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Preliminary Study on Biomass Mapping along the Coastal Zone of Hambantota Region, Sri Lanka Using Landsat Imagery

J.E. Dellysse[1], B.D. Madurapperuma[1]*, K. A.J.M. Kuruppuarachchi[2]

[1]*Department of Environmental Science and Management, Humboldt State University.*
[2]*Department of Botany, The Open University of Sri Lanka, Nugegoda, Sri Lanka*

**Corresponding author: Email: bdm280@humboldt.edu*

1 INTRODUCTION

Coastal biomes will be the primary indicators of ecological, agricultural and sociological health as climate change intensifies natural forces along the world's coastlines in the coming decades. The services of cost line vegetation offer protection from previous and current coastal land disturbances from Sea Level Rise (SLR) or tsunami-like natural disasters. Almost half of Sri Lanka's' southern coastline architecture (Illangasekare, 2006) and costal ecosystems (Dellysse and Madurapperuma, 2017) were affected by the tsunami in 2004. These coastal habitats and dynamic ecosystems become even more critically important to stabilize and conserve coastal bioshield mass and maintain ecological services (Rahman and Rahman, 2013). Remote sensing techniques such as, normalized difference vegetation index (NDVI), object-based image analysis and image classification have been widely applied for monitoring coastal habitats. This study examines the land-use changes in coastal habitats in the Hambantota district of Sri Lanka using Landsat 5 and 8 imagery with 30 m resolution to assess the resilience of several coastal vegetation pre and post 2004 tsunami-based on land-use categories within the limits of 30 m satellite imagery. The results of this study would motivate future studies with feasible technologies and address best coastal ecosystem conservation strategies. Additionally, we expect to use these results to provide proof of concept for a larger study and an updated GIS model of this coastal region will be developed using high resolution 2-10 cm aerial photographic techniques utilizing Kite Aerial Photography (KAP).

2 METHODOLOGY

A vegetation/land-use pre and post tsunami model for Hambantota coastal areas in Sri Lanka was developed using Landsat images that were acquired from the time index 2004-02-11, 2005-02-13 and 2016-11-10. These images were preprocessed using a mathematical formula to convert radiance to reflectance values which was done using ENVI® prior to normalized difference vegetation index (NDVI) calculation. The NDVI in each year was then used to detect the greenness change over time: 2004-2005 short-term, 2005-2016 long-term and 2004-2016 for the entire time step. Then, the changed images were reclassified into three classes, where negative values for vegetation i.e. decreased, zero for unchanged and positive values for regeneration. Finally, reclassified changed images were summarized by land-use/cover classes (DATA.GOV, 2015) using the tabulate area function in ArcMap® to evaluate the impact of post-tsunami in short-term and the vegetation recovery in long-term.

