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Article

Forest types in Brunei Darussalam: A case study on mangrove forests in Temburong District

Siti Mariyah Atiqah Haji Duraim, Shafi Noor Islam*

Department of Geography, Environment and Development Studies, Faculty of Arts and Social Sciences (FASS), University of Brunei Darussalam, Bandar Seri Begawan BE 1410, Brunei Darussalam
*** Corresponding author:** Shafi Noor Islam, shafi.islam@ubd.edu.bn

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Abstract: Brunei Darussalam is a small Sultanate country with diverse forest cover. One of them would be Mangrove Forest. As it has four main administrative districts, Temburong would be the chosen case study area. The methods of collecting data for this article are by collecting secondary data from official websites and the map in this article (**Figure 1**) are showing the forest cover in Brunei Darussalam as of 2020. The aim of this article is to explain the mangrove forest especially at the Temburong District. As for the objectives, it would to be able to show the different types of forests in Temburong, hoping in ability to explain the different subtypes of mangroves forest and to explain in general the green jewel of Brunei Darussalam. Temburong has become the second highest tree coverage in Brunei Darussalam of 124 kha as of 2010, while the mangrove forest covering about 66% of total mangrove forest of 12,164 km^2 out of 18,418 hectares. Mangrove forest has seven subtypes: Bakau species, Nyireh bunga, Linggadai, Nipah, Nipah-Dungun, Pedada and Nibong. Selirong Forest Reserve and Labu Forest Reserve are the two-mangrove forest reserves in Brunei Darussalam at Temburong District. Forest cover in Brunei Darussalam are 3800 hectares as of 2020 and has lost its tree coverage of 1.17 kha and one of the reasons would be forest fire and the tree cover loss due to fire is around 197 ha and the district that has lost its tree cover mostly was at Belait District of total 13.4 kha between the year 2001 until 2022.

Keywords: Brunei Darussalam forest; mangrove forest; temburong district; selirong forest reserve; Labu forest reserve

1. Introduction

Brunei Darussalam is a small Islamic sultanate country with an area of 576,532 hectares [1]. Within this small sized country, it has abundance varieties of forest [1]. As it lies along the equator, the forest type in Brunei Darussalam is in the type of tropical rainforest [1]. This type of forest is unique as it can only be found scattered in the zone of South and Central America, Africa, Indian subcontinent, and South-East Asia [2]. Brunei Darussalam is located at Borneo Island in which it shares with West Malaysia, Sabah and Sarawak and other Indonesia state, Kalimantan. Brunei Darussalam has four administrative districts: Brunei-Muara, Tutong, Belait and Temburong [1]. As for the capital city of Brunei Darussalam, it was known as Bandar Seri Begawan which located at Brunei-Muara District [3]. Brunei-Muara District is located at the northern-most of Brunei Darussalam and the smallest district among the other districts. It covers only around 570 km^2 and has 17 mukims [3]. Brunei-Muara District are well-known with the unique water village; Kampong Ayer or known as Venice of the East [3]. Tutong District located in between Brunei-Muara District and Belait District that covers 1166 km^2 [4]. It becomes the third largest district within

Brunei Darussalam [4]. The capital town is known as 'Pekan Tutong' and has 8 mukims [4]. One of the attractions would be Tasek Merimbun Heritage Park, where the natural freshwater swamp forest can be observed in which this park has been protecting the wildlife, flora, and faunas. This place has been declared to be ASEAN National Heritage Sites in 1984 [4]. Belait District is the largest district with an area of 2727 km^2 [5]. Situated next to Tutong District, it was at the western side of Tutong District. The main town would be Kuala Belait and has 8 mukims [5]. This district is where the oil and gas has been found and processed and one of the attractions is the Billionth Barrel Monument [5]. It was built to commemorate the billionth barrels of oil that have been produced [5]. Temburong District is located at the eastern-most of Brunei Darussalam in which has been separated by Brunei Bay and Malaysia border, this second largest district covered 1306 km^2 [5]. Pekan Bangar would be the main town and has 5 mukims [5]. One of the attractions is the Ulu Temburong National Park that shows the undisturbed forest of the southern part of Temburong District. It attracts local and foreign visitors through the canopy walkway that has been built 250 m high on one of the oldest rainforests in the world [5].

The methods of collecting data in this article are by reading and summarizing any data related to this article from books and official websites. The data collected are then to be used to explain all the aim and objectives of this article. The aim of this article is to explain the mangrove forests in Brunei Darussalam and specifically at the Temburong District. As for the objective of this article are it was to be able to explain in brief of Temburong Districts as well as the subtypes of mangrove forest that are available at Temburong District. It was then to describe the subtypes in general and briefly. The map in this article is made by using ArcGIS application and through this, it was able to show clearly the different types of forests in Brunei Darussalam by using different colors.

