ESTEEM Academic Journal
Vol. 11, Special Issue 1, March 2015, 150-157

COASTAL MAPPING USING UNMANNED AERIAL VEHICLE (UAV) SYSTEM: CASE STUDY CYRSTAL BAY, ALAI MELAKA

Norhadija Darwin[1], Anuar Ahmad[2], Othman Zainon[3] and Zulkarnaini Mat Amin[4]

[1,2,3,4]*Department of geoinformation, Universiti Teknologi Malaysia, Skudai Johor MALAYSIA*
[1]*norhadija.d@gmail.com;* [2]*anuarahmad@utm.my;* [3]*othmanz.kl@utm.my;*
[4]*zulkarnaini09@gmail.com*

ABSTRACT

Coastal erosion is regarded as one of the most pressing areas due to the development along the coastal line that led to the host of problems such as sea level rise along the coast, siltation and loss of coastal resource. The occurrence of coastal erosion is increasing, threatens the people living close to coastal area and caused losses along the coastal line. In addition, coastal areas are also prone to environmental hazards such as erosion and sedimentation processes may cause loss of coastal land and damage infrastructures and buildings There are many methods have been developed to map and monitor the coastal area such as total station, remote sensing technology, Global Positioning System (GPS), aerial photogrammetry and Lidar technology. The utilization of Unmanned Aerial Vehicle(UAV) system also gives an opportunity for data interoperability, data integration and data sharing that are applicable for the responsible agencies to monitor the coastal erosion and land such as state government, local authorities and land developer. UAV has been developed which offer many advantages in several mapping applications such as slope mapping, cultural heritage studies, urban deveploment, coastal and flood studies. In this study, a total of five hundred (500) aerial images of Crystal Bay, Alai Malacca were captured using high resolution compact digital camera known as Canon Power Shot SX230 HS and it has 12.1 megapixel image resolution. From the aerial images, photogrammetric image processing method was employed to produce mapping outputs such a digital surface model (DSM),contour line and orthophoto. In term of accuracy of measurement, a centimeter-level is reached by ground control point (GCP) and check point (CP) using GPS observation. Finally, the UAV has shows great potential to be used for coastal mapping applications that require goodmapping output.

Keywords: coastal erosion; mapping; Unmanned Aerial Vehicle (UAV) System.

1. INTRODUCTION

Coastal erosion is a natural disaster occurred from the interactions between natural processes and the system. It is widely believed that erosion occurs continuously along the coastline caused by combination of both natural and human factors. In addition, it is wearing a way of

p-ISSN1675-7939; e-ISSN 2289-4934

land and the removal of beach or dune sediments by tidal currents or sea level rise (Bruun, 1988, 1989; Nicholls & Tol, 2006; Schwartz, 1967; Teh & voon, 1992; Yu & Chen, 2009), wave currents (Kearney, Douglas, Kearney, & Leatherman, 2001; Silvester & Hsu, 1997), or climate changes (Adger, Hughes, Folke, Carpenter, & Rockström, 2005; Feagin, Sherman, & Grant, 2005; Zhang, Douglas, & Leatherman, 2004). Along the coast, erosion occurs over a period of time. The volume of sediment transported out is greater than the existing coast. Nowadays, control of coastal erosion is becoming an important economic and social need either in short or long term (Zamani, 1988).

Several related agencies need to monitor and take action on this issue through the mapping of coastline. Therefore, Survey Departments and Topographic Departments have conducted surveying especially to produce topographic mapping for any purpose demand for coastal area by any agencies such as surveying organization, Department of Irrigation and Drainage (DID) and Department of Environment (DOE). Basically, there are several methods in geoinformation that could be used to map or monitor the coastal erosion such as aerial photogrammetry using manned aircraft (Crowell, Leatherman, & Buckley, 1991; Kaichang, Ruijin, & Rongxing, 2003; Moore, 2000), remote sensing (Klemas, 2009; Moore, 2000), Light Detection and Ranging (Moore, 2000; Olsen, Johnstone, Kuester, Driscoll, & Ashford, 2010), Global Positioning system (Moore, 2000; Wozencraft & Millar, 2005) and Terrestrial Laser Scanning (Alho et al., 2009; Olsen, Johnstone, Driscoll, Ashford, & Kuester, 2009). However, there are some limitations for using these in obtaining aerial images. For example, according to Al-Tahir, Arthur and Davis (2011), many countries in the tropical region are covered with clouds especially during the raining and monsoon season, thus making it difficult to capture clear images. According to Biesemans, Everaerts and Lewyckyj (2005) and Everaerts (2008), there are also limitations in using satellite and manned aircraft, which are high flight cost, low ground resolution and limited time frame.

