2006).

Figure no. 4 Species diversity of mangrove areas in different Municipality of Dinagat Island



In addition, considering the actual observation and direct interview from the respondent, the mangrove forest of the Island is already degraded due to siltation and illegal tree felling. According to the local fisherman interviewed, fish catch of every fisherman is declining. Sullivan (2005) and Ellison (2008) proved that 80% of global fish catches are directly or indirectly dependent on mangroves.

Conservation status

Conservation status of the mangrove species in Dinagat Island are categorized based from Department of Environment and Natural Resources (DENR) and International Union for Conservation of Nature (IUCN) Classification (Tab. 2, Annexes). Based on DENR Administrative Order (DAO 2017), the mangrove species of Dinagat Island do not occur on the list of threatened plant species. The result of the study signify that the recorded mangrove species of Dinagat Island are still common in different mangrove sites and not yet threatened.

However from the record of the International Union for Conservation of Nature (IUCN 2016) there is one species whose conservation status is Near Threatened (NT). The species is *Sonneratia ovata* Backer (see Tab. 2, Annexes). The record of IUCN in evaluating a certain species is on global scale while the DENR record is on national scale. IUCN features a more reduced probability of categorizing and updating the species because of its large coverage.

Forest structure

The mangrove sites of Dinagat Island have an estimated vegetation cover of 30 to 40% (Fig. 5). This vegetation are dominated by trees with a diameter breast height (DBH) which ranges from 1 to 10 cm (69%), whereas 31% of the trees have a diameter of more than 10 cm (Fig. 6), and average basal area of 31 m^2/ha. The total height of the tree ranges from 3 to 8 m with an average crown diameter ranging from 1 to 5 m. Larger tree species in term of diameter and height are recorded in the Municipality of Dinagat and Basilisa mangrove forest. Mangrove areas of Cagdianao, Llamera Gaas Inlet River of Libjo and Loreto have uniform sizes, height and crown structure similar to one another.

Figure no. 5 Mangrove forest structure and density: a. Mangrove forest of Cagdianao; b. Mangrove forest of Llamera, Libjo; c. Mangrove forest of Dinagat; d. Mangrove forest of Basilisa

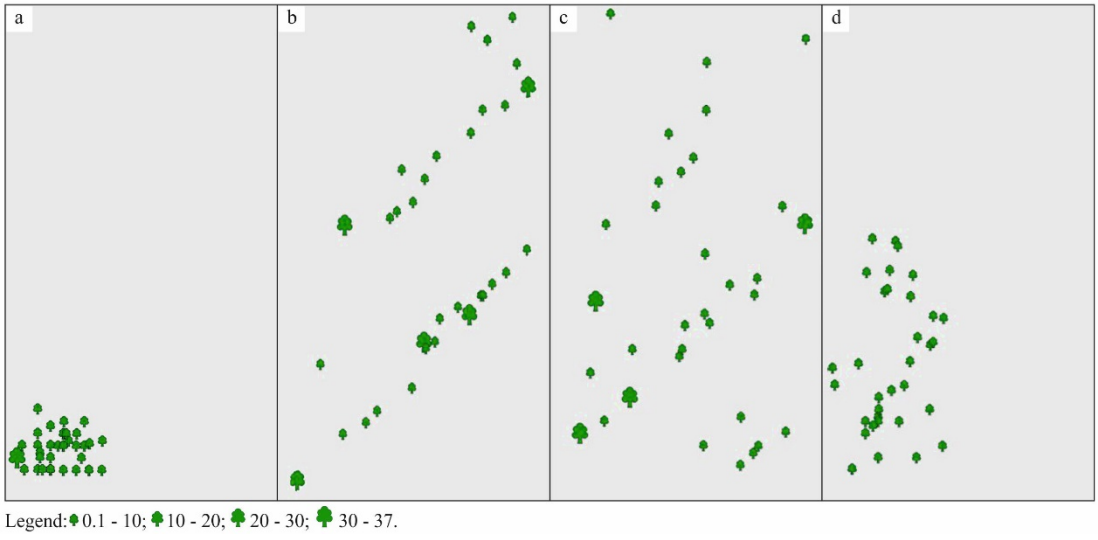
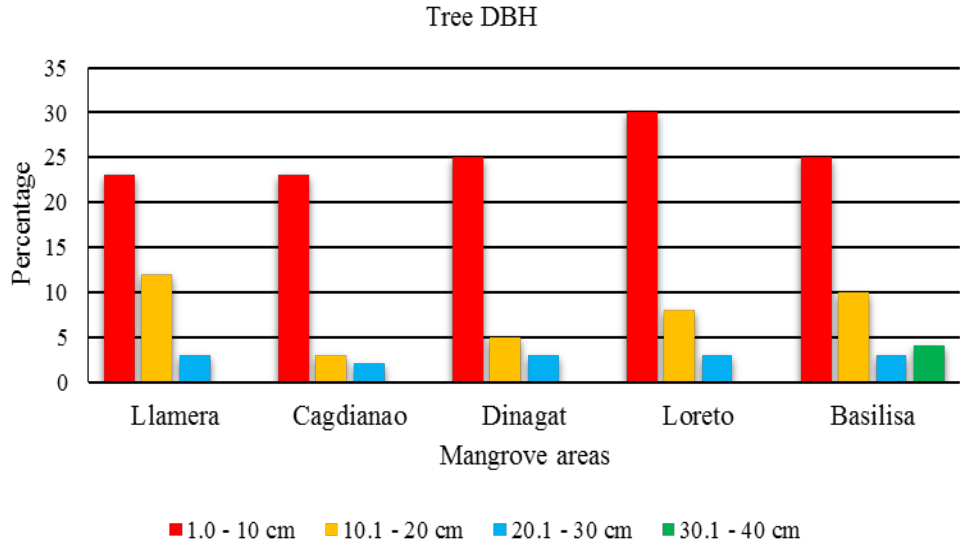


