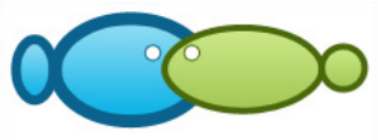
True mangrove of North Gorontalo Regency, Indonesia, their list, status and habitat-structural complexity in easternmost coast area

by Citra Panigoro

Submission date: 30-Mar-2023 09:02AM (UTC-0400)
Submission ID: 2050977597
File name: -and-habitat-structural-complexity-in-easternmost-coast-area.pdf (272.1K)
Word count: 5460
Character count: 30545



True mangrove of North Gorontalo Regency, Indonesia, their list, status and habitat-structural complexity in easternmost coast area

[1]Faizal Kasim, [1]Sitti Nursinar, [1]Citra Panigoro, [1,2]Zulkifli Karim, [1,2]Aldin Lamalango

[1] Department of Aquatic Resources Management, Faculty of Fisheries and Marine Science, Gorontalo State University, Gorontalo, Indonesia; [2] Gorontalo Coastal Ecological and Spatial Mapping Studies Club (GCESM), Dulalowo, Telaga Jaya, Gorontalo, Indonesia. Corresponding author: F. Kasim, faizalkasim@ung.ac.id

Abstract. The Gorontalo's biodiversity is well known through several iconic of mammals and birds of world conservation value. The present study aimed to revise a species list of true mangroves in easternmost coast of North Gorontalo Regency. An indexing of diversity and status IUCN red list for conservation was taken into account. Also structural complexity of habitat feature on each site was discussed at spatial interval measurement among site. The result showed that there were 19 species belonging to 9 genera within 7 families of true mangrove in easternmost coast. The known true mangrove, Rhizophoraceae, was the richest in taxa at both genus and species level. Two species found which considered globally important, i.e. *Aegiceras floridum* Roem. & Schult (locally named as Tongge) and *Ceriops decandra* (Griff.) Ding Hou (locally called as Posi-posi). Other than both were true mangroves species enlisted least concerned globally. However, since *Heritiera littoralis* Aiton (locally referred and named as Kayu tin) was the rarest species (only found 2 trees of 1 site), it then considered critically important endangered species locally. In the context of habitat structural-diversity relationship, the distinctive feature which may comparatively measurable were duration-depended tidal range, types of freshwater supply, land cover change, mangrove formation, interval level of spatial distribution scale. In current case, sampling method applied was the additional for structural complexity of mangrove diversity. Those are a comparatively features of diversity's measure was be taken into analysis among each site or other region outside North Gorontalo.

Key Words: Gorontalo's mangrove, endangered species, mangrove diversity, Bray-Curtis similarity index, coastal feature.

Introduction. Generally mangroves can be found throughout the Indonesian archipelago. So far, in Indonesia there are at least 202 species of mangrove plants, covering 89 species of trees, 5 species of palm, 19 species of climbers, 44 types of soil herbs, 44 types of epiphytes and 1 type of ferns. Among the 202 species, 43 species (including 33 tree species and some shrubs) are found as true mangroves; other species are found around mangroves and are known as associated mangrove species.

While mangrove in Indonesia has a high diversity of global species, their extent of coverage has tended declining yearly because of some disturbances and in the process of becoming ponds. The disturbances are timber extraction for commercial purposes and shifting cultivation for farms and farming areas, especially rice and coconut (Noor et al 2012). Loss of mangrove area also occurred in Gorontalo. Recently report from Department of Fisheries and Marine Gorontalo Province (2016) stated that an ongoing threated condition occurring on Gorontalo's mangrove. Of the total 17,204.84 ha mangrove forest in the southern and northern coastline of Gorontalo. Until end 2015, a number of 3,084.68 ha (about 17.9% of mangrove on Gorontalo) are damaged which of 1.107,93 ha (35.9% of total damaged mangrove) occurred in Northern Gorontalo. This threatens condition, therefore, will effect to coastal productivity and loss diversity of mangrove in Indonesia in general.

Biogeographically, Gorontalo area is located in the heart of the Wallacea, the transitional zone between the Asian, or Oriental (Paleotropical), and Australian (Notogaean). Consequently, Gorontalo has unique and rare biodiversity, home to numerous unique species (Gorlinski 2012; Mano 2016). In unique biodiversity terms, Gorontalo has a number of conservation areas namely Bogani Nani Wartabone National Park (TNBNW) in Bone Bolango Regency, Nantu-Boliyohuto Wildlife Reserve in North Gorontalo, Gorontalo and Boalemo Regency. In addition there are Panua Nature Reserve and Tanjung Panjang Nature Reserve in Pohuwato Regency, Popaya Mas Raja Nature Reserve in North Gorontalo Regency, and Tangale Nature Reserve in Gorontalo Regency, as well as mangrove forest. In terms of rare biodiversity, such important site for conservation areas was being the last strongholds for Sulawesi's richness (Corbin 2013; Nantuforest 2017). They were home to a large number of species endemic to Sulawesi like as *Macrocephalon maleo* (the incubator bird maleo), *Macaca nigra* (the crested black macaques), *Babyrousa celebensis* (babushkas or deer-pigs), *Aceros cassidix* (the red-knobbed hornbill), and *Bubalus sp.* (dwarf buffalo or anoa). These faunas were being the Gorontalo's iconic of for world conservation value (Kartika 2008).