Nowadays, aerial photogrammetry is often used for highway investigation, environmental, preliminary design and Geographic Information System (GIS). It is proven that the demand for aerial photogrammetry has increased especially after development of design, research and production of unmanned aerial vehicle (UAV) platform (Chao, Cao, & Chen, 2010) and (Breckenridge & Dakins, 2011). In aerial photogrammetry, the aircraft can be flown under the cloud and imagery could be obtained much easier than satellite imagery. Therefore, UAV system has expanded data capture opportunities for photogrammetry techniques. The UAV system uses the concepts of close range photogrammetry (CRP). In CRP, the photography is acquired where the object-to-camera distance of less than 300m (Atkinson, 2001; Cooper & Robson, 1996; Smith, 1997; Wolf, Dewitt, & Wilkinson, 2000). This study will investigate the potential use of micro fixed-wing UAV to produced the orthophoto, DSM and contour line of the coastal area.

2. METHODOLOGY

This study comprises of several phases which are preliminary study, acquiring real data, processing the data, analyzing the data and finally, draw the conclusion and providing recommendations as shown in Figure 1. In preliminary study, there are several steps that are performed. These steps are (a) Collecting, gathering and compiling related and crucial information on the proposed study from various sources such as articles, journals, books, the internet and previous theses; (b) Gaining better understanding in all aspects before data

p-ISSN1675-7939; e-ISSN 2289-4934

collection is crucial. It helps to understand more details on types of UAV either long, medium or short endurance during the data collection; (c) Exploring the suitable UAV for this study especially for large scale mapping in small format aerial photograph; (d) Choosing the suitable equipment for GCPs and CPs collection and software for data processing related to the proposed study. Data acquisition is very important for any project or study. It need to be done properly so that the objective of study could be achieved. Data acquisition involves the following; (a) Collecting images is a process that needs to be done at sites to acquire aerial photographs which is obtained from UAV system based on small format imagery; (b) Carrying out the camera calibration in order to recover the calibration parameter and later used it in digital image processing especially in the interior orientation process; (c) Establishing the GCPs using GPS technique for absolute orientation or exterior orientation and to perform aerial triangulation. The CPs are also established using GPS techniques and used for accuracy assessment.

