Population assessment of the endangered and valuable timber tree Torem (*Manilkara kanosiensis*) in Customary Forest of Lorulun, Yamdena Island, Indonesia

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Abstract. Torem (*Manilkara kanosiensis*) is a timber tree species endemic to Yamdena Island in Indonesia and the Bismarck Archipelago in Papua New Guinea. Due to its high-quality timber, the trees are harvested from its natural populations. These logging activities have put the species into the endangered category according to IUCN Red List since more than 20 years ago. In the present study, the population assessment of Torem will be conducted in the customary forest of Lorulun, Yamdena Island, Indonesia. Distance sampling using line-transect was used to assess the distribution of Torem, identify population size and structure, estimate population density, and update the conservation status of the species. The results showed Torem trees were mostly located at relatively flat areas (4.5±0.2°), with the elevation range of 81-134 m above sea level. A total of 228 individuals of Torem was located during the survey, with more than half of them (56.68%) were within 0-10 cm dbh class. The density estimate of the species was 14.8±4.4 individuals/ha. The assessment of conservation status against IUCN Red List Category and Criteria revealed that Torem was qualified for the status of Endangered A2cd, B2ab (i, ii, iv, v), C2a(i), D.

1. Introduction
Plant diversity is very vital for human survival and wellbeing. They provide many services, including supporting (base of food chains in nearly all ecosystems), provisioning (food, timber, medicines, fresh water, etc.), and regulating services (flood control, climate regulation, etc.). Despite their fundamental functions, plant diversity is rapidly declining worldwide [1]. Furthermore, Royal Botanic Garden (RBG) Kew [2] estimated one in five plant species are estimated to be threatened with extinction. In addition to habitat loss and degradation as the biggest threat, overexploitation of plant-based resources is the second most significant threat to plant species [3]. For timber trees, the threat comes from timber extraction through logging activities that have been affecting more than half of all remaining tropical forests [4]. The effect of this threat will be more severe for timber trees that have a restricted distribution range.

Torem (*Manilkara kanosiensis*) is a timber tree species from the Sapotaceae family. The species is endemic to Yamdena Island in Indonesia and the Bismarck Archipelago in Papua New Guinea [5]. Due to its high-quality timber, Torem trees are harvested from its natural populations. These logging activities have put the species into the Endangered category according to IUCN Red List since more than 20 years ago [6]. Population assessment is needed in order to get the most current information on
distribution, population size and structure, and quality of its habitat. It is necessary to update the conservation status of Torem. The only study conducted to assess the population of Torem was carried out by Boreel [7] in 2009, which showed that Torem still could be found at three locations in Yamdena Island with the density of 7-13 individuals/ha\(^1\). This study, however, covered only small parts of Yamdena Island. Thus further studies at the other locations in Yamdena Island and the Bismarck Archipelago are needed to know better the current status of the species across its natural distribution areas.

In the present study, the population assessment of Torem will be conducted in the customary forest of Lorulun, Yamdena Island, Indonesia. The aims are to assess the distribution of Torem, identify population size and structure, estimate population density, and update the conservation status of the species based on IUCN Red List Category and Criteria. The results of the present study will provide additional information on the status of the Torem population in Yamdena Island.

2. Materials and Methods

2.1. Study site and species

The study was conducted in the customary forest of Lorulun Village (7°46'27.6"S 131°20'29.8"E), Maluku Tenggara Barat District, Maluku Province on 15 April-2 May 2018. The forest is located in Yamdena Island (Figure 1), which is part of Tanimbar Archipelago and has an area of 411,481.21 ha. The climate of the island is classified as type C, according to Schmidt and Ferguson classification, or type A, according to Koppen classification. The respected highest and the lowest average temperature is 29°C and 26.5°C, whereas the highest and lowest precipitation is 564.3 mm\(^3\) and 5 mm\(^3\), respectively [8].

![Figure 1. Location of Lorulun Forest in Yamdena Island and five-line transects (red lines with number 1-5) that were placed in it.](image-url)
Torem (Manilkara kanosiensis H.J.Lan & B.Meeuse) belongs to the Sapotaceae family. It is a medium to large-sized tree mostly found in primary lowland forest with an elevation range of 0-500 m asl [9]. The timber is massive, with a density of about 1,030 kg m$^{-3}$ at 12% moisture content [10]. It is rated as durable in contact with the ground or weather [11]. People unsustainably harvested the tree and used the timber for construction, flooring, decking, turnery and carving [12]. Traditionally, timber has been part of the local community culture of totem production for a thousand years [13]. Also, the timber is found in international trade [6] and is reported to be exported to Japan [9]. According to the Ministry of Industry and Trade of the Republic of Indonesia Regulation No. 321/MPP/Kep/7/1999, the price of its wood is IDR 265,000 m$^{-3}$. The price for export, however, reaches up to IDR 7 million m$^{-3}$ [14]. Due to this massive harvesting activity, the species is classified as Endangered according to IUCN Red List [6].

2.2. Population survey

Distance sampling using line-transect was used to assess the distribution and population of Torem. A total of five line transects were placed within the customary forest (Figure 1). Using a GPS receiver, the starting point of each line transect was located, and the length of each line transect was measured. The project team walked each line transect, searching for the individual of Torem on either side of the transect line. For each individual detected, perpendicular distances were measured from the transect line to each individual and diameter at breast height (dbh) as well as environmental data (elevation, slope and aspect) were collected. For seedling, the diameter was measured around 10 cm above the ground.

