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TABLE OF CONTENTS

ANALYTICAL AND STATISTICAL APPROACHES TO STUDY THE IMPACTS OF SHORELINE CHANGE TOWARDS MANGROVES AT KUKUP ISLAND NATIONAL PARK, JOHOR

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Shoreline and mangroves form a dynamic ecosystem to coastal area. They support and supply various foods and protections to ensure the sustainability of coastal ecosystem around the world. Despite these, information that exclusively emphasize on the interaction of shoreline change and mangroves on an island is still lacking, making assessment and observation towards coastal areas on island less significant. Hence, this study is significant to provide a first view of the interaction and the relationship and response of shorelines change towards mangrove physical characteristics. GIS, remote sensing as well as statistical analysis such as DSAS and linear regression were applied to support the study that consisted of three main stages which involve data collection, data processing and comparison of mangroves physical characteristics towards the changes in shoreline positions. Finding revealed that during the time span of 2005-2011, shoreline near to Sg Ular has experienced more erosion, resulted in the shoreline shifting that was ranged between -0.02 m/y and -1.52 m/y. Further analysis of shoreline change and mangroves physical characteristic unveiled that a significant relationship of mangrove characteristics and shoreline changes rates occurred at Sg Ular. It was found that mangroves communities along the shoreline of Sg Ular was negatively influenced by the shoreline change, possibly due to mild erosion along the shoreline towards the river mouth of Sg Ular.

Keywords: *Shoreline Change, Mangroves, GIS, Remote Sensing, DSAS*

Introduction

Mangroves are a group of shrub and tree species that live along shores, rivers and estuaries in the tropics and subtropics area around the world. They are characterized by the prop roots (Omo-Irabor et al, 2010) that tolerate to different salinity and moisture changes, to distinguish their dominants towards certain area. Mangroves formed a highly dynamic and productive ecosystem, providing various resources of foods, timber, fuel and medicine (Giri et al., 2007), as well as offering conducive places for numerous animals breeding. They too serve as a protection to coastlines against wave and wind, and act as buffers to protect shoreline from erosion. Mangroves help to filter runoff generated by surrounding land uses, removing harmful chemicals and help to maintain a balance in sensitive aquatic ecosystems.

There are about 17 million hectares of mangroves worldwide (Gilman et al., 2006; Omo-Irabor et al., 2010), characterized by 84 species of plants that belongs to 39 genera in 26 families (Saenger, 2002; Adedeji et al., 2011). Omo-Irabor (2010) and FOA (2003) estimated 102,000 ha of worldwide mangroves forest were annually lost between 2000 and 2005, by direct and indirect causes of natural threats and human-induced. Droughts, floods, and geological erosion has threatened mangroves ecosystem around the world (Omo-Irabor et al., 2010) and relative sea level rise has been identified as a major factor contributing to recent losses of mangroves and other tidal wetlands (Gilman, 2004).

Dynamic phenomena like shoreline with sediment moving continually, accreted and eroded here and there (Poulus and Chronis, 2001 and Eluyodin et al., 2012) requires spatial and temporal data in order to represent and visualize the object’s shape and their positions over time. The changes in shoreline position have become a major social, economic and environmental concern to a large number of countries along the coast (Chand and Acharya, 2010). Though shoreline established equilibrium with respect to available sediment budget and prevailing near-shore marine processes (Poulos and Chronis, 2001; Eludoyin et al., 2012), small island developing states and low lying coastal areas of continents are still particularly vulnerable to small increases in sea level (Gilman et al., 2007).

Mangroves that situated along the shoreline are vulnerable to the erosion and deposition processes will result in the changes of mangroves position such as mangrove landward and seaward margins transgress seaward, mangrove landward margin transgresses inland while mangrove seaward margin erodes or mangrove seaward margin erodes, landward margin is obstructed from inland transgression (Ellison and Stoddart, 1991; Gilman et al., 2007). Thus, an in-depth study of potential effects of shoreline change towards mangrove physical characteristics thus important to supply an ample information in the maintenance of the environment, supporting plant and animal, as well as for the continuity of biological processes in the island area.