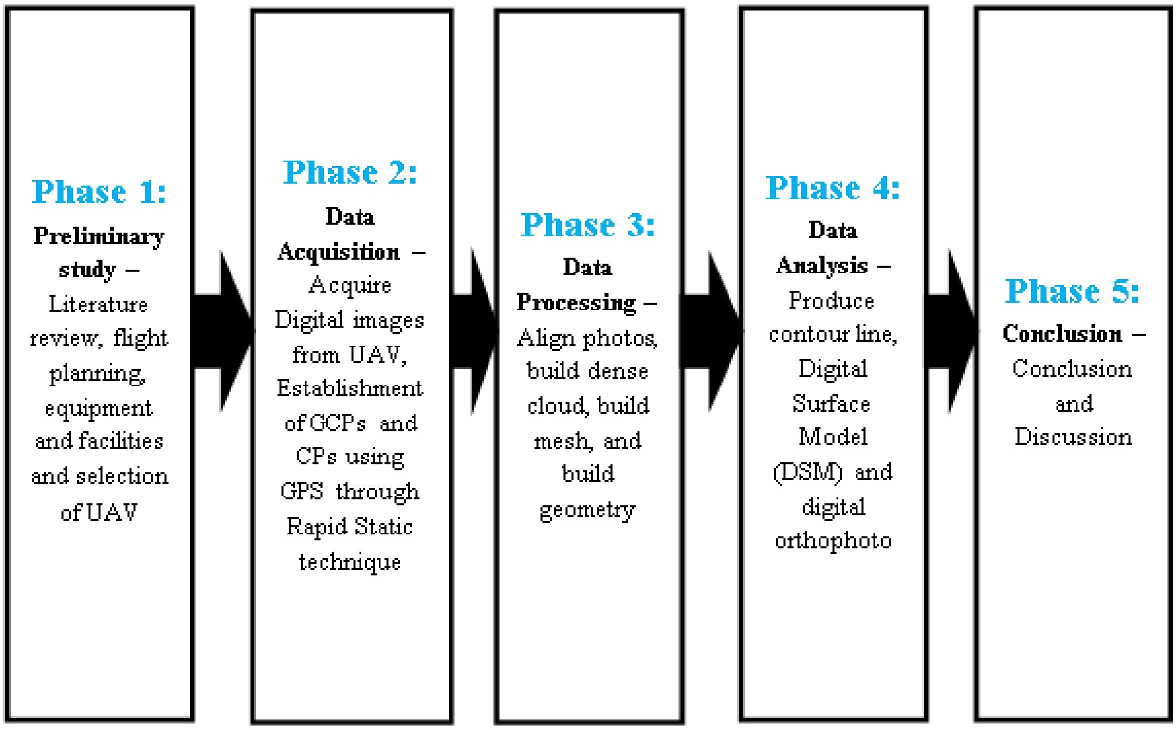


Figure 1: Flowchart of Research Methodology.

2.1 Unmanned Aerial Vehicle (UAV) and Digital Camera

UAV stands for Unmanned Aerial Vehicle which refer to an aircraft without pilot on-board. Conceptually, the UAV is equipped with devices such as digital camera (non-metric), sensors, communication tools and other payloads to perform certain activity. The technology of UAV is equipped with Global Positioning System (GPS)/Inertial Navigation System (INS), Inertial Measurement Unit (IMU), autopilot systems and others that allowed flying autonomously or manually. Autonomous flight is controlled by computer from the ground and radio modem is used for the communication between computer and UAV during the flight mission (Tahar & Ahmad, 2012).

p-ISSN1675-7939; e-ISSN 2289-4934

ESTEEM Academic Journal
Vol. 11, Special Issue 1, March 2015, 150-157

Few aspects involved in preparation of autonomous flying such as flight planning at the ground control station and instruments installation of the UAV components. The proper set up or installation of UAV and flight planning contribute to the quality of data acquisition. Flight Planning involves calculation of study area, number ofstrips required, pixel size, photo scale flying height and percentage of end lap and side lap. In general, the aerialphotographs should be overlapped at least 60 percent and side at least 30 percent. The aerial photograph is acquired using high resolution digital camera. This requirement need to be fulfilled to make sure quality photogrammetry results could be obtained. Figure 2 shows the procedure of flying the micro fixed-wing UAV will land at the starting point as described by Darwin, Ahmad and Akib (2014).

