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Mangroves of the Western Coral Triangle VU

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Abstract

The 'Mangroves of the Western Coral Triangle' is a regional ecosystem subgroup (level 4 unit of the IUCN Global Ecosystem Typology. It includes intertidal forests and shrublands of the following marine ecoregions in the Western Coral Triangle province: Banda Sea, Eastern Philippines, Halmahera, Lesser Sunda, Northeast Sulawesi, Palawan/North Borneo, Papua, and Sulawesi Sea/Makassar Strait. The diverse biota of this province includes 48 species of true mangroves, plus many mangrove-associated taxa. Mangroves had a mapped extent of 19,821 km^2 in 2020, representing 13.4% of the global mangrove resource by area.

Although only 4.7 % of the province's mangroves occur on carbonate sediments, they include fragile patches of vegetation on many of the thousands of islands in the Western Coral Triangle, Mangroves are threatened by illegal logging, conversion for agriculture or aquaculture, and industrial, urban and tourism development, including coastal land reclamation and mining. They are also threatened by climate change, especially sea-level rise, and by increasingly frequent typhoons and tropical storms.

Today the Western Coral Triangle mangroves cover ≈32% less than our estimate for 1970 based on national studies. The rate of loss declined to -6.6% from 1996 to 2020 and has slowed further since 2015. The Western Coral Triangle mangroves are estimated to decrease by -18% over the next 50 years. They are also threatened by future sea-level rise (SLR). Under a mid-high to extreme SLR scenario, more than 30% of the mangroves would be submerged by 2070. Moreover, we estimate that 4% of the mangroves are undergoing degradation and this could rise to 10.7% over a 50-year period based on analysis of the decay of vegetation indexes. These estimates are very conservative; however, no other data sources were available to measure environmental degradation at the province level.

Overall, the Western Coral Triangle mangrove ecosystem is assessed as **Vulnerable (VU).**

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Keywords:

Mangroves; IUCN Red List of ecosystems; ecosystem collapse; threats; Vulnerable.

Ecosystem classification:

MFT1.2 Intertidal forests and shrublands

Assessment's distribution:

The Western Coral Triangle province

Summary of the assessment:

Criterion	A	B	C	D	E	Overall
Subcriterion 1	VU	LC	DD	DD	NE	
Subcriterion 2	LC	LC	VU	LC	NE	VU
Subcriterion 3	DD	LC	DD	DD	NE	

CR: Critically Endangered, EN: Endangered, VU: Vulnerable, NT: NearThreatened, LC: Least Concern, DD Data Deficient, NE: Not Evaluated

Mangroves of the Western Coral Triangle VU

1. Ecosystem Classification

IUCN Global Ecosystem Typology (version 2.1, Keith *et al.* 2022):

Transitional Marine-Freshwater-Terrestrial realm

MFT1 Brackish tidal biome

MFT1.2 Intertidal forests and shrublands

MFT1.2_4_MP_30 Mangroves of the Western Coral Triangle

IUCN Habitats Classification Scheme (version 3.1, IUCN 2012):

1 Forest

1.7 Forest – Subtropical/tropical mangrove vegetation above high tide level

12 Marine Intertidal

12.7 Mangrove Submerged Roots

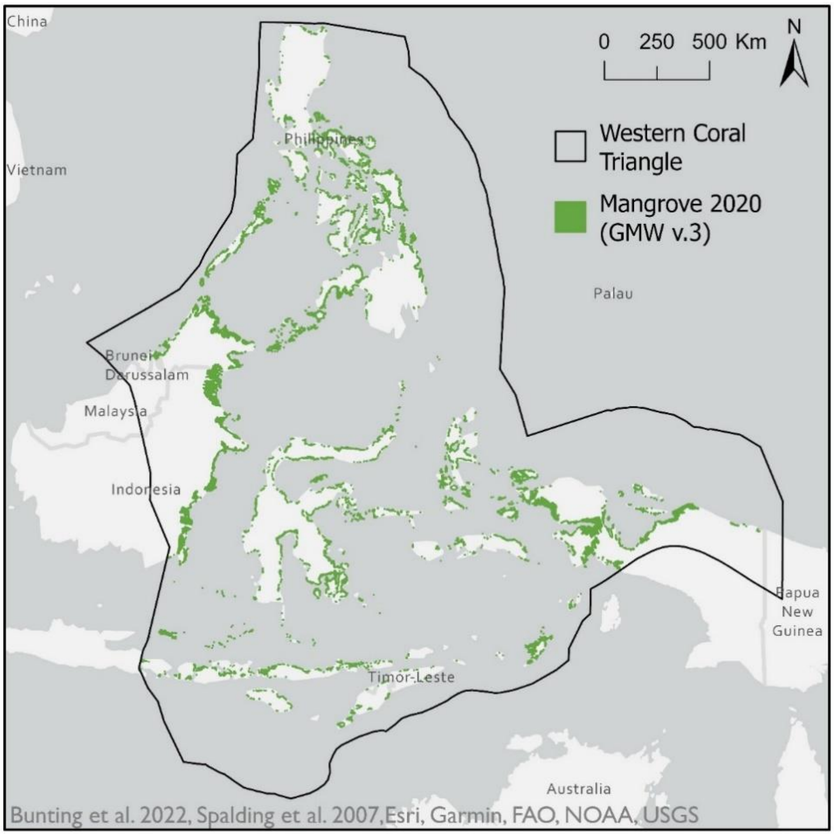
Mangroves dominated by Sonneratia alba growing on carbonate sediment on an open coast island location in Biak Regency, Papua Province, Indonesia, and typical of many *mangrove formations in the Western Coral Triangle (Photo credit: I Wayan Eka Dharmawan).*

Pristine mixed mangrove forest behind a seagrass and coral reef zone (on far left) on Wetar Island in the Moluccas, Indonesia (Photo credit: I Wayan Eka Dharmawan).

2. Ecosystem Description

Spatial distribution

The 'Mangroves of the Western Coral Triangle' includes intertidal forests and shrublands across several marine ecoregions of the Western Coral Triangle province: Banda Sea, Eastern Philippines, Halmahera, Lesser Sunda, Northeast Sulawesi, Palawan/North Borneo, Papua, and the Sulawesi Sea/Makassar Strait (Spalding *et al.*, 2007). The mangrove extent in the Western Coral Triangle province was estimated to be 19,821 km^2 in 2020 and the estimated net loss from 1996 to 2020 was -6.6 % (from Bunting *et al.*, 2022). The mangroves of



this province contribute 18.4% of the global mangrove resource by area.

Biotic components of the ecosystem (Characteristic native biota)

The diverse biota of 'Mangroves of the Western Coral Triangle' is characterised by the presence of 48 true mangroves plus other mangrove-associated plant species (IUCN, 2022). There are three mangrove tree species in the IUCN Red List of Threatened Species database (IUCN, 2022): *Avicennia rumphiana* (Vulnerable, VU), *Bruguiera hainesii* (Critically Endangered, CR) and *Camptostemon philippinensis* (Endangered, EN). There are at least 237 animal species in the taxa Actinopterygii, Amphibia, Aves, Chondrichthyes, Gastropoda, Insecta, Mammalia and Reptilia that have been associated with mangrove habitats in the IUCN Red List of Threatened Species database (IUCN, 2022) and have natural history collection records or observations within the distribution of this province (GBIF, 2021). These include seven species that are Critically Endangered, 26 Endangered species and 27 Vulnerable species. There are two iconic but Endangered animals unique to this province: the proboscis monkey (*Nasalis larvatus*) and the Komodo dragon (*Varanus komodoensis*). Other threatened mangrove-associated mammal species include several langurs, macaques, tarsiers, and otters. Two bird species are Endangered: the milky stork (*Mycteria cinerea*) and Tawi-tawi brown dove (*Phapitreron cinereiceps*). Among the mangrove-associated fish fauna there are several threatened species of rays and sawfishes. Although not included in the IUCN Red List of Threated Species database as a mangrove-associated species, the most threatened crocodile in the world, *Crocodylus mindorensis* (status Critically Endangered, CR), has been reported from mangrove areas in northern Luzon and Palawan (Philippines).

The proboscis monkey is endemic to the island of Borneo and within the Western Coral Triangle (WCT) province this unique and aquatic species is present in Brunei, Sabah (East Malaysia) and eastern Kalimantan (Indonesia). However, its mangrove, riverine and swamp habitat is rapidly being destroyed or fragmented and less than 10% of the remaining population is estimated to live within protected areas (Wardatutthoyyibah *et al.*, 2019).

The Komodo dragon is endemic to southeast Indonesia and is now present on only five islands within the Lesser Sunda islands chain (Komodo, Flores, Rinca, Gili Dasami and Gili Motang), where it occupies mainly coastal habitats including mangroves. The global population is only about 3,500 individuals, with around 70% of them having some protection within the Komodo National Park. However, the Komodo dragon is threatened by habitat loss, human disturbance, poaching and climate change (rising temperatures and sea-level rise). In 2021 IUCN elevated the threatened status of this species from Vulnerable (VU) to Endangered (EN). The flat-headed cat (*Prioilurus planiceps*) is also Endangered (EN) and the only recent sightings have been in Sabah, Kalimantan and Riau Province in eastern Sumatra. This rare cat species is semi-aquatic and is believed to feed on fish, frogs and crabs.

