Assessment of Mangrove Replanting Site at Kg Tanjung Kepah, Lekir, Perak

Nurul Fatihah Mohd Fauzi¹*, Teh Hee Min¹ and Ahmad Mustafa Hashim¹

¹Department of Civil & Environmental Engineering, Universiti Teknologi Petronas, Perak, Malaysia

E-mail: nurul_19000184@utp.edu.my

Abstract. Mangroves are formation of salt-tolerant shrubs that inhabit the inter-tidal zones of sheltered coasts like estuaries and lagoons in tropical and subtropical latitudes. They solidly secure the land from the seas, and have the capability of withstanding strong wave action and heavy storm surges. The effectiveness of mangroves as natural coastal protection buffer has been well proven in the 2004 Indian Ocean Tsunami that brought devastating economic and ecological impacts to thirteen Asian and African countries, including Malaysia. Despite the importance of mangroves in coastal protection, this intertidal vegetation has been reported to be depleted at an alarming annual rate of 1 to 2% globally due to impacts of natural processes and anthropogenic influences. Tremendous efforts of mangrove restoration have been implemented along the Malaysian shoreline in the past decade, but just a modest number have been planned or studied by environmentalists and other researchers. The plantings were mostly executed in a trial-and-error approach without having a full understanding of the site conditions. Hence, a thorough appreciation of the site condition is mandatory so as to ensure high survivability of the young mangrove saplings at the replanting sites. This paper aims to assess one of mangrove replanting sites in Malaysia which is located at Kg Tanjung Kepah, Lekir, Perak. Several mangrove replanting efforts have been undertaken by Forestry Department at the area. However, none of the mangrove seedlings survived three months after the plantation at the open area sites. Some assessment were conducted including mangrove tree assessment, current measurement, soil and water sampling as well as topography detailed survey. The analysis from the assessment shows that the mangrove replanting failures might be influenced by several possible factors, especially the shore slope and topography. Hence, the most suitable engineering approach will be suggested for future protection.

1. Introduction
Mangroves are formation of salt-tolerant shrubs or trees that inhabit the inter-tidal zones of sheltered coasts like estuaries and lagoons in tropical and subtropical latitudes [1, 2]. Mangroves are known for their capabilities that can survive in such unfavorable environmental conditions including high salinity, extreme tides, strong winds, high temperatures as well as muddy and anaerobic soils. There might be no other species of plants that have the same capability as mangroves to adapt in such extreme conditions [2].

Mangrove forests are indeed remarkable survivalists confronting the full range of the ocean. They solidly secure the land from the seas, and have the capability of withstanding strong wave action and heavy storm surges [3]. Besides, mangrove habitat has also been proven to be essential for
sustainability of the endemic and native biodiversity, the creation of fishery industry to the local market, as well as enhancing the socio-economic value of the coastal communities [4].

The effectiveness of mangroves as natural coastal protection buffer has been well proven in the 2004 Indian Ocean Tsunami (IOT 2004) that brought devastating economic and ecological impacts to thirteen Asian and African countries, including Malaysia [5]. The coastal towns located behind mangrove forests were more shielded from the harm of tsunami than those towns exposed to the open sea. Ever since the occurrence of the tsunami, the developing countries, particularly Malaysia, Thailand and the Philippines, have learnt an expensive and painful lesson, and have started the mangrove replanting efforts to protect their homelands and properties from destruction in the event of tsunamis [6, 7, 8, 9].

Despite the importance of mangroves in coastal protection, this intertidal vegetation has been reported to be depleting at an alarming annual rate of 1 to 2% globally due to impacts of natural processes and anthropogenic influences [10,11]. In spite of the fact that there are numerous restoration extends the world over, just a modest number have been planned or studied by environmentalists and other researchers [12]. The plantings were mostly executed in a try-and error approach without having a full understanding of the site conditions.

The survivability of mangroves particularly young saplings largely depends on their adaptability to the coastal environments. The majority of the mangrove restoration endeavors fail due to several possible factors such as lack of coordinated mangrove replanting methodologies, lack of understanding of the site conditions – tidal activities, wave energy density, currents, sediment transports, salinity regime, water pH, nutrient concentration, beach profile and conditions [7,13]. A thorough appreciation of the site condition is mandatory so as to ensure high survivability of the young mangrove saplings at the replanting sites.