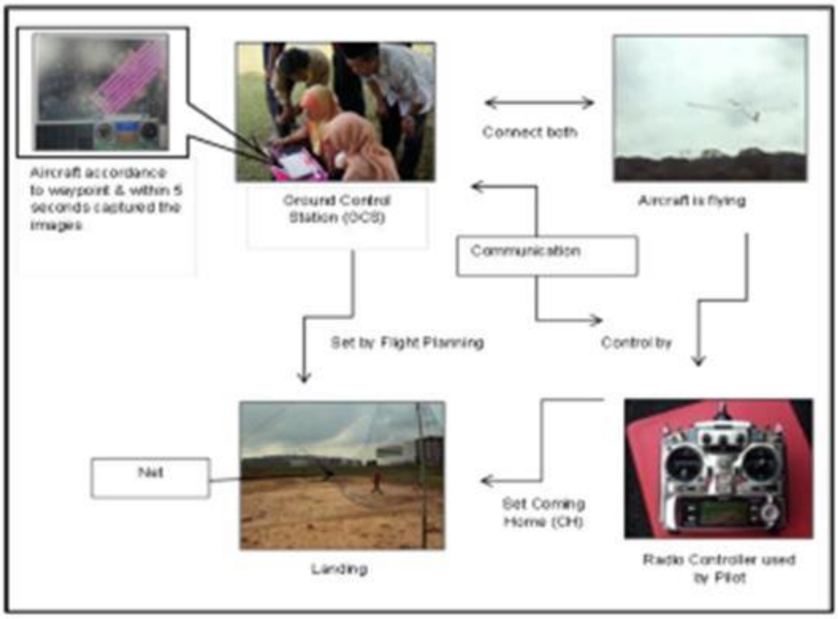


Figure 2: Pilot Station and Ground Control Station.

A digital camera attached to UAV was used for mapping coastaline by using the micro fixed-wing UAV. Figure 3(a) and (b) show the micro ixed-wing UAV and digital camera respectively. The Canon PowerShot SX260 HS digital camera with interactive 12.1 Megapixel is used for acquisition of high resolution aerial photograph. This digital camera is considered as small format camera.

(a) (b)

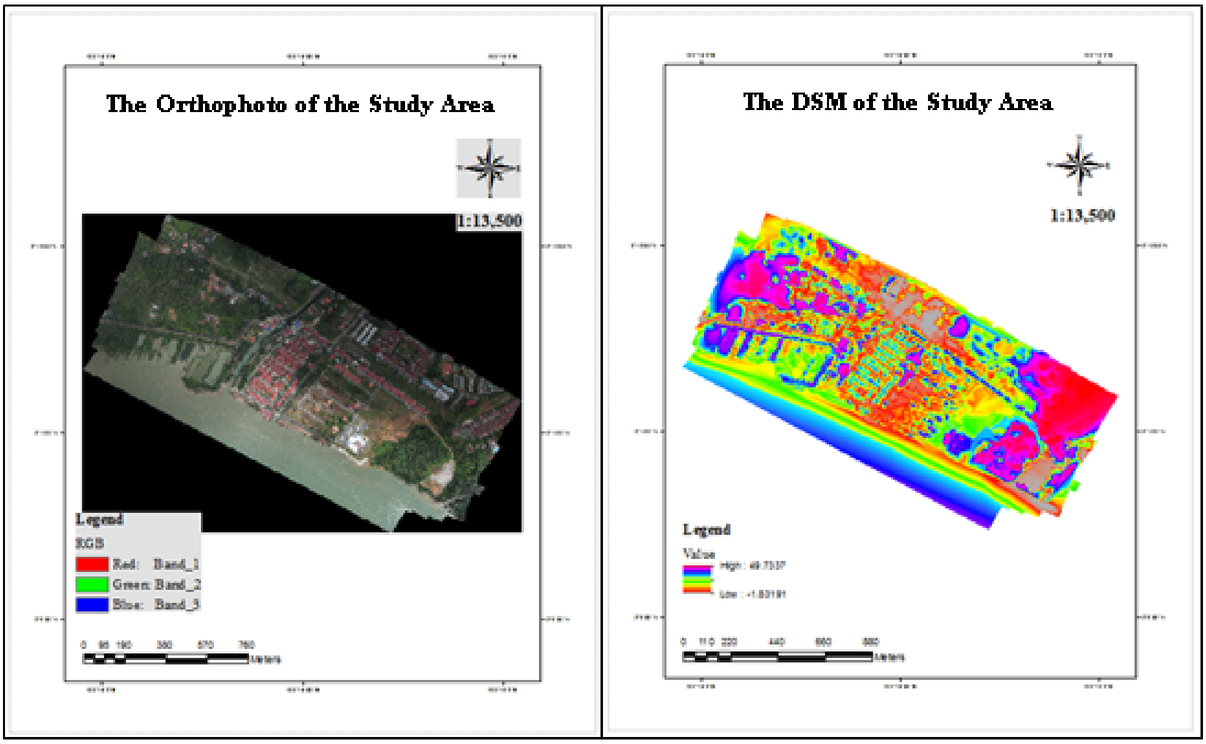
Figure 3: (a) Micro fixed-wing UAV; (b) Digital camera.

