BEACH PROFILE DYNAMICS IN DULAG, LEYTE, PHILIPPINES USING LANDSAT IMAGERY

Sheila Marie S. Rabi1, Bror Ragnar Lorenzo Isagani Collander2,Christine R. Beltran3, Rianel April A. Palo4, Humberto R. Montes Jr. 5, Pastor P. Garcia6

1Phil-LiDAR Office, Visayas State University, Baybay City, Leyte, Philippines, melynrabi@gmail.com
2Phil-LiDAR Office, Visayas State University, Baybay City, Leyte, Philippines, daneger09@gmail.com
3Phil-LiDAR Office, Visayas State University, Baybay City, Leyte, Philippines, christinebeltran.1222@gmail.com
4Phil-LiDAR Office, Visayas State University, Baybay City, Leyte, Philippines, rianelapriltatapalo@gmail.com
5 Institute of Tropical Ecologyand Environmental Management, Visayas State University, Baybay City, Leyte, Philippines, humberto_montesjr@yahoo.com
6Eco-Farm Research Management Institute, Visayas State University, Baybay City, Leyte, Philippines, pstrgrc@yahoo.com

Abstract: Shoreline is the most dynamic part of the seascape which is an indicator of coastal erosion and accretion. Shoreline change can be analyzed and quantified using remotely-sensed data measuring differences in past and present shoreline locations. Shoreline change analysis provides information for government agencies, coastal residents and consultants on coastal protection and counteractions on the adverse effects of shoreline dynamics. This study aims to examine the extent and calculate the rate of shoreline change in Dulag, Leyte, Philippines from 1989-2014 using Landsat 4, 7 and 8 imageries with 30 m resolution. Midinfrared band 5, which displays the best spectral balance of land and water, was used in the extraction of shorelines. Degree of erosion and accretion between shoreline periods were measured based from a 10.2 km baseline with 102 transect locations at 100 m interval generated using an ArcMap extension, Digital Shoreline Analysis System (DSAS) Tools. Results showed that the municipality of Dulag is experiencing erosion and accretion along its shore at the rate of 0.973 m/yr. and 1.076 m/yr. respectively. The highest incident of erosion was observed in 2004-2010 at a rate of 2.43m/yr. while highest rate of accretion was observed in 2010-2014 with 2.607 m/yr. accretion rate.

Key words: Shoreline, shoreline dynamics, Landsat, DSAS

Introduction

Coastal zones are dynamic in nature as it is exposed to natural processes and human activities. These natural processes include sediment supply that may have been caused by run-offs and wave energy. Humans also contribute to shoreline change with some of their activities catalyzing disequilibrium conditions that accelerate shoreline changes (Winarso, et al., 2001). As 37% of the global population live near coasts, many lives would be affected on the rapid change of beach profiles (Vitousel and Mooney, 1997). Thus, shoreline analysis must be conducted to solve problems brought by shoreline dynamics. The study of the rate of change in shoreline position is important for development of setback planning, hazard zoning, erosion-accretion studies, regional sediment budgets and conceptual or predictive modeling of coastal morphodynamics (Maiti and Bhattacharya, 2009). Studies have been conducted to provide information and address problems on beach dynamics issues employing various techniques for shoreline analysis. The conventional techniques for shoreline change analysis are field measurement of present mean high water level, shoreline tracing from aerial photographs and topographic sheets; comparison with the historical data using one of the several methods (Fenster et al., 1993). Among these techniques, shoreline change analysis through remote sensing using aerial and satellite photographs is one of the widely-used over years. Aerial and satellite images efficiently aid in the analysis of rapidly-changing environments (Chu, et al., 2006). Moreoever, it allows an analysis with sufficient accuracy and may be conducted for a long time frame in a low-cost way (Berlangas-Robles and Ruiz-Luna, 2002).

In the Philippines, various areas are experiencing rapid coastline change. These coastline change may have been resulted from typhoons and surges or human activities such as quarrying and land reclamation. In Dulag, Leyte, several accounts from residents thriving near coasts reported that its coastal area is rapidly changing. Thus this study was conducted to examine the extent and calculate the rate of shoreline change in Dulag, Leyte, Philippines within a 25-year period (1989-2014) using Landsat 4, 7 and 8 imageries with 30 m resolution.