Thus, this paper aims to assess one of mangrove replanting sites in Malaysia which is located at Kg Tanjung Kepah, Lekir, Perak. Several mangrove replanting efforts have been undertaken by Forestry Department at Kg Tanjung Kepah. However, none of the mangrove seedlings survived three months after the installation at the open area sites. Some assessment were conducted including mangrove tree assessment, current measurement, soil and water sampling as well as topography detailed survey at the site.

2. Methodology

2.1 Study Area

The study was carried out at Kg Tanjung Kepah (4° 07’ 00.5’’ N, 100° 43’ 36.7’’ E), which covers an area of 120 km² and located in Lekir, Perak. Lekir is one of the main villages in Manjung district, Perak and Kg Tanjung Kepah is a small fisherman’s beach located in Lekir. Kg Tanjung Kepah has the tropical rainforest climate prevailing. It is generally warm, humid and rainy throughout the entire year with the annual average temperature and rainfall of 34°C and 226 mm respectively. According to the interview with the chief of village of Tanjung Kepah, there are 484 houses in Kg Tanjung Kepah which are occupied by 1452 populations approximately. The vast majority of the locals are Malay and they engaged with agricultural, forestry and fishing industries as their main source of income.

Tanjung Kepah had experienced a crucial erosion due to uncertain reason since the IOT 2004 tragedy. The erosion has been destroying approximately more than 2 km of the previous mangrove belt extending from Kg Tanjung Kepah to Sg Tiram. As for now, part of the coastline already lined by rock revetment and series of groynes to provide protection to the eroded shoreline. However, traces of erosion are still noticeable, particularly at Tanjung Kepah. Further south, significant inner portion of the mangrove forest also have been cleared for aquaculture and fish ponds as indicated in Figure 1.
2.2 Data Collection

Data collection at Kg Tanjung Kepah are mostly assessed by conducting field assessment. The field assessment consists of five key activities which are mangrove tree assessment, current measurement, soil and water sampling as well as topography detailed survey. Mangrove tree assessment is significant to evaluate the characteristics and distribution of the existing mangrove forest at Kg Tanjung Kepah. Two transect lines were set up at the site area, consisting of three standard plots with an area of 20m x 10m each as shown in Figure 2(a) and 2(b).

Figure 2. (a) Two transect lines were set up, (b): Each transect line was set up with three standard plots size 20 m x 10 m

The plots were selected as a representative of general mangrove structure for the assessed area. A total of 32 trees within the plot are chosen to be examined. The trees are chosen based on their age categories and density within the plot.

Mangroves are tidally influenced forests, thus the position of the plot was determined by its tidal inundation depth; including high inundation (>0.8 m), medium inundation (0.4 to 0.8 m) and low inundation (<0.4m) [14]. Tidal inundation depth is an area that been flooded due to tide. The assessment covers mangrove trees with various age categories. The number of mangrove tree at each plot were counted and their species were identified. Subsequently, the detail geometry parameters for every species were measured including the total height of the tree, the height of roots, the height of trunk, the height of canopy, the diameter of the trunk, the diameter of the root, the diameter of branches, width of the root, width of canopy and number of branches (Figure 3). These parameters will able to recognize the age of the tree.
For soil sampling, five locations are selected, labeled as S1, S2, S3, S4 and S5 as shown in Figure 4. For water sampling, ten locations are chosen to be sampled from Kimi Chalet to Sg Tiram. Each location is labeled as W1 to W10 as shown in Figure 5. Random sampling is done where accessible because it is easy and convenient as mangrove forest is not uniform geographically and many obstacles can be experienced during site assessment. The in-situ testing for pH, temperature and salinity of soil are measured using the soil meter whereas for water in-situ testing, the water quality parameters are measured by using the ProDSS multiparameter for water quality.

Current measurement is also taken by using a current meter to determine the physical characteristics of currents in the site area. Before pursuing any physical parameters measurement, water depth is measured using a levelling staff. Then, dye is used to identify the direction of current propagation. Three locations are selected at the site area and labeled as C1, C2, and C3 as shown in Figure 6.
Figure 6. Locations of current measurement

Last but not least, the topographic detailed survey is evaluated by using Real Time Kinematic (RTK) and total station surveying method. RTK is used to set up two base stations in order to get the precise position from the satellite. Subsequently, using the same base stations from RTK survey as control points, a total station is used to measure some horizontal and vertical points as well as the slopes in that particular area before analysed by using ArcGIS software.