Recently, Gorontalo was declared to be the Third Conservation Province in Indonesia by the Ministry of Environment of Indonesia Government, after West Papua Province and East Kalimantan (Paino 2017). Therefore, the disclosure of mangrove forests condition as part of comprehensive management for conservation area is a need

In the present research, we conducted an inventory study upon mangrove biodiversity in Gorontalo. The aim was to check the species list of true mangroves in easternmost coast area of North Gorontalo Regency and their status to complete diversity information for Indonesia's mangrove data base. Present study also highlighted features among sites as habitat which might be the structural complexity of true mangrove species diversity in easternmost coast area.

Material and Method. Field data of the research was conducted in May – Augustus 2017 in the easternmost coast area of North Gorontalo Regency, Gorontalo Province (Figure 1).

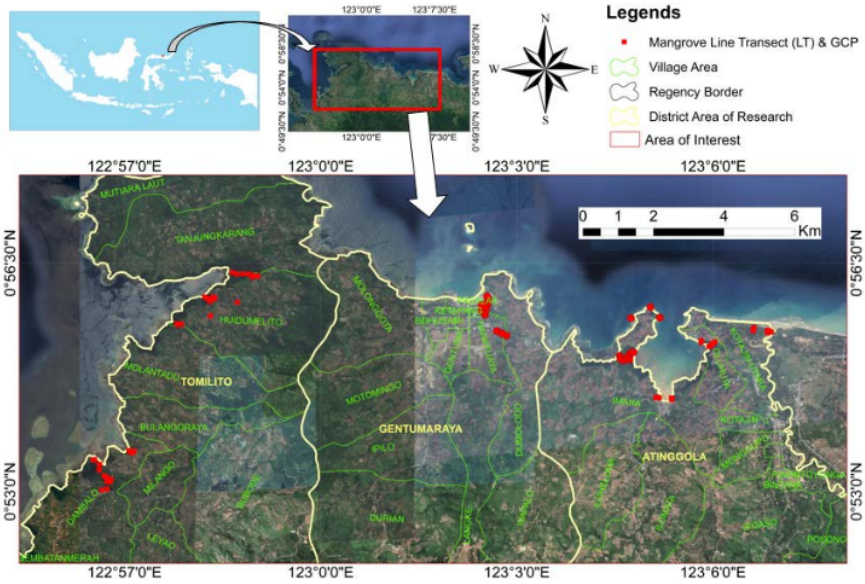


Figure 1. Field station of research location for mangrove sampling on coastal area of villages in easternmost regency area of districts, North Gorontalo Regency, Indonesia.

Description of the study sites. Site location was between latitude 0° 52′ 53.2″ – 0° 56′ 27.8″ (N) and longitude 122° 56′ 15.6″ – 123° 6′ 51.2″ (E). Administratively, sites of

study were coastal areas of 7 villages part of 3 districts; Kotajin Utara, Oluhuta, and Imana (District of Atinggola); Pasalae (District of Gentuma Raya); Tanjung Karang, Huidumelito, and Dambalo (District of Tomilito).

Based on North Gorontalo Regency profile in 2015, average temperature by Month ranged from 24.14°C (February) to 28.39°C (December) with humidity of area ranged from 61.90% (September) to 84.77% (January). The average of the highest rainy days occurred in June that was 19 days, while the highest rainfall occurred in May was 188.00 mm. The average rainy day and rainfall decreased compared to the previous year, and one of the causes is the El Nino phenomenon (BPS-Statistics of Gorontalo Utara Regency 2016).

Data collection. Purposive transect line (TL) was employed for data collection within the sites of distributed mangrove. The length of each TL varied from 150 m to 1,400 m, was only established on the widest distance of belt mangrove area within each site (village), started from the front formation (seaward) pass through the mangrove community to the back formation (landward), one to three in accordance with size of belt and shape of the mangrove extent inside each site area. The information was generated from Google Earth image in desk assign. Plot methods size 10 x 10 m (Hanum et al 2012; Jamili et al 2015) was used for vegetation sampling within each TL with an interval distance of 30 m to 50 m between plots. Each plot was divided into diagonally sub-plots size 5 x 5 m (Hidayat et al 2010). A totaling area of 5,100 square meter (0.51 ha) was resulted from regular plots were established along the totaling 13 TLs within all sites.

Type and sources of data. Only type of true mangroves was inventoried and enumerated. Type of trees and saplings categories was inventoried from each plots, seedlings from sub-plots. Mangrove species identification was based on the description of true mangroves by Kusmana et al (2003), Noor et al (2012), and Wetland International (2017). Mangrove population structure was collected from basal area (BA) and tree density parameters resulted from the number of individual mangrove trunk of tree and sapling, and their diameter at breast height (DBH) in each plot. Diameter was resulted from circumference value measured using a measuring tape, with formula of diameter = circumference.π^{-1}. Mangrove tree with trunk height >1.5 m was further categorized based on their diameter at DBH, i.e. trees has diameter of >10 cm at DBH, samplings category has diameter of 3–10 cm. Stem height <1.5 m was categorized as seedlings (Cintron & Novelli 1984; Cañizares & Seronay 2016; Jamili et al 2015; Joshi & Ghose 2014; Suk-ueng et al 2013; Winata et al 2017).

Data analysis. The IUCN statuses were taken from the IUCN Red List of Threatened Species Version 2017-2 (IUCN 2017); was taking into account features considered in the present species list for the true mangroves. Condition of mangrove communities (Joshi & Ghose 2014) including Species diversity Shannon-Wiener index, H' (Shannon & Wiener (1963) dominance Simpson's index, Cd (Simpson 1949) and evenness Pielou's index, E (Pielou 1966) were determined, also multivariate clustering (Bray-Curtis's index) for spatial discrimination of species diversity (Jumawan et al 2015) was followed, calculated using PAleontological STatistics (PAST Version 3.15)(Hammer 2017).