Accurate predictions of changes to coastal ecosystem area and health, including its response to climate change effects enables advanced planning appropriate for specific sections of coastline to minimize and offset anticipated losses, and reduce threats to coastal development and human safety (Titus, 1991; Mullane & Suzuki, 1997; Ramsar Bureau, 1998; Hansen and Biringer, 2003; Ellison, 2004; Gilman, 2004, Gilman et al., 2007). As there is still lacking information that exclusively emphasizes on the interaction of shorelines change and mangroves community, hence this study is significant to provide a first view of the interaction and the relationship and response of shorelines towards mangroves physical characteristics. This research aims at the integration of knowledge-building, the adoption of different technologies and methodologies as well as estimating, modeling and simulating the impacts and the migration of shoreline vegetation and boundaries. GIS, remote sensing as well as statistical analysis were applied to support the research that consisted of three main stages which involve data collection, data processing and comparison of mangroves physical characteristics towards the changes in shoreline positions.

Study Area

The study area took place at Kukup Island, the largest uninhabited mangrove island located 1 km offshore from the south-western tip of the state of Johor, Peninsular Malaysia. Figure 1 illustrates the location of Sg Ular at Kukup Island National Park, Johor.

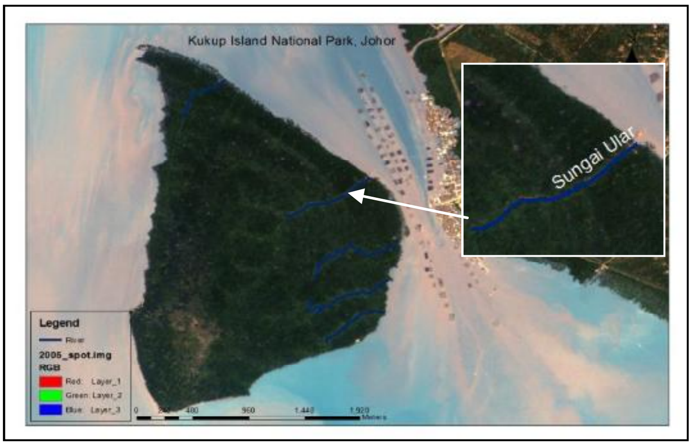


Figure 1: Location of Sg Ular at Kukup Island National Park

It is a small mangrove island (647.2 ha) surrounded by mudflats (800 ha) with mature mangrove in the interior, rapidly accreting zones on the west coast, and eroding along the south-east coast. It is a home to about 18 'true' mangrove plant species, which represents very rich species diversity if compared to other far larger mangrove areas in Peninsular Malaysia. Apart from maintaining the physical protection, this island becomes a habitat to various flora and fauna. There are six rivers located around Pulau Kukup. Sg Ular is identified as the main river contributes to freshwater supply on this island.

Methods

We represent methodology in two different parts. First part elaborates on the data collection and the next part describes on the analyses of data.

Data Collection

Data collection consists of the acquisition of primary and secondary data. It involved with the acquisition of a number of spatial and non-spatial data such as remotely sensed images (2005 and 2011), topography maps, and shoreline vegetation types and shoreline vegetation samples. Ground truth survey and mangrove profile survey were conducted to collect mangroves species in the study area.

Shoreline Change Analyses

Digital Shoreline Analysis System (DSAS) was used to perform the calculation of shoreline rate-of-change statistics (Thieler et al., 2009). In DSAS, statistics were computed by merging different historical shorelines into one layer. Three statistics were used to study shoreline change and rates of shoreline change. They were Net Shoreline Movement (NSM), End Point Rate (EPR) and Linear Regression Rate-of-Change (LRR) was used to study shoreline change. These analytical methods provide a quick run-times for statistics calculation which involved many shoreline data.

Mangrove Analyses

The main features use for the analyses was from the images of root system, leaves and the seedling. Data recorded from clinometers measurement were transformed using a standard equation to obtain the absolute height. Circumferences data recorded too during the survey were transformed to DBH using a standard equation. The location of sampled tree from GPS was transferred into GIS application for better representation and further analyses.

