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Evaluating Sedimentation Effects on Mangrove Growth: Comparative Analysis of Coastal Zones in Batu Pahat, Malaysia

Muhammad Aliyuddin Mohd Kamal[1a], Nor Baizura Hamid[2b*], Mardiha Mokhtar[3b], Aslila Abd Kadir[4b], Mohd Effendi Daud[5a] and Mohammad Ashraf Abdul Rahman[6c]

Abstract: Mangrove ecosystems, often called the rainforests of the ocean, are essential coastal habitats that offer key environmental advantages. Nevertheless, they are confronted with an impending danger from sedimentation, a complicated mix of natural and human-caused elements. The research examines the various impacts of sedimentation on the well-being of mangroves, specifically looking at Pantai Punggor and Pantai Perpat in Batu Pahat, Johor, Malaysia. Avicennia marina, a type of mangrove, is impacted by sediment accumulation and is chosen for its importance in these areas. UAV photogrammetry was applied because of its cost-effectiveness and high spatial resolution. Data underwent processing with the aid of Global Mapper and Pix4D programs, in addition to meticulous mission preparation and camera calibration. Sediment properties were examined per ASTM guidelines, utilizing sieve analysis, specific gravity, and moisture content methods with extra determination of salinity and pH from the in-situ process. The assessment of mangrove characteristics involved measuring trunk diameter with field data and tree height with UAV-derived Digital Surface and Terrain Models. The findings show notable differences between the zones in Pantai Punggor and Pantai Perpat, highlighting the negative impacts of sedimentation on the development of mangroves. Zone 3C aligns most closely with the specified ideal characteristics for mangrove height, soil composition, and environmental conditions. The results reveal significant differences in mangrove growth across sedimentation zones, with Zone 3C emerging as a key area for conservation efforts. The findings provide actionable insights for improving sediment management strategies and ensuring the sustainability of mangrove ecosystems.

Keywords: Sedimentation, mangrove, Avicennia marina, sediment deposition

1. Introduction

The mangrove ecosystems in Malaysia, known as the sea forests, have great ecological importance and are found extensively along the country's coastlines. These special forests along the coast of Malaysia are crucial for the country's diverse wildlife, providing a home for a wide variety of plants and animals, such as various types of fish, birds, and crustaceans. Also, they act as vital breeding grounds for economically important fish species, sustaining the local fishing sector. Nevertheless, these precious ecosystems are at risk from multiple sources, with sedimentation becoming a major issue. The problem of sedimentation arises from a mix of natural factors like tidal action and river flow, as well as human activities such as deforestation and changes in land use, which together upset the sediment deposition balance and endanger these ecosystems.

The health of mangroves can be impacted by sediment transport in various ways. Excessive sediment deposition can alter the physical and chemical composition of the soil, leading to a reduction in nutrients and oxygen available to mangrove roots (Ndungu et al., 2019). The aftermath is that mangroves may grow more slowly, become more susceptible to pests and illnesses, and eventually die. (J. Wang et al., 2019).

Along with soil characteristics, sediment transport impacts the hydrology of mangrove habitats. According to Basyuni et al., (2020), sediment accumulation in waterways can block them and decrease the flow, causing higher salinity and waterlogging in some places and lower salinity and drying out in others. This may change the mangrove species distribution and negatively impact the environment's biodiversity. Many methods have been created to address the harmful effects of sediment transport on the well-being of mangroves. Sediment-capturing infrastructure such as sediment ponds and check dams are deployed to reduce silt migration downstream (Razi et al., 2019). Two additional initiatives to reduce sedimentation rates are restoring injured mangrove regions and implementing sustainable land management techniques. Basyuni et al., (2020).

To conclude, sediment transportation poses a significant threat to the health and sustainability of Malaysia's mangrove ecosystems. Mangrove ecosystems are indispensable for

Authors information:
[a]Department of Infrastructure & Geomatic Engineering. Faculty of Civil Engineering and Build Environment, Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Batu Pahat, Johor. E-mail: aliyuddinkamal@gmail.com[1], effendi@uthm.edu.my[5],
[b]Department of Civil Engineering. Centre for Diploma Studies, Universiti Tun Hussein Onn Malaysia (Pagoh Campus), Pagoh Higher Education Hub, KM 1, Jalan Panchor, 84600 Panchor, Johor. E-mail: norbaizura@uthm.edu.my[2], mardiha@uthm.edu.my[3], aslila@uthm.edu.my[4],
[c]Department of Civil Engineering Technology. Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia (Pagoh Campus), Pagoh Higher Education Hub, KM 1, Jalan Panchor, 84600 Panchor, Johor. E-mail: ashrafr@uthm.edu.my[6]

*Corresponding Author: norbaizura@uthm.edu.my

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maintaining coastal stability, acting as natural buffers against erosion (Chang & Mori, 2021), and supporting a wide variety of species. In Malaysia, these ecosystems face increasing threats from sedimentation driven by tidal actions, deforestation, and changes in land use. Excessive sediment deposition can alter soil properties, disrupt water flow, and hinder mangrove growth. Although global studies have investigated the impacts of sedimen tation, there is limited research on its specific effects in Batu Pahat, Malaysia. This study addresses this gap by analyzing how sediment accumulation impacts Avicennia marina growth, utilizing advanced UAV photogrammetry and sediment analysis techniques. The novelty of this research lies in its precise, technology-driven approach to understanding these challenges and offering practical solutions.

