THE **SEBERANG PERAI PROJECT - PEMERKASAAN KOMUNITI TEMPATAN UNTUK PEMBANGUNAN EKO-PELANCONGAN YANG MAMPAN DI SEBERANG PERAI UTARA, PULAU PINANG** UNDER THE SEBERANG PERAI SMALL TOWNS GRANTS PROGRAMME

Grant Award No: SPG/179

THIRD MILESTONE REPORT

30 OCTOBER 2025

By: Malaysian Nature Society (MNS), Penang Branch

1.0 PROGRESS REPORT

The survey and detailed report on the mangrove plant survey is completed (Chapter 3.0, this report). The first draft report on herpetofauna on survey done in Phase 1 is also included (Chapter 5.0, this report). However, for item no.2 [Workshop plan, outline and curriculum to include items 2(a),(b),(c) and (d)] has been delayed. Updates on item no.2 will be supply by Mr. Tan Choo Eng at a later date.

2.0 WORKSHOP PLAN, OUTLINE AND CURRICULUM TO INCLUDE:

A. RESEARCH PLAN

B. ECO-TOURISM TRAINING WITH SPG 176 TO INCLUDE BIRDING, MANGROVE EXCURSIONS, KAMPUNG EXPERIENCE AND WILDLIFE SPOTTING (E.G., KUALA SEPETANG, BIRD ISLAND)

C. SITE MANAGEMENT PLAN

D. WEBSITE

TO BE SUBMITTED BY MR. TAN CHOO ENG ON A LATER DATE

3.0 DETAILED REPORT ON MANGROVE PLANT SURVEY (PREPARED BY DR. FOONG SWEE YEOK)

3.1 Introduction

At the convergent of terrestrial and marine environments in the tropics, mangrove ecosystems thrive on a unique habitat condition where it supports specialized flora and fauna. In Malaysia, these coastal zones are dominated by trees and a few shrubs which have evolved to adapt to fluctuating salinity, tidal cycles, soft substratum and varying

water levels. Despite being scarce (only cover around 1% of total land area of Penang), mangrove ecosystems carry invaluable services such as providing coastal protection against strong wave/tsunami, maintenance of coastal water quality, as nursery and feeding ground for fisheries, and as important habitat for fauna especially the migratory birds. Besides these, mangrove ecosystems of TAT-KM provide high education and ecotourism values by offering a sustainable way to generate revenue while conserving natural resources and supporting local communities. A recent estimation exercise completed price-tagging (in economic sense) the ecosystem services provided by TAT-KM, to better inform decision makers on the importance of mangroves. The analysis based on TESSA (Toolkit for Ecosystem Service Site-based Assessment, Peh et al., 2013) totalled more than US$23 million worth of blue carbon stored on the above ground (mainly tree biomass) and below ground (carbon rich mud substratum) in TAT-KM mangrove forests. Another US$7 million/annual of value was estimated from services in the form of harvested wild goods (mainly fishery landings), coastal protection, water quality improvement and nature-based tourism (Foong et al., 2016). Conversion of TAT-KM mangrove forests to aquaculture farms (the most plausible threat) will turn the site from carbon sink to carbon source, which significantly worsens the climate change problem. Mangroves are remarkably efficient "blue carbon" ecosystems that store vast amounts of carbon, particularly in their waterlogged soils, which is released when the forests are cleared, soil drained and exposed as in the practise of coastal aquaculture.

Our team had carried out measurements on mangrove trees' parameters such as the species, density and plant biomass which are crucial for assessing forest health because these are the main indicators of an ecosystem's overall productivity, stability, and resilience. These measurements provide a snapshot of the forest's condition and help track changes over time, which is essential for effective conservation and management.

3.2 Methods

Between November 2024 to May 2025, a total of 51 site survey spots (Figure 3.1), and another 5 detailed study plots were carried out (Figure 3.2) to discern forest condition at different geology locations and tidal ranges in TAT-KM.

Figure 3.1: Survey spots on foot (yellow placemats) Survey spots by boat (blue placemats)

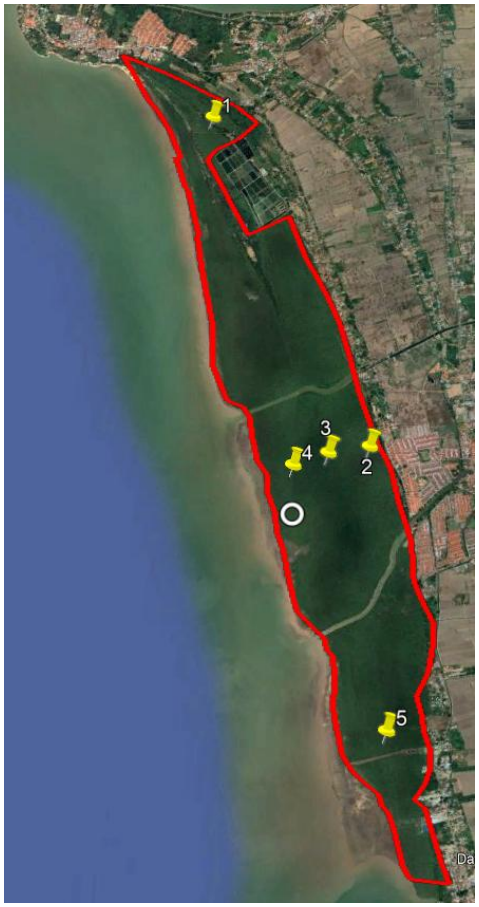


Figure 3.2: Five study plots for forest structures and soil parameters analysis.

3.2.1 General ground survey

As shown in Figure 3.1, around 50 site survey were carried out to identify mangrove plant and its associated species, and to check on the forest health such as disease and abiotic disturbance (especially erosion and changes in seawater inundation pattern). Field guides on mangrove species identification were based on Wan Juliana et al. (2010), Sabah Forestry Department (2010), Ng et al. (2002) and Tam & Wong (2000).

3.2.2 Mangrove Primary Productivity

Another 5 study plots, each measuring 314.16 m^2 in area (10 meter in radius) were set up in the field (Figure 3.2) to collect data on soil parameters (pH, salinity, surface temperature, soil water content, soil carbon content), plant biomass and plant health. These data were collected in situ and analyzed in the laboratory following methods and allometric equations in Ong et al. (1985), Pearson et al. (2007), Walker et al. (2018) and Komiyama et al. (2005).

Soil samples were collected using a 5 cm-diameter soil gouge auger, pushed to a depth between 0 cm and 70 cm. Soil pH and soil surface temperature was measured using a WateNV 230415 pH meter. Soil interstitial salinity was measured with REF211ATC Refractometer. Approximately 300 grams of soil samples were collected for subsequent chemical analysis in the laboratory. To determine soil's percentage of carbon content, soil samples were dried in a muffle furnace set at 500°C. A Van Bemmelen factor (0.58, Heaton et al., 2016) were then used to estimate soil organic carbon content (SOC).

To assess the biomass sequestered in mangrove trees, we measured the density of trees and saplings by recording the Diameter at Breast Height (DBH) at 130 cm above the ground in each study plot. Trees with DBH ≥5 cm were classified as tree and saplings with DBH less than 5 cm.

3.3 Results

3.3.1 General ground survey

Site mapping (including historical maps) and conservation status of the study site were presented in Milestone Report 2 and will not be repeated in this report. Survey results of the study sites hereon will be sectioned based on the gazettement parcels as in the Government of Penang Gazette, Jil 66, 15 December 2022. No.49. National Forestry (States of Malaysia)(Adoption) Enactment 1986, No.1291: **Figure 3.3** (Northern section, Pasir Gebu mangrove), **Figure 3.4** (Middle section, Lahar Endin mangrove) and **Figure 3.5** (Southern section, Kuala Bekah mangrove).

