MAPPING SHORELINE VULNERABILITIES USING KITE AERIAL PHOTOGRAPHS AT OLUVIL HARBOUR IN AMPARA

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ABSTRACT

The dynamics of coastal ecosystem are mainly controlled by nearshore processes, coastal geomorphology and human induced land-use changes. A rapid change of coastal shoreline due to harbour construction in Oluvil, which is in Ampara district caused a serious coastal erosion scenario. This study examines the coastal microtopography in relation to high resolution digital elevation models, coastal vegetation bioshield mass, and sea level rise. A Kite Aerial Photography (KAP) platform was created using two light-weight automatic cameras with dual bandpass Red-NIR filters, a Picavet stabilizing rig, a GPS tracker and a parafoil kite. The KAP images with high resolution were acquired at 15 m altitude and the data was processed to build mosaic images, orthorectified and georeferenced DEMS using Agisoft PhotoScan (structure-from-motion) and ENVI software. Oluvil beach habitat vulnerabilities were mapped using Normalized Difference Vegetation Index (NDVI) for vegetation bioshield mass estimation, Digital Elevation Model for sea level rise and coastal land-use changes using historical images. The image processing produced a point cloud with an average density of 20 points/cm^2; a DEM with 2 cm resolution; and an orthophoto mosaic with an average resolution of 0.5 cm. The NDVI and historical images showed a significant vegetation reduction over time. With subsequent negative impacts of coastal vulnerability such as flooding due to sea level rise. The objective of this study is to assess the vulnerabilities in Oluvil coastal beach habitats in terms of coastal erosion, sea level rise and vegetation biosheild mass and health. This work utilized KAP which has a great potential to bridge science with high spatial/temporal resolution *in-situ* data for monitoring coastal habitat vulnerabilities, and can be used for sustainable land management prior to implement any development or construction program.

Keywords: Shoreline, Oluvil Beach, Kite Aerial Photographs, NDVI, Sea Level Rise

1. INTRODUCTION

Coastal and marine ecosystems provide important ecosystem functions and services like biodiversity, ecotourism, human settlements and fishery resources. However, human settlements place greater demands on coastal lands than on inland areas (Chandrasekar et al., 2013). The coastal areas in Sri Lanka cover 24% of the total

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landmass of Sri Lanka and 32% of the total population lives along the coastal regions (Ministry of Forestry and Environment, 1999). Land-use changes in coastal habitats are vulnerable to natural and anthropogenic disasters such as, tsunami, sea level rise, coastal erosion, and invasion of exotic plants (Chandrasekar et al., 2013).

Understanding and managing these ecological functions and/or threats for the coastal ecosystem demand reliable information, which can only be acquired through high resolution imagery where coastal erosion can be monitored with high spatial and temporal resolution data that can identify minute changes to land and vegetation dynamics. In developing countries like Sri Lanka where there has been limited access to high resolution aerial photographs researchers have relied heavily on Google Earth imagery to evaluate and process imagery and develop data analysis such as change detection (Ameer, 2015). The 2015 finding on coastal erosion at Oluvil in Ampara district used historical Google Earth images to evaluated the Oluvil harbor construction influences on the land-use changes which resulted in severe coastal erosion along the beach. The major land-uses in this area affected by the erosion were coconut cultivation, vegetable cultivation and other agricultural land-uses (Ameer, 2015; Dellysse and Madurapperuma, 2017). The destruction of mangrove vegetation in this area therefore leads to less resistance from wave breaks and promotes coastal erosion.

The use of high spatio-temporal data is essential for investigating the coastal vulnerabilities like coastal erosion and sea level rise impacts on land-uses. Drone aerial photographs are widely used to create Digital Elevation Models and high resolution ortho-imagery, which has been essential in the development of maps for coastal habitats and to accurately create sea level rise models. However, it is expensive to use multi-spectral agricultural drones to collect the data and requires legal permission to operate those systems. Despite drone imagery limitations, as a good supplementary solution, we built a simple kite platform to acquire low altitude aerial images and process data for estimating coastal vegetation bioshield mass and health and sea level rise models. The kite aerial photography (KAP) has been beneficial since it is low-cost, has high spatial/temporal resolution, and subject to limited regulation. The objective of this study is to assess the vulnerabilities in Oluvil coastal beach habitats in terms of coastal erosion, sea level rise and vegetation biosheild mass and health.