Figure no. 6 Diameter sizes of Mangrove trees in Different Municipality of Dinagat Island



Unfortunately, the structure of mangrove forest on Dinagat Island is smaller and shorter compared to other Island in the Philippines particularly in Puerto Princesa, Bay with an average tree diameter of 104.5 cm, height of 15 m, and basal area of 438 m^2/ha (Dangan-Galon et al. 2016).

Mangrove species distribution

Fortunately, all the true mangrove species are recorded in the mangrove forest of the Municipality of Dinagat, 90% in Basilisa, 80% in Llamera Gaas Inlet River of Libjo, 70% in Loreto, and 60% in Cagdianao (see Tab. 1, Annexes).

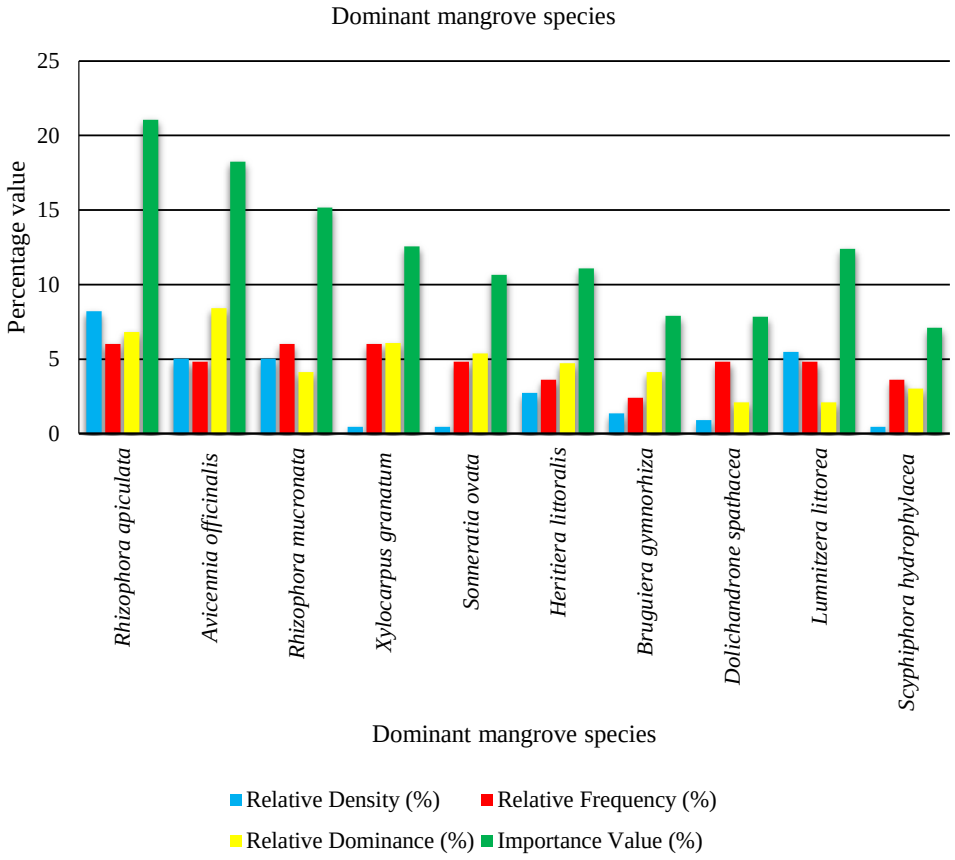
The species of *Bruguiera gymnorhiza* (L.) Lam, *Heritiera littoralis* Aiton, and *Scyphiphora hydrophylacea* C.F. Gaertn are to be distinguished within different mangrove sites. The 3 species are recorded in Libjo, Loreto and Dinagat (see Tab. 1, Annexes) and are absent in the Municipality of Cagdianao. In Basilisa 2 of the 3 species are recorded, the *Scyphiphora hydrophylacea* C.F. Gaertn species and *Heritiera littoralis* Aiton, while the species of *Bruguiera gymnorhiza* (L.) Lam. is absent.