Results and Discussion. Each sites of mangrove areas were separate sporadic. Back area of mangrove on more sites was found immediately curtailed by the foothills. No wonder since average topography of location was dominated by highlands, range from 8 m in Gentuma Raya and 9 m in Atinggola to 66 m in Tomilito. However, mostly sites, except Huidumelito, having enough fresh water supply from river (be found in Kotajin Utara and Dambalo), rills, cricks, and perhaps small stream that flows intermittently or seasonally. These outlets types of freshwater sources may be the support for the growth of mangroves in this location.

Existing species of true mangrove. Following the literature review and field survey of the present study we identified a total of 19 species of true mangroves of all 7 sites on

easternmost coast area of North Gorontalo. These species belonged into 7 different families of 9 genera. Of the 7 families, Rhizophoraceae shows the maximum richest taxa at both genus and species level. This family, often referred to as the "true mangrove family" (Duke et al 1998 in Barik & Chowdhury 2014), shows the richest assemblage in most of the mangrove ecosystems of the world, as also evident in the present study having 3 genera which are 8 species within. The details of the encountered species are given in Table 1.

Table 1

Species of true mangrove encountered on the easternmost coast area of North Gorontalo Regency and their distribution occurrence in each site

No	Family	Genera	Scientific name	Administrative area*								IUCN Red list **
				D1			D2		D3			
				Kj	Im	Ol	Ps	BR	Da	Hm	TK	
1	Myrsinaceae	*Aegiceras*	*A. corniculatum* (L.) Blanco	+	-	-	-	-	-	-	-	LC
2			*A. floridum* Roem. & Schult	+	+	-	-	-	-	-	-	NT
3	Avicenniaceae	*Avicennia*	*A. alba* Blume	+	+	+	+	+	+	+	+	LC
4			*A. marina* (Forsk.) Vierh.	+	+	-	-	+	+	+	+	LC
5			*A. officinalis* L.	+	-	-	-	-	-	-	-	LC
6	Rhizophoraceae	*Bruguiera*	*B. cylindrica* (L.) Blume	+	+	+	-	+	-	+	-	LC
7			*B. gymnorhiza* (L.) Lam.	-	-	-	-	+	-	+	+	LC
8			*B. parviflora* Wight & Arn. ex Griffith	-	-	-	-	+	+	+	+	LC
9		*Ceriops*	*C. decandra* (Griff.) Ding Hou	-	-	-	+	-	-	-	-	NT
10			*C. tagal* (Perr) C.B. Rob.	-	+		-	-	+	-	-	LC
11	Asclepiadaceae	*Gymnanthera*	*G. paludosa* (Bl.) K. Schum	-	-	-	-	-	-	+	-	Na
12	Malvaceae	*Heritiera*	*H. littoralis Aiton*	-	+	-	-	-	-	-	-	LC
13	Rhizophoraceae	*Rhizophora*	*R. apiculata* Blume	-	+		-	-	+	-	+	LC
14			*R. mucronata* Lam.	-	+	+	-	-	+	+	+	LC
15			*R. stylosa* Griff.	+	+	+	+	+	+	+	+	LC
16	Lythraceae	*Sonneratia*	*S. alba* Sm.	-	+	+	+	+	-	+	+	LC
17			*S. caseolaris* (L.) Engl.	+	+	-	+	-	-	-	-	LC
18	Meliaceae	*Xylocarpus*	*X. moluccensis* (Lam.) M. Roem.	-	+	-	+	-	-	-	-	LC
			Sum of species	8	11	5	6	7	7	9	8	

* Abbreviation of villages: Kj - Kotajin Utara, Im - Imana, Ol - Oluhuta, Ps - Pasalae, BR - Bolango Raya, Da - Dambalo, Hm - Huidumelito, TK - Tanjung Karang. Abbreviation of districts; D1 - Atinggola, D2 - Gentuma Raya, D3 - Tomilito. ** IUCN red list code: NT - Near Threatened, LC - Least Concern, VU - Vulnerable, Na - Not available.

Noor et al (2012) stated that at least 43 species, but Giesen et al (2007) stated 48 species, of the 52 of true mangrove species which are listed in Southeast Asia (SE Asia) occurs in Indonesia. Seventeen species listed in the present study are Indonesia's mangrove species which were also enlisted of SE Asia's mangrove (Giesen et al 2007; Noor 2012). One species, *Gymnanthera paludosa* (Bl.) K. Schum was unlisted in Giesen et al (2007)'s list, and also has not yet been enlisted in IUCN Red List. Noor (2012) stated if this species was possibly found throughout Indonesia coastal area, although mostly recorded on Java and Madura.

The present study found that in the easternmost area there were two species, i.e *Aegiceras floridum* Roem. & Schult (locally named as Tongge) and *Ceriops decandra* (Griff.) Ding Hou (locally called as Posi-posi) are globally considered important regarding their conservation importance as enlisted status in near globally threatened list (IUCN 2017). Likewise, we noticed another *Aegiceras (A. corniculatum* (L.) Blanco which is locally called as Tangalo putih), and *Avicennia officinalis* L. (locally named Tangalo merah) and *Heritiera littoralis* Aiton (locally referred and named as Kayu tin) were 3 species considered endangered locally in addition to the other previous of two globally important species. Moreover, *H. littoralis* was considered in current study as critically endangered since their assemblage species rarely occurred (2 tree individuals) within 1

site. Density of all category of true mangrove's list encountered during sampling in easternmost coast area is showed in Figure 2.