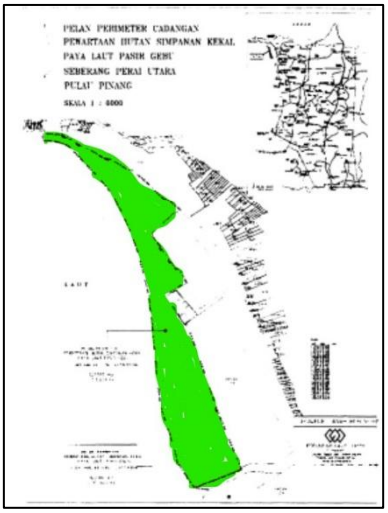


Figure 3.3

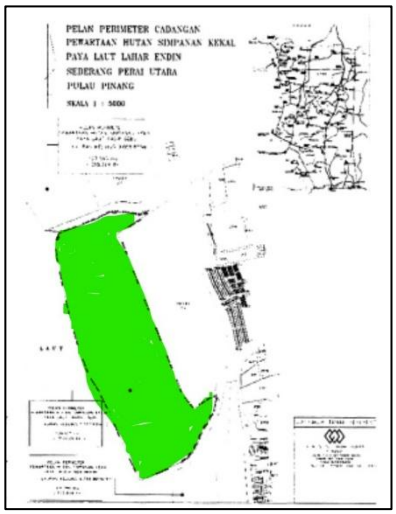


Figure 3.4

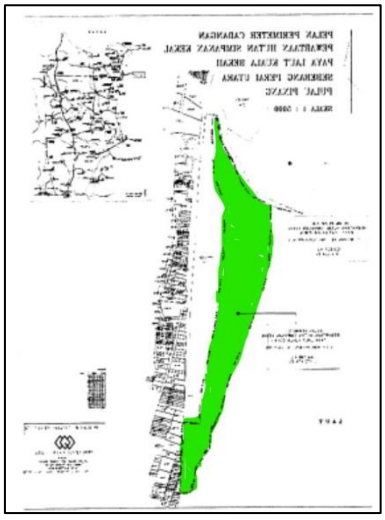


Figure 3.5

3.3.1.1. Pasir Gebu Gazetted Permanent Reserved Forest

This northern part of TAT-KM is bordered by Sungai Muda in the north and Sungai Tembus in the south. The northern coast was categorised as 'mix sand-mud beach'. The landward shore above the highest mean sea-level (HMSL) is mostly sandy (as shown in Permatang Kuching in Figure 3.7). Lower in the intertidal zone is dominated by mud (Figure 3.7 and Figure 3.6c). The historical maps of Seberang Perai show the sandy beaches were broadest near the mouth of Sungai Muda back in the 1970 arial map (Abd.Hadi et al., 2000). As this stretch of coast were exposed to severe erosion impacts, major beach filing exercise were done in the late 1990s with the placement of granite boulder groins (Figure 3.8). With the changes in longshore drifts, 2003 Indian Ocean Tsunami and other anthropogenic activities, the hydrodynamics in this coastal zone have resulted in mud accretion and encouraged the growth of mangrove trees.

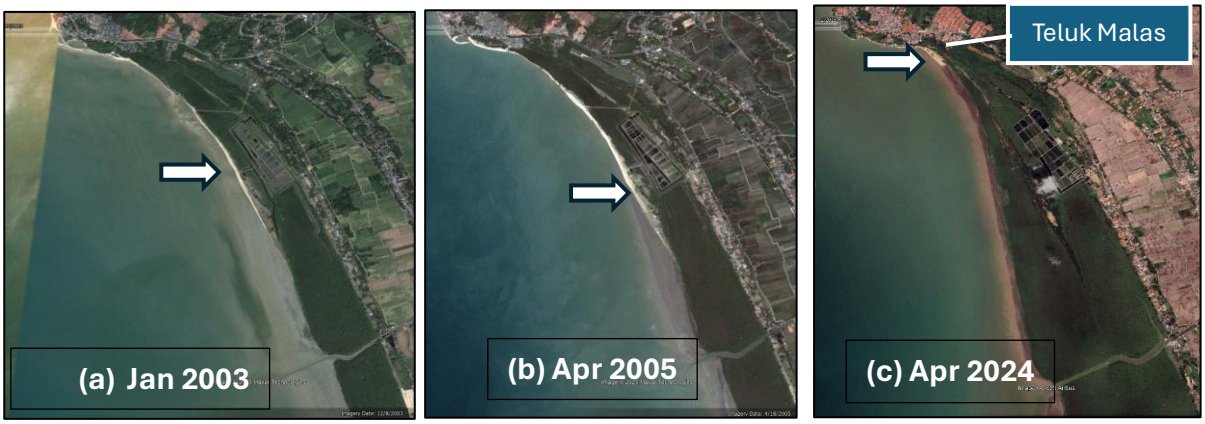


Figure 3.6: The dynamics of sandy shore (white arrows) and accretion of mud that has led to the increase in mangrove acreage: **(a)** White sandy beaches stretched from the mouth of Sungai Muda to Permatang Kuching, 2003; **(b)** Sandy beaches expanded shortly after the Indian Ocean 2024; **(c)** Current status of land cover shows mud and mangrove accretion with coarse sandy beaches confined to Teluk Malas in the north (as of Oct 2025).

Figure 3.7: Mix sandy-mud shore at the northern tip of TAT-KM, Teluk Malas (Coarse sandy on higher intertidal zone as shown in Red arrow; muddy shore in Yellow arrow)

Figure 3.8: Granite groins were placed since 1998 as erosion control and to stabilize the shoreline south from Teluk Malas (Red arrows).

The coast near Teluk Malas (5° 34'N, 100° 21'E) is the only stretch of sandy beach in Pasir Gebu Gazetted Permanent Reserved Forest. The lowest intertidal mud flat is important stop over area for the sea birds. The intertidal zone of coarse sandy beaches is void of vegetation except immediately south of the Sungai Muda river mouth where we found remnant of *Avicennia marina*, the pioneer species that thrives on lower intertidal zones **(Figure 3.9).** Immediately at the higher and firmer ground landward from the sandy beaches, *Bruguiera cylindrica* grew interspersing with the seafront species *Avicenia marina* (**Figure 3.10 & Figure 3.11**).

Figure 3.9: Remnants of *Avicennia marina* on the sandy beaches at Teluk Malas

Figure 3.10: Higher intertidal zone At Teluk Malas with firmer substratum: Healthy belt of *Bruguiera cylindrica* and *A. marina* mangrove tree growing parallel to the shoreline (Yellow arrow=mud flat; Red arrow = sandy beaches; Green arrow= mangrove belt).

Figure 3.11: *Bruguiera cylindrica* (Blue arrow) interspersing with the pioneer species *Avicennia marina* (Red arrow) at Teluk Malas.

Behind these belts of *A.marina* & *B. cylindrica* true mangrove line running parallel to the shoreline, a species-diverse back mangrove forest thrives with record of 24 species (Table 3.1). 10 out of these 24 species were exclusive mangroves which are restricted to mangrove habitat, and the other 14 species were non-exclusive and could be found in other ecosystems.

Table 3.1: Species list of mangrove plants in Pasir Gebu Gazetted Permanent Reserved Forest. (Type: E=Exclusive mangrove; N=Non-exclusive mangrove)

No.	Species	Local name	Family	Type	Figure
1	*Acanthus ebracteatus*	Jeruju putih	Acanthaceae	E	3.12
2	*Acrostichum aureum*	Piai raya	Pteridaceae	E	3.13
3	*Aganope heptaphylla*	Omis-omis	Leguminosae	N	3.14
4	*Amaranthus spinosa*	Bayam duri	Amaranthaceae	N	3.15
5	*Avicennia marina*	Api-api jambu	Avicenniaceae	E	3.16
6	*Azadirachta indica*	Pokok neem	Meliaceae	N	3.17
7	*Brownlonia tersa*	Dungun air	Malvaceae	N	3.18
8	*Bruguiera cylindrica*	Baku putih, berus	Rhizophoraceae	E	3.19
9	*Casuarina equisetifolia*	Sea pine, pokok Rhu	Casuarinaceae	N	3.20
10	*Clerodendrum inerme*	Tulang-tulang	Verbenaceae	N	3.21
11	*Croton bonpladianus*	Jungle Tulsi (India)	Euphorbiaceae	N	3.22
12	*Derris trifoliata*	Malapari, Salang, Setul	Leguminosae	N	3.23
13	*Ehretia microphylla*	Philippine tea tree	Boraginaceae	N	3.24
14	*Excoecaria agallocha*	Buta-buta	Euphorbiaceae	E	3.25
15	*Hibiscus tiliaceus*	Berbaru	Malvaceae	N	3.26
16	*Lumnitzera racemosa*	Teruntum putih	Combretaceae	E	3.27
17	*Nypa fruticans*	Nipah	Palmae	E	3.28
18	*Ochrosia oppostifolia*	Twin apple	Apocynaceae	N	3.29
19	*Pandanus odoratissimus*	Pandan laut	Pandanaceae	N	3.30
20	*Rhizophora apiculata*	Bakau minyak	Rhizophoraceae	E	3.31
21	*Senna alata*	Candle bush	Leguminosae	N	3.32
22	*Sonneratia alba*	Gedabu, Perepat	Sonneratiaceae	E	3.33
23	*Sonneratia caseolaris*	Berembang	Sonneratiaceae	E	3.34
24	*Wallastonia biflora*	Seremai, Serenah, Srunai, Sunai laut	Compositae	N	3.35