2. Forest land-cover scenarios in Brunei Darussalam

Figure 1 is showing the major types of forest in Brunei Darussalam: mixed dipterocarp forest, mangrove forest, peat swamp forest, heath forest, montane forest and also the secondary forest. The **Figure 1** also shows the cleared land, urban area, and cultivated land as well as the river in Brunei Darussalam. The **Figure 1** has clearly shown the forest cover in Brunei Darussalam which can be observed as it has different color for each of the forest types. The darker green color is showing the mixed dipterocarp forest, while the light green color is showing the secondary forest in Brunei Darussalam.

As for the purple, it shows the mangrove forest of Brunei Darussalam, red for showing peat swamp forest and while the light orange is showing the montane forest. The **Figure 1** shows the general overview and rainforest and general forest characters on Brunei Darussalam in 2020. The scenario of the forest and green space areas and rainforest areas in 2016 and 2020 is displaying the degraded pattern and the regular forest area is degrading and reducing. The **Figure 1** is showing major category of forest is mixed dipterocarp and it is covering 38% and the lowest category of forest is montane forest that covering 1.2% of total forest area in Brunei Darussalam.

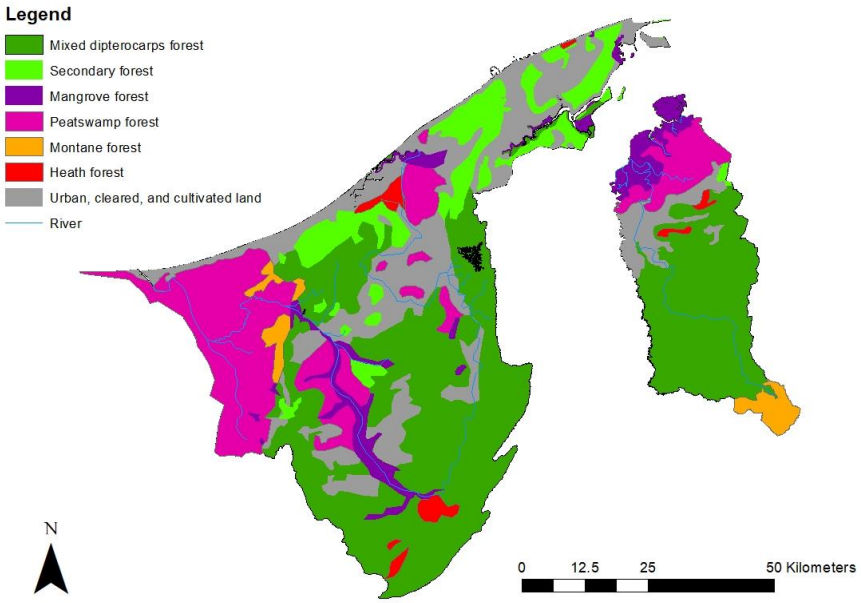

Figure 1. The forest cover and over view of land covers and rainforest areas in Brunei Darussalam in 2020.

The deforestation rates are 34.5% in the recent tenant it is gradually increasing, the forest area 104,277 ha (18%) cleaned in 1990 whereas, 200,893 ha (34.5%) where clear in 2016. This has been occurred within 40 years in Brunei Darussalam, the detail classified forest status has shown in **Table 1**. There are seven major forest classification has recognized in Brunei Darussalam [6].

The darker orange is showing the heath forest and grey color is showing the urban, cleared, and cultivated land. As for the blue lines, it shows the river channels in Brunei Darussalam. **Figure 1** shows the general overview forest covers in Brunei Darussalam in 2020. The forest area in Brunei Darussalam in the year 2020 are 3800 km^2 (World Data Atlas). In which it has lost the tree coverage of 1.17 kha and one of the reasons would be forest fire (Global Forest Watch). The tree cover loss due to fire is around 197 ha and the district that has lost its tree cover mostly was at Belait District of total 13.4 kha between the year 2001 until 2022 (Global Forest Watch).

Table 1. Occurrences of the subtypes of mangrove forest in Temburong District.

District	Subtypes	Area (ha)
Temburong	*Rhizophora apiculate*	5572
	Xylocarpus granatum	172
	Brugueira gymnorhiza	71
	Nypa fruticans	1885
	Heritiera globosa	2257
	Subtype mixtures	2008

Source: Chua et al. (1987).