Abiotic components of the ecosystem

Regional mangrove distributions are influenced by interactions among landscape position, rainfall, hydrology, sea-level, sediment dynamics, shore subsidence and storm-driven processes. As in other provinces, rainfall and freshwater, and sediment supply from rivers and tidal currents, promote mangrove establishment and persistence, while waves and strong tidal currents destabilise and erode mangrove substrata, thereby mediating local-scale dynamics in ecosystem distributions. High rainfall reduces salinity stress and increases nutrient loading from adjacent catchments, while tidal flushing also regulates salinity.

The physical environment of the Western Coral Triangle province is characterised by thousands of large to small islands, especially in the Philippines and eastern Indonesia. There are many open-coast mangrove formations fringing island coastlines and lagoons. These include scattered and fragile open coast and lagoonal mangroves growing on carbonate or mixed sediments in association with sea grass beds and coral reefs. There are also extensive deltaic and estuarine mangroves where large rivers have deposited fine alluvial sediments of terrigenous origin, as in East Kalimantan (e.g. Mahakham Delta), Sabah (e.g. Kinabatangan River), the Philippines (e.g. Mindanao River) and the Papua region (e.g. Weriaga River).

There is significant climatic variability within the Western Coral Triangle province that has a major influence on mangrove community structure. Dwarf mangroves, indicative of trees exposed to physiological stress, are common in the eastern Lesser Sunda Islands, a region characterised by low annual rainfall; while the Philippines experiences about 20 typhoons each year, which can have a devastating impact on mangrove vegetation and the supporting sediment, as well as on mangrove-associated faunal communities (Salmo, 2021). In contrast, high rainfall, and a low degree of disturbance from typhoons, is thought to account for the biologically diverse mangrove forests in the Papua region of Indonesia, where the trees are 20-30 m (and even 35 m) in height.

Dwarf mangroves indicating physiological stress due to adverse hydro-edaphic conditions in the dry climate of the eastern Lesser Sunda Islands, Indonesia (Photo credit: Frida Sidik).

Key processes and interactions

Mangroves are structural engineers and they possess traits including pneumatophores, salt excretion glands, vivipary, and propagule buoyancy that promote survival and recruitment in poorly aerated, saline, mobile, and tidally inundated substrata. They are also highly efficient in nitrogen use and nutrient resorption. Mangroves produce large amounts of detritus e.g., leaves, twigs, and fruits, which are either exported in coastal waters, buried in waterlogged sediments, or consumed by crabs, then decomposed further by fungi and bacteria, thereby mobilising carbon and nutrients to higher trophic levels.

Crabs are among the most abundant and important invertebrates. Their burrows oxygenate sediments, enhance groundwater penetration, and provide habitat for other invertebrates such as molluscs and worms. Specialised roots (pneumatophores) provide a complex habitat structure that protects juvenile fish from predators during high tides and serves as hard substratum for the attachment of algae as well as sessile invertebrates (e.g., oysters, mussels, barnacles). Mangrove canopies support invertebrate herbivores and other terrestrial biota, including reptiles, small mammals, and extensive bird communities.

Mangrove ecosystems are also major blue carbon sinks, incorporating organic matter into living biomass and sediments. Carbon storage by undisturbed mangroves can therefore make a significant contribution to climate change mitigation. Conversely, mangrove degradation or conversion to other land uses can release large quantities of carbon. A value of 370 ± 51 Mg C ha^{-1} was recorded for the above-ground biomass in mature and strictly protected *Rhizophora*-dominated forest in Banacon Island, Philippines (Camacho *et al.*, 2011, Gevaña *et al.*, 2018). Similarly, the highest average biomass carbon value reported for Indonesia was 367 ± 80 Mg C ha^{-1} in undisturbed mangroves in West Papua (Murdiyarso *et al.*, 2015).

Rhizophora mangroves growing on a coral reef flat in West Bali National Park, Indonesia (Photo credit: Frida Sidik).

Including soil carbon, which can contribute more than 90% of the ecosystem carbon (total) stored in mangrove forests, the estimated average total ecosystem carbon stock in West Papua mangroves was 1,397 Mg C ha^{-1}, with a maximum of 2,730 Mg C ha^{-1} (Murdiyarso *et al.*, 2015). In contrast, the average ecosystem mangrove carbon in 37 disturbed sites studied in the Philippines was only 400 Mg C ha^{-1}, with a very wide range from 57.7 to 1,746.6 Mg C ha^{-1}, due to significant differences site to site in the degree of disturbance caused by typhoon damage or conversion to aquaculture ponds (Salmo and Gianan, 2019).

A notable feature of the Western Coral Triangle province is the close physical and biological association between mangroves, sea grass beds and coral reefs, particularly in the Philippines and eastern islands of Indonesia (Salmo and Altomonte 2020). Many animal species, including commercially important fish and shellfish species (e.g., some snappers and penaeid prawns), move between these habitats during different stages of their life cycles. A study in the Philippines by Honda *et al.*, (2013) found that more than 20% of commercial fish species use these multiple habitats, while Mumby *et al.*, (2008) showed that coral reefs adjacent to mangroves support a much higher biomass of fish than do isolated reefs.

3. Ecosystem Threats and Vulnerabilities

Main threatening process and pathways to degradation

Mangrove ecosystems in the Western Coral Triangle face multiple threats from illegal logging, conversion for agriculture, aquaculture, or for industrial, urban and associated coastal development, including coastal land reclamation, mining and exposure to pollution from these and other coastal land use practices. The position of mangrove forests in intertidal areas also renders them vulnerable to sea-level rise caused by climate change. Typhoons and tropical storms can damage mangrove forests through direct defoliation and destruction of trees, as well as through sediment displacement, and/or mass mortality of mangrove-associated animal communities. Compared to other coastal ecosystems, however, mangroves are often less vulnerable to sea-level rise provided that sediment flows are sufficient for mangrove development to keep pace with sea-level rise (Schuerch *et al.*, 2018).

The main threats to mangroves differ greatly in nature and scale across the Western Coral Triangle province, being greatest in Sabah, East Kalimantan (conversion to agriculture, especially oil palm plantations) and the Philippines (conversion to aquaculture ponds, coastal land reclamation and development infrastructure, typhoons), whereas there are still large areas of tall primary mangroves in the Papua region (West Papua and Papua provinces) and on Palawan Island (Philippines). However, urban expansion, encroachment, and other human disturbance, even into protected mangrove habitats, are a widespread and increasing threat in this province. The open coast and lagoonal mangroves fringing many of the smaller islands are particularly susceptible to degradation by human interference, leading to loss of ecological connectivity, because they exist as small and scattered formations. Island-fringing mangroves on carbonate sediments may also be more susceptible to hydro-edaphic stress and climate change: for example, from sediment scouring by tides and storms. On a global scale, from 1996 to 2016 the loss of open coast and lagoonal mangroves on carbonate sediments was more than double that of mangroves on terrigenous sediments (Worthington *et al.*, 2020).

Mangrove degradation often begins with over-harvesting of wood and aquatic products, followed by encroachment and pollution from nearby urban, industrial or other coastal development activities. Coastal land conversion, coastal infrastructure projects (e.g. ports, harbours, sea dykes, road construction) and mining activities can also degrade adjacent mangroves indirectly by disrupting the hydrological regime and sediment supply needed to support their basic ecological functions.

Loss of sediment around mangroves due to coastal dredging for land reclamation in Manila Bay, Philippines. (Photo credit: Dixon Gevaña).

Mangroves showing little or no recovery almost 10 years after severe damage by Super Typhoon Haiyan (2013) in Lawaan Municipality, Samar, central Philippines (Photo credit: Severino G. Salmo III).

Mangrove forest destroyed during coastal road construction in Marinduque Province, Philippines (Photo credit: Dixon Gevaña).

Solid waste accumulation leading to fire damage in a coastal mangrove forest in Navotas City, Manila Bay, Philippines (Photo credit: Dixon Gevaña).

Large-scale conversion of mangroves to aquaculture ponds in Liagu, Bulungan Regency, North Kalimantan (Photo credit: Frida Sidik).

Definition of the Collapsed State of the Ecosystem

Mangroves are highly dynamic plant communities, with species distributions adjusting to local changes in tidal regimes and inundation, salinity gradients or sedimentation processes. Changes that disrupt this dynamic can impact on key mangrove ecological functions. Thus, ecosystem collapse may occur under any of the following: a) changes in climatic conditions that restrict recruitment and survival of diagnostic true mangroves; b) changes in river and other freshwater inputs and/or waves and tidal currents that destabilise and erode sediments/soils and disrupt mangrove recruitment and growth; c) changes in salinity, or pollution, leading to stress on mangroves. Ecosystem collapse is considered to occur when the tree cover of diagnostic species of true mangroves declines to zero (100% loss).

An aquaculture pond abandoned for more than 20 years and still largely devoid of mangrove recolonization, Prieto Diaz, Sorsogon Province, Philippines (Photo credit: Severino Salmo III).