Landward from the Pasir Gebu Gazetted Permanent Reserved Forest is the stateland mangrove forest. Around 28.5 hectares of this stateland forest is leased for aquaculture purposes since the late 1990s. The dominant mangrove species found here was *Avicennia marina* (95%), interspersing with *Bruguiera cylindrica* and a few *Excoecaria agallocha*.

Figure 3.12: *Acanthus ebracteatus*

Figure 3.13: *Acrostichum aureum*

Figure 3.14: *Aganope heptaphylla*

Figure 3.15: *Amaranthus spinosa*

Figure 3.16: *Avicennia marina*

Figure 3.17: *Azadirachta indica*

Figure 3.18: *Brownlonia tersa*

Figure 3.19: *Bruguiera cylindrica*

Figure 3.20: *Casuarina equisetifolia*

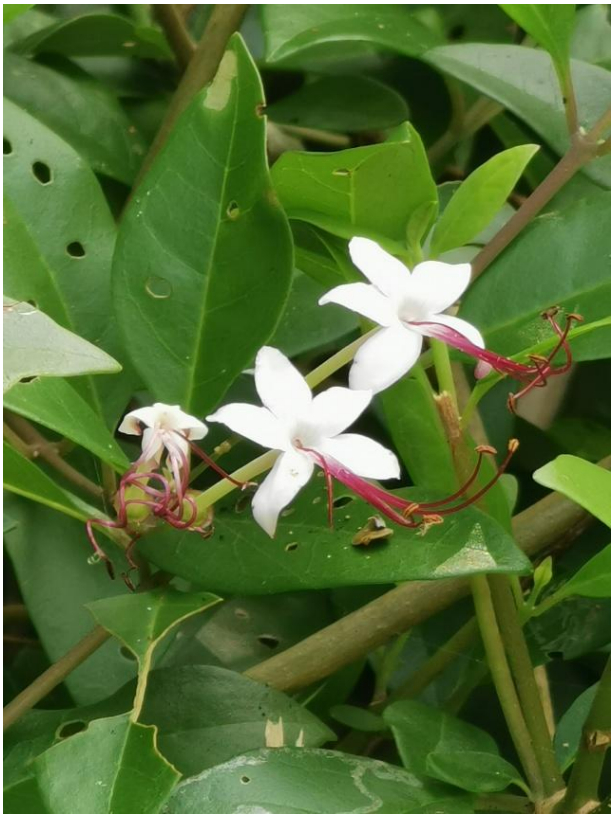


Figure 3.21: *Clerodendrum inerme*

Figure 3.22: *Croton bonpladianus*

Figure 3.23: *Derris trifoliata*

Figure 3.24: *Ehretia microphylla*

Figure 3.25: *Excoecaria agallocha*

Figure 3.26: *Hibiscus tiliaceus*

Figure 3.27: *Lumnitzera racemosa*

Figure 3.28: *Nypa fruticans*

Figure 3.29: *Ochrosia oppostifolia*

Figure 3.30: *Pandanus odoratissimus*

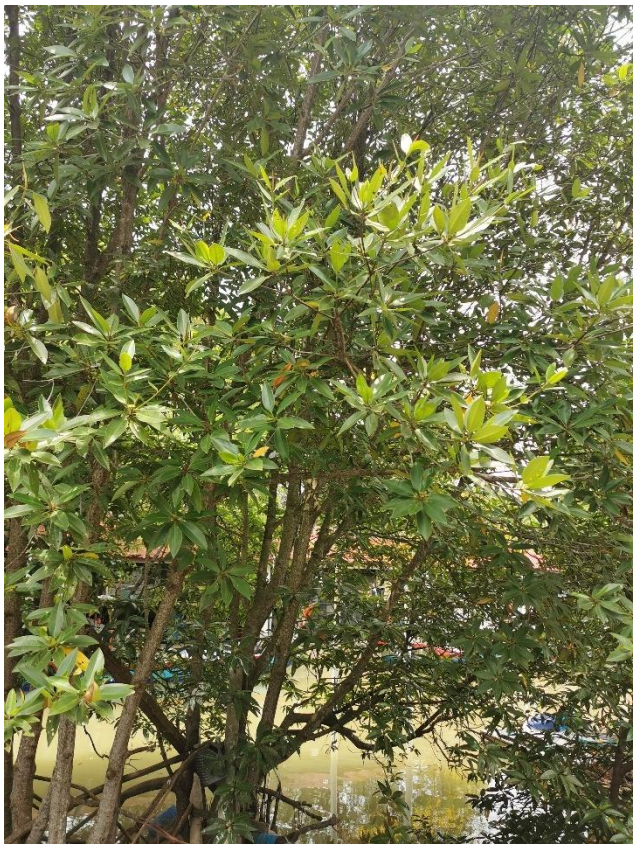


Figure 3.31: *Rhizophora apiculata*

Figure 3.32: *Senna alata*

Figure 3.33: *Sonneratia alba*

Figure 3.34: *Sonneratia caseolaris*

Figure 3.35: *Wallastonia biflora*

3.3.1.2. Lahar Endin Gazetted Permanent Reserved Forest

This middle section of the TAT-KM is bordered by Sungai Tembus in the north and Sungai Abdul in the south. It is the widest and most undisturbed and continuous patch of mangrove forest, consist of almost a pure stand of *Avicennia marina*. Figure 3.36 shows a *Bruguiera cylindrica* tree growing in an almost pure stand of *A.marina* at the mid intertidal zone.

Figure 3.36: *Bruguiera cylindrica* (Blue arrow) among the *A.marina*.

Along the two rivers of Sungai Tembus and Sungai Abdul, more exclusive mangrove trees were recorded growing along the different salinity ranges. From the mouth of the rivers, salt and wave tolerant species such as the *Avicennia marina* (dominant species, Figure 3.37), *Sonneratia alba* (Figure 3.38), *S. caseolaris* (Figure 3.39) and *Avicennia alba* (Figure 3.40) thrive. In the mid intertidal zone, *Rhizophora apiculate* (Figure 3.41), *R. mucronate* (Figure 3.42) and *Bruguiera cylindrica* (Figure 3.43) dominant and *Nypa fruticans* (Figure 3.44) could be found occupying the fresh water ends of the estuaries.

Figure 3.37: *Avicennia marina* remained the dominant mangrove species (90%-95% of forest cover) within the Lahar Endin Gazetted Permanent Reserved Forest and its surrounding state mangrove forests.

Figure 3.38: *Sonneratia alba* totally submerged in rising tide at the mouth of Sungai Abdul with *A.marina* patch at the background.