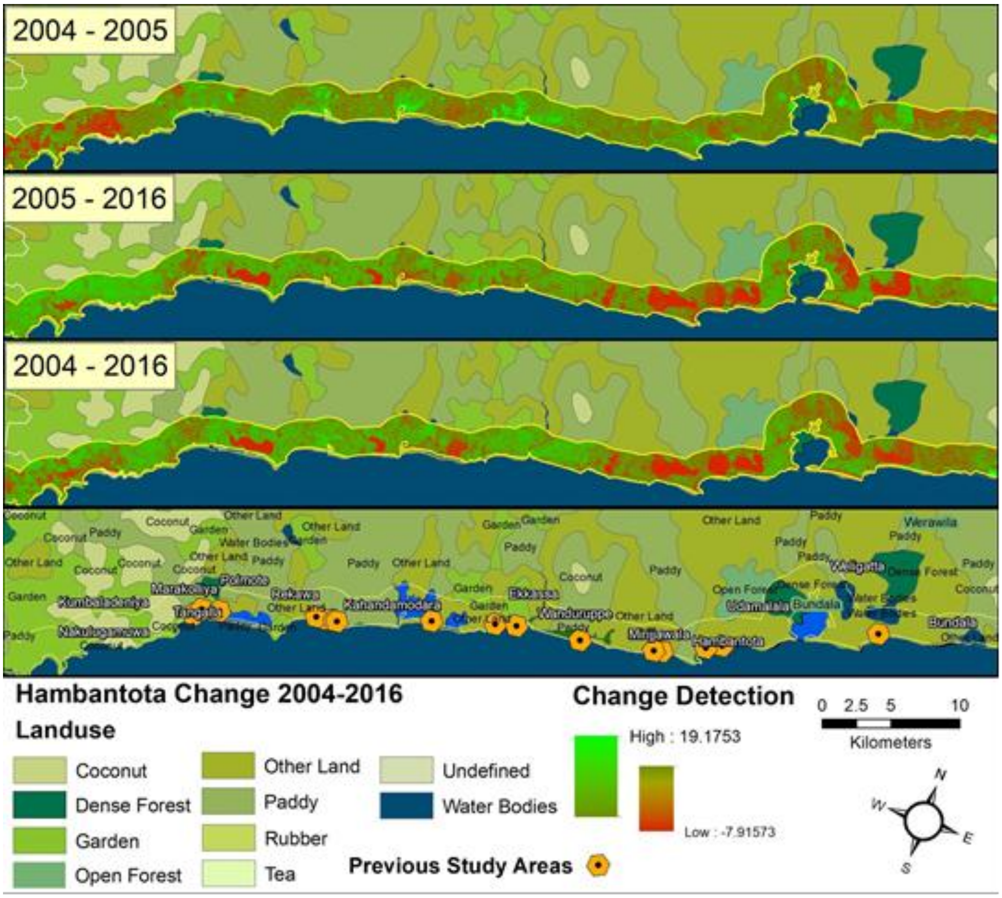

Figure 1: Vegetation change detection of Hambantota coastal regions between 2004 - 2005 (short-term after tsunami disaster), 2005 - 2016 (long-term), and 2004-2016 (entire time step) referring to land-use/cover classes. NB: NDVI change detection showed a biomass loss in red-brown and biomass increment in green. Previous study areas adopted from Bambaradeniya *et al.,* (2006) survey.

3 RESULTS AND DISCUSSION

Results of the study showed that the vegetation in Hambantota was significantly disturbed immediately after the tsunami disaster (between 2004 and 2005). Then, the vegetation had increased between 2005 and 2016 due to the implementation of coastal rehabilitation programs supporting regeneration of coastal vegetation (Figs. 1 and 2) as noted by Bambaradeniya *et al*., in 2006 (Fig. 1). This notable vegetation change was in part a result of agricultural practices where agricultural lands proved to be less influential as a prophylactic for the mitigation of wave impacts.

Although our study showed that human-influenced land uses were more vulnerable to tsunami wave action and inland flooding in the short term (2004-2005), a satisfactory regeneration had been observed in the long-term (2005-2016) due to coastal rehabilitation programs (Fig. 2). As the best management practices of coastal ecosystems for climatic vulnerabilities, it needs to further address the use of human-induced lands to transform these, at risk areas to more natural coastal habitats such as, coastal shrubs and mangroves.

Our study showed the NDVI change over time in relation to different vegetation classes, however we could not estimate biomass due to lack of *in-situ* data. High-resolution remote-sensing data (~10 cm -3 m) are useful for fine scale mapping of coastal vegetation and estimating biomass with high accuracy. For example, unmanned aerial vehicles (UAV) built with multispectral sensors are useful for generating high-quality orthoimages and 3D point cloud data for rendering biomass distribution along the coastal areas (Lopatina, 2013). A remote sensing technique such as, segmentation of orthoimage with 3D point cloud data, and classification of segments are used for measuring biomass of particular vegetation (Lopatina, 2013). Kite Aerial Photography (KAP) is reliable and affordable in developing countries like Sri Lanka. The low-cost and high spatial resolution offers substantial advantages compared to other platforms like UAV's; additionally KAP often meets any legal restrictions and issues.