Statistical analyses were then carried out to understand the relationship relies between the mangrove characteristics with shoreline changes at Sg Ular. The mangrove characteristics used in this study was indicated as the Diameter at Breast Height (DBH) and the tree height. The mangrove characteristics served as the dependent variable and shoreline changes rate was the independent variable. A linear regression analyses was performed using Microsoft Excel Software 2007, to identify the significant relationship between the two parameters. The pie chart was developed to represent the mangrove composition for Sg Ular. The selected transect line for landform interaction analyses were based on the nearest distance of the line to the mangrove tree.

Comparison of shoreline change rate and mangroves physical characteristics

Based on the findings of shoreline change and the trend rates of sea level rise, comparison will be made to identify their relationship toward the mangroves physical characteristics. It is important to reveal the significance of shoreline change due to the rise of sea level to the physical characteristics of mangrove community in Sg Ular.

Results and Discussions

Shoreline Change Study

Shoreline change study at Sg Ular began with the delineation process of multi-dated satellite images that were acquired during 2005 and 2011. Four baselines were created along the shorelines. Transect were set to be cast at 10 m spacing and 20 m length. A total of 41 transects were cast along the shorelines and used throughout this analysis. Figure 2 illustrates transects, baselines and appended shorelines on Sg Ular study area. Table 1 summarizes the shoreline change and change rate for the period of 2005 and 2011 at Sg Ular.

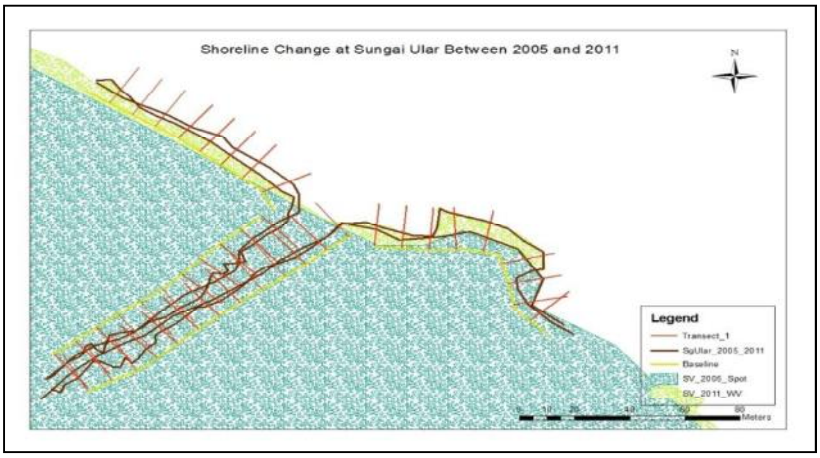


Figure 2: Transects, baselines and appended shorelines on Sg Ular

Table 1: NSM and EPR for shoreline change analysis at Sg Ular

Sg Ular 2005_2011	NSM (m/y)	EPR (m/y)
Max	-9.55	-1.52
Min	9.9	1.58
Mean	-0.58	-0.09
S.D	3.68	0.59

Figure 3 shows the net shoreline changes at each transect at Sg Ular. 16 transects including Transect Id 1, 9-11, 13-15, 19, 28-29 and 33-38 have experienced accretion between the period of 2005 and 2011. Deposited areas along the shorelines show that the accretion could be lead by the sediments that washed away via Sg Ular. The shore which is situated across the Strait of Kukup is averted from wind and waves. Alluvial deposited along the shore was retained by the vegetation's roots that inhabits along the shore, making it resistant towards waves and winds. 25 transects have experience erosion including Transect Id 2-8, 12, 16-18, 20-27, 30-32 and 39-41. Through this figure, it was confirmed that many areas along the shoreline have experienced erosion during the time span of 2005-2011 as indicated by the shoreline shift that range between -0.02 m/y and -1.52 m/y.