Materials and Methods

For this study, Dulag, in the Eastern Visayas Philippines was chosen as the area of interest. Dulag, Leyte is a third class municipality in Eastern Visayas in the Philippines. This coastal town covers 11,007 hectares of land with its coastline stretching at approximately 10.2 kms. Popularly known as the "Liberation Town", Dulag was also where Typhoon Haiyan made its second landfall. Its coastal area is exposed to various anthropogenic activities and natural occurrences.

For shoreline analysis of Dulag, five sets Landsat imageries for years 1989, 1996, 2004, 2010 and 2014 were used and downloaded from httpp://earthexplorer.usgs.gov/. As mentioned by Rosal (2015), these images are georeferenced with a better than 0.5 pixels precision. Software used in this study were ENVI 5.1 and ArcGis 10.2.2. Detection of shoreline change for the municipality uses the workflow reflected below.

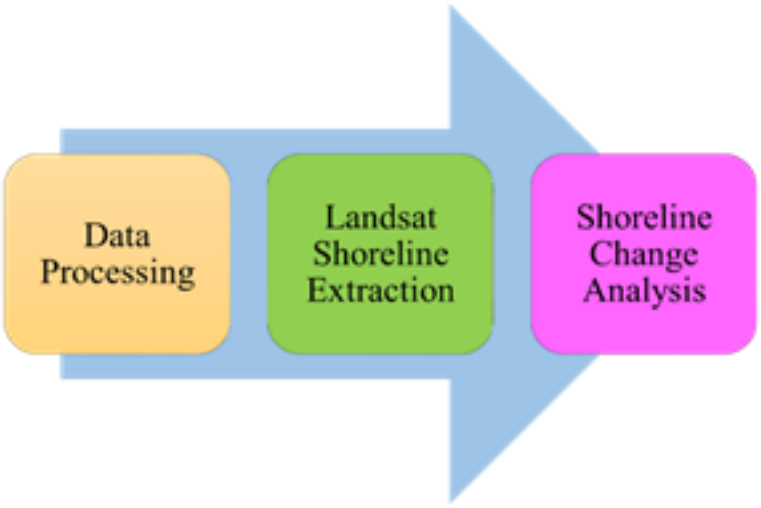
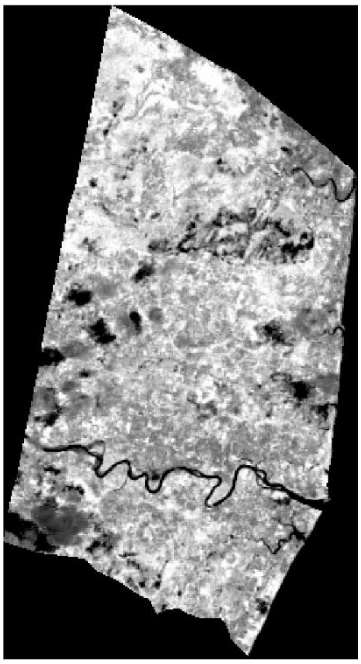
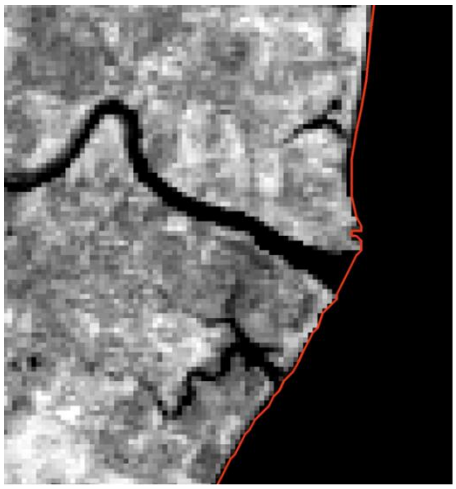


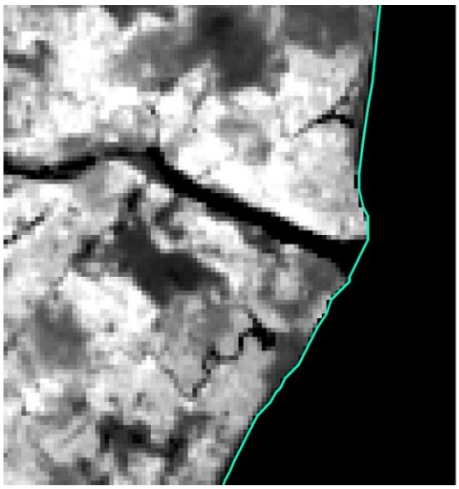
Figure 1. General Workflow for Shoreline Analysis