The 7 associate mangrove species are all recorded in the Mangrove site of Llamera Gaas Inlet River of Libjo (see Tab. 1). Four species are recorded in the Municipality of Dinagat and two species were recorded in Loreto, Basilisa and Cagdianao. *Bulbophyllum* sp. and the 2 Miscellanous species of Orchidaceae are recorded only in Llamera Gaas Inlet River of Libjo. The species of Orchidaceae are found growing in the stem and branches of the true mangrove species of Llamera Gaas Inlet River. *Nypa fruticans* Wurmb are recorded in all mangrove sites. *Acrostichum aureum* L. and *Hydnophytum formicarum* Jack are only recorded in Llamera Gaas Inlet River and Municipality of Dinagat.

Dominant species

There are four mangrove species dominating the whole mangrove forest of Dinagat Island. The species have high percentage value in terms of Relative density, frequency, dominance and importance value. These species include: *Rhizophora apiculata* Blume, *Rhizophora mucronata* Lam, *Sonneratia ovata* Backer, and *Avicennia officinale* L. (Fig. 7).

Figure no. 7 Dominant mangrove species in terms of Relative Density, Relative Frequency, Relative Dominance, and Importance Value on Dinagat Island



However the species of *Dolichandrone spathacea* (L. f.) K. Schum. and *Lumnitzera littorea* (Jack) Voigt are dominant in mangrove forest of the Municipality of Dinagat, Cagdianao, and Basilisa but less in Llamera Gaas Inlet River of Libjo and in Loreto mangrove forest. *Xylocarpus granatum* J. Koenig is also found dominant in the Municipality of Dinagat and Llamera Gaas Inlet River of Libjo but less in Basilisa, Cagdianao and Loreto mangrove forest. The forest floor of the identified mangrove forest is also dominated by the seedlings and saplings of the species of *Rhizophora apiculata* Blume, *Rhizophora mucronata* Lam, *Sonneratia ovata* Backer, and *Avicennia officinalis* L.

Threats and disturbance on Dinagat Island

Based on the interview conducted in different municipalities and through direct observation the remaining forests of Dinagat Island faced with various threats include (Tab. 3, Annexes):

- mining;
- logging and illegal felling;
- conversion of forestland to agricultural lands (Kaingin);
- mining claim;
- charcoal making;
- water supply.