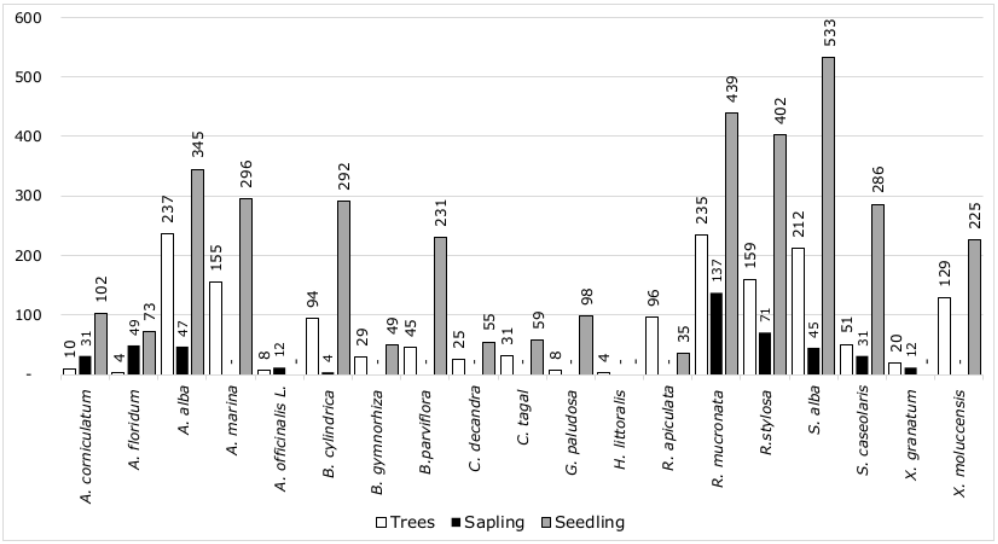


Figure 2. The mangrove species density (ind. Ha^{-1}) of each category of true mangrove list trough all sites. (Density was calculated from plots number and their size on each site).

Available publications concerning information of mangroves diversity in North Gorontalo region is limited. Among such rare publications, Gusasi (2014) recorded 10 major mangrove species and 2 minor mangrove species in Kwandang Regency, in the center part of North Gorontalo. Another report from Baderan (2013) showed that phenomenon of damage occurred in such mangrove ecosystems area due to anthropogenic activity. Related to mangrove forest management, Kusmana (2015) proposed 3 pillars for mangrove sustainable development: ecological, social, and economical. In which mangrove biodiversity is part of the ecological pillar in relation to maintain the function, productivity, and carrying capacity existed in a mangrove area.

To get comprehensive information or to compare our current results with other researches in context of mangrove status in entire Gorontalo area, new studies were needed. More detailed surveys conducted on other areas were needed to identify species occurred and found, especially to compare to threatened and endangered species with the current results. It were includes the relic and fairly intact of species status on lesser known mangrove areas, beside the method applied in other Gorontalo region. In the current research, all those variables of comparison called as structural complexity in later discussion.

Chosen variables of structural complexity analyzed in the present research on each research station in easternmost area of North Gorontalo Regency was the approach for the initial part of mangrove comparison research which was applied later to the entire North Gorontalo coastal area.

Based on method approach in present research which using standard combination of LT and plot methods, it was revealed that the longest TL, in terms of related to width of mangrove's belt, was found on site of Tanjung Karang's mangrove, as this site has the largest mangrove's belt (Figure 3). However, the highest species number of mangrove was found in Imana's mangrove (11 species) which has narrower belt with more distribution of LT used for sampling.

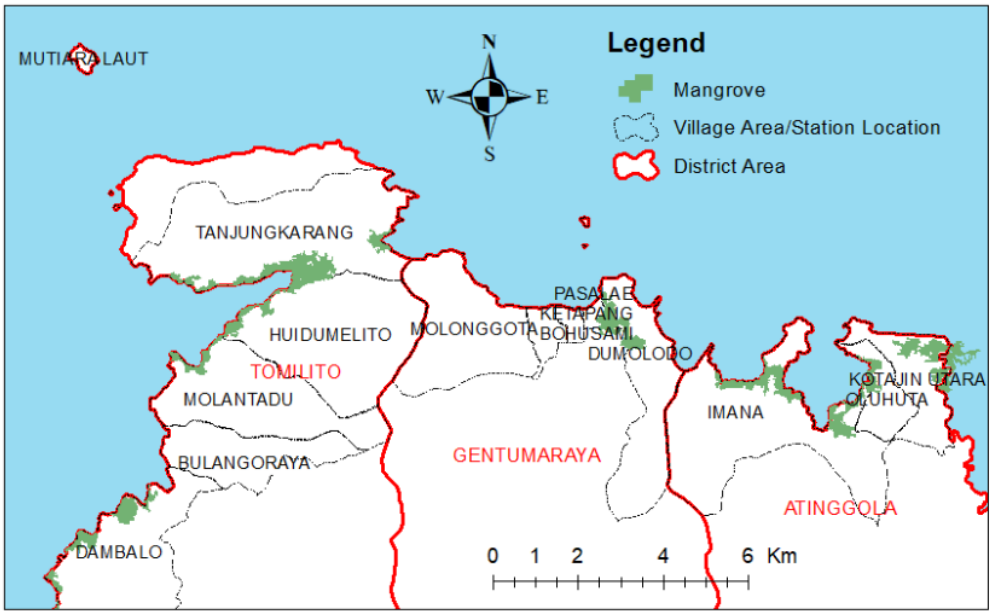


Figure 3. Mangrove area on easternmost coast area of North Gorontalo Regency.