p-ISSN1675-7939; e-ISSN 2289-4934

ESTEEM Academic Journal
Vol. 11, Special Issue 1, March 2015, 150-157

3. RESULT AND DISCUSSION

Orthophoto is one of the outputs obtained from UAV and digital camera. Orthophoto can be produced from largeformat and small format aerial photo. For large format aerial photo, two photographs are used. However, for small format aerial photo, about eight non-metric imagery including digital image from the digital camera are used to cover the study area and the aerial triangulation procedure has to be carried out for the small format aerial photo. The processing of aerial photo processing was carried out using digital photogrammetry technique and image processing software. Figure 4 (a) represents the resulting of orthophoto of Cyrstal Bay, Alai Malacca.The software can produce the automatic Digital Surface Model (DSM) extraction for each individual image and merged together as one image. This is because this software uses correlation function for image matching. Apart from that, several pairs of stereomodels are formed and can be viewed in 3D using anaglyphic glasses. This study has been carried out to prove that digital images acquired from UAV could provide the same result of DSM. Figure 4 (b) shows the general view of generated DSM.



(a) (b)

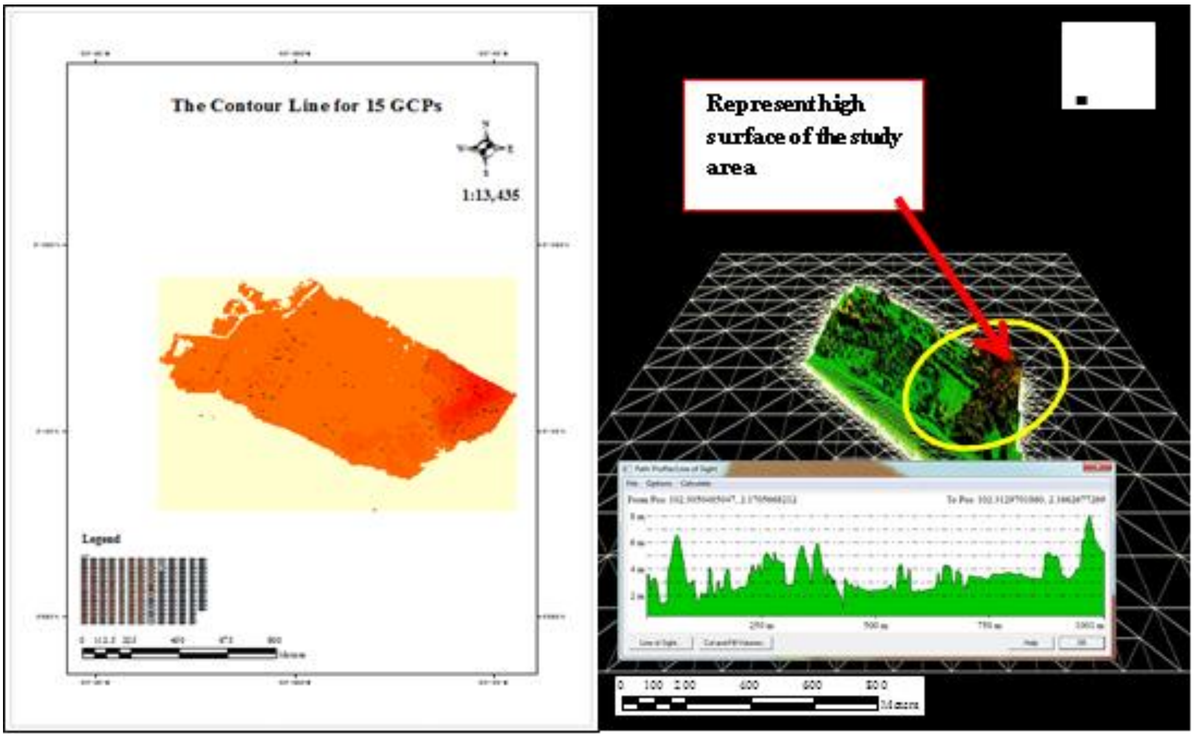
Figure 4: (a) Orthophoto; (b) DSM of the study area.