Based on the perception of the respondents, the most destructive threats that can alter the life of all biodiversity in the

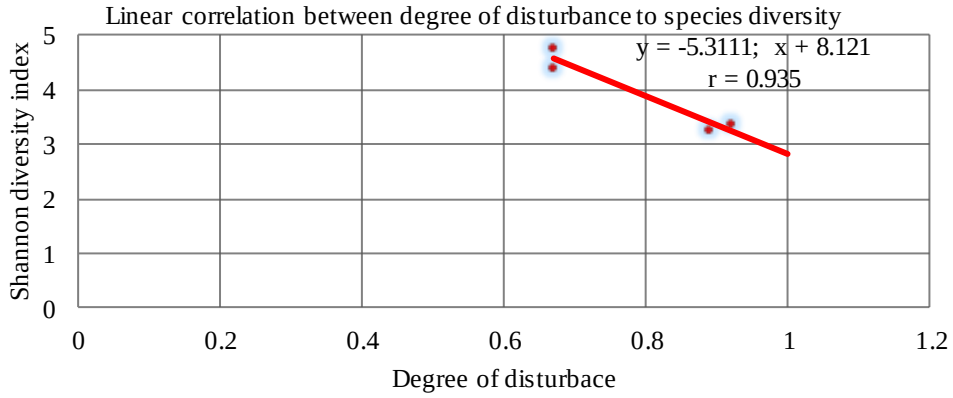
environment as well as of the people in the community is Mining followed by Illegal Logging and cutting, Kaingin, charcoal making, water supply and mining claims. Mining operation is considered as the most destructive practice, particularly Nickel and Chromite mining because it will remove all notable features from the landscape (Aw 1978).

In the Municipality of Tubajon mining is considered as the number 1 threat followed by Kaingin and Charcoal making. In the Municipality of Loreto, Libjo and Cagdianao, mining operation is also considered as number 1 threat, followed by illegal felling and Kaingin. Whereas in the Municipality of Dinagat, Basilisa and San Jose the number 1 threat is illegal tree cutting followed by Kaingin and Charcoal making. The Municipality of Dinagat consider water supply as the number 2 threat because of its limited supply (see Tab. 3, Annexes).

Based on Beynen and Townsend (2005) scoring system analysis of the degree of threats and disturbance, all areas concerned with mining operation have a rate of disturbance categorized as highly disturbed (see Tab. 3, Annexes). These areas include the Municipality of Tubajon, Loreto, Libjo and Cagdianao. Meanwhile, those areas with no mining operation are categorized only from disturbed to moderately disturbed. The Municipality of Basilisa and San Jose are characterised as moderately disturbed, while the Municipality of Dinagat characterised them as disturbed.

Based on Pearson linear correlation (r), the degree of disturbance has a negative correlation with species diversity at confident level of 94% (r = 0.935) (Fig. 8). Areas categorized as highly disturbed have lower species diversity as compared to less disturbed areas. As expected, areas with existing mining operation have lower species diversity.

Figure no. 8 Negative correlation between degree of disturbance and species diversity (Beynen and Townsend 2005)



Conclusions:

Mangrove Forest of Dinagat Island has a very low species diversity because of too many threats from mining. The forest is characterized as less dense and open. Covered by small size trees with uniform height, smaller basal area of coverage, and dominated only by 4 true mangrove species in terms of relative frequency, density and dominance, as well as on the importance value namely *Sonneratia ovata* Backer,

Rhizophora apiculata Blume, *Avicennia officinalis* L., and *Rhizophora mucronata* Lam.

Rezumat:

COMPOZIȚIA ȘI DIVERSITATEA SPECIILOR DE MANGROVE DIN INSULA DINAGAT, FILIPINE

Decretul nr. 63 din 25 Iunie 1914 și Proclamația nr. 391, semnate de Președintele Manuel L. Quezon în 13 Martie 1939, au stat la baza declarării Insulei Dinagat ca Arie de Importanță Minerală. Studiul vizează evaluarea compoziției și diversității speciilor de mangrove din Insula Dinagat, Filipine. Un număr maxim de 15 parcele au fost marcate la o distanță de 300 m. Plantele din interiorul pătratelor au fost identificate și apoi numărate. Plantele cu un Diametru al Trunchiului (DBH) egal sau mai mare de 1 cm au fost măsurate. Rezultatele au indicat un număr de 17 specii clasificate în 13 familii și 15 genuri, dintre care 10 fac parte din grupa mangrovelor adevărate, iar 7 ca specii de mangrove asociate. Cel mai reprezentativ gen a fost *Rhizophora*. Dintre mangrovele adevărate cea mai reprezentativă familie a fost Rhizophoraceae, iar pentru speciile de mangrove asociate Orchidaceae. Valoarea diversității speciilor a fost scăzută (1,3 – 1,6). Pădurea de mangrove a fost dominată de copaci cu un DBH cuprins între 1 și 10 cm (69%) și 31% mai mare de 10 cm. Media ariei bazale a fost de 31 m^2/ha. Înălțimea totală a fost cuprinsă între 3 și 8 m, cu o medie a coronamentului de 3 m. Speciile dominante au fost *Sonneratia ovata* Backer, *Rhizophora apiculata* Blume, *Avicennia officinalis* L. și *Rhizophora mucronata* Lam. Zonele miniere funcționale au avut o diversitate mai scăzută. Diversitatea redusă a speciilor care formează pădurea de mangrove din Insula Dinagat impune o atenție deosebită din partea guvernului, sectorului privat, companiilor miniere și a comunităților locale pentru protecția și conservarea acesteia, pentru oamenii de pe insulă care depind de pescuit, ca principala lor sursă de venit.