Threat Classification

IUCN Threat Classification (version 3.3, IUCN 2022)) relevant to mangroves of the Western Coral Triangle:

- 1 Residential & Commercial Development
  - 1.1 Housing & Urban Areas
  - 1.2 Commercial & Industrial Areas
  - 1.3 Tourism & Recreation Areas
- 2 Agriculture & Aquaculture
  - 2.4 Marine & Freshwater Aquaculture
    - 2.4.1 Subsistence/Artisanal Aquaculture
    - 2.4.2 Industrial Aquaculture
- 4 Transportation & Service Corridors
  - 4.1 Roads & Railroads
- 5 Biological Resource Use
  - 5.1 Hunting & Collecting Terrestrial Animals
  - 5.3 Logging & Wood Harvesting
  - 5.4 Fishing & Harvesting Aquatic Resources
- 7 Natural System modifications
  - 7.2 Dams & Water Management/Use
- 8 Invasive & Other Problematic Species, Genes & Diseases
  - 8.1 Invasive Non-Native/Alien Species/Diseases
- 9 Pollution
  - 9.1 Domestic & Urban Wastewater
    - 9.1.1 Sewage
    - 9.1.2 Run-off
  - 9.2 Industrial & Military Effluents
    - 9.2.1 Oil Spills
    - 9.2.2 Seepage from Mining
  - 9.3 Agricultural & Forestry Effluents
    - 9.3.1 Nutrient Loads
    - 9.3.2 Soil Erosion, Sedimentation
  - 9.4 Garbage & Solid Waste
- 10 Geological events
  - 10.1 Volcanoes
  - 10.2 Earthquakes/Tsunamis
- 11 Climate change & severe weather
  - 11.1 Habitat Shifting & Alteration
  - 11.4 Storms & Flooding
  - 11.5 other (Sea-level rise)

4. Ecosystem Assessment

Criterion A: Reduction in Geographic Distribution

Subcriterion A1 measures the trend in ecosystem extent during the last 50-year time period: Unfortunately, there is currently no common regional dataset that provides information for the entire target area in 1970. However, country-level estimates of mangrove extent can be used to extrapolate the trend between 1970 and 2020. Accordingly, we compiled reliable published sources (see appendix 3) that contain information on mangrove area estimates close to 1970 (both before and after) for each country within the province. These estimates were then used to interpolate the mangrove area in 1970 in each country. By summing these estimates, we calculated the total mangrove area in the province. We only considered the percentage of each country's total mangrove area located within the province and the estimated figures for 1970 should be considered only indicative (see appendix 3 for further details of the methods and limitations).

In contrast, to estimate the Western Coral Triangle mangrove area from 1996 to 2020, we used the Global Mangrove Watch Version 3 (GMW v3.0) spatial dataset. The mangrove area in the province (and in the countries within) was corrected for both omission and commission errors, utilizing the equations in Bunting *et al.* (2022).

The Western Coral Triangle	2020*	1970*	Net area Change (Km^2)	% Net Area Change	Rate of change (%/year)
	19,820	29,181	-9,366	-32%	-0.64%

** Details on the methods and references used to estimate the mangrove area in 1970 are listed in appendix 3. Total mangrove area in 2020 is based on the Global Mangrove Watch Version 3 (GMW v3.0) dataset.*

Results from the analysis of subcriterion A1 (Annex 3) show that the Western Coral Triangle has lost approximately 32 % of its mangrove area over the past 50 years (1970-2020). This net change in area is due to the high rate of mangroves loss in Indonesia (0.73%/year), which accounts for 70% of the Western Coral Triangle province mangroves. All countries in this province have lost over 30% of their mangrove areas in the last 50 years, except the Philippines, which has experienced a minimal net loss of about 1%. However, more than 40% of the original mangrove area in the Philippines was lost prior to 1970, with the major cause being mangrove conversion to aquaculture ponds (Primavera, 2000). Given that the change in geographical distribution since 1970 is above the 30% risk threshold, but below 50%, the Western Coral Triangle mangrove ecosystem is assessed as **Vulnerable (VU)** under subcriterion A1.

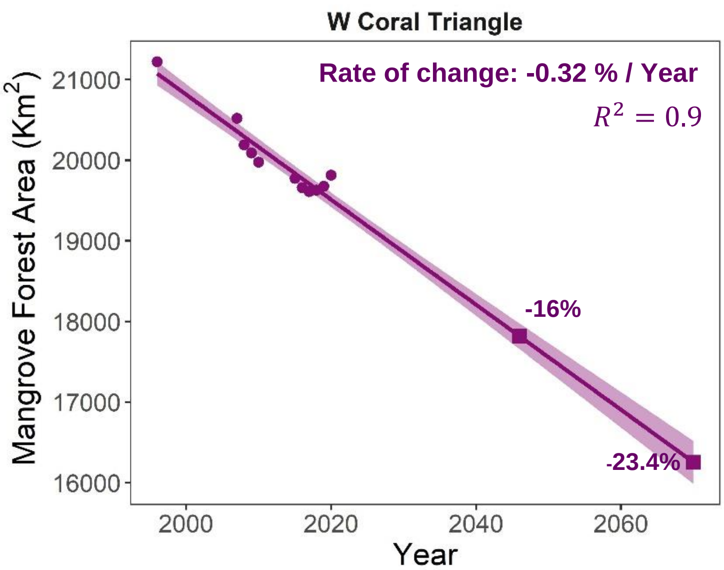


Figure 1. Western Coral Triangle province mangrove extent decline projected to 2070. Circles represent the province mangrove area between 1996 and 2009. Area estimates are based on GMW v3.0 dataset and equations in Bunting *et al.* (2022). The solid line and shaded area are the linear regression and 95% confidence intervals. Squares show the Western Coral Triangle province predicted mangrove area for 2046 and 2070.

Subcriterion A2 assesses the change in mangrove ecosystem extent in any 50-year period, including from the present to the future: The Western Coral Triangle province mangroves showed a net area loss of ≈ 6.6% (1996-2020) based on the GMW v3.0 dataset (Bunting *et al.*, 2022). This value reflects the offset between areas gained (0.07%/year) and lost (0.35%/year). The largest decline in mangrove area occurred between 1996 and 2015, but since then there has been a deceleration in net area loss. Applying a linear regression to the area estimations between 1996 and 2020 we obtained a rate of change of -0.3 % per year (figure 1). Assuming this trend continues in the future, it is predicted that the extent of mangroves in the Western Coral Triangle province will decrease by -16% from 1996 to 2046; by -23.4% from 1996 to 2070; but only by 18.0% from 2020 to 2070. Given that these predicted changes in mangrove extent are less than the 30% risk threshold, the Western Coral Triangle mangrove ecosystem is assessed as **Least Concern (LC)** under subcriteria A2a and A2b.

Subcriterion A3 measures change in mangrove area since 1750. Unfortunately, there are no reliable data on the mangrove extent for the entire province during this period, and therefore the Western Coral Triangle mangrove ecosystem is considered **Data Deficient (DD)** for this subcriterion.

Overall, the ecosystem is assessed as **Vulnerable (VU)** under criterion A.

Criterion B: Restricted Geographic Distribution

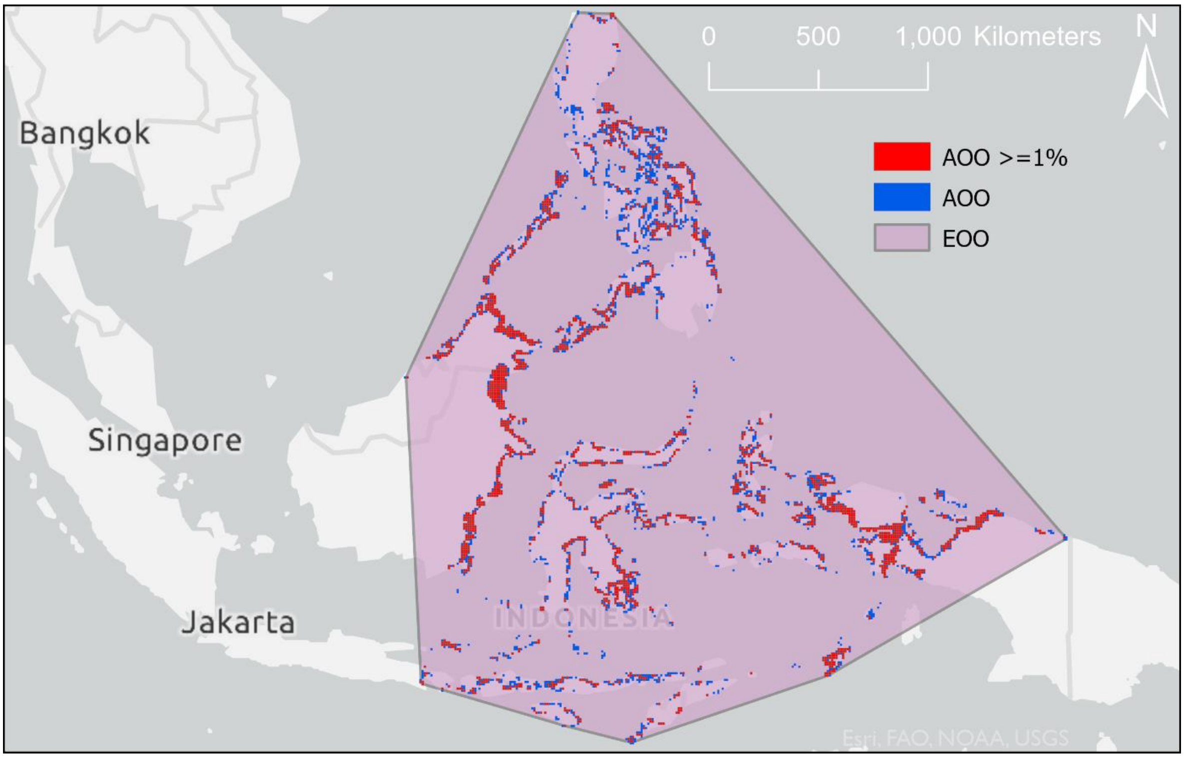


Figure 2. 2020 Western Coral triangle mangrove Extent Of Occurrence (EOO) and Area Of Occupancy (AOO). Estimates based on 2020 GMW v3.0 spatial layer (Bunting *et al.*, 2022). The red 10 x 10 km grids are covered in more than 1% by the ecosystem, and the blue grids <1%.