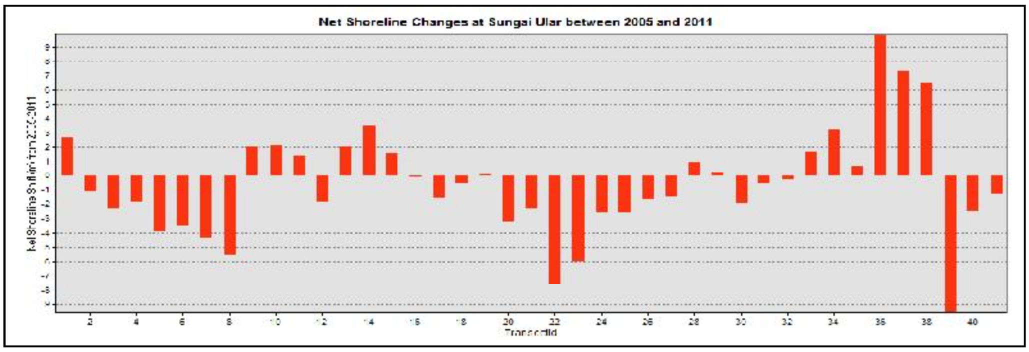
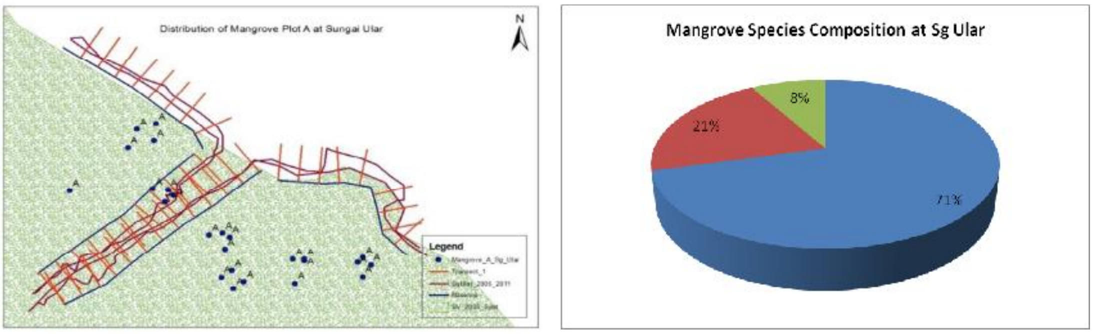


Figure 3: Net shoreline changes at each transect at Sg Ular

Mangrove Analyses

Sg Ular was characterized by three mangrove species which are Rhizophora apiculata (Bakau Minyak), Rhizophora mucronata (Bakau Kurap) and Brugueira gymnorhiza (Tumu Merah). Figure 4 (a) shows the distribution of mangroves at Sg Ular while Figure 4 (b) illustrates the mangrove distributions found in Sg Ular area.



(a) (b)

Figure 4: (a) Distribution of Mangroves on Plot A at Sg Ular; (b) Mangrove composition at (Plot A). (Blue = Rhizophora apiculata, Red = Rhizophora mucronata , Green = Brugueira gymnorhiza)

Four points within plot A labeled as A1(a), A2(a), A2(b), and A(c) were selected to study the relationship of mangrove physical characteristics with shoreline changes rates. These points were located around the river mouth of Sg Ular which is believed to have significant relations with shoreline processes. The mean physical characteristics of Rhizopora apiculata communities were studied to determine the interactions of mangrove physical characteristics with shoreline processes. A significant relationship of mangrove characteristics and shoreline changes rates were found at Sg Ular. Figure (5) to (6), shows the significant relationship of mangrove characteristics (Rhizophora apiculata) with the shoreline changes rate.