Distinctive spatial diversity of true mangroves. Vijayan et al (2015) stated that different species of mangrove revealed the degree of dispersion of the individual species among them in an area, expressed in terms their occurrence. Furthermore, their distribution is determined by salinity, species and sub-species competition and other physical factors. Composition and arrangement of physical matter at a location defined as habitat structure which has at least 3 major elements: structural complexity, heterogeneity and scale. While the structural complexity represents variation in habitat structure attributable to the abundance of individual structural components, it will essential to interpret effects of its measurement between different studies and habitats to understand the conditions under which habitat structure affects the density and diversity of species (Beck 1998; Byrne 20009). There were the direct and indirect relationships among habitat structure and ecological variables. In term of the present study of North Gorontalo's true mangrove, the habitat structure for their ecological variables (physically soil and water condition) which linked to their distinctively spatial distribution, occurrence, and diversity may influenced by sociocultural and form of landscape within each location of this research.

In context of index measurement, present study easternmost area of North Gorontalo found that the highest value according to both Shannon-Wiener (H') index and Simpson's index (Cd) was found in Dambalo which were dominated by 2 communities equally; *Avicennia marina* (Forsk.) Vierh, which locally is called as Tangalo Putih and *Xylocarpus moluccensis* (Lam.) M. Roem. (locally refereed as Antai). Whereas, the lowest was in Oluhuta which the true mangrove consisted predominantly of 3 species of genera members, different each other, i.e *Rhizophora mucronata Lam.* (locally named Songge), *Sonneratia alba* (locally called Yapi yapi) and *Bruguiera cylindrica* which locally is called Bido-Bido. Information of some vary indexes which was analyzed the mangrove diversity based on number of individuals of all category (trees, saplings and seedling) on each site is showed in Figure 4.

Interestingly, as seen in Figure 4, there was no consistency between both result of Simpson's index and Shannon-wiener's index related to generally theoretical understanding about correlation between the numbers of plots sampling and diversity; more plots higher diversity. In this term, it seems that Shannon-Wiener's index may best represent the applied method, whereas Simpson's index result may use to indicate the

worked habitat features on sites of current study. In the present study, while the main distinctive habitat feature among sites were freshwater supply availability (only not available in Huidumelito) which thus influence salinity, also the extent and spatial distribution pattern of true mangrove communities formed by the topographic condition in back landscape of habitat in each sites, another which may distinctively effect was current method approach which effect to applied size of TL and number of plots within in each site related to their size of mangrove belt. Thus, all of these were considered as factors of structural complexity in this current study situation which will be the comparable measurement of similar research, either to adjacent mangrove habitats within other coast area of North Gorontalo or to mangrove habitats in southern coast area of Gorontalo Province.

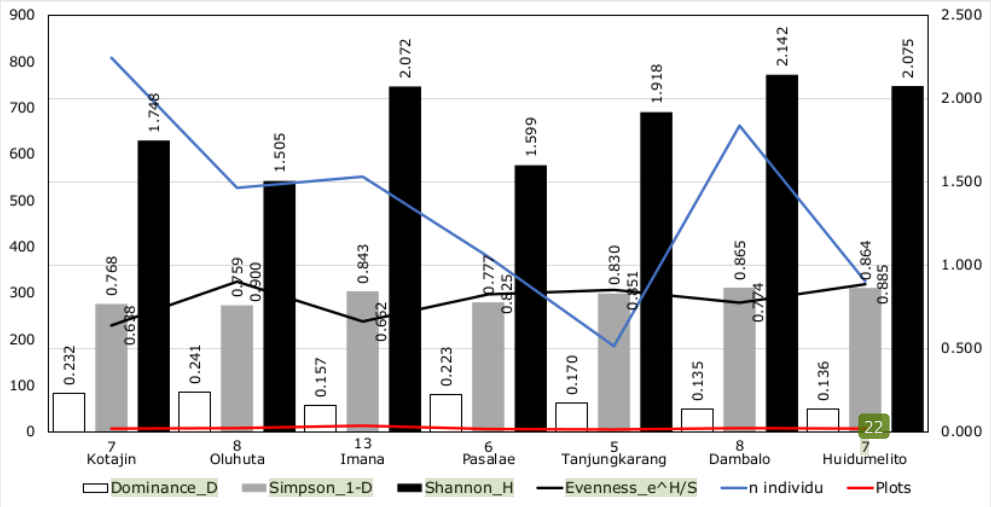


Figure 4. Various diversity index information of true mangroves species among each site in easternmost coast area of North Gorontalo Regency. (The infomation was counted from all structure categories of trees, saplings and seedlings).

The spatial discriminative analysis based on some current information's of true mangrove species diversity on each site in easternmost coast area in North Gorontalo is show in Figure 5.

The results show that there are 2 main clustering between sites within easternmost coast area at similarity level of 0.675. The first cluster was Tanjung Karang which has own typical habitat separately (in field, was characterized by long duration of inundation of tide since only have a narrow tidal range. Thus, a canoe is required to survey in front formation and crawled between the tree branches at the backward formation of mangrove). Second one was the combination of sites cluster where have similar typical of duration of tidal inundation which differ than Tanjung Karang, as the primary typical of habitat difference.

The second main cluster was clustered further at hierarchy value of their similarity based on the typical features of each site. For example, while Dambalo and Kotajin Utara which featured by the richness of freshwater supply from big stream relatively within them as their main habitat structure of similarity, habitat of Oluhuta and Imana, in other hand, was joint their similarity by same flat area as their main habitat feature, beside of the adjacent area each other in their scale. Likewise, habitat on Pasalae and Huidumelito were featured by their same situation may relate to associated type of mangrove (not accounted and inventory in current study) and land cover change. Therefore, all of these habitat combinations features within them may as distinctive typical to differ from Tanjung Karang.