3. The geo-environmental characteristics of Temburong District

Temburong District is the green jewel of Brunei Darussalam [7]. Temburong District has become the second highest tree cover in Brunei Darussalam of 124 kha as

of 2010. Temburong District has 5 mukims and covered of 1306 km^2 wide [8]. Main town would be Pekan Bangar and has many places of interest with a breathtaking views of abundance flora and fauna and natural environments. Such as Labu Estate Village, Ulu Temburong National Park, Selirong Island, Bukit Patoi Recreational Park, Batang Duri Recreational Park, Taman Aie Tenub, Wasai Deraya Rimba and Wasai Deraya Belukar [8]. Not only the areas of interests would attract locals and foreigners to come visit, but the unique local cuisine would also be one of the main reasons for people to come. The local cuisine would be the Udang Galah (king prawn), Wajid Temburong and the Cendol Temburong [8]. There are two ways to go to Temburong District, either by boat or car. If travelled by boats, visitors may come from jetty at Brunei River and may arrive at Bangar Town [8] as for travelling by car, visitors may go through the Temburong Bridge or the official name Sultan Haji Omar Ali Saifuddien Bridge that has been officially opened to public recently on 17 March 2020. The bridge has become a new attraction after the restrictions have been lifted after COVID-19 hits. The bridge has become the longest bridge in Asia, with a length of 26.3 km [9].

4. Places of interest in Temburong District

Some of the places mentioned above will be described in this part. Ulu Temburong National Park covers 500 km^2 of southern part of Temburong District at the undisturbed rainforest [8]. At this park, visitors may observe the panoramic views of rainforest's diverse treetop ecosystem through the 250 m high canopy walkway [8]. This park is covered of mixed dipterocarp forest and montane forest in which it has becoming the oldest rainforest in the world. This park can be found within the Batu Apoi Forest Reserve [10]. Selirong Island Forest Recreation Park covers 2566 hectares that was composed of pristine mangrove forests [1]. This island is located at the northern part of Temburong District and can be accessed only by boats from Bandar Seri Begawan [1]. It is an amazing home for flora and fauna species [11]. Bukit Patoi Forest Recreation Park located within the Peradayan Forest Reserve which also can be accessed only by boats. This park has been a good destination for forest trekking and has a forest trail of 1.6 km that winds up and down the mountainside up to the peak. This park is consisting of rocky mixed dipterocarp forest and the pristine Kerangas forest that mostly dominated by Agathis species. Bukit Patoi has a height of 310 m above sea level [1].

5. Mangrove forests in Temburong District

In **Figure 2**, at the Temburong District, it shows that there are three types of forest that are covering the area; mangrove forest, heath forest, mixed dipterocarp forest and montane forest. Mangrove forests in Temburong District covered around 12,164 km^2 out of 18,418 hectares [1] in which it means that mangrove forests in Temburong covered around 66% of total area of mangrove in total of Brunei Darussalam [12]. Mangrove forest has been proposed to be divided into three parts for conservation, preservation and environmental protection: timber production. 393 hectares of mangrove forest of Temburong District are proposed to be preserved, 4238 hectares for conservation and 7533 hectares for environmental protection [12]. In Temburong

mangrove forest, the dominant species that grow on this area are *Rhizophora* species (*Bakau*) The *Rhizophora* species are *Rhizophora apiculate* (*Bakau minyak*) and *Rhizophora mucronate* (*Bakau kurap*). Other species can be found in Temburong mangrove forest, includes the *Xylocarpus granatum* (*Nyireh bunga*), *Bruguiera gymnorhiza* (*Linggadai*), *Nypa frutican* (*Nipah*), *Heritiera globosa* (*Nipah-Dungun*), *Oncosperma tigillarium* (*Nibong*) and *Sonneratia caseolaris* (*Pedada*) [13]. In Temburong mangrove forest, there are about six different subtypes that can be found as mentioned in **Table 1**. The *Rhizophora* (*Bakau*) species can be observed at Selirong Forest Reserve, as for *Sonneratioa caseolaris* (*Pedada*), and *Oncosperma tigillarium* (*Nibong*) can be found along Temburong and Labu rivers. While *Xylocarpus granatum* (*Nyireh bunga*) and *Bruguiera gymnorhiza* (*Linggadai*) can be found at Labu Reserve and Pulau Siarau.