2.3. Data analysis

The extent of occurrence (EOO) and Area of occupancy (AOO) of Torem were estimated from the presence points of Torem using the GeoCAT website (http://geocat.kew.org). IUCN [15] defined EOO as "the area contained within the shortest continuous imaginary boundary which can be drawn to encompass all the known, inferred or projected sites of present occurrence of a taxon, excluding cases of vagrancy." For AOO, it was defined as "the area within its 'extent of occurrence' which is occupied by a taxon, and excluding cases of vagrancy."

Distance data were analyzed using the software program Distance 6.0 to estimate the density of Torem. Through a graphical interface in the program, users are allowed to enter, import, view and analysis the data [16]. Detailed procedures of the analysis using Distance 6.0 was provided by Thomas et al. [17]. In the present study, the analysis was performed using the Conventional Distance Sampling engine and was run based on the assumption that all objects at zero distance were detected. The engine modeled detection probability as a function of distance from line transect [17].

All gathered data were used to assess the conservation status of the species using the IUCN Red List Criteria and Category [18]. There are five quantitative criteria (A-E) that were used in the assessment. Those are (a) Declining population, (b) Geographic range size, and fragmentation, decline or fluctuations, (c) Small population size and fragmentation, decline, or fluctuations (d) Tiny population or very restricted distribution, and (e) Quantitative analysis of extinction risk. Based on this assessment, the species was then assigned into one of the following eight categories: Data Deficient (DD), Least Concern (LC), Near Threatened (NT), Vulnerable (VU), Endangered (EN), Critically Endangered (CR), Extinct in The Wild (EW), and Extinct (Ex).

3. Results and Discussion

3.1. Species distribution

The distribution of Torem in the customary forest of Lorulun Village was assessed using five line transect with a total length of 9.515 km (Figure 1). The species was found at three (transect 1, 2 and 4) of five-line transects placed in the study area. The trees were mostly located at relatively flat areas (4.5±0.2°), with the elevation range of 81-134 m above sea level (asl). As the areas were flat, Torem was observed to have no preference in terms of the aspect. Locations of Torem in the present study
had higher elevation compared with the previous study by Boreel [7] that located torem trees at an
elevation range of 51-64 m asl.

Based on GPS points of Torem trees located by the present study, GeoCAT estimated that the EOO
and AOO of the species were 3.976 km$^2$ and 24 km$^2$, respectively (Figure 2). If all of the locations of
the species from the present study and study by Boreel [7] in 2009 were combined, the respected EOO
and AOO of the species in Yamdena Island were 103.2 km$^2$ and 36 km$^2$, respectively. Furthermore,
the AOO would become 60 km$^2$ if records of the species in Papua New Guinea from Global
Biodiversity Information Facility (https://www.gbif.org) were included in the calculation. For this
case, however, the EOO was not applicable as it covered a vast area of ocean.

![Figure 2. Calculation of Extent of Occurrence (EOO) and Area of Occupancy (AOO) of Torem (Manilkara kanosiensis) using GeoCAT (http://geocat.kew.org).](image)

3.2. Population status and density estimate

A total of 228 individuals of Torem was located during the survey, with more than half of them
(54.8%) were within 0-2 cm dbh class (Figure 3). The number of mature individuals was c. 91
individuals, which was estimated from individuals with dbh more than 30 cm. It seems that the young
individuals of Torem had a deficient ability to grow and become mature individuals, as indicated by an
extreme reduction in the number of individuals from 0-2 cm to the higher dbh classes. This pattern of
poor regeneration was also observed by [19] when they studied the seasonal forests in the Tanimbar
Archipelago. The underlying mechanism of this high seedling death rates might correlate to several
factors, including seedling size [20], recent seedling growth [21 - 23], seedling photosynthetic capacity
[24], seed mass [25], light availability [26, 27], microclimate [28], soil moisture [29 - 31], herbivory
[32], vegetation cover [33] and distance to mature trees [34]. A further detailed study is needed to
confirm which factor is responsible for the high seedling mortality of Torem.
Figure 3. Population structure of Torem (*Manilkara kanosiensis*) in Yamdena Island based on diameter classes.

The density estimate of the species, as calculated by Distance software, was 14.8±4.4 individuals/ha. This density estimate was higher compared to the density of 10.3±1.7 individuals/ha obtained by [7]. Lower density attained by Boreel was reasonable as his study only measured individual trees with a diameter greater than or equal to 10 cm.

3.3. Conservation status and implications

All the results from the present study combined with the study of [7] and the presence records of Torem in Papua New Guinea were used to assess the conservation status of the species against all the IUCN Red List Category and Criteria. The assessment result showed Torem was qualified for the status of Endangered A2cd, B2ab (i, ii, iv, v), C2a(i), D. Although the category of Endangered is still the same with the current status (Endangered A1cd+2cd, C2a), the criteria being used were slightly different. The criterion of A1 was not used anymore in the present study as the cause of the population reduction may not have ceased. Instead, the A2 criterion was used based on a suspected decline in AOO (sub-criterion c) and a potential level of exploitation (sub-criterion d). Furthermore, additional criteria of B2 (geographic range in the form of AOO) and D (tiny population) were included since information on AOO, and population size was available.

As the threats from logging activities and habitat conversion are still continuing, comprehensive conservation actions are required in order to protect Torem from further population size decline. Thus, the following actions were recommended to be implemented for the in-situ conservation of Torem. Those were i) increasing the protection level of the forest through periodic patrol of the staff of Forestry Agency, ii) increasing local communities awareness regarding the conservation status of Torem, and iii) disseminating information of Torem to the broader public and stakeholders through online media. In addition to in-situ approaches, several ex-situ conservation actions could also be used for the conservation of Torem. These include planting the species in Botanic gardens and arboretums and storing the seeds of the species at seed bank facilities. These plant materials might be used for display and education purposes, and natural population enrichment through reintroduction programs.

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