Criterion B measures the risk of ecosystem collapse associated with restricted geographic distribution, based on standard metrics (Extent of Occurrence EOO, Area of Occupancy AOO, and Threat-defined locations).

Province	Extent of Occurrence EOO (Km^2)	Area of Occupancy (AOO)	Criterion B
Western Coral Triangle	5,748,374	2,426	LC

For 2020 the Western Coral Triangle province AOO and EOO were measured as 2,426 grid cells 10 x 10 km and 5,748,374 km^2 respectively (figure 2), based on the GMW v3.0 dataset. Considering the very high number of threat-defined locations, there is no evidence of plausible catastrophic threats leading to potential disappearance of mangroves across their extent.

As a result, the Western Coral Triangle mangrove ecosystem is assessed as **Least Concern (LC)** under criterion B.

Criterion C: Environmental Degradation

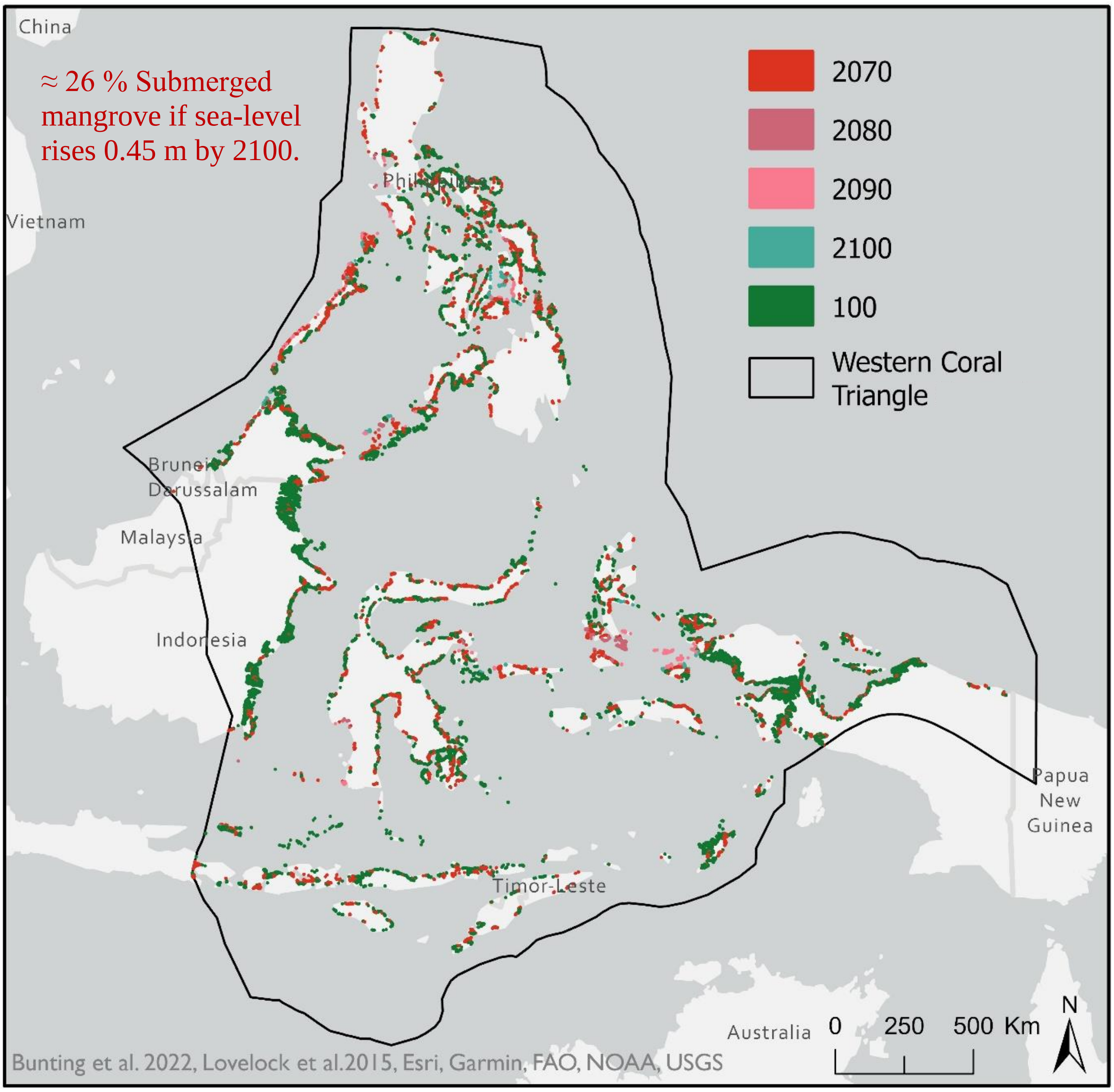


Figure 3. Western Coral Triangle mangrove forest predicted decade of submerge under IPCC RCP 6 scenario (0.45 m Global SLR by 2100), based on the model of Lovelock *et al.*, (2015). Mangrove extent based on 2020 GMW v3.0 spatial layer (Bunting *et al.*, 2022).

Criterion C measures the environmental degradation of abiotic variables necessary to support the ecosystem.

Subcriterion C1 measures environmental degradation over the past 50 years: There are no reliable data to evaluate this subcriterion for the entire province, and therefore the Western Coral triangle mangrove ecosystem is considered to be **Data Deficient (DD)** for subcriterion C1.

Subcriterion C2 measures environmental degradation in the future, or over any 50-year period, including from the present: A model on the impact of sea-level rise (SLR) accounting for sediment supply and its effects on coastal submersion (Lovelock *et al.*, 2015) was applied to the Western Coral Triangle mangrove province (2020 spatial layer GMW v3.0 dataset), to estimate the percentage of mangrove area that would be submerged over the next 50 years. The model assumes homogenous SLR across the province and does not account for mangrove landward migration.

Using this model and considering a plausible mid-high SLR scenario (IPCC RCP6, 0.45 m SLR by 2100), ≈26% of the Western Coral Triangle mangrove forest ecosystem would be submerged by 2070 (Figure 3). Under a more extreme SLR scenario (1.4 m SLR by 2100), the area projected to be submerged by 2070 is above the 30% extent, but below the 50% extent of decline threshold. We considered that no mangrove recruitment can occur in a submerged system (100% relative severity). Therefore, using the precautionary principle, the Western Coral Triangle's mangrove ecosystem is evaluated as **Vulnerable (VU)** under subcriterion C2.

Subcriterion C3 measures change in abiotic variables since 1750: There is a lack of reliable historic data covering the entire province, and therefore the Western Coral Triangle province is classified as **Data Deficient (DD)** for this subcriterion.

Overall, the Western Coral Triangle mangrove ecosystem is assessed as **Vulnerable (VU)** under criterion C.

Criterion D: Disruption of Biotic Processes or Interactions

The global mangrove degradation map developed by Worthington and Spalding (2018) was used to assess biotic degradation in the Western Coral Triangle province. This map is based on degradation metrics calculated from vegetation indices (NDVI, EVI, SAVI, NDMI) using Landsat times series between ≈2000 and 2017. These indices represent vegetation greenness and moisture condition.

Mangrove degradation was calculated at the pixel scale (30 m resolution), on areas intersecting with the 2017 mangrove extent map (GMW v2). Mangrove pixels were classified as degraded if two conditions were met: 1) at least 10 out of 12 degradation indices showed a decrease of more than 40% compared to the previous period, and 2) all twelve indices did not recover to within 20% of their pre-2000 value (detailed methods and data are available at: maps.oceanwealth.org/mangrove-restoration/). The decay in vegetation indices has been used to identify mangrove degradation and abrupt changes, including mangrove die-back events, clear-cutting, fire damage, and logging; as well as to track mangrove regeneration (Lovelock *et al.*, 2017; Santana *et al.*, 2018; Murray *et al.*, 2020; Aljahdali *et al.*, 2021; Lee *et al.*, 2021). However, it is important to consider that changes observed in the vegetation indices can also be influenced by data artifacts (Akbar *et al.*, 2020). Therefore, a relative severity level of more than 50% but less than 80% was assumed.

The results from this analysis show that over a period of 17 years (~2000 - 2017), 3.6% of the Western Coral Triangle mangrove area has degraded, resulting in an average annual rate of degradation of 0.21%. Assuming this trend remains constant, +11% of the W. Coral Triangle's mangrove area will be classified as degraded in a 50-year period. Since less than 50% of the ecosystem will meet the category thresholds for criterion D, the ecosystem is assessed as **Least Concern (LC)** under subcriterion D2b.

No data were found to assess the disruption of biotic processes and degradation over the past 50 years (subcriterion D1) or since 1750 (subcriterion D3). Thus, both subcriteria are classified as **Data Deficient (DD).**

Overall, the Western Coral Triangle ecosystem remains **Least Concern (LC)** under criterion D.

Criterion E: Quantitative Risk

No model was used to quantitatively assess the risk of collapse for this ecosystem; hence criterion E was **Not Evaluated (NE).**

5. Summary of the Assessment

CRITERION			
A. Reduction in Geographic Distribution	**A1** Past 50 years	**A2** Future or Any 50y period	**A3** Historical (1750)
	VU	**LC**	**DD**
B. Restricted Geo. Distribution	**B1** Extent of Occurrence	**B2** Area of Occupancy	**B3** # Threat-defined Locations < 5?
	LC	**LC**	**No**
C. Environmental Degradation	**C1** Past 50 years (1970)	**C2** Future or Any 50y period	**C3** Historical (1750)
	DD	**VU**	**DD**
D. Disruption of biotic processes	**D1** Past 50 years (1970)	**D2** Future or Any 50y period	**D3** Historical (1750)
	DD	**LC**	**DD**
E. Quantitative Risk analysis	**NE**		
OVERALL RISK CATEGORY	**VU**		

DD = Data Deficient; LC = Least Concern; NE = Not Evaluated; VU = Vulnerable.