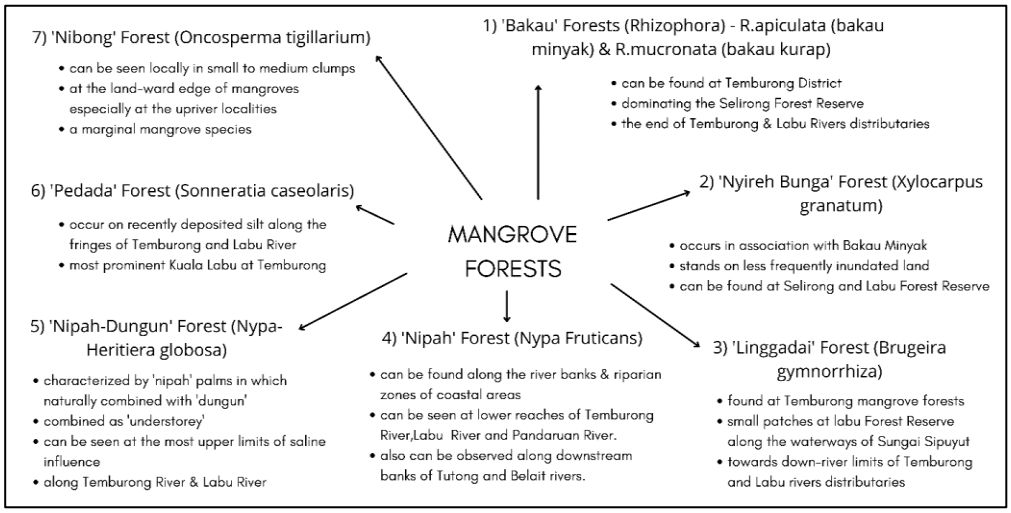

Figure 2. Different types of species of mangrove forest.
(author's own) Sources: Forestry Department (2011).

5.1. *Bakau* forest

Rhizophora species can mostly be seen in Temburong District as wide as about 5570 ha. Forestry Department [1] *Rhizophora* species has its unique roots design as where the word "*Rhizophora*" in Greek means "root bearer" [14]. In Brunei Darussalam, two species dominate, known as *R. apiculata* and *R. mucronata* [1]. Their leaves are eye-shaped with a size of 8 cm to 15 cm long, while the older leaves tend to have black spots that are distributed evenly on the bottom [15]. This is called cork warts that act as air exchangers of the tree [16]. Through these cork warts, the air enters and will be stored in leaf aerenchyma. After the air has been heated by the transpiration, the air will be transported within the plant itself, thus giving enough oxygen to the roots to survive the poor mud environments and eventually will transfer the oxygen to the mud as well [14,15].

5.2. *Nyireh bunga* forest

Xylocarpus species that dominate only the *X. granatum*. The word 'granatum' means full of seeds thus it has a round or cannon-shaped fruit [14–16]. The Malay name for this species was *Nyireh bunga* but other than *X. granatum*, it is also known

as *Carpa obovata* [14–16]. This medium tall tree has a nice camouflage pattern, but the bark was smooth with reddish orange color when mature and it will show its new green bark when it flakes off in patches [14–16]. To attract pollinators especially bees as they only bloom seasonally, it produces a 'strong and pleasant scent' however, it was still in the range of small size flowers with only 0.5 cm in white pinkish color [15].

The cannon-ball shaped fruits when mature will release its 8 to 10 seeds after its splits open. According to Burkill, the roots of this tree can be useful in the medicinal world as it helps in the recovery of cholera, while its dark bark helps in dysentery and its seeds can be used in various ailments such as hair oil.

5.3. *Linggadai* forest

Bruguiera species in Brunei is *B. gymnorrhiza* is a long-lived tree as it grows slowly but it will grow up to 10 m tall with a rough, black bark when mature and hairless-glossy green to grey when young [17]. It can be found in the middle part of the mangrove community that according to Singaporean specialists, this type of mangrove species grows best in dry, well aerated soils conditions towards the landward side [16]. Their unique leaves with hairless and roughly elliptical turn yellow when old and when it's young, the color was apple green but shows a pink color when hit with direct sun [17]. The seeds or propagules develop on their parent trees through the fruits but once mature, the seeds disperse themselves but without the weight on the other end makes it difficult to root itself into the mud [17].

5.4. *Nipah* forest

Nypa fruticans live in small and sometimes large colonies with features with no trunks but only rhizomes (the underground stem) [18]. This type of mangrove belongs to Palmae family [19–23] and other researchers also said that belongs them to Arecaceae family [21,24]. *Nypa* loves to live in brackish water environments thus it is also called "the mangrove palm" [20,25–27]. Their leaves can be identified easily as they are different from any other mangrove tree leaves. The leaves are called fronds that have a palm or feather-like appearance and are about 5 cm to 9 cm long, but some fronds may be leaning away from the center of the growing plants [18]. For them to germinate, the seeds that are inside the globular shaped fruit which are in chestnut brown color will break away when ripe with its fibrous coating. This coating helps in floating on the swamps' water which then will germinate itself when they reach the muddy soil banks [18]. Another feature that is unique other than the other mangrove trees is that the rhizome area can resist any water flow without causing it to move around.