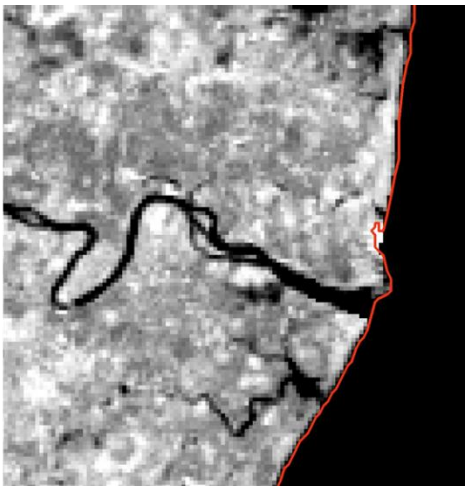
Data Pre-processing. Pre-processing of the available data includes Layer Stacking and Data subsetting. Landsat datasets for each time frame are satellite images that correspond a certain band layer that need be stacked in one single image file for more efficient analysis and easier management of components. Using ENVI, band layers were stacked in a single multilayer image file. All multilayer images that represent the above-mentioned years, however, cover the whole province of Leyte. A subset was then created limited to the boundaries of the target municipality. Using an ENVI basic tool, a subset was created using ROI as the extent.



Landsat Shoreline Extraction. For the extraction of shorelines from the images for each year, two methods such as manual digitization and software-based classification. For the extraction of shorelines, band 5 was used to delineate water and land boundaries. According to Chen (2003), band 5 displays a strong contrast between water and land because it highly exhibits a high degree of absorption of mid-infrared energy by water and strong reflectance on it by vegetation and other land features. Using band ratio tool in ENVI, land-water interface was delineated. Manual digitizing was then performed in ArcGis following the edges of the images generated after performing band ratio. According to reports as mentioned by Rosal (2015), manual digitization requires skills and must be performed carefully so as not to overestimate shoreline changes between time frames.







Shoreline Change Analysis. Shoreline positions and changes were analyzed using Digital Shoreline Analysis System tools in ArcGis. Through the tool, 102 transects were generated. Change detection was calculated and analyzed by measuring the distance by one shoreline representing one time frame to another through measure tool in ArcGis. Determining whether the particular area of the coastline undergo erosion or accretion is through visual inspection of the shoreline positions. Basically, an erosion can be concluded if the shoreline of the present year lies behind the shoreline extracted from the previous year. Accretion on the other hand can be deduced if shoreline of the present is positioned in front of the previous year (Figure 2).

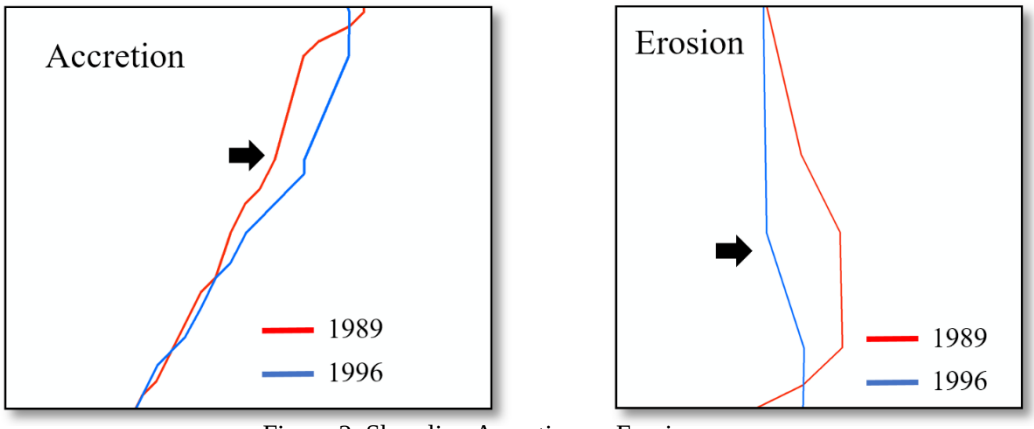


Figure 2. Shoreline Accretion vs Erosion

Results and Discussion

The shoreline of the municipality of Dulag was successfully extracted using Band 5 for all the acquired Landsat images. Figure 3 shows the highlighted shorelines for the different years that Landsat images were acquired. The parallel black diagonal bars represent a total of 102 transect lines generated using DSAS tool in ArcGis, laid at a distance of 100 m. from each other.

