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Research paper



Impact of Shoreline Changes to the Coastal Development

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Abstract

The coast zone is one of the most fragile area in Malaysia and can be affected easily due to environmental threats. This study mainly focuses on analysis impact of shoreline changes on coastal development using Geographical Information System (GIS) approach to produce geospatial visualization and identify the changes areas along Sabak Bernam to Kuala Selangor. This study evaluates the shoreline changes using topographic maps in 1993 and SPOT 5 satellite images in 2013. The major findings of this study were the highest impact that caused by erosion was from Sungai Burung to Sungai Panchang Bedena and the development that have been affected in this area for 5 years (2018) and 10 years (2023) ahead were residential area, school and aquaculture activities. However, the lowest impact of erosion was occurred from Sungai Nipah to Sungai Nibong and there was no development affected in the year 2018 till 2023. The results obtained from this study are very important for the government's future policy and the development strategy along coastal area and at the same time it helping in dealing with the phenomenon of sea level rise and climate change.

Keywords: *Climate changes; Sea level rise; Shoreline changes; Geographical Information System (GIS); Erosion and accretion*.

1. Introduction

A shoreline is defined as a boundary between land and water. In [1] provided the definition of shoreline is a line between the lowest tide and high tide reading. Shoreline position defines the boundaries of a country. Shoreline changes consider as a major dynamic changes in coastal areas [2-4], where the shoreline position will changes due to two major factors which area natural activities and human activities. Shoreline changes occur due to natural activities through a process of unification between waves, currents, tides and river flow often lead to conflict in the process of coastal erosion as has been investigated by [5]. While, the changes occur due to human activities through the increasing population and unplanned development at coastal area. According to [3], smoothly changing shoreline and fragile are regarded as one of the major issues for coastal zones to determine the boundary of a region. Thus, mapping of shoreline position is important task to determine boundary of region.

Malaysia is a country with 4800 km of shoreline including islands where west coast of Peninsular Malaysia composed of muddy beach while east coast of Peninsular Malaysia is sandy beach. Regarding to the [6] reported by Stanley states that by 1390 kmof the 4809 kmof shoreline in Malaysia is experiencing erosion. In addition, > 30% of the shoreline in Malaysia experienced the coastal erosion. Study from [7-8] stated that the shoreline changes will occur with two phenomena either erosion or accretion inducted by sea level rise, wave and sediment transport. > 70% of the world's shoreline faces coastal erosion phenomenon and this issue has a serious impact on coastal countries [9]. The Rapid changes in shoreline are not only affected to the physical environment, but it also affect to the social and economic activities of coastal communities. Therefore, shoreline change studies are an important task for the monitoring, prevention and conservation of coastal zones.

In the past, field measurement techniques were conducted to determine shoreline changes, where this technique was conducted to collect coastal data positions [10, 3]. Presently, there are many techniques used for determination of shoreline changes and each technique has its own goals and advantages. It happens because the rapid technology improvement has no limitation to overcome this problem. The Geographical Information System (GIS) and Remote Sensing technology is recognized as an effective technique in the process of monitoring, analyzing, and predicting shoreline changes. It can be proven by many researcher have been conducted their studies using GIS and remote sensing approach to determine the shoreline changes such as [9, 11-13]. On the other hand, using this technique is able to produce valuable result and information.

This study explores shoreline changes using the GIS approach and calculates the rate of shoreline change. The main goal of this study is to identify the affected location with erosion and accretion phenomena. In addition, this study also takes into account the infrastructure that are experiencing damage due to the phenomenon of

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shoreline changes. At the end of this study, projection of shoreline has been made to identify the position of shoreline intern of 5 and 10 year.

2. Material and Method

According to [14] stated that Malaysia is a country that has a 4809 km shoreline including Sabah and Sarawak coastal area. At west coast of Malaysia, more than half of the coastline is made up of a muddy beach while the rest is sand and reclaimed areas. Regarding to [15] states that the muddy coastal areas usually have lower surface slope up to saline water that can flood the coastal area up to several km to land. This present study covers shoreline area in the district of Selangor which is from Sg. Bernam to Sg. Kuala Selangor at 100°47'30.87"E to 101°13'58.83"E and 3°49'50.79"N to 3°20'21.12"E as shown in Fig. 1. Selangor coastal located at west coast of Peninsular Malaysia characterized as muddy coastal area. These study area also involves 1 km towards the land and 1 km towards the sea from the coastline. Therefore, to overcome this problem the shoreline was divided into smaller units called Sub Unit Management (SUM) for monitoring and managing the shoreline changes. SUM is a length of shoreline with coherent characteristics in terms of natural coastal processes and land use. There are 15 SUM zones in this study where divided according to the purpose of the study area as show in Table 1.