5.5. *Nipah-Dungun* forest

This type of mangrove tree has been listed as 'endangered' on the IUCN Red List of Threatened Species [28]. This tree can only grow up to 20 m to 35 m tall only as the bole is usually short with a diameter of 100 cm [29]. However, it has a dense canopy thus it stays evergreen. The buttress roots appear extending like a snake about 200–400 cm from the tree itself [30].

5.6. *Pedada* forest

Soneratia casseolaris is surrounded by vertical roots that arose from the muddy soil like pencil-like structure called pneumatophores, this evergreen tree has grown up to 15 m to 20 m tall. It mostly can be found on coastal mangrove communities especially with a slow water movement [31,32]. Their leaves have been marked to have a 'tidy' appearance and give a beautiful columnar crown. Each of the leaves are short-stalked and has a leathery texture. The leaves have length of 4.5–13 cm and width of 1.5–7 cm that gives it the shape of an oval to drop-shaped [33]. Their large bat pollinated with dark-petals flowers can be seen at the end of the leafy branches of the trees. With its scent like sour milk has attracted the bats and moths with moreover they only bloom for one night. But according to Giesen [15], the flowers are visited by the bees and birds at dawn also as it has powderpuff features that come with pinkish white stamens. The green globular fruit has its own flattened cup-like structure to hold them, and they also have a leathery texture on them. When it falls onto the water, it floats away as the seed has its own buoyancy structure. Their young fruits are sour and can be used to flavor curries and chutneys according to [34].

5.7. *Nibong* forest

Oncosperma tigillarium belongs to the Arecaceae (Palmar) family and they grow in clusters that are mostly found in coastal areas of Southeast Asia. With a maximum height growth of 30 m as they need full coverage of sun, their trunks are slender with 15 cm in diameter, and some say it may grow up to 25 cm [35,36]. The trunks can be observed in greyish, light brown in color with their visible leaf scar rings that are black in color that spread like spines all over the plants. The crown shaft is in light green color that connects with its foliage that appear as feather-shaped (fronds) as arched with drooping leaflets which appear in shades of green [36,37]. Just as any other trees, to germinate, they also grew their own flowers and fruits. Their flowers are yellow that can grow for 80 cm long which have emerged from the fronds and arranged in groups of 3, 2 male flowers: 1 female flower. In other countries they will bloom only during summer. While for their globose fruits, they turn purple-black when ripe, as for other countries they will only bloom during winter season [36,37].

6. The importance of mangrove forests to ecosystems and humans

Mangrove forest in Brunei Darussalam used to become the major sources of wood and firewood [38]. Mangroves are known as the rainforest of the sea [39]. Thus, it also acts as a good exporter of nutrients to their nearby systems, especially to the marine organism which makes them their food base as well as their nursery and breeding grounds. Mangroves also act as surges and strong winds breaker in the river if there were storms involved. Along the riverbanks, when there were mangrove trees growing, it helps in preventing extremes erosion of the banks [40] (**Table 2**).

Table 2. Explaining the properties and characteristics of mangrove forests' species.

Mangrove forests	
Rhizophora sp. i) *R. apiculata* (*Bakau minyak*) ii) *R. mucronata* (*Bakau kurap*)	Leaves: eye-shaped (8–15 cm long): older - have black spots distributed evenly - cork warts. Flower: only on hard & thick calyx: petals - thin & fall off soon after blossoming. Fruit: brown & long propagule (on parent tree). Roots: 1) stilt roots: arches from lower trunks; 2) prop roots: grow downwards from branches. Human uses: firewood, charcoal, tannins, toughen fishing lines & ropes, pilings, house frames, building fish traps and timber.
Xylocarpus sp. *X. granatum* (*Nyireh bunga*)	Trunk*:* 3–8 m to 20 m tall: bark-smooth, reddish orange, flaking off in patches: blotchy - resembles camouflage uniforms. Leaves: comprising 2–4 pairs of leaflets (3.5–12 cm long). : oval/oblong (tip rounded rather than sharp). : thick & leathery. : in spiral. : orange red. Flower: tiny (0.5 cm), white to pinkish in clusters on an inflorescence. : has a 'strong but pleasant scent'. : pollinated by bees. : bloom seasonally. Fruits: globular & large (10–25 cm in diameter). : cannonball/bowling ball shape. : has a brown & corky seeds (8–10 seeds). : developed rapidly - one fruit per inflorescence. : ripe fruit may be up to 2–3 kg each, which then splits open & drops releasing seeds. Roots: older trees - enlarged of well-developed buttress roots: narrow ribbon-like extending away from the trunk. *Granatum means full of seeds. Human uses*:* timber, firewood, tanning and medicinal uses: bark - dysentery: roots - cholera: seeds - various ailments.
Bruguiera *B. gymnorrhiza* (*Linggadai*)	Trunk: 10 m tall. : crown conical at first, then irregular. : rough, black bark. : from green at young to grey, glossy & hairless. Leaves: opposite, crowded at the ends of branches. : roughly elliptical & hairless. : young leaves - glossy apple green. : old leaves - yellow. : margins plain-not toothes/scalloped, slightly rolled under. : tip pointed but without spine-base narrowed. : fall early. Flowers: 40 mm long. Petals: creamy white. Sepals: green in shade & pink in light. Fruits: fleshy berry - 25 mm long. : germinating on tree - ribbed, brown hypocotyl -110 mm long. Roots: knee-roots. *Trees grow slowly & probably quite long-lived. Human uses: tanning and yields a black dye.