Every coastal area has different heights and surface that deliver different contours. Hence, this assessment studies on the capabilities of micro fixed-wing UAV for height determination. Cyrstal Bay, Alai Malacca is one of the study areas to investigate the damage of coastal erosion through the contour lines. Aerial images that have 3D coordinate namely; latitude, longitude and height have been processed to produce DTM and orthophoto which then produces its contour line.The contour lines were produced successfully using Global Mapper software for Cyrstal bay, Alai Malacca. All contours are generated with five (5) meter contour

p-ISSN1675-7939; e-ISSN 2289-4934

ESTEEM Academic Journal
Vol. 11, Special Issue 1, March 2015, 150-157

internal and generate area features colored based on the current elevation shadier in addition to contours. Figure 5 (a) shows the contour line of the study area and (b) the DEM 3D view of the study area.



(a) (b)

Figure 5: (a) Contour Line; (b) DTM 3D View.

4. CONCLUSION

Geographic Information Systems have revolutionized the way spatial data/information is acquired, stored, managed, and displayed. In the past the acquisition of spatial data was done mainly with analogue theodolite and levels, and the recording and storage of these data were done in analogue manner. Data management was a very awkward exercise and the display was in the form of paper maps. Recent developments in information and digital technologies, communication and digital photogrammetry for coastal map has improved computing speed and computer hard disk space, have impacted tremendously the way spatial data is acquired, stored, managed, and displayed.

As conclusion, this paper presents a potential of the utilization of UAV technology that can significantly contribute to mapping coastal area based on photogrammetric method. It is very important in order to improve the production of coastal erosion map and provide the map to the relevant agencies with faster, cheaper and easy to handle it. Based on the literature review, the UAV is becoming increasingly popular since this technology offers advantages such as able to conducting photogrammetric survey under the cloud, providing different views and tilted images of the surveyed objects for mapping, monitoring and surveying. It is hope that the implementation of UAV technology could assist many agencies for mapping coastal erosion with good mapping output.

p-ISSN1675-7939; e-ISSN 2289-4934

REFERENCES

Adger, W. N., Hughes, T. P., Folke, C., Carpenter, S. R., & Rockström, J. (2005). Social-ecological resilience to coastal disasters. *Science*, *309*(5737), 1036-1039.

Alho, P., Kukko, A., Hyyppä, H., Kaartinen, H., Hyyppä, J., & Jaakkola, A. (2009). Application of boat-based laser scanning for river survey. *Earth Surface Processes and Landforms, 34*(13), 1831-1838.

Al-Tahir, R., Arthur, M., & Davis, D. (2011). *Low cost aerial mapping alternatives for natural disasters in the Caribbean.* Paper presented at the FIG Working Week.

Atkinson, K. B. (2001). *Close range photogrammetry and machine vision*. Whittles Publishing.

Biesemans, J., Everaerts, J., & Lewyckyj, N. (2005). *PEGASUS: Remote sensing from a HALE-UAV*. Paper presented at the ASPRS annual convention.

Breckenridge, R. P., & Dakins, M. E. (2011). Evaluation of bare ground on Rangelands using unmanned aerial vehicles: A case study. *GIScience & Remote Sensing*, *48*(1), 74-85.

Bruun, P. (1988). The Bruun rule of erosion by sea-level rise: a discussion on large-scale two- and three-dimensional usages. *Journal of Coastal Research*, 627-648.

Bruun, P. (1989). Coastal engineering and use of the littoral zone. *Ocean and Shoreline Management*, *12*(5), 495-516.

Chao, H., Cao, Y., & Chen, Y. (2010). Autopilots for small unmanned aerial vehicles: a survey. *International Journal of Control, Automation and Systems, 8*(1), 36-44.

Cooper, M., & Robson, S. (1996). *Theory of close range photogrammetry*. Whittles Publishing.