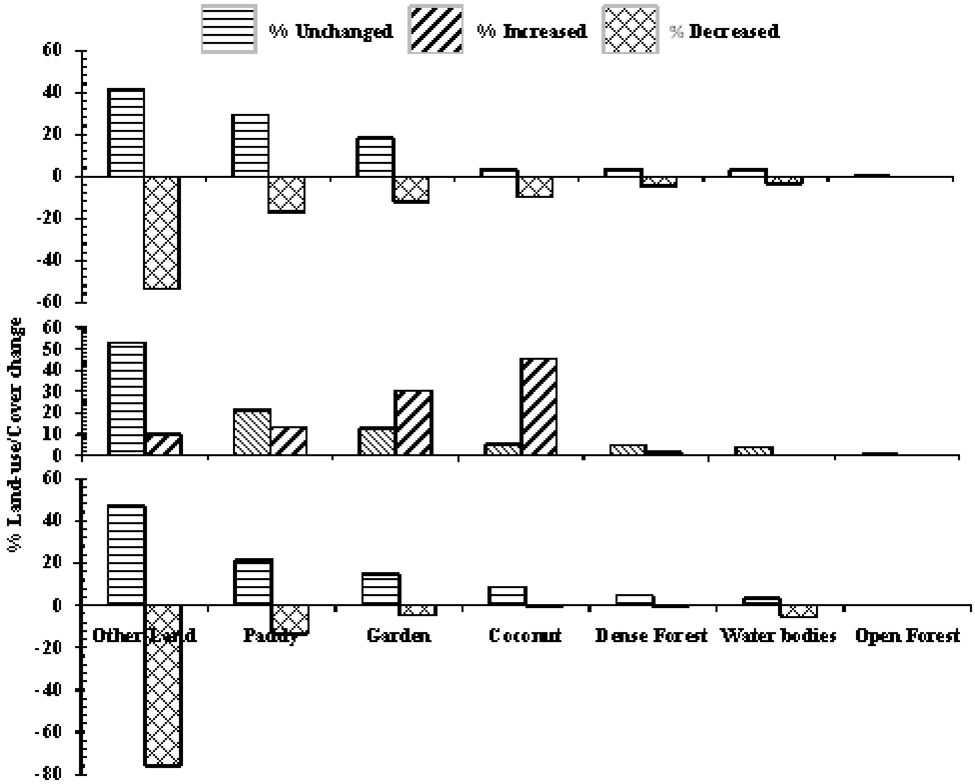

Figure 2: Vegetation biomass change (NDVI) in relation to land-use/cover category of Hambantota coastal habitats between 2004 - 2005 (short-term after tsunami disaster), 2005 - 2016 (long-term), and 2004-2016 (entire time step).

KAP specific kite designs also offer advantages such as stability in varying wind conditions. Furthermore, digital cameras can be modified with expanded capabilities through open source software and commercial grade dual band pass Red-NIR filters to obtain NIR images for creating NDVI. As an example, the southern coast of Durai Island, Indonesia used KAP for mapping sand beaches and rocky outcrops with 3.1 cm spatial resolution (Currier, K. (2015). Furthermore, the study revealed that the kite was better suited for windy conditions, which is applicable for the Sri Lankan coastal regions of Hambantota. As a result KAP has a multitude of positive capabilities which are necessary if Sri Lanka is to obtain high resolution images. A future comparative analysis of vegetation biomass i.e. changes detection, would be beneficial to the scientific community and to the people of Sri Lanka.

4 CONCLUSIONS AND RECOMMENDATIONS

The results of this study revealed that the vegetation affected had been intensively recovered by 2016. It is further suggested that a government funded incentives program be established for coastal communities for the purpose of converting their agricultural lands to sustainable land-use/cover classes (i.e. coconut and coastal shrub vegetation) to mitigate the tsunami and cyclone effects and also to provide greater soil stabilization to mitigate increased wave action as a result of SLR. Even though, Landsat satellite data has advantages as it can explain changes to certain extent with low cost, the obvious limitation of the study is the low 30 m resolution of Landsat images that can hinder minor land-use changes of vegetation. Therefore, our study can be used as a baseline data set for future comprehensive studies and collecting in-situ data using Kite Aerial Photography.

REFERENCES

Bambaradeniya, C., Perera, S., and Samarawickrema, P. (2006). A rapid assessment of post-tsunami environmental dynamics in relation to coastal zone rehabilitation and development activities in the Hambantota District of Southern Sri Lanka. IUCN Occasional paper - No. 10.

Currier, K. (2015). Mapping with strings attached: Kite aerial photography of Durai Island, Anambas Islands, Indonesia. *Journal of Maps,* 11(4): 589-597.

DATA.GOV (2015). Integrated: Geospatial Toolkit GIS data for Sri Lanka from NREL. Retrieved from http://en.openei.org/doe-opendata/dataset/5eb97f54-f1cb-452b-828c-7ff318f280f1/resource/89d4faa0-e4ee-4a7c-8374 d6c073955b7c/download/srilgstdata190.zip

Dellysse, J.E., and Madurapperuma, B.D. (2017). Tsunami effects and mitigation results for South-east Regions in Sri Lanka. IdeaFest Conference, 21st April 2017, 2nd Floor Library, Humboldt State University.

Illangasekare, T., Tyler, S.W., Clement, T.P., Villholth, K.G., Perera, A.P.G.R.L., Obeysekera, J., Gunatilaka, A., Panabokke, C.R., Hyndman, D.W., Cunningham, K.J., and Kaluarachchi, J.J. (2006) Impacts of the 2004 tsunami on groundwater resources in Sri Lanka. *Water Resources Research*, 42(5): W05201.

Lopatina, A. (2013). Rapid assessment of energy biomass resources using aerial photographs from unmanned aerial vehicles, Master's thesis in Forestry and Environmental Engineering, Finnish-Russian Cross-Border University (CBU), Faculty of Forestry, University of Eastern Finland, 32 p.

Rahman, M. A., and Rahman, M. A. (2013). Effectiveness of coastal bio-shield for reduction of the energy of storm surges and cyclones. Procedia Engineering, 56,