Overall, the status of the Western Coral Triangle mangrove ecosystem is assessed as **Vulnerable (VU).**

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7. Appendices

1. List of Key Mangrove Species

List of plant species considered true mangroves according to IUCN Red List of Threatened Species (RLTS) spatial data (IUCN, 2022). We included species whose range maps (polygons and points) intersected with the boundary of the marine provinces/ecoregions described in the distribution section.

Class	Order	Family	Scientific name	RLTS category
Liliopsida	Arecales	Arecaceae	*Nypa fruticans*	LC
Magnoliopsida	Caryophyllales	Plumbaginaceae	*Aegialitis annulata*	LC
Magnoliopsida	Ericales	Primulaceae	*Aegiceras corniculatum*	LC
Magnoliopsida	Ericales	Primulaceae	*Aegiceras floridum*	NT
Magnoliopsida	Fabales	Fabaceae	*Cynometra iripa*	LC
Magnoliopsida	Fabales	Fabaceae	*Dalbergia candenatensis*	LC
Magnoliopsida	Gentianales	Rubiaceae	*Scyphiphora hydrophylacea*	LC
Magnoliopsida	Lamiales	Acanthaceae	*Acanthus ebracteatus*	LC
Magnoliopsida	Lamiales	Acanthaceae	*Acanthus volubilis*	LC
Magnoliopsida	Lamiales	Acanthaceae	*Avicennia alba*	LC
Magnoliopsida	Lamiales	Acanthaceae	*Avicennia marina*	LC
Magnoliopsida	Lamiales	Acanthaceae	*Avicennia officinalis*	LC
Magnoliopsida	Lamiales	Acanthaceae	*Avicennia rumphiana*	VU
Magnoliopsida	Lamiales	Bignoniaceae	*Dolichandrone spathacea*	LC
Magnoliopsida	Malpighiales	Euphorbiaceae	*Excoecaria agallocha*	LC
Magnoliopsida	Malpighiales	Euphorbiaceae	*Excoecaria indica*	DD
Magnoliopsida	Malpighiales	Rhizophoraceae	*Bruguiera cylindrica*	LC
Magnoliopsida	Malpighiales	Rhizophoraceae	*Bruguiera exaristata*	LC
Magnoliopsida	Malpighiales	Rhizophoraceae	*Bruguiera gymnorhiza*	LC
Magnoliopsida	Malpighiales	Rhizophoraceae	*Bruguiera hainesii*	CR
Magnoliopsida	Malpighiales	Rhizophoraceae	*Bruguiera parviflora*	LC
Magnoliopsida	Malpighiales	Rhizophoraceae	*Bruguiera sexangula*	LC
Magnoliopsida	Malpighiales	Rhizophoraceae	*Ceriops australis*	LC
Magnoliopsida	Malpighiales	Rhizophoraceae	*Ceriops tagal*	LC
Magnoliopsida	Malpighiales	Rhizophoraceae	*Ceriops zippeliana*	LC
Magnoliopsida	Malpighiales	Rhizophoraceae	*Kandelia candel*	LC
Magnoliopsida	Malpighiales	Rhizophoraceae	*Rhizophora apiculata*	LC
Magnoliopsida	Malpighiales	Rhizophoraceae	*Rhizophora mucronata*	LC
Magnoliopsida	Malpighiales	Rhizophoraceae	*Rhizophora stylosa*	LC
Magnoliopsida	Malvales	Malvaceae	*Brownlowia argentata*	DD
Magnoliopsida	Malvales	Malvaceae	*Brownlowia tersa*	NT
Magnoliopsida	Malvales	Malvaceae	*Camptostemon philippinensis*	EN
Magnoliopsida	Malvales	Malvaceae	*Camptostemon schultzii*	LC
Magnoliopsida	Malvales	Malvaceae	*Heritiera littoralis*	LC
Magnoliopsida	Myrtales	Combretaceae	*Lumnitzera littorea*	LC
Magnoliopsida	Myrtales	Combretaceae	*Lumnitzera racemosa*	LC
Magnoliopsida	Myrtales	Lythraceae	*Pemphis acidula*	LC
Magnoliopsida	Myrtales	Lythraceae	*Sonneratia alba*	LC
Magnoliopsida	Myrtales	Lythraceae	*Sonneratia caseolaris*	LC
Magnoliopsida	Myrtales	Lythraceae	*Sonneratia lanceolata*	LC
Magnoliopsida	Myrtales	Lythraceae	*Sonneratia ovata*	NT
Magnoliopsida	Myrtales	Myrtaceae	*Osbornia octodonta*	LC

Class	Order	Family	Scientific name	RLTS category
Magnoliopsida	Sapindales	Meliaceae	*Aglaia cucullata*	DD
Magnoliopsida	Sapindales	Meliaceae	*Xylocarpus granatum*	LC
Magnoliopsida	Sapindales	Meliaceae	*Xylocarpus moluccensis*	LC
Polypodiopsida	Polypodiales	Pteridaceae	*Acrostichum aureum*	LC
Polypodiopsida	Polypodiales	Pteridaceae	*Acrostichum speciosum*	LC

2. List of Associated Species

List of taxa that are associated with mangrove habitats in the IUCN Red List of Threatened Species (RLTS) database (IUCN, 2022). We included only species with entries for Habitat 1.7: "Forest - Subtropical/Tropical Mangrove Vegetation Above High Tide Level" or Habitat 12.7 for "Marine Intertidal - Mangrove Submerged Roots", and with suitability recorded as "Suitable", with "Major Importance" recorded as "Yes", and any value of seasonality except "Passage", Presence recorded as "Extant" or "Possibly Extinct" and "Origin" as "Native" or "Reintroduced". The common names are those shown in the RLTS, except common names in brackets, which are from other sources.

Class	Order	Family	Scientific Name	RLTS category	Common Name
Magnoliopsida	Fabales	Fabaceae	*Cynometra ramiflora*	LC	
Actinopterygii	Albuliformes	Albulidae	*Albula glossodonta*	VU	Shortjaw bonefish
Actinopterygii	Anguilliformes	Muraenidae	*Gymnothorax monochrous*	LC	Monochrome moray
Actinopterygii	Atheriniformes	Atherinidae	*Atherinomorus lacunosus*	LC	Hardyhead silverside
Actinopterygii	Atheriniformes	Phallostethidae	*Neostethus amaricola*	DD	
Actinopterygii	Atheriniformes	Phallostethidae	*Phallostethus lehi*	DD	
Actinopterygii	Beloniformes	Zenarchopteridae	*Dermogenys collettei*	LC	
Actinopterygii	Beloniformes	Zenarchopteridae	*Dermogenys sumatrana*	LC	[Sumatran halfbeak]
Actinopterygii	Clupeiformes	Clupeidae	*Anodontostoma selangkat*	LC	Indonesian gizzard shad
Actinopterygii	Clupeiformes	Clupeidae	*Nematalosa nasus*	LC	Bloch's gizzard shad
Actinopterygii	Clupeiformes	Clupeidae	*Sardinella albella*	LC	White sardinella
Actinopterygii	Clupeiformes	Clupeidae	*Sardinella melanura*	LC	Blacktip sardinella
Actinopterygii	Clupeiformes	Engraulidae	*Coilia neglecta*	LC	Neglected grenadier anchovy
Actinopterygii	Clupeiformes	Engraulidae	*Encrasicholina punctifer*	LC	Buccaneer anchovy
Actinopterygii	Clupeiformes	Engraulidae	*Setipinna breviceps*	LC	[Shorthead hairfin anchovy]
Actinopterygii	Clupeiformes	Engraulidae	*Thryssa kammalensis*	DD	[Kammal thrysa]
Actinopterygii	Clupeiformes	Engraulidae	*Thryssa mystax*	LC	Moustached thryssa
Actinopterygii	Elopiformes	Elopidae	*Elops hawaiensis*	DD	Giant herring
Actinopterygii	Elopiformes	Elopidae	*Elops machnata*	LC	[Tenpounder]
Actinopterygii	Gobiiformes	Eleotridae	*Bostrychus sinensis*	LC	Four-eyed sleeper
Actinopterygii	Gobiiformes	Eleotridae	*Butis amboinensis*	LC	Ambon gudgeon
Actinopterygii	Gobiiformes	Eleotridae	*Butis butis*	LC	Crimson-tipped gudgeon
Actinopterygii	Gobiiformes	Eleotridae	*Butis gymnopomus*	LC	Striped crazy fish
Actinopterygii	Gobiiformes	Eleotridae	*Butis koilomatodon*	LC	Marblecheek sleeper
Actinopterygii	Gobiiformes	Eleotridae	*Eleotris fusca*	LC	Brown spinecheek gudgeon
Actinopterygii	Gobiiformes	Eleotridae	*Eleotris melanosoma*	LC	Broadhead sleeper
Actinopterygii	Gobiiformes	Eleotridae	*Oxyeleotris urophthalmus*	DD	
Actinopterygii	Gobiiformes	Gobiidae	*Amblygobius esakiae*	LC	Snout-spot goby