1.1 Mangrove Ecosystem Characteristic

Mangrove ecosystems are characterized by their remarkable adaptive abilities to thrive in challenging coastal environments,

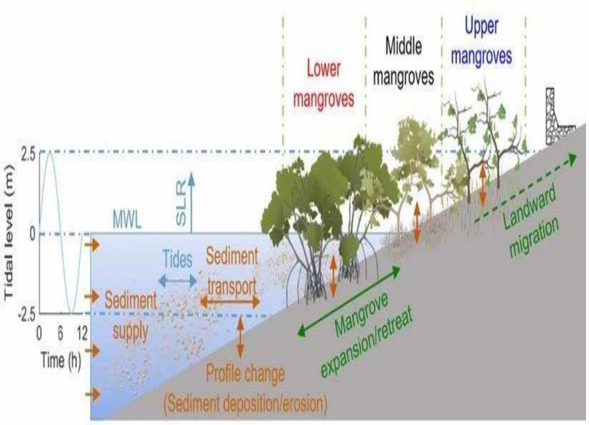

Figure 1. Schematic overview of the bio-morphodynamic modeling (Xie et al., 2022)

making them rich and unique habitats. These environments usually include six various types of mangroves and ten plant species associated with the habitat, amounting to a total of 16 species. The makeup of these species may differ across various places, with certain regions showing greater diversity. Avicennia marina, Suaeda maritima, and Sesuvium portulacastrum are some of the notable species that are common in the area. These mangroves play a crucial role in coastal ecosystems and offer necessary ecological services. Previous research offers significant insights into the mangrove ecosystem's species diversity and geographical spread (Singh, 2020). Figure 1 depicts the schematic overview of the bio-morphodynamic modeling.

One of the defining characteristics of mangrove habitats is their ability to thrive in challenging conditions. Mangroves have progressed to withstand high temperatures, salinity, low oxygen levels, and contaminated environments. (Mohanta et al., 2020). Their roots are specially adapted to handle waterlogged soils, which can vary widely in salinity, ranging from 2% to 90%.[5]. The ability of mangroves to adapt to shifts in sea level and harsh weather conditions allows them to be resilient. Their distinct physical makeup enables them to strain and capture sediments and nutrients, which are vital in maintaining water quality and stabilizing shorelines.

Mangrove forests can differ in their physical appearance, as mangrove trees can be small shrubs or tall giants reaching heights of 5 to 25 meters. The height and shape of the mangroves are influenced by different factors, such as the age of the forest and local environmental conditions. The wide variety of traits creates a broad spectrum of habitats for different wildlife species, turning mangrove ecosystems into a hotspot for biodiversity. Furthermore, mangrove environments are recognized for their importance in supporting a diverse range of aquatic and land-based creatures, demonstrating their critical significance for the overall well-being and ability to withstand the challenges of coastal ecosystems across the globe (Hai et al., 2020).

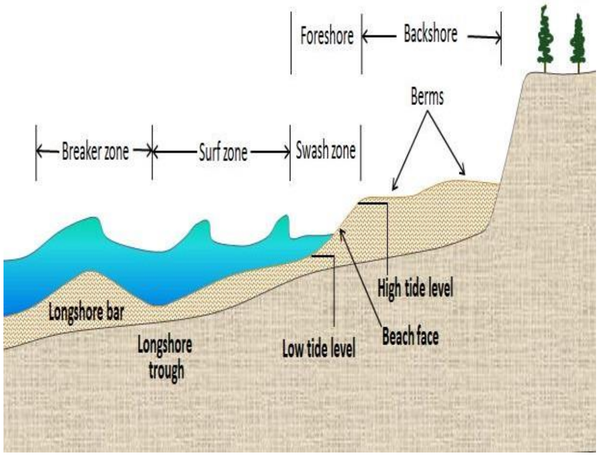

Figure 2. The components of a sandy marine beach (Earle et al., 2015).