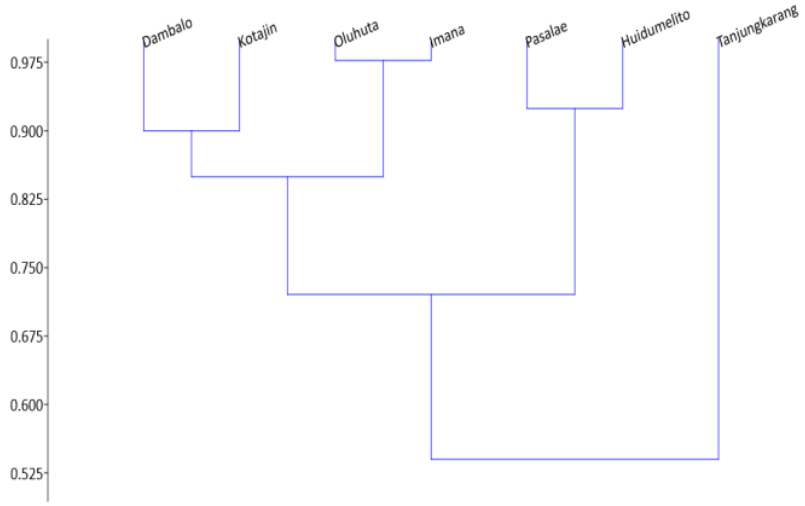


Figure 5. Dendogram of similarity clustering of distinctive true mangrove diversity spatially each site on easternmost coast area of North Gorontalo Regency.

The effect of each habitat's feature on mangrove diversity above, was a coarsely estimation that only based on the main typical observed together during where field survey and mangrove data's collecting was conducted. It must be details analysis performed to specify the correlation among typical features within each sites more precisely, which are more focused relate to method analysis approaches and others of structure complexity component within each site compared. However, present study revealed the advantage of multivariate clustering approach to understand briefly which features has the main effect no true mangrove diversity in easternmost coast.

Conclusions. A number of 19 species of true mangrove, belonging to 9 genera of 7 families, were identified in the present study on easternmost coast of North Gorontalo Regency. Of 9 families, Rhizophoraceae was the richest in taxa at both genus and species level. Among 19 species encountered, *A. floridum* and *C. decandra* were 2 important species regarding to their conservation importance status which is enlisted globally as near threatened (NT) species. Generally, encountered species were enlisted in IUCN redlist least concerned (LC) species. However, *A. corniculatum*, and *A. officinalis* and *H. littoralis* were 3 species considered endangered locally. Moreover, since *H. littoralis* was a rarest occurred in easternmost coast (only 2 trees found during field survey on all site), thus, it was considered into critically endangered species locally.

In habitat's diversity context, there were general features among sites in easternmost coast of North Gorontalo which may considered as habitat structural which is distinctive for true mangrove's diversity within North Gorontalo coast area level when compared to other area, and among each sites within. Combination of all those features then may be the representation common feature of North Gorontalo for true mangrove species habitat. In the present study, it was presented the by their value of similarity of 0.675. This similarity value of the true mangrove's diversity, from regency level to village level (site) (the measure of spatially scale interval), are resulted by features of structural complexity of habitat (sites) which has effect on the true mangrove's diversity. In one side, those were habitat features which including duration of tidal inundation, presence of types of freshwater supply to coastline inlet (river, rills, creeks, and perhaps bourn), anthropogenic influencing land cover change, and spatial distribution pattern of mangrove. In another side, there was an addition to those habitat features measurement for true mangrove diversity i.e. the method applied which depend to the extent and distribution formation of mangrove habitat.

All above were a comparability measurement of habitat structural which may be current distinctive diversity found to the true mangrove occurrence in easternmost most coast area, which may be considered in further comparative research of mangrove either within adjacent habitat in North Gorontalo area or in other place in Gorontalo.

Acknowledgements. We are grateful for the close collaboration between Gorontalo Coastal Ecological and Spatial Mapping Studies Club (GCESM) and Jalipati Tuheteru, Olpien Umar, and Sandrianto (members of DEHETO Club) in completing this study. Special thanks also to all students of Aquatic Resources Management Department for dedication in data collecting and also to the local fishermen for providing support during the research. This study was partly funded by KEMERINTEKDIKTI RI for Fundamental Competition Grand First Year 2017-2018.

References

Baderan D. W. K., 2013 [Economic valuation model as basic for rehabilitation of mangrove forest damage in Coastal Area Kwandang Sub-district Gorontalo Utara District Gorontalo Province]. Ph.D. Thesis, Faculty of Geography, Gadjah Mada University, Yogyakarta. [In Indonesian].

Barik J., Chowdhury S., 2014 True mangrove species of Sundarbans Delta, West Bengal, Eastern India. Check List 10(2):329–334.

Beck M. W., 1998 Comparison of the measurement and effects of habitat structure on gastropods in rocky intertidal and mangrove habitats. Marine Ecology Progress Series 169:121-178.

Byrne L. B., 2009 Habitat structure: a fundamental concept and framework for urban soil ecology. Urban Ecosystems 12:21. https://doi.org/10.1007/s11252-009-0085-z.

Cañizares L. P., Seronay R. A., 2016 Diversity and species composition of mangroves in Barangay Imelda, Dinagat Island, Philippines. AACL Bioflux 9(3):518-526.

Cintron G., Novelli Y. S., 1984 Methods for studying mangrove structure. In: The mangrove ecosystem: research methods. Snedaker S. C., Snedaker J. G. (eds), pp. 91-113, Paris, UNESCO.