Table 2. (*Continued*).

Mangrove forests	
Nypa fruticans (*Nipah*)	Trunk: lack of trunks. Leaves: palm-shaped (5–9 cm long). Flowers: appear on a long stalk (1 m) - inflorescence. : male - long spike. Ripe: golden yellow with sticky pollen. : encased in bracts - resemble a cone. Fruits: chestnut brown - globular shape (20–25 cm). : each fruit bears one seed - germinate while on parent tree - starts to fall off: seedling out from trunk. : seedling - fibrous coating - helps in floating. Roots: mostly horizontal & underground - rhizome. : 70 cm in diameter - creeping in mud. : shoots emerge from stem. : can resist swift running water better than other mangrove trees species. Human uses: historically provided useful products to indigenous people living near or in the coastal & estuarine mangrove forest. Cigarette wrappers, roof thatching, roof of boats, umbrella, sun-hat, raincoat, basket, mat, bags, floats of fishnets, fishing poles, brooms, ropes, firewood, food, vinegar, biofuel, alcohol and for medicinal. Purpose: herpes, tooth-ache, headache.
Nypa-heritiera (*Nipah-Dungun*)	Trunk: 20–50 m tall Roots: short bole - 100cm in diameter. : ridge like buttress: 250–350 cm tall. : extending snake-like: 200–400 cm from the tree. Human uses: flooring, interior finishing, furniture, panelling, general planking, plywood manufacture and rice-pounding blocks native boats.
Soneratia *S. caseorolaris* (*Pedada*)	Trunk: brown to grey-slightly fissured. : 15–20 m tall. Leaves: branches droop - crown resembles weeping willow. : shortly stalked, leathery leaf blades - vary from oval to drop-shaped. : 4.5–13 cm by 1.5–7cm. Flowers: dark-red -1.5 cm wide : pinkish white stamens, filamentous & powderpuff-like when fully open. : ends of leafy branches - open at dusk - last only for 1 night. : butter/sour milk-nectar rich smell. Fruits: round & leathery berries - 7.5cm wide. : seated on flattened, cup-like petals. : buoyant, water-dispersed, irregular shape - 7mm long. Human uses: food: edible fruits, leaves & flowers. vinegar, chutneys & curries, clear jellies (pectin from fruits). Medicine: against intestinal worms and treat coughs, sprains, swellings, smallpox, and timber.
Oncosperma otigillarium (*Nibong*)	Trunk: up to 25 cm - diameter: 10–25 cm. : slender, straight/slightly curved. : greyish, light brown color. Leaves: scar-rings-long downward/horizontally spreading. : black spines - flat: 2.5–6.5 cm long. : crown shaft - light green - 1.5 cm long. : 2.4 cm long -elegantly arched, finely pinnate with sharp dropping leaflets. : uniformly distributed on the rachis & long in the median part: 50 cm. Flowers: ramified & thorny. : blooming season-summer. Fruits: globose -12 mm in diameter. : green to blackish when ripe. : blooming season - winter. Human uses: fish traps and timber.
	Sources: Forestry Dept (2011), Fisheries Dept website, Wild Sinapore website, NParks (2023) and Fern (2023).

7. Forest reserve for mangrove forest

Reserving forest areas is important to protect the pristine forests from any exploitation from human activities. Thus, laws and regulations have been implemented. In Brunei, mangrove forest especially at the Temburong area, have been gazette into forest reserve such as at the Selirong and Labu [13]. Those two areas are named as "Selirong Forest Reserve" (SFR) and "Labu Forest Reserve" (LFR). SFR is composed of 2409 hectares in which 94% of its surface area were occupied by mangrove while LFR composed of 5124 hectares of mangroves in which covers the northern and western parts of the LFR [13].