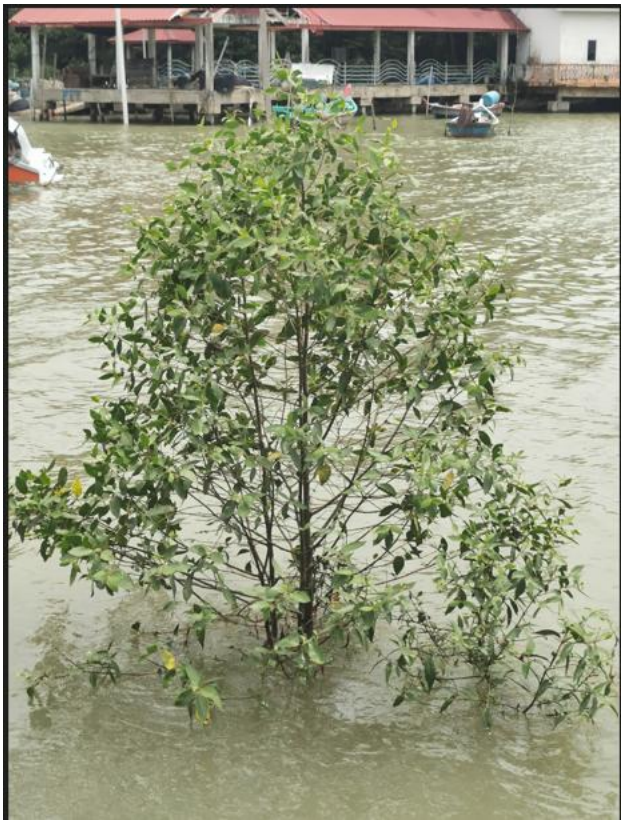


Figure 3.39: *Sonneratia caseolaris* (the Berembang tree as preferred by the mating fireflies), found submerging in high tide at the Sungai Abdul Fishermen Jetty.

Figure 3.40: *Avicennia alba*, another pioneer species. Like the *A.marina*, this api-api putih is able to tolerate longer hours of submerge in lower intertidal zone

Figure 3.41: *Rhizophora apiculata*, the species preferred in charcoal making and thus widely planted in Kuala Sepetang Managed Mangrove Forest. Due to availability of seedlings and ease of maintenance at nursery, this bakau minyak trees were planted in many mangrove rehabilitation projects. However, care should be taken to plant the right species at the right places.

Figure 3.42: *Rhizophora mucronate* (bakau kurap), another species preferred in charcoal making. Grows well at the intertidal zone. However, like the *R. apiculate*, both species do not do well if planted at the lower intertidal zone which is submerged for longer periods and experiences more wave impact and marine-like conditions.

Figure 3.43: *Bruguiera cylindrica* (bakau putih) shares the middle intertidal zone with the *Rhizophora* species was the second most found exclusive mangrove, after *A.marina*.

Figure 3.44: *Nypa fruticans* usually found at the freshwater zone/back mangrove area

As the higher intertidal zones/back mangrove have been reclaimed as housing/industrial area, very little mangrove associated plants were found in this section of TAT-KM (as recorded in Pasir Gebu Gazetted Permanent Reserved Forest). Table 3.2 lists all mangrove (exclusive and non-exclusive) found in Lahar Endin Gazetted Permanent Reserved Forest and its surrounding state land forest.

Table 3.2: Species list of mangrove plants in Lahar Endin Gazetted Permanent Reserved Forest. (Type: E=Exclusive mangrove; N=Non-exclusive mangrove)

No.	Species	Local name	Family	Type
1	*Acanthus ebracteatus*	Jeruju putih	Acanthaceae	E
2	*Acrostichum aureum*	Piai raya	Pteridaceae	E
3	*Avicennia alba*	Api-api putih	Avicenniaceae	E
4	*Avicennia marina*	Api-api jambu	Avicenniaceae	E
5	*Bruguiera cylindrica*	Baku putih, berus	Rhizophoraceae	E
6	*Casuarina equisetifolia*	Sea pine, pokok Rhu	Casuarinaceae	N
7	*Derris trifoliata*	Malapari, Salang, Setul	Leguminosae	N
8	*Excoecaria agallocha*	Buta-buta	Euphorbiaceae	E
9	*Hibiscus tiliaceus*	Berbaru	Malvaceae	N
10	*Nypa fruticans*	Nipah	Palmae	E
11	*Rhizophora apiculata*	Bakau minyak	Rhizophoraceae	E
12	*Rhizophora mucronata*	Bakau kurap	Rhizophoraceae	E
13	*Sonneratia alba*	Gedabu, Perepat	Sonneratiaceae	E
14	*Sonneratia caseolaris*	Berembang	Sonneratiaceae	E
15	*Wallastonia biflora*	Seremai, Serenah, Srunai, Sunai laut	Compositae	N

3.3.1.3. Kuala Bekah Gazetted Permanent Reserved Forest

The smallest patch of forest in the TAT-KM, the Kuala Bekah Gazetted Permanent Reserved Forest faces the most thread from its surrounding state land forest. Encroachment happened since 2003 and the latest were recorded at the year of 2024 (after the announcement of the gazettement). Figure 3.45 shows the encroachment sites as recorded by satellite images dated 5 April 2024. Two patches of mangrove were cleared and one of it turned into oil palm plantation and industrial buildings since 2003 (or maybe earlier, see Figure 3.46 and Figure 3.47). The latest encroachment was to convert the mangrove into aquaculture ponds (Figure 3.48, Figure 3.49 and Figure 3.50). Three of these ponds were surveyed in March 2025.

Figure 3.45: Kuala Bekah Gazetted Permanent Reserved Forest and the encroached sites (red dotted polygons). Google map dated 5 April 2024. Encroachment A: Conversion to aquaculture ponds and with canal excavation (first detected in December 2023); Encroachment B: Conversion to industrial buildings (since 2003); Encroachment C: Conversion to oil palm plantation (since 2003).

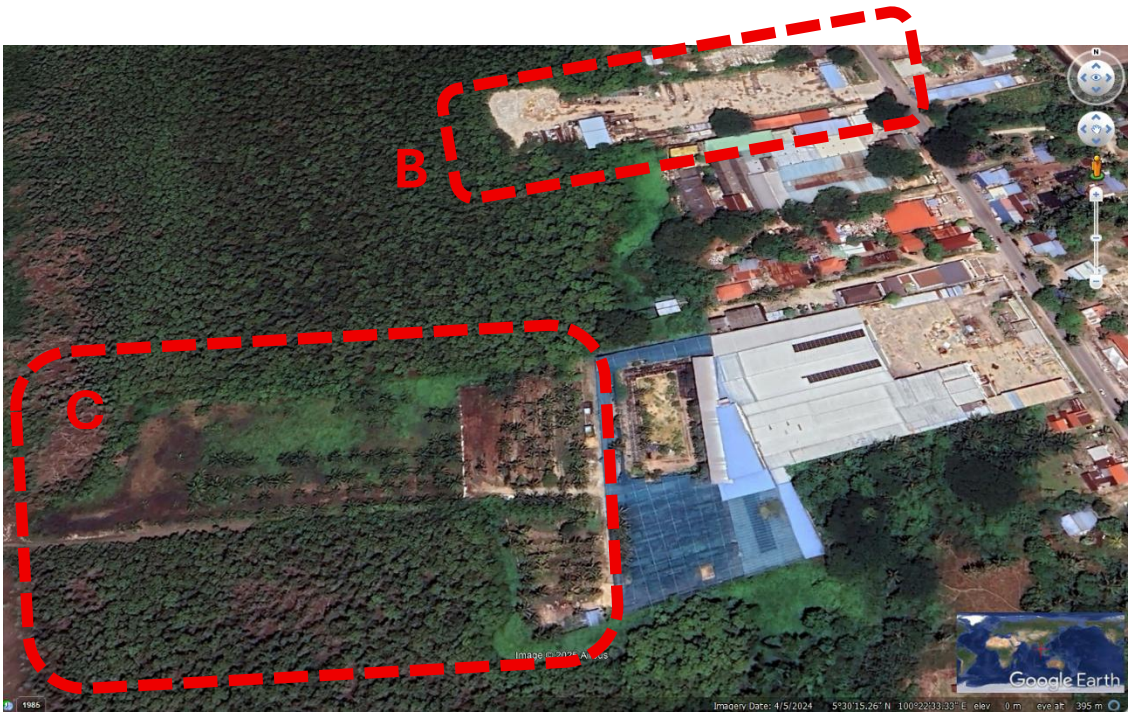


Figure 3.46: Encroachment B and Encroachment C since 2003 (Google map dated 5 April 2024)

Figure 3.47: Encroachment C happened in 2003 (maybe earlier) and since planted with oil palm trees and coconut trees.

Figure 3.48: Encroachment A happened just recently (Google Map first recorded in December 2023). A canal was dug to supply sea water for the aquaculture pond, led to massive damage.