Corbin J., 2013 Restoring mangrove forests in Indonesia's Tanjung Panjang area through the use of market-based incentives: lessons learned from international case studies. Master Thesis in Marine Management, Dalhousie University Halifax, Nova Scotia.

Gorlinski V., 2012 Encyclopædia Britannica: Gorontalo Province, Indonesia. https://www.britannica.com/place/Gorontalo. Accessed on 28 October 2017.

Giesen W., Wulffraat S., Zieren M., Scholten L., 2007 Mangrove guidebook for southeast Asia. Bangkok: Rap Publication, Food and Agriculture Organization of the United Nations Regional Office for Asia and the Pacific, 769 pp.

Gusasi F., 2014 Analysis of mangrove forest ecological function in Kwandang District, North Gorontalo Regency (Indonesia). Bachelor Thesis of Department of Biology Education, FMIPA, State University of Gorontalo http://eprints.ung.ac.id/7027/. Accessed on 20 Februari 2015.

Hanum I. F., Kamziah A. K., Nurul S. S., 2012 Plant diversity and biomass of Marudu Bay mangroves in Malaysia. Pakista Journal of Botany 44(Special Issue):151-156.

Hammer Ø., 2017 Reference manual PAleontological Statistics Version 3.15. Natural History Museum University of Oslo.

Hidayat T., Kusuma C., Tiryana T., 2010 Species composition and structure of secondary mangrove forest in Rawa Timur, Central Java. AACL Bioflux 10(4):675-686.

Jamili, Sani A., Djalante R., Pasolon Y. B., 2015 Mangrove composition and structure at small islands in Wakatobi National Park, Southeast Sulawesi. Proceedings of the 13th International Conference on Environment, Ecosystems and Development (EED '15). Kuala Lumpur, Malaysia, April 23-25, 2015. ISBN: 978-1-61804-301-6. Pp. 168-178.

Joshi H. G., Ghose M., 2014 Community structure, species diversity, and aboveground biomass of the Sundarbans mangrove swamps. Tropical Ecology 55(3):283-303.

Jumawan J., Flores F. L., Aragon R. T., Villamor J. M. C., Sagot J. C., Taguse H. C., Genecera J., Banas G. G., Depamaylo A. M. V., 2015 Diversity assessment and spatial structure of mangrove community in a rehabilitated landscape in Hagonoy, Davao Del Sur, Philippines. AES Bioflux 7(3):475-482.
Kartika S. N., 2008 Your biodiversity in my backyard: key local stakeholders' perceptions of biodiversity conservation in Gorontalo, Indonesia. Ph.D. Thesis of Lincoln University.
Kusmana C., Onrizal, Sudarmadji, 2003 Types of mangrove tree in Bintuni Gulf, Papua (Indonesia). Faculty of Forestry Institu Pertanian Bogor-Coorporation of PT Bintuni Utama Murni Wood Industries, Bogor, 64 pp.
Kusmana C., 2015 Integrated sustainable mangrove forest management. Journal of Natural Resources and Environmental Management 5(1):1-6.
Mano D. H., 2016 Gorontalo becomes third conservation province in Indonesia [Indonesia]. http://www.antaragorontalo.com/berita/31516/gorontalo-jadi-provinsi-konservasi-ketiga-di-indonesia. Accessed on 30 October 2017.
Noor Y. R., Khazali M., Suryadiputra N. N., 2012 [A field guide of Indonesian mangrove]. 3rd Reprint. PHKA/WI-IP, Bogor. [In Indonesian].
Paino C., 2017 Gorontalo Sebagai Provinsi Konservasi, Apa yang Harus Dibenahi? http://www.mongabay.co.id/2017/02/17/gorontalo-sebagai-provinsi-konservasiapa-yang-harus-dibenahi/. Accessed on 30 October 2017.
Pielou E. C., 1966 The measurement of diversity in different types of biological collections. Journal of Theoretical Biology 13:131-144.
Shannon C. E., Wiener W., 1963 The mathematical theory of communication. Urban University Press, Illinois.
Simpson E. H., 1949 Measurement of diversity. Nature 163:688 doi:10.1038/163688a0.
Suk-ueng N., Buranapratheprat A., Gunbua V., Leadprathom N., 2013 Mangrove composition and structure at the Welu Estuary, Khlung District, Chanthaburi Province, Thailand. IOSR Journal of Environmental Science, Toxicology and Food Technology 7(5):17-24.
Vijayan V., Rahees N., Vidyasagaran K., 2015 Plant diversity and structural dynamics of mangroves in the southwest coast of Kerala, India. Applied Ecology and Environmental Research 13(4):1055-1067.
Winata A., Yuliana E., Rusdiyanto E., 2017 Diversity and natural regeneration of mangrove vegetation in the tracking area on Kemujan Island, Karimunjawa National Park, Indonesia. AES Bioflux 9(2):109-119.
*** BPS-Statistics of Gorontalo Utara Regency, 2016 North Gorontalo. The official website of the BPS-Statistics of Gorontalo Utara Regency. https://gorontaloutarakab.bps.go.id/ Accessed on 23 June 2017.
*** Department of Fisheries and Marine Gorontalo Province, 2016 Mangrove forest damage in Gorontalo is increasingly alarming (Indonesia). https://gorontaloprov.go.id/informasi/berita/prov-gorontalo/kerusakan-hutan-mangrove-di-gorontalo-yang-kian-mengkhawatirkan. Accessed on 26 August 20174.
*** IUCN, 2017 The IUCN red list of threatened species. Version 2017-2. http://www.iucnredlist.org. Accessed on 23 August to 14 September 2017.
*** Nantuforest.org. 2017 About Nantu. 2017. https://www.nantuforest.org/about-nantu. Accessed on 24 August 2017.
*** Wetland International. Mangrove. http://www.wetlands.or.id/mangrove/mangrove.php Accessed on 6 June to 10 September 2017.