1.2 Sediment Transport

Sediment transport is a dynamic and complex process primarily driven by fluid flow forces like water, wind, or human activities. In the case of water-driven sediment transport, rivers and streams are the main pathways for sediment movement (Dietrich et al., 2020). River flow creates shear stress on the riverbed, leading to sediment particles' dislodgement and downstream transport. (Parker et al., 2016). Fluvial transport is a process that is required to shape the river channels and build sediment along river networks. It plays a vital role in restructuring soil and sediments across landscapes. A component of the sandy marine beach is shown in Figure 2.

The zigzag pattern of particles on beaches is caused by the movement of coastal sediment due to waves and their circular motion. (Komar, 2017). Longshore sediment transport plays a role in shaping barrier islands and beaches and influences coastal ecosystems' dynamics. Moreover, sediments in estuaries and tidal flats are transported by tidal currents, moving them around within these coastal areas (McLachlan et al., 2021). Coastal sediment transport is essential for preserving the balance and structure of shoreline environments.

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Sediment transport driven by wind is common in dry and coastal regions. Fine particles, such as sand and dust, are easily entrained and carried by wind breezes (Nickling et al., 2019). Aeolian processes, including saltation (hopping and bouncing of particles) and suspension (particles suspended in the air), can carry sediments over long distances (Pahtz et al., 2020). This wind-driven sediment transport can have a range of outcomes, from manipulating desert landscapes to impacting air quality and human health, particularly in areas liable to dust storms (Lancaster et al., 2019). Understanding these different modes of sediment transport is necessary for controlling and lessening their impacts on both natural and human-modified environments.

1.3 Sediment Deposition Affecting Mangrove

Mangroves play a crucial role in influencing sediment deposition and, in turn, are significantly impacted by sediment rates. These ecosystems are nature's way of regulating sediment transport and maintaining the elevation of coastal areas. They effectively reduce sediment movement by slowing down water flow and providing a habitat where suspended sediments can settle. The intricate root networks and prop roots of mangroves act as natural barriers, trapping sediments and promoting sediment deposition within their vicinity, as observed in the study by Besset et al. (2019). This process not only helps mangrove ecosystems grow taller but also leads to the formation of mudflats and marshy regions in coastal areas.

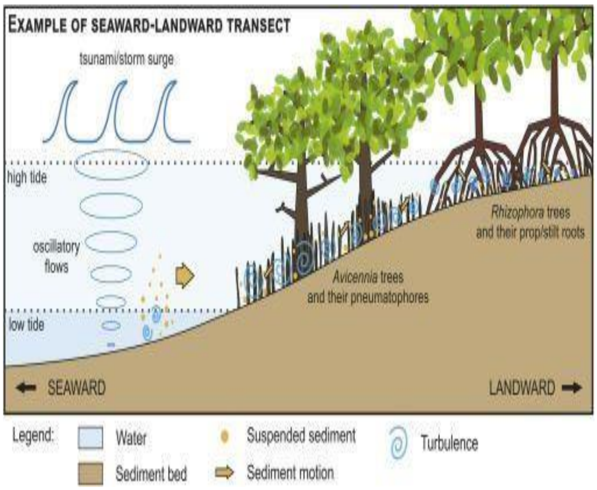

Figure 3. The process of sedimentation at mangrove area (Minor et al., 2021).

Sediment accumulation rates in mangrove environments are influenced by various factors, including tidal patterns, vegetation density, and hydrodynamics, as demonstrated by research by Asp et al. (2018). These variables interact to determine the extent and rate of sediment buildup within the mangrove ecosystem. Such sediment deposition is vital for mangroves' overall health and development, allowing them to thrive in their unique coastal habitats and providing essential ecological services.

Figure 3 shows the process of how the sediment carried into the mangrove area. Furthermore, mangrove ecosystems are known for enriching sediment with organic matter and nutrients. Mangroves absorb and retain these nutrients, resulting in a nutrient-rich environment that supports diverse organisms, as evidenced by studies like Salmo et al., (2029). The complex nutrient cycling processes in mangrove sediments play a vital role in maintaining the ecosystem's health, benefiting both the flora and fauna that call these habitats home. In addition to their ecological significance, mangroves serve as natural barriers against coastal erosion by reducing wave energy and preventing shoreline erosion through sediment accumulation, making them indispensable in safeguarding coastal communities and infrastructure, as highlighted in research by Saintilan et al. (2020). The intricate relationship between mangrove ecosystems and sediment rates underscores their importance in coastal management, conservation efforts, and the broader environmental context.

1.4 Existing Research at Pantai Punggor and Pantai Perpat

The study by Siddiq et al. (2023) emphasizes the important influence of sediment accumulation on the ecological well-being of mangroves within the research site. Accretion and erosion are critical in shaping their state due to dynamic processes.

The research conducted by Kaamin et al. (2018) expands on this understanding and discusses real-world findings from research carried out in the identical region. The study records noticeable alterations in the shape of the shoreline over time, indicating that the relationship between sediment movement and coastal characteristics is continually changing.