2. METHODOLOGY

A KAP platform was created using two light-weight automatic cameras with dual bandpass Red-NIR filters, Picavet stabilizing rig, GPS tracker and a Parafoil kite. Two cameras, one RGB camera and the other camera with Red-NIR filters were set together to take images synchronously (Figs. 1 & 2). The high resolution KAP images were processed to build mosaic images, orthorectified and georeferenced DEMS using

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structure-from-motion (SfM) and remote sensing software (Agisoft PhotoScan and ENVI respectively). KAP has been utilized for coastal mapping under two scenarios: (i) Normalized Difference Vegetation Index (NDVI) for vegetation bioshield mass estimation (ii) Digital Elevation Model for sea level rise. In addition, Google historic images were utilized to assess the coastal vegetation changes before and after the development of Oluvil harbor.

Fig. 1. Set up Picavet stabilizing rig with two cameras

Fig. 2. A kite up in the air at Oluvil beach

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3. RESULTS AND DISCUSSION

A total of 518 images were acquired at 15 m altitude. The images were mosaic to produce a point cloud data with an average density of 20 points/cm^2; a DEM with an average horizontal resolution of 2.23 cm; and an orthophoto mosaic with an average resolution of 0.56 cm. The mosaic images covers approximately 0.56 ha though portions of the mosaic images were visibly distorted and has created holes in some portions of the images. We were able to walk approximately 190 m along the beach towards the Light house, as prevailing wind direction and coconut trees created ground barriers and limited our operation of the kites flight path over the study area. The mosaic orthophoto images depict the fine details of coastal features such as buildings, tower, coastal vegetation, boats, rock wall and river (Fig. 3).

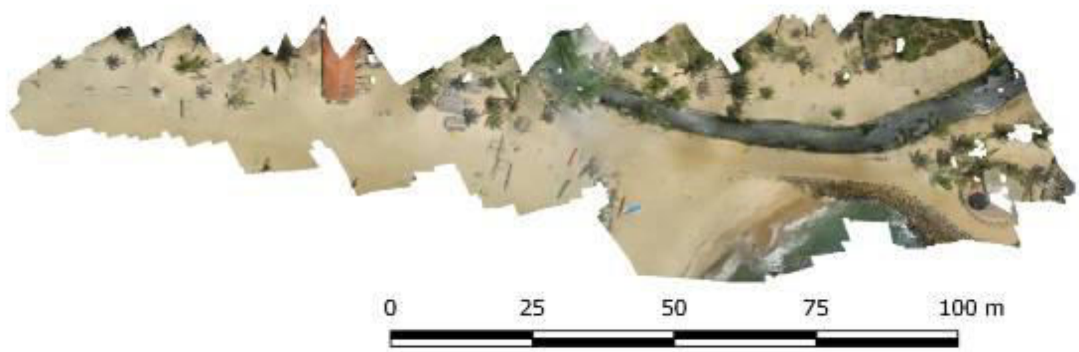

Fig. 3. Mosaic orthophoto imagery at the Oluvil beach

The inherent errors were associated with mosaic imagery due to uncertainty of positional measurements due to varying wind speed and direction and were derived from SfM method. The root mean square (RMS) reprojection error for the dataset was 0.57 pixels. A similar method adopted by Currier (2015) obtained 1.22 pixels RMS error. Therefore, results are given the high accuracy for mosaic images.

NDVI is a good indication of vegetation bioshield mass estimation and vegetation health. The NDVI values along the coast ranged from 0 to 0.4 and the coconut plantation has been shown to have the highest NDVI values (Fig. 4). The coconut plantation showed a lean distribution along the coast and some trees were weak due to severe erosion (Fig. 5). This may have contributed to relatively low NDVI values for coastal vegetation.

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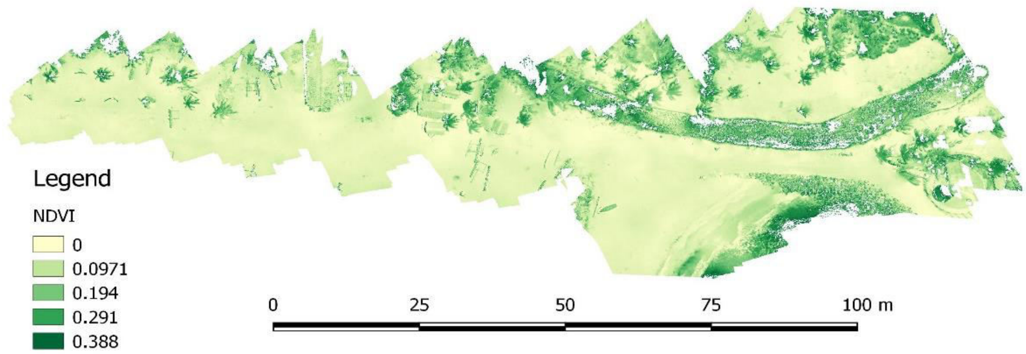