3. Results and Discussion

3.1 Mangrove Distribution

Based on the analysis of mangrove tree assessment, it is demonstrated that the pattern of dominant species of the mangrove forest at Kg Tanjung Kepah is as explained in the pie chart below. The major species at Kg Tanjung Kepah is *Sonneratia alba* (56%), followed by *Avicennia alba* (34%) and *Rhizophora apiculata* (10%). The trend of the distribution can be associated with the surrounding environment as it is located near the shoreline. Different species has different ways of surviving in the anaerobic condition. Such factors include salinity, pH level, soil and water condition, predominant wave, contamination, and deforestation [15,16]

![Mangrove species distribution at Kg Tanjung Kepah](image)

Figure 7. Mangrove species distribution at Kg Tanjung Kepah

Different mangrove species distribution at Kg Tanjung Kepah also can be related with the mangrove zonation along the shoreline. Most of the time, *Sonneratia alba* and *Avicennia alba* species occupy the seaward zone because they have pneumatophorous aerial roots that could grapple and support the plant from tides and inundation [17]. Moreover, the *Avicennia-Sonneratia* species can endure high saltiness conditions as the salinity increases towards the tidal coast [18]. They have the specialty in acting as a sink for the saltwater that enables them to act as the first barrier to any wave action.
The age of existing mangrove trees at Kg Tanjung Kepah are ranging from 3 to 20 years old. Mangrove trees that age from sapling to 3 years old are considered as young mangroves. In the interim, 7-15 years old are classified as mid-age mangroves. Lastly, the age of mangrove trees from 16 to 20 years old and above are categorized as mature trees. Figure 8 shows that the existing mangrove trees at Kg Tanjung Kepah are dominated by mid-age trees which is 56%, while mature and young trees have the equal distribution which is 22% only.

3.2 Soil Physical Parameters

In a mangrove area, the physical composition of the soil which comprises of silt, clay and sand involves the process of accretion and erosion. The sediment particles are brought by waves and trapped on the floor of mangrove forest during tidal inundation because of the thickness of mangrove vegetation, which subsequently increases the sedimentation [19, 20]. However, the mangrove sediments can be remarkably altered during extremely high waves by erosional processes [21]. These two processes can alter the soil physical properties and could prompt changes in species zonation. Figure 9 below demonstrates the particle size distribution of soil at Kg Tanjung Kepah.

The graph shows that the percentage finer at S1, S3 and S5 are quite similar which comprise of silty-clay soil texture while S2 and S4 soil distribution consist of sandy-clay soil structure. Thus, based on the observation at the site areas. S1, S3 and S5 are the areas where the mangrove replantation failed to survive whereas S2 and S4 are the areas where mangrove still standing strong and survived well. This proves that different soil texture would give different impact to the mangrove survivability at mangrove restoration areas.

Table 1 shows the physical parameters of soil at Kg Tanjung Kepah such as pH, temperature, salinity and moisture content. For soil pH, mangrove grow best between 5-6.5. As for temperature, S1, S3 and S4 are quite high compared to S2 and S5 because they are exposed directly under the sunlight.
without any tree protection. However, the weather and the time when data were taken also might be the additional factor that influence the results. S5 has the highest salinity which is 25 ppm due to highest density of mangrove in that particular area.

### Table 1. Soil physical parameters at Kg Tanjung Kepah

| Sample | pH  | Temperature (°C) | Salinity (ppm) | Moisture content (%) |
|--------|-----|------------------|----------------|---------------------|
| S1     | 5   | 36               | 16             | 26.58               |
| S2     | 6   | 29               | 17             | 31.58               |
| S3     | 5   | 36               | 23             | 47.17               |
| S4     | 6.5 | 37               | 20             | 100.00              |
| S5     | 6   | 27               | 25             | 59.38               |

### 3.3 Water Physical Parameters

Table 2 exhibited the water quality parameters at Kg Tanjung Kepah. Lower pH means the water is more acidic. W5 at Kg Tanjung Kepah contains the highest pH value which is 8.34. This proves that the water in that area is more alkaline compared to others and might be the reason why the mangrove saplings could not survive.