Crowell, M., Leatherman, S. P., & Buckley, M. K. (1991). Historical shoreline change: error analysis and mapping accuracy. *Journal of Coastal Research*, 839-852.

Darwin, N., Ahmad, A., & Akib, W. A. A. W. M. (2014). The potential of low altitude aerial data for large scale mapping. *Jurnal Teknologi*, *70*(5).

Everaerts, J. (2008). The use of unmanned aerial vehicles (UAVs) for remote sensing and mapping. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, *37*, 1187-1192.

Feagin, R. A., Sherman, D. J., & Grant, W. E. (2005). Coastal erosion, global sea-level rise, and the loss of sand dune plant habitats. *Frontiers in Ecology and the Environment*, *3*(7), 359-364.

Kaichang, D., Ruijin, M., & Rongxing, L. (2003). Geometric processing of Ikonos stereo imagery for coastal mapping applications. *Photogrammetric Engineering & Remote Sensing*, *69*(8), 873-879.

p-ISSN1675-7939; e-ISSN 2289-4934

Kearney, M. S., Douglas, B., Kearney, M., & Leatherman, S. (2001). *Late Holocene sea level variation*. San Diego, CA: Academic Press.

Klemas, V. V. (2009). The role of remote sensing in predicting and determining coastal storm impacts. *Journal of Coastal Research*, 1264-1275.

Moore, L. J. (2000). Shoreline mapping techniques. *Journal of Coastal Research*, 111-124.

Nicholls, R. J., & Tol, R. S. (2006). Impacts and responses to sea-level rise: A global analysis of the SRES scenarios over the twenty-first century. *Philos Trans A Math Phys Eng Sci, 364*(1841), 1073-1095. doi: 10.1098/rsta.2006.1754

Olsen, M. J., Johnstone, E., Driscoll, N., Ashford, S. A., & Kuester, F. (2009). Terrestrial laser scanning of extended cliff sections in dynamic environments: Parameter analysis. *Journal of Surveying Engineering, 135*(4), 161-169.

Olsen, M. J., Johnstone, E., Kuester, F., Driscoll, N., & Ashford, S. A. (2010). New automated point-cloud alignment for ground-based light detection and ranging data of long coastal sections. *Journal of Surveying Engineering, 137*(1), 14-25.

Schwartz, M. L. (1967). The Bruun theory of sea-level rise as a cause of shore erosion. *The Journal of Geology*, 76-92.

Silvester, R., & Hsu, J. R. (1997). *Coastal stabilization* (Vol. 14). World Scientific Singapore.

Smith, M. (1997). Close range photogrammetry and machine vision. *Survey Review, 34*(266), 276-276.

Tahar, K. N., & Ahmad, A. (2012). A simulation study on the capabilities of rotor wing unmanned aerial vehicle in aerial terrain mapping. *International Journal of Physical Sciences, 7*(8), 1300-1306.

Teh, T. S., & Voon, P. K. (1992). *Impact of sea level rise on the coastal zone of Malaysia*. Kuala Lumpur: WWF Malaysia Resource Library Economic Planning Unit.

Wolf, P. R., Dewitt, B. A., & Wilkinson, B. E. (2000). *Elements of Photogrammetry: with applications in GIS* (Vol. 3). New York: McGraw-Hill.

Wozencraft, J., & Millar, D. (2005). Airborne lidar and integrated technologies for coastal mapping and nautical charting. *Marine Technology Society Journal, 39*(3), 27-35.

Yu, K., & Chen, T. (2009). Beach sediments from Northern South China Sea suggest high and oscillating sea levels during the late Holocene. *Earth Science Frontiers, 16*(6), 138-145. doi: 10.1016/s1872-5791(08)60110-4

Zamani, M., (1988). Coastal erosion: Problems and solutions. *Proceedings of the 11th Annual Seminar of the Malaysian Society of Marine Sciences*.

Zhang, K., Douglas, B. C., & Leatherman, S. P. (2004). Global warming and coastal erosion. *Climatic Change, 64*(1-2), 41-58.

p-ISSN1675-7939; e-ISSN 2289-4934