Received: 02 October 2017. Accepted: 19 November 2017. Published online: 27 November 2017.
Authors:
Faizal Kasim, Gorontalo State University, Faculty of Fisheries and Marine Science, Department of Aquatic Resources Management, Indonesia, Gorontalo 96128, Kota Gorontalo, Kota Tengah, Dulalowo Timur, Jambura Campus, Jl. Sudirman No. 6, e-mail: faizalkasim@ung.ac.id
Sitti Nursinar, Gorontalo State University, Faculty of Fisheries and Marine Science, Department of Aquatic Resources Management, Indonesia, Gorontalo 96128, Kota Gorontalo, Kota Tengah, Dulalowo Timur, Jambura Campus, Jl. Sudirman No. 6, e-mail: imelbanu.sinar@gmail.com
Citra Panigoro, Gorontalo State University, Faculty of Fisheries and Marine Science, Department of Aquatic Resources Management, Indonesia, Gorontalo 96128, Kota Gorontalo, Kota Tengah, Dulalowo Timur, Jambura Campus, Jl. Sudirman No. 6, e-mail: citrapanigoro@ung.ac.id
Zulkifli Karim, Gorontalo State University, Faculty of Fisheries and Marine Science, Department of Aquatic Resources Management, Indonesia, Gorontalo 96128, Kota Gorontalo, Kota Tengah, Dulalowo Timur, Jambura Campus, Jl. Sudirman No. 6; Gorontalo Coastal Ecological and Spatial Mapping Studies Club (GCESM), Indonesia, Gorontalo, 96181, Telaga Jaya, Dulalowo, e-mail: zulkiflikarim23@gmail.com
Aldin Lamalango, Gorontalo State University, Faculty of Fisheries and Marine Science, Department of Aquatic Resources Management, Indonesia, Gorontalo 96128, Kota Gorontalo, Kota Tengah, Dulalowo Timur, Jambura Campus, Jl. Sudirman No. 6; Gorontalo Coastal Ecological and Spatial Mapping Studies Club (GCESM), Indonesia, Gorontalo, 96181, Telaga Jaya, Dulalowo, e-mail: aldin14lamalango@gmail.com

How to cite this article:
Kasim F., Nursinar S., Panigoro C., Karim Z., Lamalango A., 2017 True mangrove of North Gorontalo Regency, Indonesia, their list, status and habitat-structural complexity in easternmost coast area. AACL Bioflux 10(6):1445-1455.

True mangrove of North Gorontalo Regency, Indonesia, their list, status and habitat-structural complexity in easternmost coast area

ORIGINALITY REPORT

12%	9%	9%	6%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to STKIP Sumatera Barat Student Paper	1%
2	doaj.org Internet Source	1%
3	psasir.upm.edu.my Internet Source	1%
4	1library.net Internet Source	1%
5	A Ghofar, S Redjeki, H Madduppa, M Abbey, N Tasunar. "Inclusive blue swimming crab fishery management initiative in Betahwalang Demak, Indonesia", IOP Conference Series: Earth and Environmental Science, 2018 Publication	1%
6	ph01.tci-thaijo.org Internet Source	1%
7	dspace.library.uvic.ca Internet Source	1%

8	www.innspub.net Internet Source	1 %
9	www.agir-dolj.ro Internet Source	<1 %
10	krex.k-state.edu Internet Source	<1 %
11	A Nursafingi. "Participatory land-use planning for strengthening the village land resources management: a case study of Gorontalo, Indonesia", IOP Conference Series: Earth and Environmental Science, 2021 Publication	<1 %
12	dalspace.library.dal.ca Internet Source	<1 %
13	Loren B. Byrne. "Habitat structure: A fundamental concept and framework for urban soil ecology", Urban Ecosystems, 08/08/2007 Publication	<1 %
14	researcharchive.lincoln.ac.nz Internet Source	<1 %
15	repositorio.unifesp.br Internet Source	<1 %
16	MW Beck. "Comparison of the measurement and effects of habitat structure on gastropods	<1 %

	in rocky intertidal and mangrove habitats", Marine Ecology Progress Series, 1998 Publication	
17	bahankuliah-tha.blogspot.com Internet Source	<1 %
18	www.mdpi.com Internet Source	<1 %
19	www.britannica.com Internet Source	<1 %
20	www.frontiersin.org Internet Source	<1 %
21	hal.archives-ouvertes.fr Internet Source	<1 %
22	environmentclearance.nic.in Internet Source	<1 %
23	unesdoc.unesco.org Internet Source	<1 %
24	www.science.org Internet Source	<1 %
25	avianres.biomedcentral.com Internet Source	<1 %
26	mbox.thejakartapost.com Internet Source	<1 %

27	Nabeelah Bibi Sadeer, Mohamad Fawzi Mahomoodally. "Introduction to mangrove plants: protectors of the marine environment and an asset for human health", Elsevier BV, 2022 Publication	<1 %
28	repository.ub.ac.id Internet Source	<1 %
29	www.vub.ac.be Internet Source	<1 %
30	repository.um.edu.my Internet Source	<1 %
31	sdh.tnu.edu.vn Internet Source	<1 %

Exclude quotes	Off	Exclude matches	Off
Exclude bibliography	Off		