Figure 3.49: More earthworks were captured by the satellite image dated 5 April 2024.

We did a thorough survey of the encroachment A parcel to record the damage. However, no survey was able due to inaccessible of encroachment B and encroachment C. Figure 3.50 shows the 3 ponds excavated since 2023. No aquaculture activity was detected. The extend of the damage was shown in Figure 3.51 that shows a canal with width at least 30 meters were dug, cutting across the mangrove forest towards the sea front 500 meter away. After approximately one year from the last excavation activity at encroachment site A, seedlings of the dominant species, *Avicennia marina* were seen growing along the canal (Figure 5.32). This is a clear sign that provided the surrounding forests are healthy, natural regeneration will take place without the need for human intervention.

Figure 3.50: 3 abandoned aquaculture ponds at Encroachment Site A (5° 30’ 33.64” N, 100° 22’ 30.83” E). Photo dated March 2025

Figure 3.51: A canal with width 30+ meters and length 500+ meters at Encroachment Site A (5° 30’ 33.64” N, 100° 22’ 30.83” E). Photo dated March 2025

Figure 3.51: Natural regeneration of seedlings of *Avicennia marina* at Encroachment Site A canal (5° 30' 33.64" N, 100° 22' 30.83" E). Photo dated March 2025

The surrounding forest were of almost a pure stand of *Avicennia marina* (Figure 3.52) and healthy. However, the open encroached area recorded a few non-exclusive mangrove species such as the *Ipomea pes-caprae* (Figure 3.53) and *Solanum torvum* (Figure 3.54)

Figure 3.52: A healthy pure stand of *Avicennia marina* dominating Kuala Bekah Gazetted Permanent Reserved Forest.

Figure 3.53: Spread of ground dwellers *Ipomea pes-caprae* on the disturbed site in Kuala Bekah Gazetted Permanent Reserved Forest.

Figure 3.54: Records of *Solanum torvum*, a non-exclusive mangrove shrub commonly found on disturbed sites.

3.3.1 Mangrove Primary Productivity and Health Status

Five study plots with each measuring 32 m^2 in area (10 meter in radius) were set up in the field (as shown in Figure 3.2) to collect data on soil parameters (pH, EH, salinity, surface temperature, soil water content, soil carbon content), plant biomass and plant health. These 5 study plots were selected based on tidal ranges (lower, mid and highest intertidal zones) and management parcels (representing all three Gazetted Permanent Reserved Forests in TAT-KM) (Figure 3.2 below). Table 3.3 shows the results of these 5 study plots.

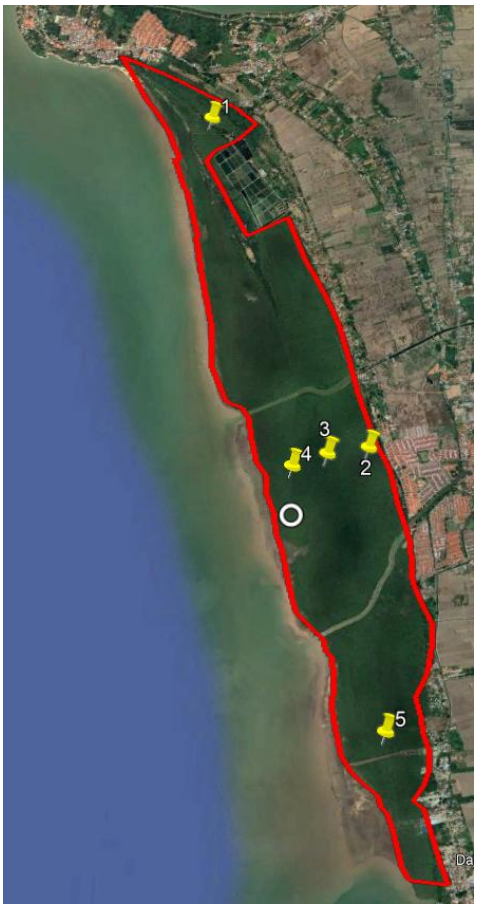


Figure 3.2: Five study plots for the detail mangrove forest productivity study. Drop pin 1= Pasir Gebu; Drop pin 2, 3 and 4 = Lahar Endin; Drop pin 5= Kuala Bekah. Each study plot measured 32 m^2 in area.

Table 3.3: Parameters collected from 5 study plot to discern mangrove trees' primary productivy and also health conditions in TAT-KM.

Parameter	Study Plot				
	1	**2**	**3**	**4**	**5**
Location relative to site	Pasir Gebu Gazetted Permanent Reserved Forests	Lahar Endin Gazetted Permanent Reserved Forests	Lahar Endin Gazetted Permanent Reserved Forests	Lahar Endin Gazetted Permanent Reserved Forests	Pasir Gebu Gazetted Permanent Reserved Forests
Tidal zone	Mid intertidal	Lower intertidal	Mid intertidal	Highest intertidal	Mid intertidal
Forest condition	Disturbed, beside a forest path	Undisturbed	Undisturbed	Undisturbed	Disturbed but rehabilitating
Number of mangrove tree in the study plot (no/32 m^2)	50	60	36	52	30
Number of samplings in the study plot (no/m^2)	18	56	33	37	28
Species of tree	100 % *A.marina*	77% *A.marina*; 23% *B. cylindrica*	100 % *A.marina*	100 % *A.marina*	100 % *A.marina*
Total carbon sequestered in tree biomass (t C ha^{-1})	173	69	98	219	109
Top soil pH	5.27	6.16	6.68	7.18	6.90
Top soil temperature (°C)	27.6	27.4	27.2	27.2	27.6
Top soil salinity (ppt)	20.0	23.3	26.7	23.3	23.3
% Soil Organic Carbon	8.6	6.7	5.6	7.4	7.9
Photo of site	**Figure 3.55**	**Figure 3.56**	**Figure 3.57**	**Figure 3.58**	**Figure 3.59**

Figure 3.55: 10 meter radius study plot at the Pasir Gebu Gazetted Permanent Reserved Forests (Site 1, as in Figure 3.2). Pure stand of *Avicennia marina* (api-api jambu) with mostly adult trees measuring more than 10 meters in height. Regeneration rate was the lowest among all 5 study plots with little seedlings observed. However, soil organic carbon percentage was the highest (8.6%), denotes a high decomposition rate at this higher tidal zone.

Figure 3.56: 10 meter radius study plot at the Lahar Endin Gazetted Permanent Reserved Forests (Site 2, as in Figure 3.2) and the lowest intertidal zone (nearest to the sea). Mixed stand of *Avicennia marina* (api-api jambu) and *Bruguiera cylindrica* (bakau putih) with mostly young trees and saplings measuring less than 10 meters in height. Regeneration rate was the highest among all 5 study plots with dense seedlings/samplings observed, denotes a young and growing population.

Figure 3.57: 10 meter radius study plot at the Lahar Endin Gazetted Permanent Reserved Forests (Site 3, as in Figure 3.2), and at the middle intertidal zone (half way between the sea and terrestrial zone). Almost a pure stand of mature *Avicennia marina* (api-api jambu) and some saplings of *Bruguiera cylindrica* (bakau putih). Regeneration rate was relatively good with average dense seedlings/samplings observed, denotes healthy forest condition.

Figure 3.58: 10 meter radius study plot at the Lahar Endin Gazetted Permanent Reserved Forests (Site 4, as in Figure 3.2), and at the highest intertidal zone (near terrestrial zone). Almost a pure stand of mature *Avicennia marina* (api-api jambu) and some saplings of *Bruguiera cylindrica* (bakau putih). Regeneration rate was not good for the dominant species (*A.marina*), but pockets of very dense *Bruguiera* cylindrica seedlings/samplings observed (orange arrows). This suggest bigger seeds/propagule of *B.cylindrica* were able to be detained in this forest zone but the smaller coin-size *A.marina* seeds were washed away by tidal water.