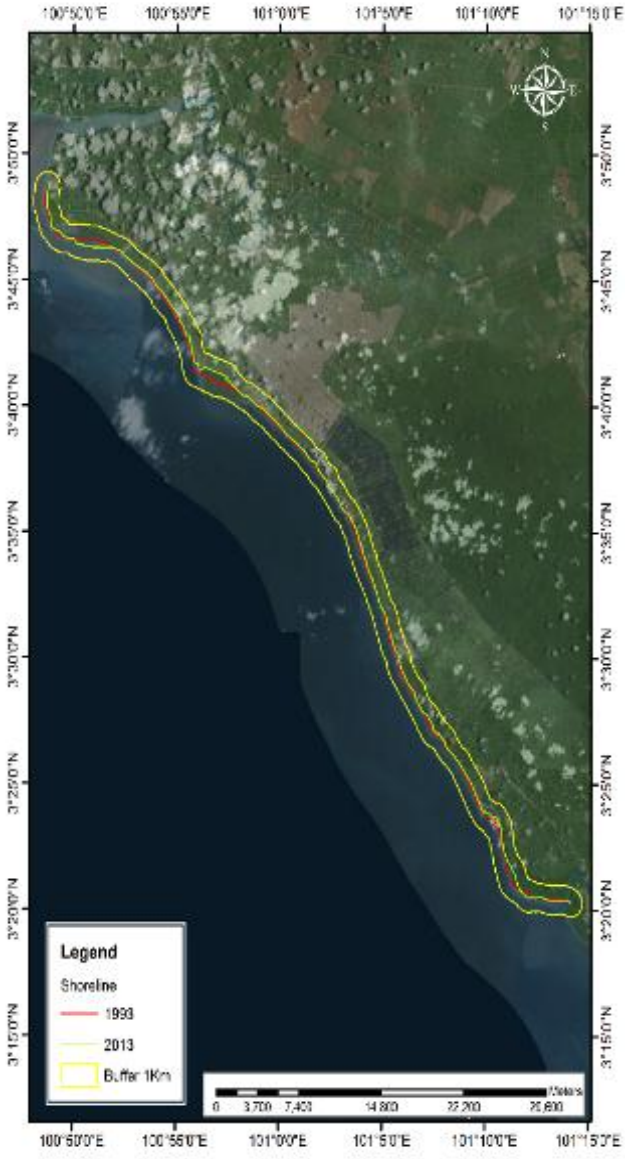


Fig. 1: Study area

Table 1: Sub Unit Management (SUM) from Sabak Bernam to Kuala Selangor.

Sub Unit Management (SUM)	From	To
SUM 1	Sg Bernam	Sg Bagan Nakhoda Omar
SUM 2	Sg Bagan Nakhoda Omar	Sg Banting
SUM 3	Sg Banting	Sg Burung
SUM 4	Sg Burung	Sg Panchang Bedena
SUM 5	Sg Panchang Bedena	Sg Besar
SUM 6	Sg Besar	Sg Haji Dorani
SUM 7	Sg Haji Dorani	Sg Nipah
SUM 8	Sg Nipah	Sg Nibong
SUM 9	Sg Nibong	Sg Pasir Panjang
SUM 10	Sg Pasir Panjang	Sg Sekinchan
SUM 11	Sg Sekinchan	Sg Lima
SUM 12	Sg Lima	Sg Tengkorak
SUM 13	Sg Tengkorak	Sg Tengi
SUM 14	Sg Tengi	Sg Terap
SUM 15	Sg Terap	Sg Kuala Selangor