8. Conclusion

Brunei Darussalam has an area of 576,532 ha and Temburong District's tree covers of 124 kha and as for the mangrove forest in Brunei Darussalam, especially at the Temburong District has covered 12,164 km^2 out of 18,418 hectares. That covers around 66% of the mangrove forest cover of Brunei in total. Forest cover in Brunei has decrease in tree coverage, and one of the reasons would be due to forest fires which affects mostly at Belait District of total 13.4 kha as of 2001 to 2020. Temburong is known as the "green jewel" of Brunei Darussalam, and it has many places of interest that mostly covers the natural environment. One of the places are known as Ulu Temburong National Park that are located at Batu Apoi Forest Reserve, in which they are covered of mixed dipterocarp forest and montane forest. The other places of interest are part of the forest reserves in Brunei Darussalam in which they are known as Selirong Forest Reserve and Labu Forest Reserve. This area is covered by mangrove forest. The mangroves area at Temburong has been divided for conservation, preservation, and environmental protection. At Selirong Forest Reserve, *Bakau* species are the most dominant with other subtypes of *Nyireh bunga* species. As for Labu Forest Reserve, it has *Rhizophora* species, *Xylocarpus granatum*, *Bruguiera gymnorhiza*, *Nypa frutican*, *Heritiera globose*, *Oncosperma tigillarium* and *Sonneratia caseolaris*. As mangrove forests are easy to exploit, thus implementing laws and regulations are important to protect it from extreme human activities as mangrove forest becoming one of the major sources of wood and natural habitat for marine organisms for eating ground and breeding ground. Another importance of mangrove forests is as wind breaker and helps in preventing extreme erosion of riverbanks. It was hope that by implementing laws and regulations as well as preserving the mangrove forests, it might reduce the loss of natural habitat for the marine biodiversity for the future generations. By preserving the present environment, the future generations may be able to enjoy and appreciates on today's beautiful natural environment.

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References

1. Forestry Department. Sustainable Forestry in Brunei Darussalam. Borneo Printers & Trading; 2011.
2. Goldsmith FB. Tropical Rain Forest: A Wider Perspective. Springer Dordrecht; 1998.
3. Information Department. Brunei-Muara District. Brunei Darussalam: English News Division, Information Department Prime Minister's Office; 2010.
4. Information Department. Tutong District. Brunei Darussalam: English News Division, Information Department Prime Minister's Office; 2013.
5. Information Department. Belait District. Brunei Darussalam: English News Division, Information Department Prime Minister's Office; 2011.
6. Brunei Darussalam-forest area. Available online: https://knoema.com/atlas/Brunei-Darussalam/topics/Land-Use/Area/Forest-area (accessed on 8 October 2023).
7. Temburong. Available online: https://factsanddetails.com/southeast-asia/Brunei/sub5_10d/entry-6744.html (accessed on 12 July 2023).
8. Information Department. Temburong District. Brunei Darussalam: English News Division, Information Department Prime Minister's Office; 2011.
9. Rasidah HAB. Temburong bridge opens to traffic today. Available online: https://thescoop.co/2020/03/17/temburong-bridge-opens-to-traffic-today/ (accessed on 12 July 2023).
10. Usa I. Brunei Mineral, Mining Sector Investment and Business Guide. International Business Publications; 2019. p. 237
11. Pulau Selirong Forest Recreation Park. Available online: http://virtual-bruneidarussalam.blogspot.com/2014/07/pulau-selirong-forest-recreation-park.html (accessed on 12 July 2023).
12. Zamora PM. Mangrove resources of Brunei Darussalam: Status and management. In: Silvestre G, Matdanan HGH, Sharifuddin PHY, et al. (editors). The Coastal Resources of Brunei Darussalam: Status, Utilisation and Management, Proceedings of the ICLARM Conference; Department of Fisheries, Ministry of Industry and Primary Resources, Bandar Seri Begawan, Brunei Darussalam and International Center for Living Aquatic Resources Management, Manila, Phillipines; 1992. pp. 39–58.
13. Chua TE, Chou LM, Sadorra MSM. The Coastal Environmental Profile of Brunei Darussalam: Resource Assessment and Management Issues. The International Center for Living Aquatic Resources Management (ICLARM); 1987.
14. Bakau. Available online: http://wildsingapore.com/wildfacts/plants/mangrove/rhizophora/rhizophora.htm (accessed on 8 October 2023).
15. Mangrove cannon-ball tree or Nyireh bunga. Available online: http://wildsingapore.com/wildfacts/plants/mangrove/xylocarpus/granatum.htm (accessed on 8 October 2023).
16. Nipah palm. Available online: http://www.wildsingapore.com/wildfacts/plants/mangrove/nypa/nypa.htm (accessed on 8 October 2023).
17. Glen HF. Bruguiera gymnorrhiza (L.) Lam. Available online: https://pza.sanbi.org/bruguiera-gymnorrhiza (accessed on 8 October 2023).
18. Tsuji K, Ghazalli MNF, Ariffin Z, et al. Biological and ethnobotanical characteristics of Nipa palm (Nypa Fruticans Wurmb.): A review. Sains Malaysiana 2011; 40(12): 1407–1412.
19. Burckill IH. "Nipa". In A Dictionary of the Economic Products of the Malay Peninsula, Vol 2. 1935. pp. 1557–1561.
20. Corner EJH. Wayside Trees of Malaya, 4th ed. Malayan Nature Society; 1997.
21. Gee CT. The mangrove palm Nypa in the geologic past of the New World. Wetlands Ecology and Management 2001; 9: 181–203. doi: 10.1023/A:1011148522181
22. Jian S, Ben J, Ren H, Yan H. Low genetic variation detected within the widespread mangrove species Nypa fruticans (Palmae) from Southeast Asia. Aquatic Botany 2010; 92(1): 23–27. doi: 10.1016/j.aquabot.2009.09.003
23. Uhl NW, Dransfield J. Genera Palmarum. Allen Press; 1987.
24. Hamilton LS, Murphy DH. Use and management of Nipa palm (Nypa fruiticans, arecaceae): A review. Economic Botany 1988; 42: 206–213. doi: 10.1007/BF02858921
25. Baja-Lapis AC, David ME, Reyes CG, Audije BS. ASEAN's 100 Most Precious Plants. The European Commission; 2004.
26. Tomlinson PB. The Botany of Mangroves. Cambridge University Press; 1986.
27. Whitmore TC. Palms of Malaysia. Oxford University Press; 1973.