Additionally, utilizing UAV photogrammetry is revolutionizing how sediment volumes are measured, and shoreline changes are monitored, providing unmatched precision and efficiency. (Mokhtar et al., 2023). The potential of this technology extends further to assess vertical vegetation structure, like determining tree heights through creating and analysing Digital Terrain Models (DTM) and Digital Surface Models (DSM). The versatility and practicality of UAV-based techniques in improving our understanding of coastal ecosystems and their complex dynamics are highlighted by their multi-dimensional functionality.

2. Materials and method

Figure 4. Study area, including the zones.

2.1 Description of the Site Location

The study initially focused on Pantai Punggor and Pantai Perpat as the chosen research areas. One of the areas in Batu Pahat that experience notable erosion and accretion phenomena

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is Pantai Punggor and Pantai Perpat. The coastal area in Batu Pahat shows considerable diversity (Kaamin et al., 2018). Sabri et al,. (2023) research on shoreline changes reveals how the condition of mangroves on both beaches can be impacted within a year due to variations in the shoreline (Mokhtar et al., 2020).

Figure 4. shows the study area and the zones. This research was conducted at Pantai Punggor and Pantai Perpat, two coastal zones in Batu Pahat, Johor, Malaysia. These areas were divided into three zones based on sedimentation levels: Zone 1 (minimal sedimentation), Zone 2 (moderate sedimentation), and Zone 3 (high sedimentation). Avicennia marina was chosen as the focal species due to its prevalence in these environments and its sensitivity to sediment changes (Hassan et al., 2016). The area that already has buildings (Zone 2) was neglected because this study focuses on finding the effect of sediment deposition on mangrove growth.

2.2 UAV Photogrammetry

Unmanned Aerial Vehicles (UAVs) were used for their cost-efficiency and ability to capture high-resolution spatial data (Sabri et al., 2022). Key steps included careful mission planning, camera calibration, and the integration of Ground Control Points (GCPs) to ensure accuracy (Siddiq et al., 2021). Data from the UAV flights were processed using Pix4D and Global Mapper software to create Digital Surface Models (DSM) and Digital Terrain Models (DTM). Tree heights were derived by subtracting the DTM from the DSM, and accuracy was validated using root mean squared error (RMSE) analysis.

2.3 Characteristics of Site Location

2.3.1 Mangrove Characteristic

The data for the mangrove sample was collected along 100 meters of coastline for both locations. Mangrove trunks were assessed according to their diameter and height. Field data collection at Pantai Punggor and Pantai Perpat calculated the average diameter of mangrove trees to determine the trunk diameter. The tree's height was calculated using UAV photogrammetry to generate DSM and DTM. Subtracting the DTM from the DSM determines the tree's height as outlined in (Ruzgiene et al., 2015). The model's accuracy was assessed based on the maps' root mean squared error (RMSE).

2.3.2 Sediment Characteristics

The sediment sample for this investigation was obtained from the highest tide location of each zone in the Pantai Punggor and Pantai Perpat using a hand auger. Soil samples were collected in accordance with ASTM International's Standard Practice for Field Collection of Soil Samples for Subsequent Lead Determination (ASTM E 1727) (Pazi et al., 2021) to ensure consistency and reliability. The particle size distribution of the soil samples was determined through sieve analysis, specific gravity, and moisture content techniques following the Standard Test Method for Particle-Size Analysis of Soils (ASTM D 422) (Beretta et al., 2018) to understand sediment density and water retention capabilities. Additionally, tests for salinity and pH of the sediment were analyzed to evaluate soil conditions for mangrove health. These parameters were selected to provide a comprehensive understanding of the sediment's impact on mangrove health.

2.4 Analytical Framework

To enable effective comparison, the data were normalized using the min-max scaling technique. This method adjusted the varying measurement scales to a common range, ensuring a robust and accurate statistical analysis of both sediment characteristics and mangrove growth metrics typically between 0 and 1 (Cotton-Barratt et al., 2020).

The most widely used method of normalization is min-max normalization, which involves transforming the values to a scale between 0 and 1 using the following formula (Perminov et al., 2017):

$$X' = \frac{X - Xmin}{Xmax - Xmin} \quad (1)$$

Table 1: Mangrove Characteristics Based on Zones

Size	Zone 1			Zone 2			Zone 3		
	A	B	C	A	B	C	A	B	C
Avg Height (m)	6.08	5.91	7.28	3.79	7.29	5.14	2.46	2.70	7.09
Avg Diameter (m)	0.21	0.22	0.24	0.17	0.26	0.18	0.11	0.17	0.24
Density (Tree/m^2)	0.38	0.44	0.31	0.56	0.31	0.5	0.63	0.5	0.31

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3. Results

3.1 Mangrove Characteristics

Table 1 provides a comparative analysis of tree characteristics across three different zones, each divided into three subcategories: A, B, and C.