To determine and analysis shoreline changes, the GIS approach employed in this study. Based on the previous study by [7-8, 16-17], GIS approach was able to determine and analyze the shoreline changes phenomena meanwhile in [3] stated that using ArcGIS software also able to generate the spatial model to identify the shoreline changes. This study used shoreline topographic 1993 from Department of Survey and Mapping Malaysia (JUPEM) as a reference line whilst Spot 5 satellite image year 2013 were used as investigation data. Table 2 indicates the data sources used for determination of shoreline changes along Sabak Bernam to Kuala Selangor area. Processed satellite images are used to determine position of shoreline by using digitizing techniques. After that, the overlapping of shoreline with different year was made to determine the erosion and accretion phenomena. ArcGIS software is used to create spatial model to extract the shoreline changes. Therefore, generated spatial model processing able to determine the erosion accretion area automatically based on steps and processes that have been modelled.

Table 2: Data sources used for the study

Type of data	Year	Scale/Resolution
Topographic map	1993	1: 50 000
SPOT 5	2013	2.5 meter

3. Results and Discussion

Changes in the shoreline occur over time and weather until now. This is not a new issues but it has been faced by coastal countries ever since. Shoreline changes give an impact to boundary of country and also to coastal communities. Mapping of shoreline changes is an important step to identify position of shoreline and ensure the pattern of changes. Therefore, this study was conducted to identify the pattern of shoreline changes along the Sabak Bernam to Kuala Selangor coast. The shoreline of the study area is about 80 km which is divided in part of 15 SUM. Shorelines were extracted from topographic map as a baseline and SPOT 5 as investigation shoreline changes. Based on topographic maps and satellite imagery, changes can be seen from 1993 up to 2013 and Fig. 3 indicated the shoreline changes between Sabak Bernam and Kuala Selangor. Regarding to NCES 1986 stated that Selangor was categorized as the third highest state facing the erosion event during 1986 investigation. The results showed that significant changes were noticed along the Sabak Bernam and Kuala Selangor coastal area during 20 years from 1993 to 2013.



Fig. 2: Shoreline changes between Sabak Bernam and Kuala Selangor from 1993 to 2013

Based on the result, there are several areas in this study experiencing shoreline changes phenomena either erosion or accretion. The total eroded area is about 829.54 hectares while the total of accretion is about 685.02 hectares. Hence, the total percentage of the erosion calculated within the study area is 54.7%. While, for the total percentage of accretion is about 45.2% along the Sabak Bernam to Kuala Selangor shoreline. According to the NCES 1986 study, about 45 of the 75 erosion areas was categorized as the worst areas are located on the west coast of peninsular Malaysia where this area activities are urbanization and agriculture. This study has been proven by [18], stated that the erosion that occurs on the west coast of the peninsular Malaysia usually occurs along the coastal agricultural lands found in Sabak Bernam, Selangor. Table 3 illustrated the rate of changes among 15 MU along Sungai Sabak Bernam to Sungai Kuala Selangor.

Table 3: The area of erosion and accretion between Sabak Bernam and Kuala Selangor from 1993 to 2013

Sub Unit Management (SUM)	Location	Erosion (Ha)	Percentage of Erosion (%)	Accretion (Ha)	Percentage of Accretion (%)
SUM1	Sg bernam to Sg Bagan Nakhoda Omar	107.33	7.09%	131.36	8.67%
SUM 2	Sg Bagan Nakhoda Omar to Sg Banting	49.12	3.24%	0.17	0.01%
SUM3	Sg Banting to Sg Burung	159.79	10.55%	0.00	0.00%
SUM 4	Sg Burung to Sg Panchang Bedena	12.68	0.84%	251.00	16.57%
SUM 5	Sg Panchang Bedena to Sg Besar	0.26	0.02%	162.99	10.76%
SUM 6	Sg Besar to Sg Haji Dorani	51.20	3.38%	26.79	1.77%
SUM 7	Sg Haji Dorani to Sg Nipah	14.99	0.99%	0.05	0.00%
SUM 8	Sg Nipah to Sg Nibong	7.55	0.50%	5.80	0.38%
SUM 9	Sg Nibong to Sg Pasir Panjang	14.93	0.99%	7.77	0.51%
SUM 10	Sg Pasir Panjang to Sg Sekinchan	85.80	5.66%	0.00	0.00%
SUM 11	Sg Sekinchan to Sg Lima	64.14	4.23%	0.00	0.00%
SUM 12	Sg Lima to Sg Tengkorak	23.12	1.53%	0.00	0.00%
SUM 13	Sg Tengkorak to Sg Tengi	51.50	3.40%	59.40	3.92%
SUM 14	Sg Tengi to Sg Terap	184.46	12.18%	25.30	1.67%
SUM 15	Sg Terap to Sg Kuala Selangor	2.66	0.18%	14.39	0.95%
	Total	829.54	54.77%	685.02	45.23%