Fig. 4. NDVI change at the coastal habitats of Oluvil beach

Fig. 5. The coconut plantation at the Oluvil beach

A historical land-use change at Oluvil beach observed using Google Earth images (Fig. 6). As the boundary of the study area boundary (a red minimum bounding box in Fig. 6.) showed a significant reduction of coastal land mass especially from 2010 to 2016. The shoreline has been cut off towards the inland areas where those periods and notable vegetation changes was observed from 2013 to 2016. There was not much coastline change in 2006 and 2009 although Oluvil Harbor started in 2006. However, Ameer (2015) reported that harbor construction during 2006 to 2009 caused erosion resulting in more land retreated into the sea.

The KAP was important to identify physical features of the beach accurately and the temporal data was useful to do the change detection and NDVI. High resolution DEM's also have several applications such as creating sea level rise models with tidal

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information, which generate contour lines for coastline change monitoring and creating detailed terrain dynamics and physical features such as slope and aspect.

A sea level rise model varying from 0.5 m to 2.0 m at 0.5 m interval was created using QGIS sea level rise module (Fig. 7). We selected the particular elevation range because our ground control points at the sea-water interface and the highest elevation at the light house was estimated as range between 0.5 and 2.0 m respectively. According to the results over 50% of the inland beach area becomes inundated if the sea level rise were to increase by 1.5 m. At 2.0 m inundation level a small portion of light house and tiny fragmented inland areas will remain.

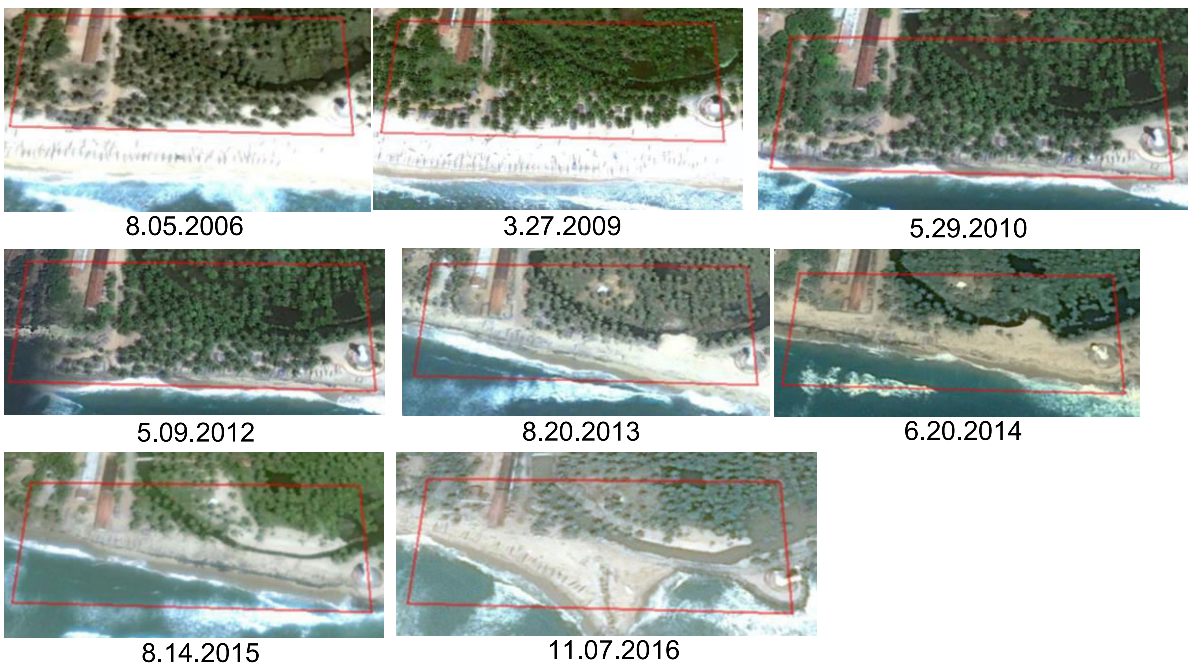

Fig. 6. Historical coastal land-use change in Oluvil beach resulting in severe erosion. A red bounding box has shown the sample area

As reported by Ameer (2015), a significant land-use change in the Oluvil beach due to harbor construction and also be effected by the sea level rise. The alarming sea level rise, flooding and erosion vulnerabilities can be mitigated via the establishment of a coastal green belt of mangrove vegetation. Monitoring the changes of coastal hinterlands (Zahir and Abdul Hameed, 2013) additionally, predicting sea level rise in future scenario will be useful for better management of coastal lands for climatic and/or anthropogenic vulnerabilities.