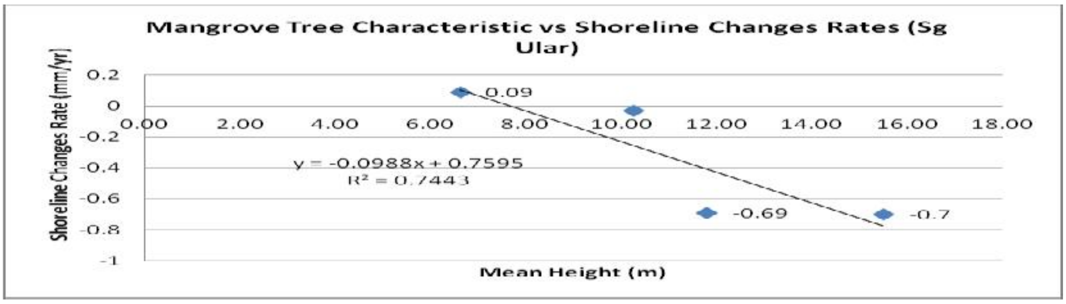


Figure 5: Relationship of tree height and shoreline changes rates at

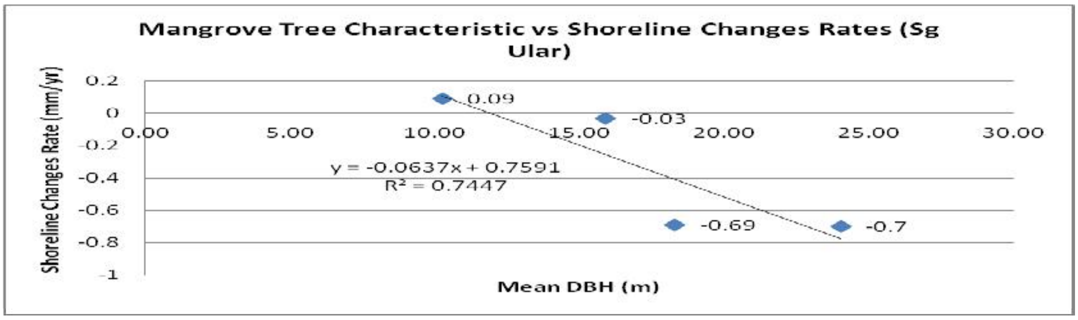


Figure 6: Relationship of Diameter at Breast Height (DBH) and shoreline changes rates at

Comparison of Mangrove Physical Characteristics to Rates of Shoreline Change and SLR

Overall mangrove shoreline changes are variable around Pulau Kukup mangrove. According to Duke et al., (1992), it is expected that any shoreline retreat resulting in mangrove loss will be offset by sediment deposition in another location allowing new colonization and fertile sediment. In general, Pulau Kukup was greatly eroded at the South East Coast (Plot A). The mean diameter and height of mangrove trees can be classified as important physical characteristics that control the role and existence of the species in intertidal area.

The mangrove physical characteristic in Plot A was negatively correlated to the shoreline changes rate. It is possibly due to the general processes occurred along the intertidal area. The South East Coast of Pulau Kukup experienced mild erosion along the shoreline towards the river mouth of Sg Ular. The mean height and DBH was highest at the most eroded area A1 (a) and decreased gradually to A2(C). Mean diameter and height of mangrove trees can be classified as important physical characteristics of mangrove tree that control the role and existence of the species in intertidal area. Diameter at breast height and tree height represented the maturity of the mangrove in term of allometric relations. It is used to examine how an individual tree changed during the growth from seedling to adult tree (Aiba and Kohyama, 1997).

In this case, the maturity of mangrove tree is important because the development of roots configuration system was largely related to the aged of the tree. In mature tree, they have fully developed root configurations system that helps to reduce the erosion effects in shoreline by trapping sediment particles and slowing down the wave action (Kathiresan and Bingham, 2001). A mature mangrove trees are capable to withstand the impacts from larger wave actions therefore, it is generally found at the most eroded area. Fully-grown Rhizophora apiculata was equipped with complex stilt root system which anchored the substrate better and trapped more sediment to stabilize its structure.

Conclusion

The primary objective of this research was to observe the relationship of shoreline change and mangroves physical characteristics. It was found that mangroves communities along the shoreline of Sg Ular was negatively influenced by the shoreline change, possibly due to mild erosion along the shoreline towards the river mouth of Sg Ular. Despite some areas along the shoreline experienced erosion during the time span, the location of Sg Ular itself that located at the east part of island and hindered from the open sea enable the mangrove community to maintain their survival. However, a detail study is still needed to be carried out in order to determine the erosion and deposition that might occurred along the whole shoreline of Kukup Island and it impact towards the other shoreline vegetation.

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