Fig. 4 indicated the higher eroding occurred at SUM 14 that starting from Sungai Tengi to Sungai terap and Fig. 5 illustrated the higher accretion has occurred at SUM 4 starting from Sungai burung to Sungai Panchang Bedena which are 184.46 hectares with 12.2% and 251.00 hectares with 16.6% respectively. SUM 14 was categorized as the higher eroding area because this area low land area and having development activities nearest to the coast as shown Fig. 6. However, SUM 4 covers from Sungai Burung to Sungai Panchang Bedena is a places that has been deposited with sand as shows as Fig. 7. It is causes of this area was classify as the higher accretion area. Meanwhile, there are some areas that have not experienced accretion phenomena such as in MU3, SUM 10, SUM 11 and SUM 12. The shoreline SUM 3 covers from Sungai Banting to Sungai Burung, while SUM 10 to SUM 12 was covers from Sungai Pasir Panjang to Sungai Tengkorak.

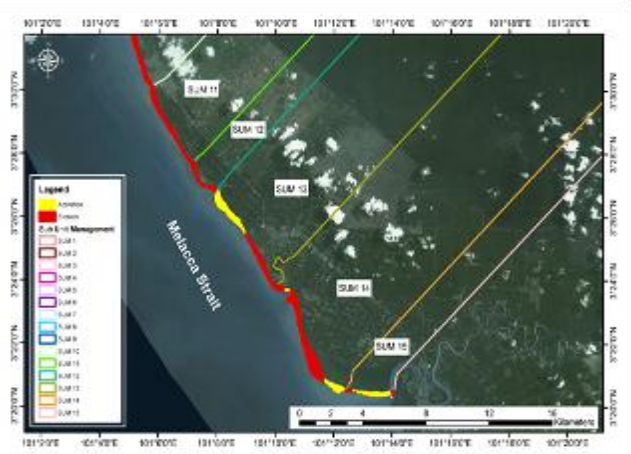


Fig. 4: Critical erosion occurred at SUM 14 from Sungai Tengi to Sungai Terap

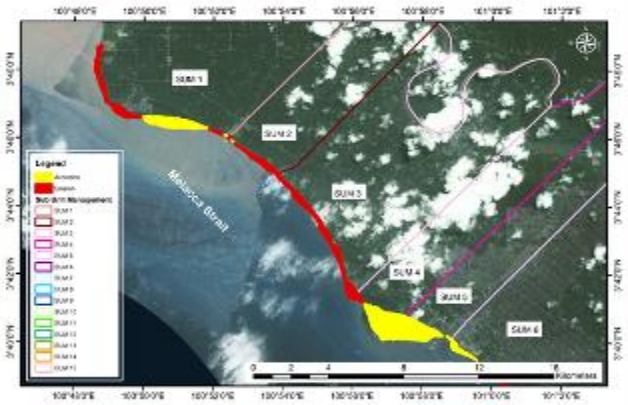


Fig. 5: Critical shoreline accretion occurred at SUM 4 from Sungai Burung to Sungai Panchang Bedena.



Fig. 6: Eroding shoreline at Sungai Tengi (2016).



Fig. 7: Accretion shoreline at Bagan Sungai Burung (2016).

Development issues in coastal areas have become a platform for discussion among the people of various layers, whether among local and international experts. This is because coastal areas are fragile and sensitive to the natural and man-made changes. This area is always been a region that easily affected even the activities that lead to any change in the environment started in the middle of the mainland, but the effects always end up in the offshore. Table 4 shows the annual rate of erosion and accretion in 15 SUM. Among the entire SUM, the maximum erosion rate occurred at SUM 14 with 30.11 meter per year between the years. Meanwhile, the most accreting occurred at SUM 4 with 78.98 meter per year. Among the main causes of sediment deposition in Sum 4 is that area consists of mangrove area while SUM 14 was categories as the most erosion area because that area having development nearest to the coastal area.