Class	Order	Family	Scientific Name	RLTS category	Common Name
Actinopterygii	Gobiiformes	Gobiidae	*Amblygobius linki*	LC	Link's goby
Actinopterygii	Gobiiformes	Gobiidae	*Amblygobius stethophthalmus*	LC	Freckled goby
Actinopterygii	Gobiiformes	Gobiidae	*Asterropteryx semipunctata*	LC	[Starry goby]
Actinopterygii	Gobiiformes	Gobiidae	*Boleophthalmus boddarti*	LC	Boddart's goggle-eyed goby
Actinopterygii	Gobiiformes	Gobiidae	*Brachygobius doriae*	LC	Bumblebee goby
Actinopterygii	Gobiiformes	Gobiidae	*Brachygobius xanthozonus*	DD	Bumblebee fish
Actinopterygii	Gobiiformes	Gobiidae	*Caragobius urolepis*	LC	Scaleless worm goby
Actinopterygii	Gobiiformes	Gobiidae	*Cryptocentrus leptocephalus*	LC	Pink-speckled shrimpgoby
Actinopterygii	Gobiiformes	Gobiidae	*Drombus triangularis*	LC	Brown drombus
Actinopterygii	Gobiiformes	Gobiidae	*Eugnathogobius mindora*	LC	
Actinopterygii	Gobiiformes	Gobiidae	*Feia nympha*	LC	Nymph goby
Actinopterygii	Gobiiformes	Gobiidae	*Glossogobius circumspectus*	LC	Circumspect goby
Actinopterygii	Gobiiformes	Gobiidae	*Gobiopterus brachypterus*	DD	
Actinopterygii	Gobiiformes	Gobiidae	*Gnatholepis ophthalmotaenia*	LC	
Actinopterygii	Gobiiformes	Gobiidae	*Mahidolia mystacina*	LC	Flagfin prawn goby
Actinopterygii	Gobiiformes	Gobiidae	*Mangarinus waterousi*	DD	
Actinopterygii	Gobiiformes	Gobiidae	*Mugilogobius cavifrons*	LC	Bandfin mangrove goby
Actinopterygii	Gobiiformes	Gobiidae	*Oligolepis acutipennis*	LC	Paintedfin goby
Actinopterygii	Gobiiformes	Gobiidae	*Oligolepis stomias*	DD	Plain teardrop goby
Actinopterygii	Gobiiformes	Gobiidae	*Oxyurichthys lonchotus*	LC	Speartail mudgoby
Actinopterygii	Gobiiformes	Gobiidae	*Oxyurichthys ophthalmonema*	LC	Eyebrow goby
Actinopterygii	Gobiiformes	Gobiidae	*Oxyurichthys takagi*	LC	
Actinopterygii	Gobiiformes	Gobiidae	*Parachaeturichthys polynema*	LC	Lancet-tail goby
Actinopterygii	Gobiiformes	Gobiidae	*Paratrypauchen microcephalus*	LC	Comb goby
Actinopterygii	Gobiiformes	Gobiidae	*Periophthalmus minutus*	LC	Minute mudskipper
Actinopterygii	Gobiiformes	Gobiidae	*Psammogobius biocellatus*	LC	Sleepy goby
Actinopterygii	Gobiiformes	Gobiidae	*Redigobius balteatus*	LC	Girdled goby
Actinopterygii	Gobiiformes	Gobiidae	*Stenogobius ophthalmoporus*	LC	
Actinopterygii	Gobiiformes	Gobiidae	*Stigmatogobius sella*	LC	
Actinopterygii	Gobiiformes	Gobiidae	*Trypauchen vagina*	LC	Burrowing goby
Actinopterygii	Mugiliformes	Mugilidae	*Planiliza subviridis*	LC	Greenback mullet
Actinopterygii	Ophidiiformes	Carapidae	*Encheliophis homei*	LC	Silver pearlfish
Actinopterygii	Ophidiiformes	Dinematichthyidae	*Alionematichthys plicatosurculus*	LC	Folded viviparous brotula
Actinopterygii	Perciformes	Ambassidae	*Ambassis nalua*	LC	Scalloped perchlet
Actinopterygii	Perciformes	Ambassidae	*Ambassis macracanthus*	DD	Estuarine glass perchlet
Actinopterygii	Perciformes	Ambassidae	*Ambassis vachellii*	LC	Vachell's glassfish
Actinopterygii	Perciformes	Carangidae	*Atule mate*	LC	Yellowtail scad
Actinopterygii	Perciformes	Datnioididae	*Datnioides polota*	LC	Silver tiger fish
Actinopterygii	Perciformes	Ephippidae	*Platax orbicularis*	LC	Orbiculate batfish
Actinopterygii	Perciformes	Epinephelidae	*Epinephelus coioides*	LC	Orange-spotted grouper
Actinopterygii	Perciformes	Epinephelidae	*Epinephelus itajara*	VU	Atlantic goliath grouper
Actinopterygii	Perciformes	Epinephelidae	*Epinephelus malabaricus*	LC	Malabar grouper
Actinopterygii	Perciformes	Epinephelidae	*Epinephelus miliaris*	LC	Netfin grouper
Actinopterygii	Perciformes	Epinephelidae	*Epinephelus polystigma*	LC	White-dotted grouper
Actinopterygii	Perciformes	Epinephelidae	*Epinephelus tauvina*	DD	Greasy grouper
Actinopterygii	Perciformes	Gerreidae	*Gerres erythrourus*	LC	Deep-bodied mojarra

Class	Order	Family	Scientific Name	RLTS category	Common Name
Actinopterygii	Perciformes	Haemulidae	*Diagramma labiosum*	LC	Painted sweetlips
Actinopterygii	Perciformes	Haemulidae	*Plectorhinchus gibbosus*	LC	Brown sweetlips
Actinopterygii	Perciformes	Leiognathidae	*Leiognathus equulus*	LC	Common ponyfish
Actinopterygii	Perciformes	Lethrinidae	*Lethrinus harak*	LC	Thumbprint emperor
Actinopterygii	Perciformes	Lethrinidae	*Lethrinus laticaudis*	LC	Grass emperor
Actinopterygii	Perciformes	Lethrinidae	*Lethrinus nebulosus*	LC	Spangled emperor
Actinopterygii	Perciformes	Lethrinidae	*Lethrinus ornatus*	LC	Ornate emperor
Actinopterygii	Perciformes	Lethrinidae	*Lethrinus semicinctus*	LC	Black-spot emperor
Actinopterygii	Perciformes	Lutjanidae	*Lutjanus fulviflamma*	LC	Dory snapper
Actinopterygii	Perciformes	Lutjanidae	*Lutjanus fulvus*	LC	Blacktail snapper
Actinopterygii	Perciformes	Microdesmidae	*Parioglossus formosus*	LC	
Actinopterygii	Perciformes	Microdesmidae	*Parioglossus palustris*	LC	
Actinopterygii	Perciformes	Microdesmidae	*Parioglossus rainfordi*	LC	
Actinopterygii	Perciformes	Microdesmidae	*Parioglossus raoi*	LC	Yellow dartfish
Actinopterygii	Perciformes	Pomacentridae	*Neopomacentrus taeniurus*	DD	Freshwater damsel
Actinopterygii	Perciformes	Sciaenidae	*Aspericorvina jubata*	LC	Prickly croaker
Actinopterygii	Perciformes	Sciaenidae	*Johnius australis*	LC	Bottlenose jewfish
Actinopterygii	Perciformes	Sciaenidae	*Johnius belangerii*	LC	Belanger's croaker
Actinopterygii	Perciformes	Sciaenidae	*Johnius borneensis*	LC	Hammer croaker
Actinopterygii	Perciformes	Sciaenidae	*Johnius carouna*	LC	Caroun croaker
Actinopterygii	Perciformes	Sciaenidae	*Johnius plagiostoma*	LC	[Large-eye croaker]
Actinopterygii	Perciformes	Sciaenidae	*Johnius trachycephalus*	LC	Leaftail croaker
Actinopterygii	Perciformes	Sciaenidae	*Johnius weberi*	LC	
Actinopterygii	Perciformes	Sciaenidae	*Nibea coibor*	DD	
Actinopterygii	Perciformes	Sciaenidae	*Nibea microgenys*	LC	[Small-mouthed croaker]
Actinopterygii	Perciformes	Sciaenidae	*Panna microdon*	LC	[Panna croaker]
Actinopterygii	Perciformes	Sciaenidae	*Pennahia anea*	LC	Grey fin jew fish
Actinopterygii	Perciformes	Siganidae	*Siganus guttatus*	LC	Golden rabbitfish
Actinopterygii	Perciformes	Siganidae	*Siganus lineatus*	LC	Lined rabbitfish
Actinopterygii	Perciformes	Siganidae	*Siganus vermiculatus*	LC	Vermiculated spinefoot
Actinopterygii	Perciformes	Terapontidae	*Mesopristes argenteus*	LC	Silver grunter
Actinopterygii	Pleuronectiformes	Cynoglossidae	*Cynoglossus abbreviatus*	DD	Three-lined tongue sole
Actinopterygii	Pleuronectiformes	Cynoglossidae	*Cynoglossus puncticeps*	LC	Speckled tonguesole
Actinopterygii	Pleuronectiformes	Cynoglossidae	*Cynoglossus sibogae*	DD	
Actinopterygii	Pleuronectiformes	Cynoglossidae	*Paraplagusia sinerama*	LC	Dusky tongue sole
Actinopterygii	Pleuronectiformes	Paralichthyidae	*Pseudorhombus arsius*	LC	Largetooth flounder
Actinopterygii	Pleuronectiformes	Soleidae	*Brachirus aspilos*	LC	Dusky sole
Actinopterygii	Pleuronectiformes	Soleidae	*Paradicula setifer*	LC	
Actinopterygii	Scorpaeniformes	Platycephalidae	*Cymbacephalus beauforti*	LC	Crocodile fish
Actinopterygii	Tetraodontiformes	Monacanthidae	*Colurodontis paxmani*	DD	Paxman's leatherjacket
Actinopterygii	Tetraodontiformes	Tetraodontidae	*Arothron manilensis*	LC	Narrow-lined puffer
Actinopterygii	Tetraodontiformes	Tetraodontidae	*Arothron reticularis*	LC	Reticulated pufferfish
Amphibia	Anura	Dicroglossidae	*Fejervarya cancrivora*	LC	Asian brackish frog
Amphibia	Anura	Dicroglossidae	*Limnonectes acanthi*	NT	Busuanga wart frog
Aves	Accipitriformes	Accipitridae	*Accipiter melanochlamys*	LC	Black-mantled goshawk
Aves	Ciconiiformes	Ciconiidae	*Leptoptilos javanicus*	VU	Lesser adjutant