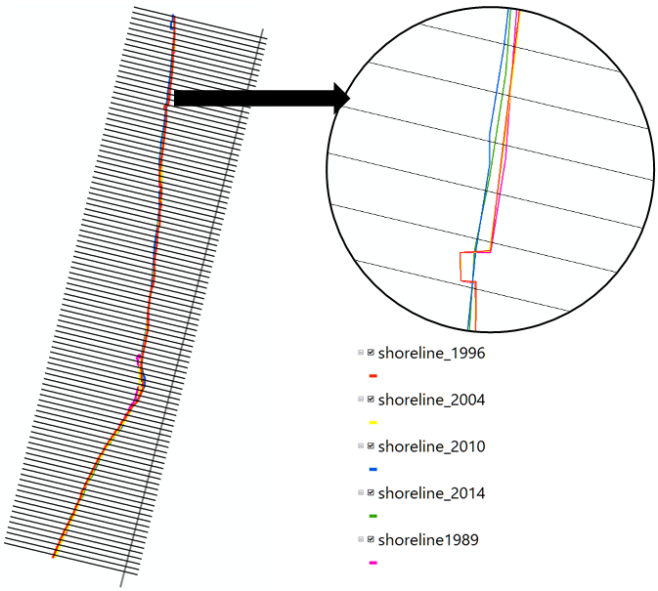
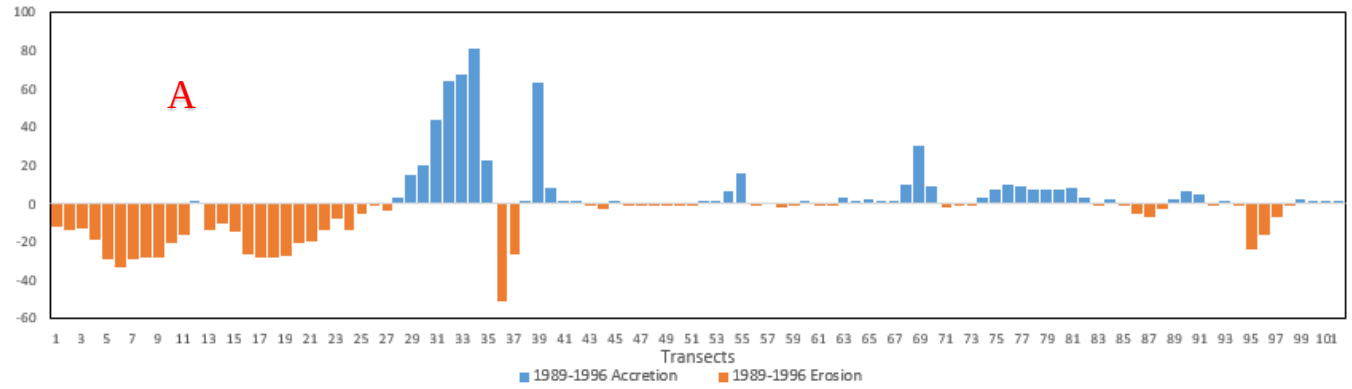
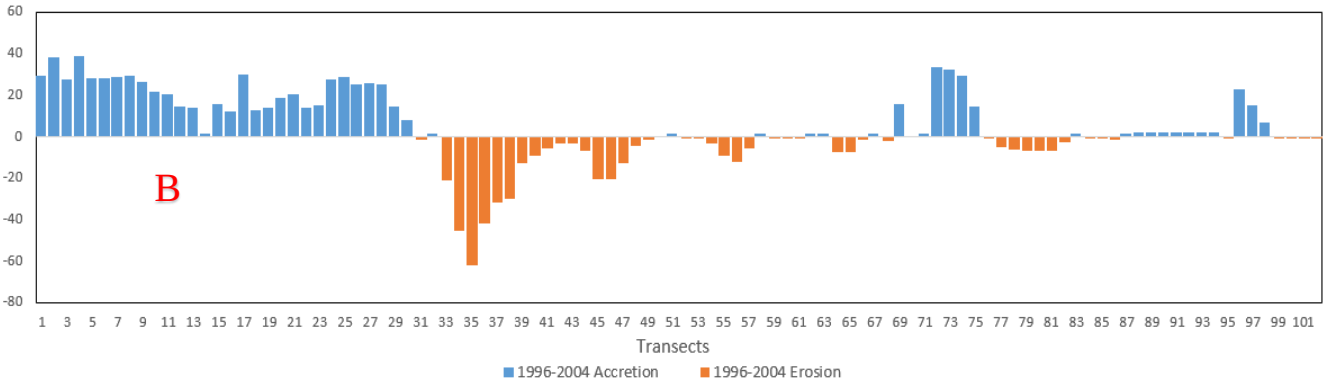
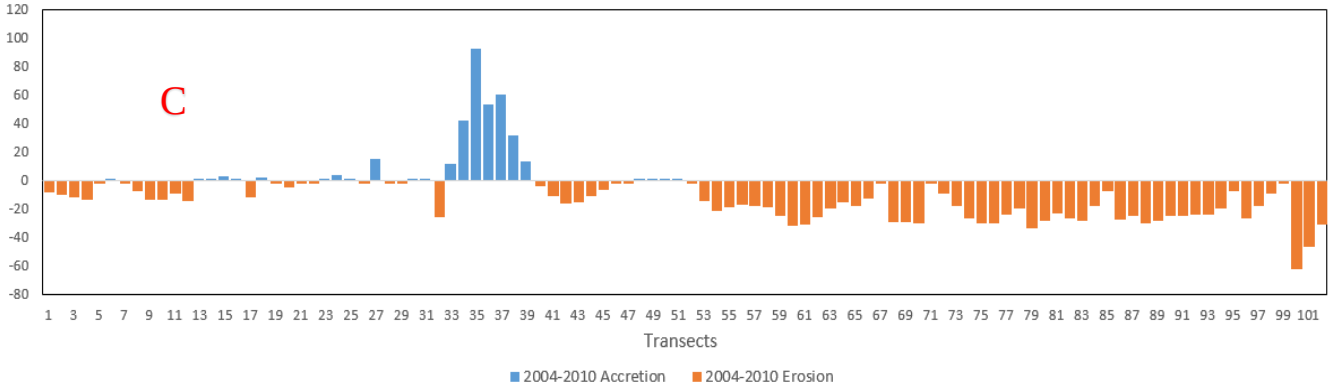