In Zone 1, the average tree height ranges from 5.91 meters in subcategory B to 7.28 meters in subcategory C, with an average diameter varying between 0.21 meters (subcategory A) and 0.24 meters (subcategory C). The tree density in Zone 1 is highest in Subcategory B at 0.44 trees per square meter and lowest in Subcategory C at 0.31 trees per square meter.

In Zone 2, the average tree height spans from 3.79 meters in subcategory A to 7.29 meters in subcategory B. The average diameter in this zone is slightly larger than in Zone 1, with subcategory B having the largest diameter at 0.26 meters. The density varies significantly, with subcategory A showing the highest density at 0.56 trees per square meter and subcategory B the lowest at 0.31 trees per square meter.

Zone 3 exhibits the most variation in tree heights, ranging from 2.46 meters in subcategory A to 7.09 meters in subcategory C. The average diameter follows a similar trend, with the smallest trees in subcategory A (0.11 meters) and the largest in subcategory C (0.24 meters). Interestingly, Zone 3 has the highest tree density overall, with subcategory A reaching 0.63 trees per square meter, while subcategories B and C both have lower densities at 0.5 and 0.31 trees per square meter, respectively.

The study found notable differences in mangrove growth across the three zones. Zone 1 exhibited the tallest trees and largest trunk diameters, while Zone 3, heavily affected by sediment accumulation, showed stunted growth. For instance, trees in Zone 1C had an average height of 7.28 meters, compared to just 2.46 meters in Zone 3A. The findings highlight the detrimental impact of excessive sediment accumulation, which restricts nutrient and oxygen availability to mangrove roots.

3.2 Sediment Characteristics

Table 2 provides detailed soil characteristics for three zones with three subcategories (A, B, and C). The characteristics analyzed include Specific Gravity (Gs), Particle Distribution (Silt Clay) percentage, Moisture Content percentage, pH Level, and Salinity in parts per thousand (ppt).

In Zone 1, the Specific Gravity ranges from 2.63 (A) to 2.77 (C), indicating slight variations in soil density. The Particle Distribution (Silt Clay) is relatively high, with values between 75% (B) and 88% (C), suggesting a clay-rich soil. Moisture Content is highest in subcategory C at 35% and lowest in A at 23%. The pH levels slightly vary from neutral to slightly acidic, ranging from 6.49 (B) to 7.14 (A). Salinity levels are consistent, ranging between 24.5 and 25.8 ppt.

Table 2: Sediment Characteristics Based on Zones

Characteristic	Zone 1			Zone 2			Zone 3		
	A	B	C	A	B	C	A	B	C
Specific Gravity (Gs)	2.63	2.73	2.77	2.66	2.75	2.67	2.62	2.65	2.77
Particle Distribution (Silt Clay) (%)	82	75	88	17.71	85.86	25.72	10.34	14.27	84.89
Moisture Content (%)	23	25	35	16	31	17	6	8	33
pH Level	7.14	6.49	6.77	7.02	6.68	7.31	6.49	6.07	6.84
Salinity (ppt)	24.5	24.6	25.8	18.7	23.4	24.1	21.5	20.4	25.8

Zone 2 exhibits similar patterns in Specific Gravity, with values ranging from 2.66 (A) to 2.75 (B). However, there is significant variability in Particle Distribution, with subcategory A having a notably lower percentage (17.71%) than B (85.86%). Moisture Content varies from 16% (A) to 31% (B). The pH levels are fairly consistent and slightly acidic, ranging from 6.68 (B) to 7.02 (A). Salinity in Zone 2 is generally lower than in Zone 1, with values between 18.7 (A) and 24.1 (C) ppt.

In Zone 3, the Specific Gravity is similar across subcategories, ranging from 2.62 (A) to 2.77 (C). The Particle Distribution varies widely, from as low as 10.34% (A) to 84.89% (C), indicating a

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diverse soil composition. Moisture Content is lowest in subcategory A at 6% and highest in C at 33%. The pH levels indicate more acidic conditions in Zone 3, ranging from 6.07 (C) to 7.31 (A). Salinity also varies, with subcategory C showing the highest value at 25.8 ppt, similar to Zone 1, while subcategory A has the lowest at 21.5 ppt.

The sediment analysis revealed that Zone 3 had the highest silt-clay content, reaching up to 84.89% in subzone 3C. This high concentration of fine particles correlates with poor drainage and reduced aeration, which are detrimental to mangrove growth (Gao et al., 2023). Zone 1, on the other hand, had a more balanced particle distribution and neutral pH levels, making it more conducive to healthy mangrove development. Moisture content was also notably higher in Zone 3, creating waterlogged conditions unfavorable for mangroves. These findings demonstrate the critical relationship between sediment composition and mangrove health.