The temperature for all the locations are more or less the same considering the water are exposed to the sunlight and also the time during water samplings which is on the evening. W9 at estuary of Sg Tiram contains the highest dissolved oxygen which is 13.96 mg/L. This is because there are less bacteria or aquatic animal in the estuary area, thus less consuming of dissolved oxygen. W5 holds the highest salinity which is 25.14 ppm. This is because W5 has the greatest density of mangrove trees which requires more saline water to survive.

### Table 2. Water physical parameters at Kg Tanjung Kepah

| Sample | pH  | Temperature (°C) | DO (mg/L) | SAL (ppt) | Turbidity (NTU) | TSS (mg/L) |
|--------|-----|------------------|-----------|-----------|----------------|------------|
| W1     | 4.2 | 29.8             | 3.56      | 0.32      | 14.1           | 36.33      |
| W2     | 6.6 | 32.7             | 8.44      | 13.3      | 12.1           | 2.67       |
| W3     | 8.1 | 36.5             | 8.34      | 23.8      | 17.4           | 1.33       |
| W4     | 7.8 | 36.3             | 6.18      | 19.7      | 247            | 303.00     |
| W5     | 8.3 | 34.8             | 10.6      | 25.1      | 278            | 272.67     |
| W6     | 7.8 | 35.5             | 4.97      | 24.8      | 289            | 254.67     |
| W7     | 7.9 | 36               | 6.72      | 24.1      | 56.9           | 104.67     |
| W8     | 7.3 | 36.9             | 3.14      | 21.5      | 84.9           | 80.67      |
| W9     | 7.4 | 33.5             | 13.9      | 20.3      | 76.3           | 20.67      |
| W10    | 4.6 | 32.9             | 7.68      | 10.0      | 67.6           | 2.00       |

The turbidity and total suspended solid (TSS) of water at W4, W5 and W6 are high compared to others. All of them are located around Kg Tanjung Kepah area. The high readings might due to the wave orbital movement that caused the sediments to be stirred up depending on the water depth in that particular area.

### 3.4 Surface current analysis

The surface current flow depends on the movement of wind, tides and water density. Table 3 displays the surface current measurement at Kg Tanjung Kepah. The surface current flow at C2 and C3 are high compared to C1 because there are mangrove trees that act as the obstacles thus making the current flow fluctuates.
Table 3. Surface current measurement at Kg Tanjung Kepah

| Location | Distance travelled (cm) | Time taken (s) | Velocity (cm/s) |
|----------|-------------------------|----------------|-----------------|
| C1       | 210                     | 19             | 11.05           |
| C2       | 210                     | 4              | 52.5            |
| C3       | 210                     | 3.93           | 53.44           |

3.5 Topographic Survey

Based on RTK and total station survey at Kg Tanjung Kepah, 80 points were managed to be captured where accessible. Figure 10 demonstrates that the slope elevation are varies at the site area after being analysed by ArcGIS software. However, it is obvious that the failed mangrove replanting area has much lower elevation compared to other topography area around it. The slope elevation are ranging from 1.9 to 2.4 m. The analysis was done upon 0.3 m above the mean sea water level (MSL). Therefore, the area might need to be stabilised with sediments first before replanting mangrove trees in the future.

Figure 10. Slope elevation at Kg Tanjung Kepah

4. Conclusion and Recommendation

Mangrove forests are very important and unique as it can act as natural coastal protection buffer. It is essential to preserve the valuable mangrove forests to protect our beloved nation from tsunami in the future. In order to preserve the mangroves and ensuring the successful mangrove restoration effort, detailed study upon the site condition is mandatory. Based on the field assessments conducted at Kg Tanjung Kepah, the results shows that the mangrove replanting failures might due to shore slope and topography condition. The slope elevation is too low and consist of muddy soils. Hence, the survivability of young mangrove saplings are rather low as their roots are not strong enough to support them. As a result, it is recommended to install coastal protection such as geotextile tubes to allow the sediments stabilisation first before pursuing any mangrove replanting activities.
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