Table 4: The annual rate of erosion and accretion between Sabak Bernam and Kuala Selangor from 1993 to 2013

Sub Unit Management (SUM)	Erosion (m)	Accretion (m)	Rate Per Year (m/year)	
			Erosion	Accretion
SUM 1	372.73	547.96	18.64	27.40
SUM 2	272.52	22.36	13.63	1.12
SUM 3	429.06	0.00	21.45	0.00
SUM 4	250.26	1579.54	12.51	78.98
SUM 5	25.77	1221.27	1.29	61.06
SUM 6	157.76	329.02	7.89	16.45
SUM 7	151.31	20.77	7.57	1.04
SUM 8	130.67	110.67	6.53	5.53
SUM 9	149.38	170.75	7.47	8.54
SUM 10	189.43	0.00	9.47	0.00
SUM 11	205.1	0.00	10.26	0.00
SUM 12	247.91	0.00	12.40	0.00
SUM 13	219.63	392.57	10.98	19.63
SUM 14	602.28	285.62	30.11	14.28
SUM 15	75.23	167.43	3.76	8.37

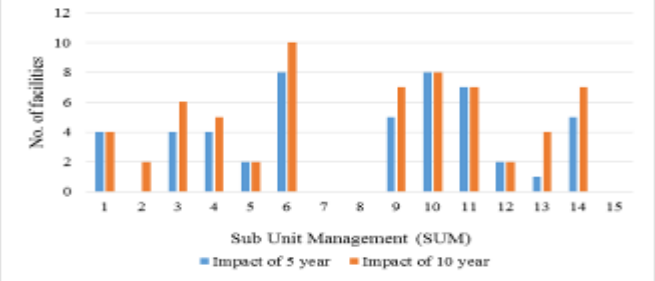


Fig. 8: Destruction facilities impact of shoreline changes for 5 and 10 year projection.

This study was investigated the projection of shoreline changes within 5 and 10 years using shoreline 2013 as a baseline. As for Fig. 8, the results show that in the next 5 years development of SUM 6 will face a high destruction of facilities followed by the SUM 10 area comprising housing, aquaculture, resorts and infrastructures as shown in Fig. 8. Meanwhile, for the 10 years impact, the area that has the most impact on coastal development is also in the SUM 6 area between Sungai Besar and Sungai Haji Dorani. Additionally, the Fig. 8 shows that SUM 7, SUM 8 and SUM 15 areas have not undergone any changes to coastal development from 2018 to 2023. Fig. 9 shows the development at Bagan Nakhoda Omar which will face the highest impact in 2018 and 2023. Reduction of coastal development should be undertaken, there are several management strategies for sea level rise phenomena to be listed for this situation that can occur at any time. This strategy includes provision for inventory before, during and after the occurrence of sea level rise. In addition, each development carried out at the seaside should take into account either long-term or short-term effects.



Fig. 9: The current situation shows the development nearest at Sungai Haji Dorani, Haji Dorani Resort (April 2017).

Shoreline changes can give impact to human social life and also their socio-economy. In addition, this phenomena also give an impact to damage the existing infrastructure such as houses, mosques, recreation areas, damage crops and reduces the income of catchment of fish by fishermen. These issues was affected the socio-economic community and the expectations that occur in the future have yet to be clearly identified. Effect of inundation and changes in shoreline impacts on the socio-economic development of local communities [19]. Regulatory and improvements can do to control and address these issues.

4. Conclusion

The coastal area is an important natural resource and it should be protected for being fragile because this area most easily changed due to the environment activities. This paper highlighted the importance of monitoring shoreline changes. Development of new technology nowadays has given an advantage to address these issues effectively [20]. The phenomenon of higher erosion was occurred between Sungai Tengi to Sungai Terap, while the higher accretion phenomenon has occurred from Sungai Burung to Sungai Panchang Bedena. The study area could be used as a preliminary study to investigate the shoreline changes in Selangor coastal area. In addition, the results from this study can provide information for development planning to well organize for the future development.