3.3 Normalised Result

In Table 3, the detailed analysis reveals the varying conditions of the mangrove area and sediment properties in the study area. Zone 1 stands out due to the robust tree growth and higher salinity in subcategory C, while Zone 2 displays strong growth characteristics in subcategory B. On the contrary, Zone 3's subcategory A indicates the least favorable conditions, with growth-related characteristics near zero, signifying an unsuitable environment for tree growth.

This research builds on existing knowledge by providing a detailed, site-specific analysis of sedimentation impacts on mangroves. Studies like Besset et al. (2019) have reported similar challenges, where excessive sedimentation restricts root oxygenation and nutrient absorption. However, this study's use of UAV photogrammetry adds a new layer of precision, offering highly accurate spatial and elevation data that enhance our understanding of these dynamics. For instance, the ability to generate Digital Terrain Models has provided clearer insights into the micro-topography influencing sediment deposition patterns.

The findings underscore the urgent need for interventions to mitigate sedimentation in mangrove ecosystems. Practical measures such as constructing sediment traps and restoring degraded areas can help manage sediment levels effectively (Horstman et al., 2014). Moreover, policymakers should focus on sustainable land-use practices to reduce sediment influx into coastal areas. By integrating advanced monitoring tools like UAV photogrammetry into conservation strategies, authorities can enhance the resilience of mangrove ecosystems and promote long-term ecological sustainability.

Table 3: Normalised Data of Each Zone

Zone		Normalised: Characteristics				
		Height of Tree (m)	Trunk Diameter (m)	Particle Distribution %	pH Level	Salinity (ppt)
1	A	0.48	0.83	1.09	0.91	0.70
	B	0.46	0.92	0.98	0.36	0.71
	C	0.64	1.08	1.18	0.59	0.86
2	A	0.18	0.50	0.11	0.81	0.00
	B	0.64	1.25	1.15	0.52	0.57
	C	0.36	0.58	0.23	1.05	0.65
3	A	0.00	0.00	0.00	0.36	0.34
	B	0.03	0.50	0.06	0.00	0.20
	C	0.61	1.08	1.14	0.65	0.86

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4. Conclusion

This study highlights how sedimentation impacts mangrove growth by altering soil and water conditions. Through the use of UAV photogrammetry and standardized sediment analysis, the research provides detailed insights into these effects. The findings support the development of practical sediment management strategies and stress the importance of conserving mangrove ecosystems. The research provides an in-depth analysis of how sediment transport impacts mangrove forests, revealing that excessive sediment buildup can alter soil properties, limiting nutrient and oxygen availability to mangrove roots. This, in turn, may impede growth and increase susceptibility to pests and diseases. These findings focus on the role of local authorities such as the Forestry Department and Department of Irrigation and Drainage on the necessity of effective management strategies, urging conservation efforts to prioritize reducing sediment pollution and restoring water flow patterns within mangrove ecosystems. The study emphasizes the importance of mangroves in coastal resilience and ecological balance, calling for continued research by other universities and dedicated conservation efforts to protect these vulnerable coastal habitats in Malaysia and elsewhere.

Challenges in collecting field data emerge from the dense structure of mangrove habitats, which makes it difficult to access due to thick vegetation. Furthermore, despite its potential for data collection, there are lingering doubts about the reliability of UAV monitoring for data collection. Additionally, the sampling procedure is limited by the need to carry out collections when tides are at their lowest, increasing the research project's logistical challenges. To ensure that the sample is collected in good condition, it is important to create a systematic and appropriate schedule for data collection in future studies. Furthermore, an appropriate timetable can help prevent situations like blurry or cached images. This is due to the significance of the images in producing a high-quality ortho mosaic, which is crucial for generating precise data for DSM and DTM.

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6. References

Adrian L., Allan M. (2000). On the significance of the H/E ratio in wear control: a nanocomposite coating approach to optimised tribological behavior Wear 246:1-11.

Asp, N., Gomes, V., Schettini, C., Souza-Filho, P., Siegle, E., Ogston, A., Nittrouer, C., Silva, J., Nascimento, W., Souza, S., Pereira, L., & Queiroz, M. (2018). Sediment dynamics of a tropical tide-dominated estuary: Turbidity maximum, mangroves and the role of the Amazon River sediment load. Estuarine Coastal and Shelf Science, 214, 10–24. https://doi.org/10.1016/j.ecss.2018.09.004

ASTM D 422. (2014). Standard Test Method for Particle-Size Analysis of Soils. American Society of Testing and Materials.