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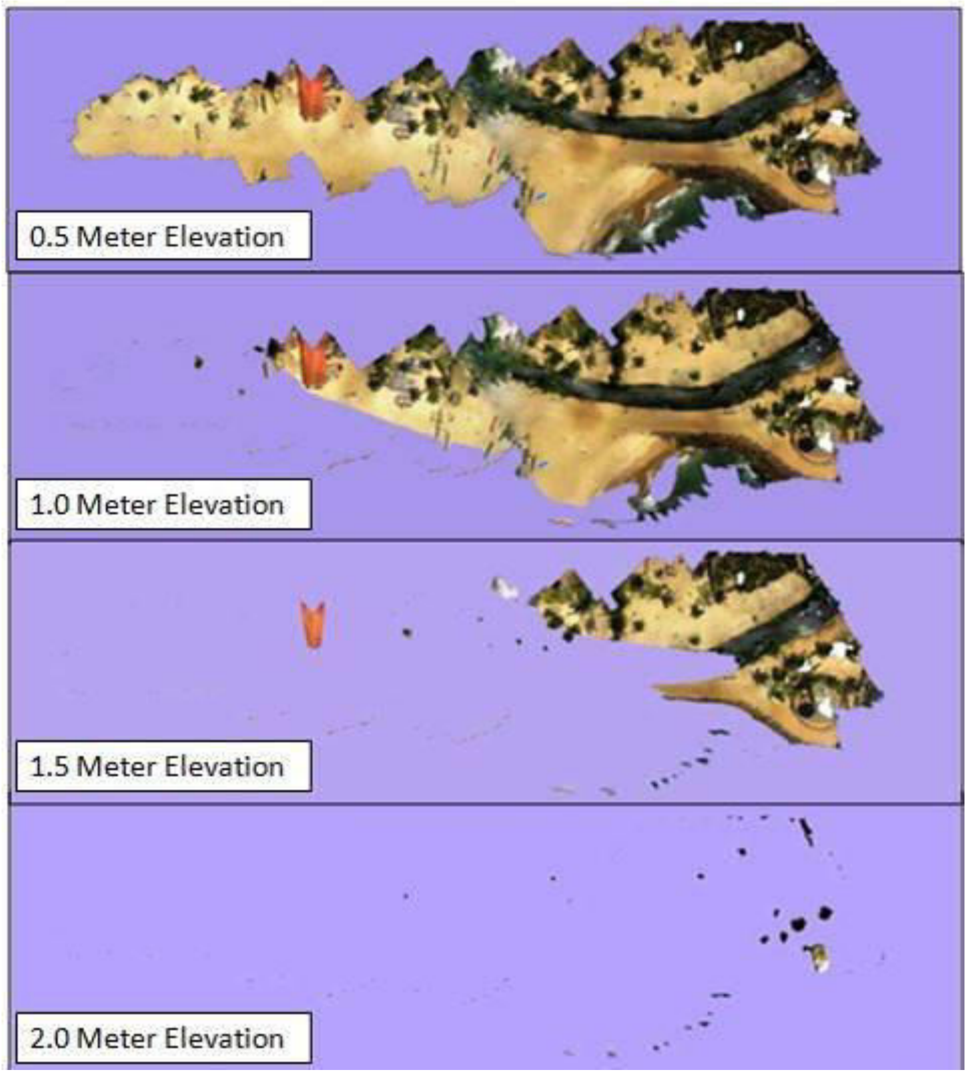

Fig. 7. Sea Level rise model in Oluvil beach from 0.5 m to 2.0 threshold

4. CONCLUSION

This study showed how coastal beach habitats became vulnerable due to erosion resulting from degradation of coastal vegetation and a lack of rock barriers to provide resistant to wave actions. It is necessary to understand the historical land-use and coast line changes in Oluvil to make precautions prior to the harbor construction. High resolution images produced through this study are useful to update the existing land-use maps in Oluvil beach area for better land management for harbor development. The sea level rise model showed that significant beach habitats was inundated at 2 m. Therefore, it is important to make sustainable land-use planning to mitigate the impact of coastal vulnerabilities, such as sea level rise and flooding due to anthropogenic climate changes in the future.

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