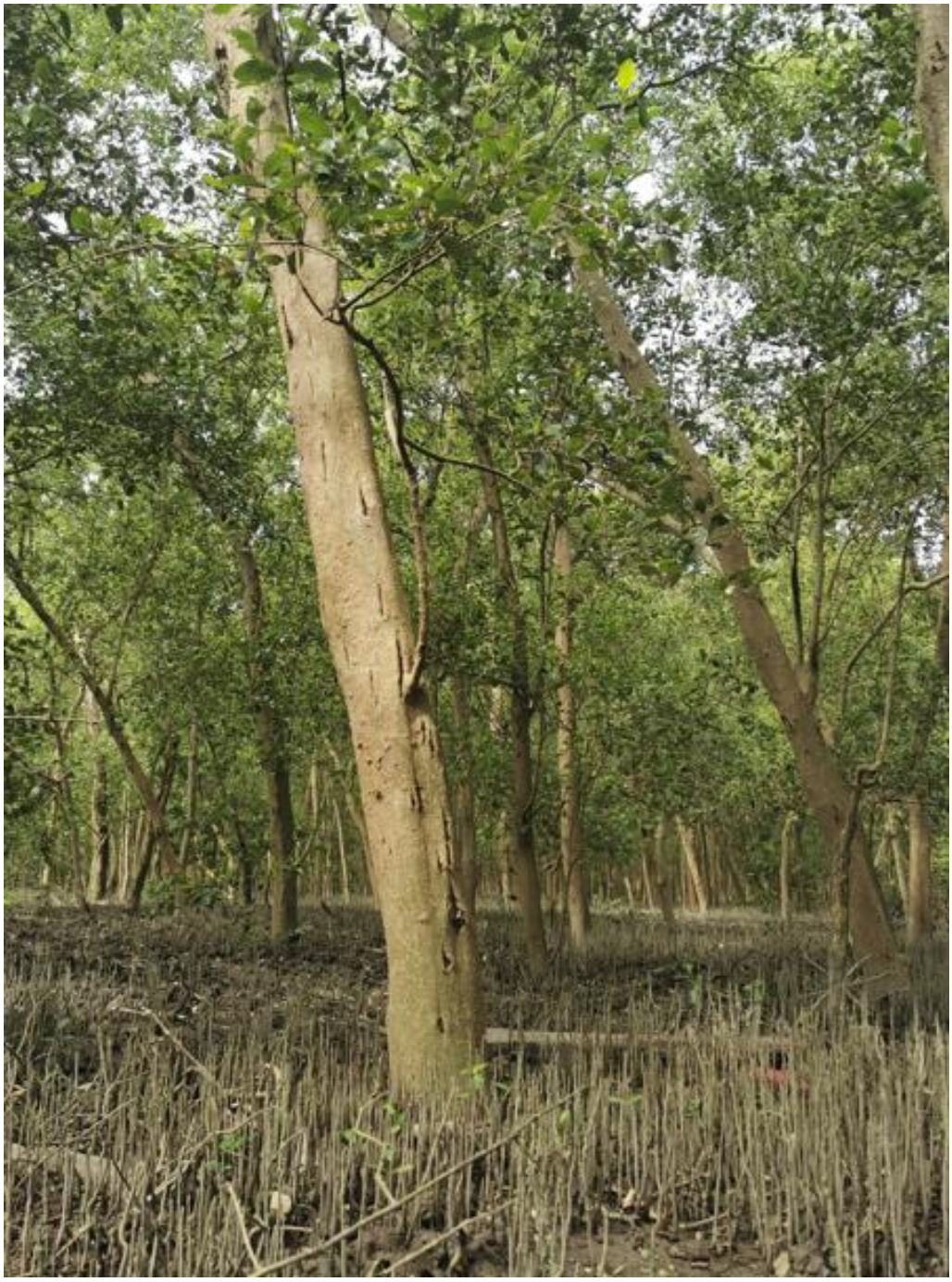


Figure 3.59: 10 meter radius study plot at the Kuala Bekah Gazetted Permanent Reserved Forests (Site 5, as in Figure 3.2), and at the mid intertidal zone. Almost a pure stand of mature *Avicennia marina* (api-api jambu) and some seedlings were observed. Regeneration rate was quite good for the dominant species. The forest canopy at this site was relatively open and dry, could be caused by the recent (2003) illegal dredging of canal and aquaculture ponds nearby.

The mangrove health and productivity study revealed variability in these 5 plots. Site 4 achieved the highest in terms of carbon sequestered in trees' biomass (219 t C ha^{-1}), a mono species site at the highest intertidal zone in Lahar Endin Gazetted Permanent Reserved Forests. Whereas Site 2 at the same forest plot but at the lowest intertidal zone had only recorded 69 t C ha^{-1} of primary productivity. This shows tidal position and forest age have significantly affected the productivity of mangrove forest. However, site 2 also recorded the highest number of mangroves tree, with more than one dominant species (*Avicennia marina* and *Bruguiera cylindrica*) and also the healthiest in terms of regeneration with 56 samplings counted in a mere 1-meter square of area. This translated to the overall age of the forest with many younger trees (lower diameter at breast height) and more samplings. All 5 plots showed above average primary productivity as compared to other forest types in the region with an average carbon sequestration of 134 t C ha^{-1}. As compared to healthy full grown tropical rain forest in Sarawak (>175-200 t C ha^{-1}, Brwon et al., 1991) or the Food & Agricultural Organisation (FAO, 1981) estimation for closed tropical Asian forests (80 t C ha^{-1}). The mangrove trees' biomass as carbon trap alongside with the even more significant sediment carbon trap in the ecosystem makes the ecosystems among the most carbon-rich biomes on earth. Mangrove sediments are exceptionally efficient at carbon sequestration, burying organic carbon in their waterlogged, low-oxygen soils where it can remain stored for centuries to millennia. This aspect is extremely critical to "blue carbon" initiatives for Malaysia and globally as a whole.

3. 4 Conclusion & Recommendations

Out of the 3 parcels of gazetted permanent protected forest, Pasir Gebu in the north recorded the highest number of plant species. However, most of these trees were non-exclusive mangrove species and grew at the highly disturbed back mangrove area. Lahar Endin, the middle parcel has the widest continuous mangrove covering various tidal ranges. The lowest sea-front belt of the mangrove was relatively young and healthy with ground covered in dense mat of seedlings. The highest intertidal belt of mangrove forest here too was covered in full grown mangrove forest and recorded a very high carbon sequestration in the trees' biomass which was higher than a full grown and healthy tropical rain forest. This study clearly demonstrates the importance of mangrove ecosystems as carbon trap needed to combat climate change, alongside renewable energy and energy efficiency. The TAT-KM as coastal mangrove ecosystem supports lower mangrove tree biodiversity with *Avicennia marina* as the dominant species. This translates into careful selection for the right species of mangrove to be planted at the right places, which is critical as mismatch leads to high seedling mortality, ecological damage to existing habitats, and failed restoration efforts. Further recommendations on the TAT-KM mangrove ecosystems as follow:

(1) Gazette the rest of the state land mangrove forest in TAT-KM as permanent protected forest.
(2) Apply for RAMSAR, IBA, FlyWay and many other intergovernmental treaties that provide the framework for national action and international cooperation for the conservation and "wise use" of TAT-KM and their resources.

(3) Convert the existing aquaculture ponds in Pasir Gebu (28.5 hectare, Figure 3.60) into open roosting site for the migratory birds as practised in MaiPo, HongKong.
(4) Mark the herony site in Lahar Endin permanent protected forest as 'no-entry zone' for all forms of activity.