ASTM E 1727. (2020). Standard Practice for Field Collection of Soil Samples for Subsequent Lead Determination. American Society of Testing and Materials.

Basyuni, M., Ramli, M. F., Ariffin, J., & Abdul Aziz, H. (2020). Impacts of sedimentation on mangrove ecosystems: A review. Sains Malaysiana, 49(3), 587-599.

Beretta, F., Shibata, H., Cordova, R., De Lemos Peroni, R., Azambuja, J., & Costa, J. F. C. L. (2018). Topographic modelling using UAVs compared with traditional survey methods in mining. REM - International Engineering Journal, 71(3), 463–470. https://doi.org/10.1590/0370-44672017710074

Besset, M., Gratiot, N., Anthony, E. J., Bouchette, F., Goichot, M., & Marchesiello, P. (2019). Mangroves and shoreline erosion in the Mekong River delta, Viet Nam. Estuarine Coastal and Shelf Science, 226, 106263. https://doi.org/10.1016/j.ecss.2019.106263

Chang, C. W., & Mori, N. (2021). Green infrastructure for the reduction of coastal disasters: a review of the protective role of coastal forests against tsunami, storm surge, and wind waves. Coastal Engineering Journal, 63(3), 370–385. https://doi.org/10.1080/21664250.2021.1929742

Cotton-Barratt, O., MacAskill, W., & Ord, T. (2020). Statistical normalization methods in interpersonal and intertheoretic comparisons. The Journal of Philosophy, 117(2), 61–95. https://doi.org/10.5840/jphil202011725

Dietrich, W. E., Day, G. A., Parker, G., & Hobbs, B. F. (2020). The physics and evolution of subaqueous sand dunes. Annual Review of Fluid Mechanics, 52, 29-59.

Earle, S., & Earle, S. (2015, September 1). 17.3 Landforms of Coastal Deposition. Pressbooks. https://opentextbc.ca/geology/chapter/17-3-landforms-of-coastal-deposition/.

Gao, J., Chen, L., Lu, H., Meng, X., Cao, X., Wang, D., Xie, L., Kwan, K., & Hu, B. (2023). The dynamic mechanism of rapid sediment deposition in the mangrove region of the Guangxi Beibu Gulf. Ocean Dynamics, 73(12), 743–760. https://doi.org/10.1007/s10236-023-01579-3

Hai, N., Dell, B., Phuong, V., & Harper, R. (2020). Towards a more robust approach for the restoration of mangroves in Vietnam. Annals of Forest Science, 77(1). https://doi.org/10.1007/s13595-020-0921-0

Hassan, M. I., & Rahmat, N. H. (2016). THE EFFECT OF COASTLINE CHANGES TO LOCAL COMMUNITY'S SOCIAL-ECONOMIC. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences/International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XLII-4/W1, 25–36. https://doi.org/10.5194/isprs-archives-xlii 4-w1-25-2016

Horstman, E., Dohmen-Janssen, C., Bouma, T., & Hulscher, S. (2014). Tidal-scale flow routing and sedimentation in mangrove forests: Combining field data and numerical modelling. Geomorphology, 228, 244–262. https://doi.org/10.1016/j.geomorph.2014.08.011

Kaamin, M., Daud, M. E., Sanik, M. E., Ahmad, N. F. A., Mokhtar, M., Ngadiman, N., & Yahya, F. R. (2018). Mapping shoreline position using unmanned aerial vehicle. AIP Conference Proceedings. https://doi.org/10.1063/1.5055465

Komar, P. D. (2017). Beach Processes and Sedimentation. 3rd ed. Routledge.

Lancaster, N. (2019). Aeolian Geomorphology: An Introduction [Wiley].

McLachlan, Andrew, Alan C. Brown, and Thomas A. Schlacher. (2021). The Biology of Beaches and Coasts. 3rd ed. Oxford University Press.

Minor, M. L., Zimmer, M., Helfer, V., Gillis, L. G., & Huhn, K. (2021). Flow and sediment dynamics around structures in mangrove ecosystems—a modeling perspective. In Elsevier eBooks (pp. 83–120). https://doi.org/10.1016/b978-0-12-816437-2.00012-4

Mohanta, Pradhan, B., & Sahu, S. (2020). Assessment of species diversity and physicochemical characteristics of mangrove vegetation in Odisha, India. In Elsevier eBooks (pp. 135–151). https://doi.org/10.1016/b978-0-12-819532-1.00006-8

Mohd Razi, N. A. A., Mohd Razif, N. H., Ahmad, A., & A. Aziz, N. (2019). Evaluating the effectiveness of sedimentation pond and sediment trap for river management: A review. Malaysian Journal of Civil Engineering, 31(3), 284-297.