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References

[1] G. Bengen. (2010). Ekosistem dan sumberdaya persisiran dan laut serta pengelolaan secara terpadu dan berkelanjutan. Prosiding Pelatihan Pengelolaan Wilayah Pesisir Terpadu, 28-55

[2] Elizabeth H, B. and I. L. T. (2005). Shoreline Definition and Detection : A Review Shoreline Definition and Detection : A Review, (214), 688–703.

[3] Mills, J. P., Buckley, S. J., Mitchell, H. L., Clarke, P. J., & Edwards, S. J. (2005). A geomatics data integration technique for coastal change monitoring, 664, 651–664.

[4] Maiti, S., & Bhattacharya, A. K. (2009). Shoreline change analysis and its application to prediction: A remote sensing and statistics based approach. Marine Geology, 257(1–4), 11–23.

[5] Ekhwan, M., Toriman, H., & Lah, C. (2007). Ciri hidrologi dan hakisan tebing sungai di Sungai Lendu, Alor Gajah Melaka, 2(2), 1–19.

[6] Stanley Consultants, Inc. (1986). National Coastal Erosion Study. Phase ii. Feasibility studies-Unit Perancang Ekonomi, Jabatan Perdana Menteri, Kuala Lumpur, Malaysia, Vol. 1.

[7] Nayak, S. (2002). Use of satellite data in coastal mapping. Indian Cartographer, 10.

[8] Sanil Kumar, V., Pathak, K. C., Pednekar, P., Raju, N. S. N., & Gowthaman, R. (2006). Coastal processes along the Indian coastline. Current Science, 91(4), 530–536.

[9] Addo, K. A., & Kufogbe, K. S. (2011). Quantitative Analysis of Shoreline Change Using Medium Resolution Satellite Imagery in Keta , Ghana, 1(1), 1–9.

[10] Pujotomo, M. S. (2009). Coastal changes assessment using multi spatio-temporal data for coastal spatial planning Parangtritis beach Yogyakarta Indonesia.

[11] Nizam, K., Maulud, A., & Rafar, R. M. (2013). Determination the impact of sea level rise to shoreline changes using GIS, 0–5.

[12] Tran Thi, V., Tien Thi Xuan, A., Phan Nguyen, H., Dahdouh-Guebas, F., & Koedam, N. (2014). Application of remote sensing and GIS for detection of long-term mangrove shoreline changes in Mui Ca Mau, Vietnam. Biogeosciences.

[13] Anand, R., Chandrasekar, B. N., & Magesh, S. K. N. S. (2016). Shoreline change rate and erosion risk assessment along the Trou Aux Biches – Mont Choisy beach on the northwest coast of Mauritius using GIS-DSAS technique. Environmental Earth Sciences, 75(5), 1–12.

[14] Department of Irrigation and Drainage Malaysia. (2017). http://www.water.gov.my/index.php/pages/view/

[15] Abdul Azhim Mustapa. (2007). Kajian kesan ombak dan hakisan di kawasan pinggir pantai paya bakau di Sungai Burung, Selangor (Vol. 16). Malaysia.

[16] Umar, Z., Abdul, W., Wan, A., Akib, M., & Ahmad, A. (2013). Monitoring Shoreline Change using Remote Sensing and GIS : A Case Study of Padang Coastal Area, Indonesia, 8–10.

[17] Moussaid, J., Ait, A., Zourarah, B., & Maanan, M. (2015). Using automatic computation to analyze the rate of shoreline change on the Kenitra coast, Morocco, 102, 71–77.

[18] M. Ghazali, N. H. (2006). Coastal erosion and reclamation in Malaysia. Aquatic Ecosystem Health and Management, (2012), 37–41.

[19] Fazly Amri Mohd, Khairul Nizam Abdul Maulud, Othman A. Karim, Muhammad Afiq Ibrahim, Yannie Anak Benson & Ahmad Khairi Abd. Wahab. 2018. Integration of Geospatial Method and Hydrodynamic Modelling to Study the Impact of Sea Level Rise on the Coastal Area. *Jurnal Kejuruteraan*, 30(1), 76–88.

[20] Azid, A., Noraini, C., Hasnam, C., Juahir, H., Amran, M. A., Toriman, M. E., Kamarudin, A., 2015. Coastal Erosion Measurement along Tanjung Lumpur to Cherok Paloh, Pahang during the Northeast Monsoon Season. Journal Teknologi, 1, 27–34.