28. Fern K. Heritiera globosa. Available online: https://tropical.theferns.info/viewtropical.php?id=Heritiera+globosa (accessed on 8 October 2023).
29. Kostermans AJGH. A monograph of the genus Heritiera*, Aiton** (StercuL). Reinwardtia 1959; 4(4): 465–583. doi: 10.55981/reinwardtia.1959.991
30. Fern K. Xylocarpus granatumm. Available online: https://tropical.theferns.info/viewtropical.php?id=Xylocarpus+granatum (accessed on 8 October 2023).
31. Sonneratia caseolaris-(L.) Engl. Available online: https://pfaf.org/user/Plant.aspx?LatinName=Sonneratia+caseolaris (accessed on 8 October 2023).
32. Oncosperma tigillarium. Available online: https://www.nparks.gov.sg/florafaunaweb/flora/2/6/2659 (accessed on 8 October 2023).
33. Bruguiera gymnorrhiza (L.) Lam. Available online: https://www.nparks.gov.sg/florafaunaweb/flora/3/2/3260 (accessed on 12 May 2023).
34. Burkill IH. A Dictionary of the Economic Products of the Malay Peninsula. Ministry of Agriculture, Malaysia; 1993. pp. 1241–2444.
35. Sonneratia caseolaris (L.) Engl. Available online: https://www.nparks.gov.sg/florafaunaweb/flora/3/3/3343 (accessed on 8 October 2023).
36. Oncosperma tigillarium. Available online: https://palmpedia.net/wiki/Oncosperma_tigillarium (accessed on 8 October 2023).
37. Xylocarpus granatum J. Koenig. Available online: https://www.nparks.gov.sg/florafaunaweb/flora/4/8/4836 (accessed on 8 October 2023).
38. Lim TS, Sharifuddin PM. Charcoal production on Brunei. Brunei Mus.J. 1975; 3(4): 201–220.
39. Quarto A. The mangrove forest: Background paper. Available online: https://ramsar.org/fr/node/39069 (accessed on 8 October 2023).
40. Hamid HLHA. Brunei Darussalam: Mangrove-friendly aquaculture. In: Primavera JH, Garcia LMB, Castaños MT, et al. (editors). Mangrove-Friendly Aquaculture, Proceedings of the Workshop on Mangrove-Friendly Aquaculture; 11–15 January 1999; Iloilo City, Philippines. Southeast Asian Fisheries Development Center, Aquaculture Department; 2000. pp. 95–103.