Mokhtar, M., Daud, M. E., Kaamin, M., Sabri, M. S., Hayazi, F., Hisham, M. H., Siddiq, M. I., Azmi, M. a. M., Hamid, N. B., & Noor, H. M. (2023). Beach profile and shoreline sediment properties at eroded area in Batu Pahat. Construction Technologies and Architecture. https://doi.org/10.4028/p-ny3700

Mokhtar, M., Hayazi, F., Hamzah, A. S. A., Isnin, M. S. S., Kaamin, M., Azmi, M. A. M., & Hamid, N. B. (2020). Condition Survey of Eroded Area in Pantai Punggur, Malaysia Shoreline Using UAV Photogrammetry. Solid State Technology, 63(3), 826-833.

Ndungu, L. K., Steele, J. H., Hancock, T. L., Bartleson, R. D., Milbrandt, E. C., Parsons, M. L., & Urakawa, H. (2019). Hydrogen peroxide measurements in subtropical aquatic systems and their implications for cyanobacterial blooms. Ecological Engineering, 138, 444–453. https://doi.org/10.1016/j.ecoleng.2019.07.011

Nickling, W. G. (2019). "Aeolian Sediments and Processes." In Coastal Sediments, edited by S. L. Namikas and J. D. Rosati, 161-183. Springer.

Pähtz, T., & Durán, O. (2020). Unification of Aeolian and Fluvial Sediment Transport Rate from Granular Physics. Physical Review Letters, 124(16). https://doi.org/10.1103/physrevlett.124.168001

Parker, G. (2016). Physics of sediment transport by wind and water. Annual Review of Fluid Mechanics, 48, The :711-738.

Pazi, A. M. M., Khan, W. R., Nuruddin, A. A., Adam, M. B., & Gandaseca, S. (2021). Development of Mangrove sediment Quality Index in Matang Mangrove Forest Reserve, Malaysia: A synergetic approach. Forests, 12(9), 1279. https://doi.org/10.3390/f12091279

Perminov, Nikolay & Smirnov, Maksim & Nigmatullin, Raoul & Talipov, Anvar & Moiseev, Sergey. (2017). SRA vs histograms in the noise analysis of SPAD.

Ruzgienė, B., Berteška, T., Gečyte, S., Jakubauskienė, E., & Aksamitauskas, V. Č. (2015). The surface modelling based on UAV Photogrammetry and qualitative estimation. Measurement, 73, 619–627. https://doi.org/10.1016/j.measurement.2015.04.018

Sabri, M. S., Daud, M. E., & Mokhtar, M. (2022). Effect of soil shear strength on shoreline changes at Batu Pahat coastal area. Journal of Sustainable Underground Exploration, 2(1). doi: 10.30880/jsue.2022.02.01.002.

Saintilan, N., Khan, N. S., Ashe, E., Kelleway, J. J., Rogers, K., Woodroffe, C. D., & Horton, B. P. (2020). Thresholds of mangrove survival under rapid sea level rise. Science, 368(6495), 1118–1121. https://doi.org/10.1126/science.aba2656

Salmo, S. G., Malapit, V., Garcia, M. C. A., & Pagkalinawan, H. M. (2019). Establishing rates of carbon sequestration in mangroves from an earthquake uplift event. Biology Letters, 15(3), 20180799. https://doi.org/10.1098/rsbl.2018.0799

Siddiq, M. I., Daud, M. E., Kaamin, M., Mokhtar, M., Omar, A. S., & Duong, N. A. (2022). Investigation of Pantai Punggur Coastal Erosion by using UAV Photogrammetry. International Journal of Nanoelectronics & Materials, 15, 61-69.

Siddiq. "THE INVESTIGATION OF SHORELINE CHANGES BY USING UAV PHOTOGRAMMETRY AT PANTAI PUNGGUR ." Faculty of Civil and Built Environment Universiti Tun Hussein Onn Malaysia , July 2023.

Singh, J. K. (2020). Structural characteristics of mangrove forest in different coastal habitats of Gulf of Khambhat arid region of Gujarat, west coast of India. Heliyon, 6(8), e04685. https://doi.org/10.1016/j.heliyon.2020.e04685

Wang, J., Sun, J., Yu, Z., Li, Y., Tian, D., Wang, B., Li, Z., & Niu, S. (2019). Vegetation type controls root turnover in global grasslands. Global Ecology and Biogeography, 28(4), 442–455. https://doi.org/10.1111/geb.12866

Xie, D., Schwarz, C., Kleinhans, M. G., Zhou, Z., & Van Maanen, B. (2022). Implications of coastal conditions and Sea-Level rise on mangrove vulnerability: A Bio-Morphodynamic Modeling study. Journal of Geophysical Research Earth Surface, 127(3). https://doi.org/10.1029/2021jf006301

DOI: https://doi.org/10.22452/mjs.vol45sp1.7
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