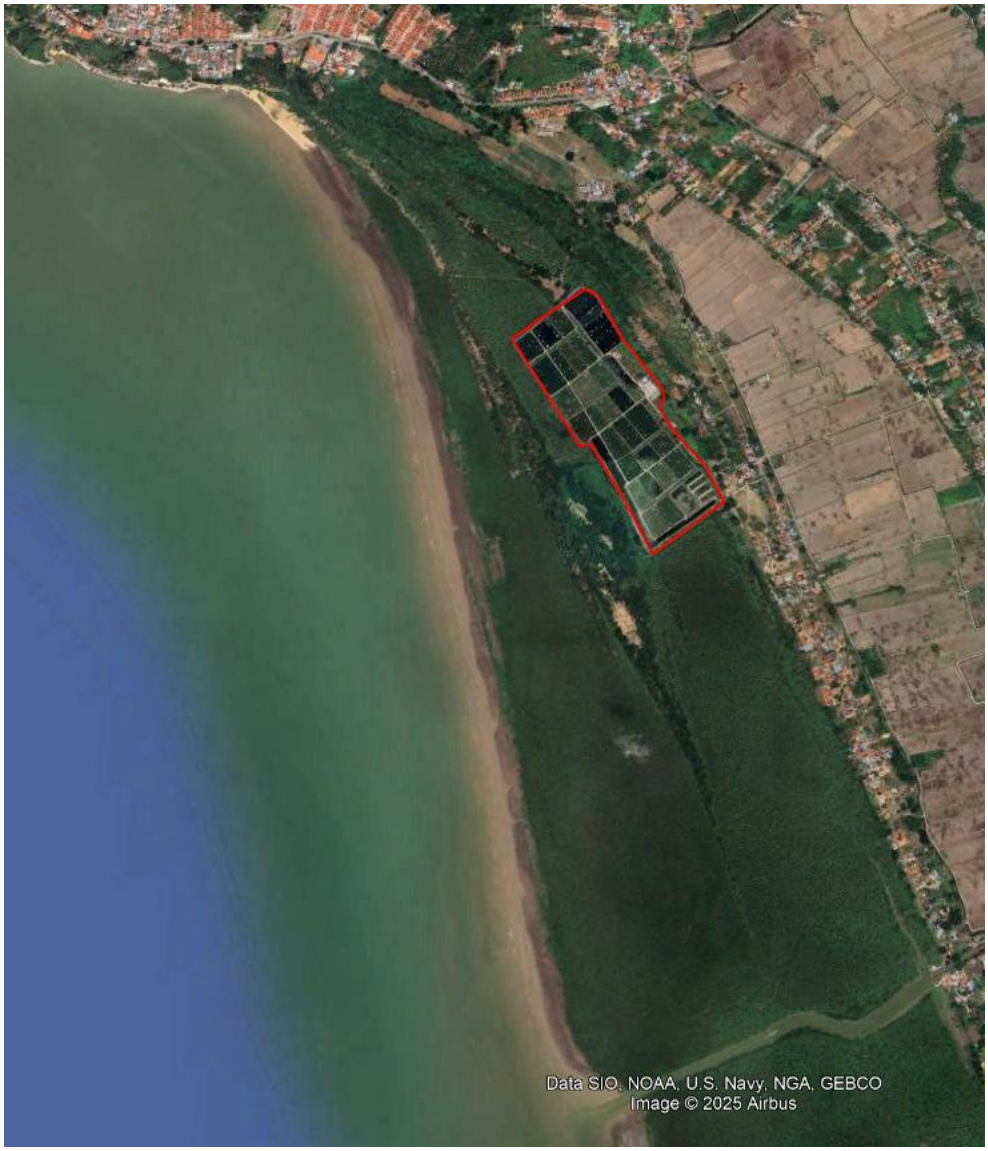


Figure 3.60: Existing aquaculture pond in TAT-KM (in red polygon), potentially to be converted to migratory birds' high tide roosting area.

Reference List

Abd.Hadi, A.R., Mohd Zaki, I. & Ramachandram, Y. V. (2000). *Coastal Sedimentation and Recent Coastline Changes Along the Seberang Perai Coast, Pulau Pinang*. Gelogical Society of Malaysia Annual Geological Conference 2000. Sept 8-9 2000, Penang.

Foong, S.Y. Yeap, C.A. & Butt, C. (2016) *A pilot rapid assessment of selected ecosystem services provided by the Teluk Air Tawar-Kuala Muda Coast IBA in Pulau Pinang*. Kuala Lumpur:

Malaysian Nature Society (MNS Conservation Publication No.16). ISBN 978-9681-51-2

Heaton, L., Fullen, M.A. & Bhattacharyya, R. (2016). Critical analysis of the van Bemmelen Conversion Factor used to convert soil organic matter data to soil organic carbon data: Comparitive analysis in a UK loamy sand soil. *Espaco Aberto* 6(1): 35-44.

Komiyama, A. Poungparn, S. Kato, S. (2005). Common allometric equations for estimating the tree weight of mangroves. *Journal of Tropical Ecology* 21: 471-477.

Ng. P.K.L. & Sivasothi, N. (2002). A Guide to the Mangroves of Singapore 1. Singapore Science Centre. ISBN 981-04-1307-6

Pearson, Timothy R.H.; Brown, Sandra L. & Birdsey, Richard A. 2007. *Measurement guidelines for the sequestration of forest carbon*. *Gen*. *Tech*. *Rep*. *NRS-18*. *Newtown Square, PA*: U.S. Department of Agriculture, Forest Service, Northern Research Station. 42 p.

Peh, K.S.H., Balmford, A.P., Bradbury, R.B., Brown, G., Butchart, S.H.M. Hughes, F.M.R., Stattersfield, A.J., Thomas, D.H.L, Walpole, M., Birch, J.C. (2013). *Toolkit for Ecosystem Service Site-based Assessment (TESSA)*. Cambridge, U.K. Available from: http://dx.doi.org/10.1013/j.eocser.2013.06.003.

Sabah Forestry Department (2010). Mangroves of Sabah: An Introduction to the Flora & Fauna. ISBN 978-967-0180-007.

Tam, N.F.Y. & Wong, Y.S. (2000) Field Guide to Hong Kong Mangroves. City University of Hong Kong Press. ISBN 962-937-056-5

Walker, SM, TRH Pearson, FM Casarim, N Harris, S Petrova, A Grais, E Swails, M Netzer, KM Goslee, S Brown and G Sidman. 2018. Standard Operating Procedures for Terrestrial Carbon Measurement: Version 2018. Winrock International.

Wan Juliana, W.A., Damanhuri, A., Razali, M.S., Norhayati, A. & Latiff, A. (2010) Mangrove Flora of Langkawi. Langkawi Research Centre, Institute Alam Sekitar & Pembangunan (LESTARI), UKM and Lembaga Pembangunan Lankawi (LADA).

4.0 DETAILED REPORT ON BIRD SURVEY TO COVER PHASE 1 FROM DECEMBER 2024 TO MARCH 2025

TO BE SUBMITTED BY MR. KANDA KUMAR AND MR. TAN CHOO ENG ON A LATER DATE

5.0 DETAILED REPORT ON HERPETOFAUNA AND SMALL MAMMAL SURVEY TO COVER PHASE 1 FROM DECEMBER 2024 TO MARCH 2025

5.1 Introduction

Reptiles and amphibians, or collectively known as herpetofauna, is a diverse group of vertebrates. They are cold-blooded and most of them lay eggs. Reptiles distinguished by having scales while amphibians are characterized by their dual mode life stages, aquatic and terrestrial.

In Malaysia, we have at least 268 species of reptiles consisting of 143 species of lizards, 23 species of turtles and 216 species of snakes. While amphibians, Malaysia has at least 279 species amphibians which consist of frogs and caecilians. Penang is home to 70 species of reptiles and 26 species of amphibians.

The Teluk Air Tawar–Kuala Muda (TAT-KM) coastal zone, located in northern Seberang Perai, Penang, represents one of Malaysia's most ecologically significant habitats. Encompassing approximately 72 square kilometers, this area comprises a mosaic of mudflats, mangrove forests, and intertidal zones, which collectively support a high level of biodiversity and provide essential ecosystem services. In 2022, Penang state executive council agreed to gazette the area into three permanent forest reserve, namely Pasir Gebu reserved forest (127.58ha), Lahar Endin reserved forest (129.1ha), Kuala Bekah reserved forest (69.7ha). Although this initiative does not cover the whole stretch of TAT-KM, it is a crucial step to ensure the preservation of what is left in term of mangrove forest in the state mainland.

Recognized as both an Important Bird and Biodiversity Area (IBA) and a Key Biodiversity Area (KBA), the site plays a critical role in the East Asian–Australasian Flyway, serving as a stopover and wintering ground for numerous migratory shorebird species. Notably, it hosts globally threatened birds such as the Spoon-billed Sandpiper (*Calidris pygmaea*), Nordmann's Greenshank (*Tringa guttifer*), and Asian Dowitcher (*Limnodromus semipalmatus*).