Class	Order	Family	Scientific Name	RLTS category	Common Name
Aves	Ciconiiformes	Ciconiidae	*Mycteria cinerea*	EN	Milky stork
Aves	Columbiformes	Columbidae	*Ducula badia*	LC	Mountain imperialpigeon
Aves	Columbiformes	Columbidae	*Goura cristata*	VU	Western crowned-pigeon
Aves	Columbiformes	Columbidae	*Phapitreron cinereiceps*	EN	Tawitawi brown-dove
Aves	Coraciiformes	Alcedinidae	*Ceyx pusillus*	LC	Little kingfisher
Aves	Coraciiformes	Alcedinidae	*Halcyon coromanda*	LC	Ruddy kingfisher
Aves	Coraciiformes	Alcedinidae	*Halcyon pileata*	VU	Black-capped kingfisher
Aves	Cuculiformes	Cuculidae	*Phaenicophaeus sumatranus*	NT	Chestnut-bellied malkoha
Aves	Galliformes	Megapodiidae	*Megapodius freycinet*	LC	Dusky scrubfowl
Aves	Gruiformes	Rallidae	*Megacrex inepta*	LC	New guinea flightless rail
Aves	Passeriformes	Acanthizidae	*Gerygone hypoxantha*	VU	Biak gerygone
Aves	Passeriformes	Acanthizidae	*Gerygone magnirostris*	LC	Large-billed gerygone
Aves	Passeriformes	Acanthizidae	*Gerygone sulphurea*	LC	Golden-bellied gerygone
Aves	Passeriformes	Aegithinidae	*Aegithina tiphia*	LC	Common iora
Aves	Passeriformes	Artamidae	*Melloria quoyi*	LC	Black butcherbird
Aves	Passeriformes	Cisticolidae	*Orthotomus ruficeps*	LC	Ashy tailorbird
Aves	Passeriformes	Cisticolidae	*Prinia familiaris*	NT	Bar-winged prinia
Aves	Passeriformes	Meliphagidae	*Gavicalis versicolor*	LC	Varied honeyeater
Aves	Passeriformes	Meliphagidae	*Lichmera indistincta*	LC	Brown honeyeater
Aves	Passeriformes	Meliphagidae	*Lichmera squamata*	LC	Scaly-breasted honeyeater
Aves	Passeriformes	Meliphagidae	*Myzomela erythrocephala*	LC	Red-headed myzomela
Aves	Passeriformes	Meliphagidae	*Philemon buceroides*	LC	Helmeted friarbird
Aves	Passeriformes	Monarchidae	*Myiagra ruficollis*	LC	Broad-billed flycatcher
Aves	Passeriformes	Muscicapidae	*Cyornis omissus*	LC	Sulawesi blue-flycatcher
Aves	Passeriformes	Muscicapidae	*Cyornis rufigastra*	LC	Mangrove blue-flycatcher
Aves	Passeriformes	Oriolidae	*Oriolus flavocinctus*	LC	Green oriole
Aves	Passeriformes	Pachycephalidae	*Pachycephala arctitorquis*	LC	Wallacean whistler
Aves	Passeriformes	Pachycephalidae	*Pachycephala cinerea*	LC	Mangrove whistler
Aves	Passeriformes	Pachycephalidae	*Pachycephala phaionota*	LC	Island whistler
Aves	Passeriformes	Petroicidae	*Microeca flavigaster*	LC	Lemon-bellied flyrobin
Aves	Passeriformes	Petroicidae	*Microeca hemixantha*	NT	Tanimbar flyrobin
Aves	Passeriformes	Petroicidae	*Peneoenanthe pulverulenta*	LC	Mangrove robin
Aves	Passeriformes	Rhipiduridae	*Rhipidura fuscorufa*	NT	Cinnamon-tailed fantail
Aves	Passeriformes	Sturnidae	*Aplonis crassa*	NT	Tanimbar starling
Aves	Passeriformes	Sturnidae	*Aplonis mysolensis*	LC	Moluccan starling
Aves	Psittaciformes	Cacatuidae	*Cacatua haematuropygia*	CR	Philippine cockatoo
Aves	Psittaciformes	Psittacidae	*Loriculus exilis*	LC	Pygmy hanging-parrot
Aves	Psittaciformes	Psittacidae	*Prioniturus verticalis*	CR	Sulu racquet-tail
Aves	Strigiformes	Strigidae	*Ninox rudolfi*	NT	Sumba boobook
Aves	Suliformes	Anhingidae	*Anhinga melanogaster*	NT	Oriental darter
Chondrichthyes	Carcharhiniformes	Carcharhinidae	*Carcharhinus amblyrhynchoides*	VU	Graceful shark
Chondrichthyes	Carcharhiniformes	Carcharhinidae	*Carcharhinus amboinensis*	VU	Pigeye shark
Chondrichthyes	Carcharhiniformes	Carcharhinidae	*Carcharhinus melanopterus*	VU	Blacktip reef shark
Chondrichthyes	Carcharhiniformes	Carcharhinidae	*Negaprion acutidens*	EN	Sharptooth lemon shark
Chondrichthyes	Myliobatiformes	Dasyatidae	*Brevitrygon imbricata*	VU	Bengal whipray
Chondrichthyes	Myliobatiformes	Dasyatidae	*Himantura leoparda*	VU	Leopard whipray

Class	Order	Family	Scientific Name	RLTS category	Common Name
Chondrichthyes	Myliobatiformes	Dasyatidae	*Himantura uarnak*	EN	Coach whipray
Chondrichthyes	Myliobatiformes	Dasyatidae	*Himantura undulata*	EN	Honeycomb whipray
Chondrichthyes	Myliobatiformes	Dasyatidae	*Maculabatis gerrardi*	EN	Whitespotted whipray
Chondrichthyes	Myliobatiformes	Dasyatidae	*Maculabatis macrura*	EN	Sharpnose whipray
Chondrichthyes	Myliobatiformes	Dasyatidae	*Maculabatis pastinacoides*	EN	Round whipray
Chondrichthyes	Myliobatiformes	Dasyatidae	*Pastinachus ater*	VU	Broad cowtail ray
Chondrichthyes	Myliobatiformes	Dasyatidae	*Pastinachus gracilicaudus*	EN	Narrow cowtail ray
Chondrichthyes	Myliobatiformes	Dasyatidae	*Pastinachus solocirostris*	EN	Roughnose cowtail ray
Chondrichthyes	Myliobatiformes	Dasyatidae	*Pateobatis bleekeri*	EN	Bleeker's whipray
Chondrichthyes	Myliobatiformes	Dasyatidae	*Pateobatis uarnacoides*	EN	Whitenose whipray
Chondrichthyes	Myliobatiformes	Dasyatidae	*Urogymnus lobistoma*	EN	Tubemouth whipray
Chondrichthyes	Rhinopristiformes	Pristidae	*Anoxypristis cuspidata*	EN	Narrrow sawfish
Chondrichthyes	Rhinopristiformes	Pristidae	*Pristis clavata*	EN	Dwarf sawfish
Chondrichthyes	Rhinopristiformes	Pristidae	*Pristis pristis*	CR	Largetooth sawfish
Chondrichthyes	Rhinopristiformes	Pristidae	*Pristis zijsron*	CR	Green sawfish
Gastropoda	Cycloneritida	Neritidae	*Clithon faba*	LC	
Gastropoda	Cycloneritida	Neritidae	*Neritodryas subsulcata*	DD	Weakly cut nerite
Gastropoda	Ellobiida	Ellobiidae	*Cassidula crassiuscula*	LC	
Gastropoda	Ellobiida	Ellobiidae	*Cassidula multiplicata*	LC	
Gastropoda	Ellobiida	Ellobiidae	*Cylindrotis quadrasi*	LC	
Gastropoda	Ellobiida	Ellobiidae	*Ellobium aurismidae*	LC	Midas ear Cassidula
Gastropoda	Ellobiida	Ellobiidae	*Laemodonta bella*	LC	
Gastropoda	Ellobiida	Ellobiidae	*Laemodonta punctigera*	LC	
Gastropoda	Ellobiida	Ellobiidae	*Melampus sulculosus*	LC	
Gastropoda	Littorinimorpha	Littorinidae	*Littoraria undulata*	LC	[Robust shell]
Gastropoda	Neogastropoda	Conidae	*Conus austroviola*	DD	
Gastropoda	Neogastropoda	Conidae	*Conus frigidus*	LC	Frigid cone
Gastropoda	Neogastropoda	Conidae	*Conus furvus*	LC	[Dark cone]
Gastropoda	Neogastropoda	Conidae	*Conus insculptus*	LC	[Engraved cone]
Gastropoda	Neogastropoda	Conidae	*Conus varius*	LC	[Freckled cone]
Gastropoda	Sorbeoconcha	Potamididae	*Cerithidea ornata*	LC	
Insecta	Odonata	Coenagrionidae	*Mortonagrion astamii*	EN	
Insecta	Odonata	Libellulidae	*Pornothemis starrei*	NT	[Mangrove marshal]
Mammalia	Carnivora	Felidae	*Prionailurus planiceps*	EN	Flat-headed cat
Mammalia	Carnivora	Mustelidae	*Aonyx cinereus*	VU	Asian small-clawed otter
Mammalia	Carnivora	Mustelidae	*Lutrogale perspicillata*	VU	Smooth-coated otter
Mammalia	Cetartiodactyla	Bovidae	*Bubalus depressicornis*	EN	Lowland anoa
Mammalia	Cetartiodactyla	Phocoenidae	*Neophocaena phocaenoides*	VU	Indo-pacific finless porpoise
Mammalia	Cetartiodactyla	Suidae	*Sus barbatus*	VU	Bearded pig
Mammalia	Chiroptera	Hipposideridae	*Coelops frithii*	NT	Tail-less leaf-nosed bat
Mammalia	Chiroptera	Megadermatidae	*Megaderma spasma*	LC	Lesser false vampire
Mammalia	Chiroptera	Pteropodidae	*Acerodon celebensis*	VU	Sulawesi fruit bat
Mammalia	Chiroptera	Pteropodidae	*Acerodon leucotis*	VU	Palawan fruit bat
Mammalia	Chiroptera	Pteropodidae	*Macroglossus sobrinus*	LC	Hill long-tongued fruit bat
Mammalia	Chiroptera	Pteropodidae	*Pteropus conspicillatus*	EN	Spectacled flying fox
Mammalia	Chiroptera	Pteropodidae	*Pteropus macrotis*	LC	Large-eared flying fox