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Annexes:

Table no. 1 Distribution of mangrove species per sampling site

Scientific name	Sampling site					F
	Libjo	Loreto	Dinagat	Cagdianao	Basilisa	
True mangrove						
Avicennia officinalis L.		x	x	x	x	4
Bruguiera gymnorhiza (L.) Lam	x	x	x			2
Dolichandrone spathacea (L. f.) K. Schum.	x		x	x	x	4
Heritiera littoralis Aiton	x		x		x	3
Lumnitzera littorea (Jack) Voigt	x		x		x	4
Rhizophora apiculata Blume	x	x	x	x	x	5
Rhizophora mucronata Lam.	x	x	x	x	x	5
Sonneratia ovata Backer		x	x	x	x	4
Scyphiphora hydrophylacea C.F.Gaertn	x	x	x		x	3
Xylocarpus granatum J. Koenig	x	x	x	x	x	5
Subtotal	8	7	10	6	9	38
Associate mangrove						
Nypa fruticans Wurmb	x	x	x	x	x	5
Caesalpinia crista L.	x	x	x		x	4
Acrostichum aureum L.	x		x	x		3
Hydnophytum formicarum Jack	x		x			2
Bulbophyllum sp.	x					1
Orchidaceae	x					1
Subtotal	7	2	4	2	2	17
Total	15	12	14	8	11	55

Table no. 2 Classification and conservation status (IUCN 2016; DAO 2017) of true mangrove species on Dinagat Island

Common name	Scientific Name	Family name	Conservation Status	
			IUCN	DAO
Api-api	*Avicennia officinalis* L.	Acanthaceae	LC	Not assessed
Busain	*Bruguiera gymnorhiza* (L.) Lam	Rhizophoraceae	LC	Not assessed
Tui	*Dolichandrone spathacea* (L. f.) K. Schum.	Bignoniaceae	LC	Not assessed
Dungon late	*Heritiera littoralis* Aiton	Malvaceae	LC	Not assessed
Tabau	*Lumnitzera littorea* (Jack) Voigt	Combretaceae	LC	Not assessed
B-lalake	*Rhizophora apiculata* Blume	Rhizophoraceae	LC	Not assessed
B-babae	*Rhizophora mucronata* Lam.	Rhizophoraceae	LC	Not assessed
Nilad	*Scyphiphora hydrophylacea* C.F. Gaertn	Rubiaceae	LC	Not assessed
Pedada	*Sonneratia ovata* Backer	Lythraceae	NT	Not assessed
Tabigi	*Xylocarpus granatum* J. Koenig	Meliaceae	LC	Not assessed

Note: LC – least concern; NT – near threatened

Table no 3 Ranking of threats and disturbances in the seven municipalities of Dinagat Island

Threats	Municipality							Rank
	Tubajon	Loreto	Dinagat	San Jose	Basilisa	Libjo	Cagdianao	
Mining								
	1	1	-	-	-	1	1	1*
Illegal Logging and cutting								
	-	2	1	1	1	2	2	2
Kaingin								
	2	3	-	2	2	3	3	3
Charcoal making								
	3	-	-	3	3	4	-	4
Water supply								
	-	-	2	4	4	-	3	5
Mining claim								
	-	-	3	5	5	-	-	6
Degree of disturbance								
	0.89 HD	1.0 HD	0.56 D	0.67 MD	0.67 MD	0.92 HD	0.83 HD	

Note: Rank 1- most destructive in the area; HD - highly disturbed; MD - moderately disturbed; D – disturbed