In addition to avian diversity, the area supports various mammals, including the Long-tailed Macaque (*Macaca fascicularis*) and Silver Leaf Monkey (*Trachypithecus cristatus*), and sustains rich marine and estuarine life. The mangrove ecosystem contributes to coastal protection, carbon storage, and local fisheries, making it vital for both biodiversity and community livelihoods. Despite its ecological importance, the Teluk Air Tawar–Kuala Muda habitat is increasingly threatened by aquaculture expansion, pollution, and land-use changes.

A few publications are available for the diversity of herpetofauna in the state but none specifically for TAT-KM area.

5.2 Methodology

Survey was done along forest trails and driving along the road while the main survey done along the TAT-KM coastline, along the paddy fields and its surrounding areas. The survey was done both during night and daytime.

Sampling done involving a few observers walking along the trail/transect (using flashlight at night) trying to locate the animals by chance. The sighting was either done by direct observation of the animals (Visual Encounter Survey) or by listening to their calls (Vocal Survey).

5.2.1 Study Sites

The herpetofauna survey was conducted within the Teluk Air Tawar–Kuala Muda coastal zone, encompassing mangrove forests, mudflats, and adjacent terrestrial habitats. The area was selected due to its ecological significance and potential to support diverse amphibian and reptile species.

5.2.2 Survey Period

Field surveys were carried out over a period of two weeks during covering both daytime and nighttime sessions to account for diurnal and nocturnal species.

5.2.3 Survey Techniques

A combination of standard herpetological survey methods was employed:

a) **Visual Encounter Surveys (VES)**

Transects were established across different habitat types. Observers walked slowly along these transects, visually scanning for amphibians and reptiles on the ground, vegetation, and water bodies.

b) Time-Constrained Searches

Specific microhabitats such as under logs, leaf litter, tree bark, and rock crevices were searched within a fixed time frame to detect cryptic species.

c) Vocal Sampling

Amphibians are identifiable by their calls. During each visit, all calls were recorded and compared with database of calls available online and from the researchers personal database.

d) Nocturnal Surveys

Night surveys conducted using headlamps and torches to detect nocturnal species, when particularly amphibians are active.

e) Opportunistic Encounters

Any herpetofauna observed outside of formal survey efforts were recorded, provided location and habitat data were noted.

For each area, the following data were recorded:

1. Species identification
2. GPS coordinates
3. Habitat type
4. Microhabitat description
5. Time and date
6. Behavior and activity

Photographs were taken for documentation and verification purposes. Where necessary, specimens were temporarily captured for closer examination and released immediately after identification.

5.3 Results

In total, 11 species of amphibians and 33 species of reptiles were successfully recorded.

5.3.1 Checklist of herpetofauna of TAT-KM

(A) Amphibians

Family Dicroglossidae

1. Marten's Round Tongue Floating Frog, *Occidozyga martensii*
2. Grass Frog, *Fejevarya limnocharis*
3. Mangrove Frog, *Fejevarya cancrivora*

Family Microhylidae

1. Butler's Rice Frog, *Microhyla butleri*
2. Dark-sided Chorus Frog, *Microhyla heymonsi*
3. Banded Bullfrog, *Kaloula pulchra*
4. *Micryletta* cf. *subaraji*

Family Bufonidae

1. Sunda Toad, *Duttaphrynus* cf. *bengalensis*

Family Ranidae

1. White-lipped Frog, *Hylarana labialis*
2. Cricket Frog, *Hylarana nicobariensis*
3. Rough-sided Frog, *Hylarana glandulosa*
4. Common Greenback, *Hylarana erythraea*

Family Rhacophoridae

1. Four-lined Tree frog, *Polypedates leucomystax*
2. Malayan Slender Frog, *Polypedates discantus*

(B) Reptiles

<u>Snakes</u>

Family Typhlopidae

1. Brahminy Blind Snake, *Indotyphlops braminus*

Family Acrochordidae

1. Elephant Trunk Snake, *Acrochordus javanicus*
2. Granulated Snake, *Acrochordus granulatus*

Family Homalopsidae

1. Puff-faced Water Snake, *Homalopsis buccata*
2. Plumbeous Water Snake, *Hypsiscopus plumbea*
3. Schneider's Bockadam, *Cerberus schneiderii*
4. Rainbow Watersnake, *Enhydris enhydris*

Family Pythonidae

1. Reticulated Python, *Malayopython reticulatus*

Family Xenopeltidae

1. Irridescent Earth Snake, *Xenopeltis unicolor*

Family Colubridae

1. Indochinese Ratsnake, *Ptys korros*
2. Keeled Ratsnake, *Ptyas carinatus*
3. Keel-bellied Whip Snake, *Dryophiops rubescens*
4. Painted Bronzeback, *Dendrelaphis pictus*
5. Golden Treesnake, *Chrysopelea ornata*
6. Oriental Whip Snake, *Ahaetulla prasina*

Family Viperidae

1. Mangrove Pit Viper, *Trimeresurus purpureomaculatus*

Family Elapidae

1. Monocled Cobra, *Naja kaouthia*
2. Sunda King Cobra, *Ophiophagus bungarus*

Lizards

Family Gekkonidae

1. Flat-tailed House Gecko, *Hemidactylus platyurus*
2. Spiny-tailed House Gecko, *Hemidactylus frenatus*
3. Murray's House Gecko, *Hemidactylus murrayi*
4. Twin-spotted House Gecko, *Gekko monarchus*
5. Four-clawed Gecko, *Gehyra mutilata*

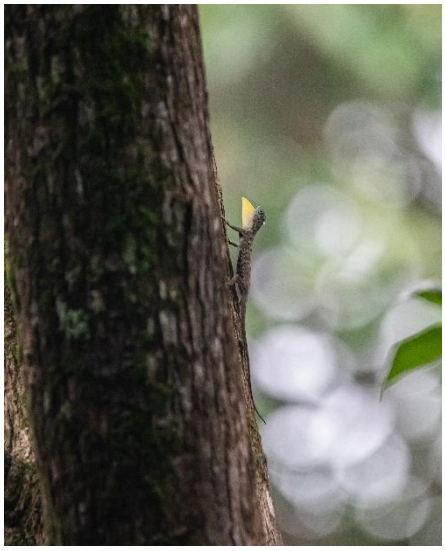
Family Scincidae

1. Many-lined Sun Skink, *Eutropis multifasciata*

2. Mangrove Skink, *Emoia atrocostata*
3. Bowring's Supple Skink, *Lygosoma bowringii*

Family Agamidae

1. Garden Fence Lizard, *Calotes versicolor*
2. Green Crested Lizard, *Bronchocella cristatella*
3. Common Flying/Gliding Lizard, *Draco sumatranus*



Family Varanidae

1. Water Monitor Lizard, *Varanus salvator*
2. Clouded Monitor Lizard, *Varanus nebulosus*

Turtles and tortoises

Family Geoemydidae

1. Malayan Box Turtle, *Cuora couro*
2. Black Marsh Turtle, *Siebenrockiella crassicolis*

Discussion

Species recorded from this study was mainly an expected species to occur in such habitat. The only notable record is the Deli Frog, *Icryletta* cf. *subaraji* which is more of a forest species.

Reference List

Ibrahim, J., M. S. Shahrul Anuar, A. Norhayati, K. O. Chan, and M. A.Muin. 2008. The Common Amphibians and Reptiles of Penang Island.Malaysia. Penang State Forestry Department. 116pp.

Charlton, Tom.2019. A Guide to Snakes of Peninsular Malaysia and Singapore. Natural History Publications (Borneo)

Frost, D. R. (2017). Amphibian species of the world: An online reference (Version 6.0). Available at http://research.amnh.org/herpetology/amphibia/index.html (Accessed March 21, 2025).

Uetz, P., & Hallermann, J. (2016). The reptile database. Retrieved from http://www.reptile-database.org (Accessed March 21, 2025).

Das, I. (2015). A field guide to the reptiles of South-east Asia, Myanmar, Thailand, Laos, Cambodia, Vietnam, Peninsular Malaysia, Singapore, Sumatra, Borneo, Java, Bali. Bloomsbury, London, UK.

Berry, P. Y., & Hendrickson, J. R. (1963). Notes on the herpetology of the Malay Peninsula. Fieldiana Zoology, 45(4), 31–42.