Class	Order	Family	Scientific Name	RLTS category	Common Name
Mammalia	Chiroptera	Pteropodidae	*Pteropus melanopogon*	EN	Black-bearded flying fox
Mammalia	Chiroptera	Pteropodidae	*Pteropus neohibernicus*	LC	Great flying fox
Mammalia	Chiroptera	Pteropodidae	*Pteropus temminckii*	VU	Temminck's flying fox
Mammalia	Chiroptera	Vespertilionidae	*Myotis hasseltii*	LC	Lesser large-footed myotis
Mammalia	Chiroptera	Vespertilionidae	*Pipistrellus ceylonicus*	LC	Kelaart's pipistrelle
Mammalia	Chiroptera	Vespertilionidae	*Scotorepens sanborni*	LC	Northern broad-nosed bat
Mammalia	Eulipotyphla	Erinaceidae	*Echinosorex gymnura*	LC	Moonrat
Mammalia	Primates	Cercopithecidae	*Macaca brunnescens*	VU	Buton macaque
Mammalia	Primates	Cercopithecidae	*Macaca fascicularis*	EN	Long-tailed macaque
Mammalia	Primates	Cercopithecidae	*Macaca ochreata*	VU	Booted macaque
Mammalia	Primates	Cercopithecidae	*Presbytis chrysomelas*	CR	Bornean banded langur
Mammalia	Primates	Cercopithecidae	*Nasalis larvatus*	EN	Proboscis monkey
Mammalia	Primates	Cercopithecidae	*Trachypithecus auratus*	VU	Spangled ebony langur
Mammalia	Primates	Cercopithecidae	*Trachypithecus cristatus*	VU	Silvery lutung
Mammalia	Primates	Tarsiidae	*Tarsius dentatus*	VU	Dian's tarsier
Mammalia	Primates	Tarsiidae	*Tarsius lariang*	DD	Lariang tarsier
Mammalia	Primates	Tarsiidae	*Tarsius pelengensis*	EN	Peleng tarsier
Mammalia	Primates	Tarsiidae	*Tarsius tumpara*	CR	Siau island tarsier
Reptilia	Squamata	Elapidae	*Ophiophagus hannah*	VU	King cobra
Reptilia	Squamata	Pythonidae	*Python bivittatus*	VU	Burmese python
Reptilia	Squamata	Scincidae	*Emoia atrocostata*	LC	Littoral whiptail-skink
Reptilia	Squamata	Varanidae	*Varanus komodoensis*	EN	Komodo dragon
Reptilia	Squamata	Varanidae	*Varanus melinus*	EN	Banggai island monitor
Reptilia	Squamata	Varanidae	*Varanus rainerguentheri*	LC	
Reptilia	Squamata	Varanidae	*Varanus rudicollis*	DD	Roughneck monitor
Reptilia	Squamata	Varanidae	*Varanus salvator*	LC	Common water monitor

3. National Estimates for Subcriterion A1

To estimate the Western Coral Triangle mangrove ecosystem extent in 1970, we gathered reliable information on the mangrove area for each country within the province around this period (Table b). We then estimated the mangrove area in 1970 for each country, assuming a linear relationship between mangrove extent and time. Finally, we summed up the country estimates to determine the total mangrove area in the Western Coral Triangle province. We assumed that the percentage of mangrove extent by country within the province remained constant over time, as the percentages did not change between 1996 and 2020 (GMW v3.0 dataset). Using mangrove area estimates from different sources can lead to uncertainty (Friess and Webb, 2014); however, there were no regional statistics or global studies available for this time period. Thus, the estimates for 1970 should be considered only indicative.

Table a. Estimated mangrove area by country in 1970 and 2020. Estimates for 2020 mangrove area are based on the Global Mangrove Watch Version 3 (GMW v3.0) dataset. The references used to calculate mangrove area for each country in 1970 are listed below in Table b.

Year	Country total 2020*	Within province 2020*	Country total 1970**	Within province 1970**
Brunei	115	115	194	185
Indonesia	29,534	1,3840	46,608	21,841
Malaysia	5,246	3,007	7,357	4,217
Philippines	2,848	2,848	2,880	2,881
Timor-Leste	11	10.50	5,748	57
The Western Coral Triangle		**19,820**		**29,181**

Table b. List of selected studies considered to have reliable information on mangrove area for the period around 1970 in each country of the West Coral Triangle province.

Country	Year	Mangrove area (Ha)	Reference
Brunei Darussalam	1979	18,418	Anderson, J. A. R., & Marsden, D. (1984). Brunei Forest Resources and Strategic Planning Study Report.
Brunei Darussalam	1992	17,000	Spalding, M.D., Blasco, F., & Field, C.D. (eds.) (1997). World Mangrove Atlas. The International Society for Mangrove Ecosystems, Okinawa, Japan. 178 pp.
Indonesia	1982	4,251,011	FAO (2003). Status and trends in mangrove area extent worldwide. By Wilkie, M.L., & Fortuna, S. Forest Resources Assessment Working Paper No. 63. Forest Resources Division. FAO, Rome.
Indonesia	2020	2,953,398.4	Bunting, P., Rosenqvist, A., Hilarides, L., Lucas, R. M., Thomas, N., Tadono, T., Worthington, T. A., Spalding, M.D., Murray, N. J., & Rebelo, L.-M. (2022). Global Mangrove Extent Change 1996–2020: Global Mangrove Watch Version 3.0. Remote Sensing, 14(15), 3657. https://doi.org/10.3390/rs14153657
Malaysia	1975	688,634	FAO (1982). Management and utilization of mangroves in Asia and the Pacific. FAO environment paper 3. 160 pp.
Malaysia	1977	655,572	de la Cruz, A.A. (1984). A realistic approach to the use and management of mangrove areas in Southeast Asia. In: Teas, H.J. (eds) Physiology and management of mangroves. Tasks for vegetation science, vol 9. Springer, Dordrecht. https://doi.org/10.1007/978-94-009-6572-0_9
Malaysia	1978	637,739	Ong, J.E. (1978). *Mangroves in Malaysia*. Cited by Snedaker, S.C. (1984): The mangroves of Asia and Oceania: status and research planning. In: Proceedings of the Asian Mangrove Symposium. Soepadmo, E., Rao, A.N., & Macintosh, D.J. (eds.) 24-29 August 1980, Kuala Lumpur, Malaysia. pp. 5-15.
Malaysia	1979	652,219	Sasekumar, A. (1980). Status report on impact of pollution on mangrove ecosystems and related research programmes in Malaysia. Country paper presented during the 12th annual seminar/convention. Federation of Institutions for Marine and Freshwater Sciences.
Philippines	1970	288,035	Gilbert, A.J., & Janssen, R. (1997). The use of Environmental Functions to Evaluate Management Strategies for the Pagbilao Mangrove Forest. CREED Working Paper Series No. 15.
Timor Leste	1940	9,000	MacKinnon, J., Beudels, R.C., & Robinson, A.H. (1982). National conservation plan for Indonesia. V. 4: Nusa Tenggara. FAO-FO--INS/78/061 Field report 44.
Timor Leste	1982	4,000	MacKinnon, J., Beudels, R.C., & Robinson, A.H. (1982). National conservation plan for Indonesia. V. 4: Nusa Tenggara. FAO-FO--INS/78/061 Field report 45
For all countries			FAO (2003). Status and trends in mangrove area extent worldwide. By Wilkie, M.L., & Fortuna, S. Forest Resources Assessment Working Paper No. 63. Forest Resources Division.