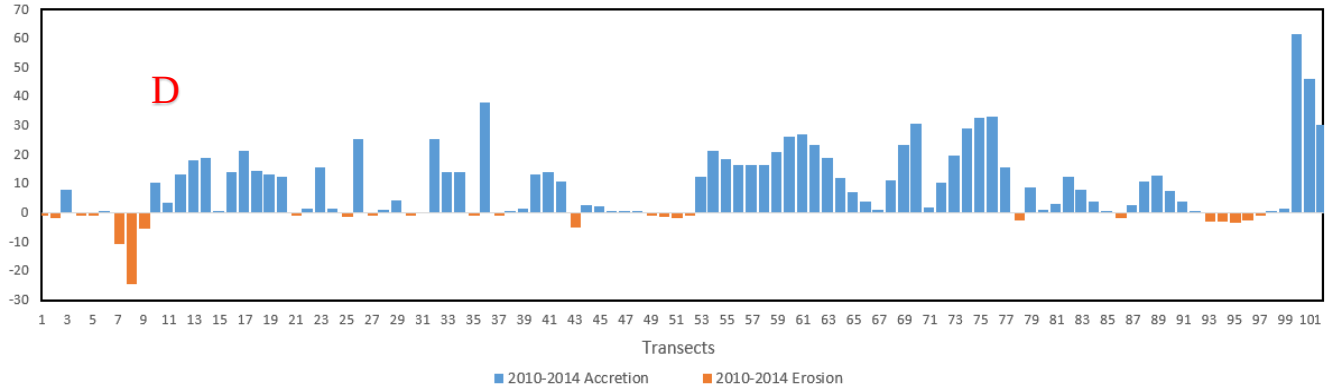
Figure 3. The shore profile of the municpality of Dulag, zoomed in (upper right) to properly emphasize the differences of shoreline movement over several years.

The charts below (Grouped together as a multi-image, Figure 4) show the total shore erosions/accretions for each timeframe, from 1989-1996, 1996-2004, 2004-20010, and 2010 to 2014, respectively. From the shorelines extracted as shown in Figure 3, the distance and direction of the shoreline moving across each transect line was measured. For each time-frame, the total values of accretion and erosion of Dulag were found to be highly variegated.









Examining the above images, it can be deduced that the shoreline of Dulag is rapidly changing showing accretion and erosion across the stretch of the municipality. The graphs shown in Figure 4 show that the high values of erosion and accretion are not located in just one area, but are somehow moving northward. The areas where once there were high rates of accretion and erosion then become more stable. Comparing figures 4A, and 4B it can be observed that from 1989-2004, the areas that experienced erosion from 1989-1996 recovered and accreted sediments on 1996-2004 especially on the 30 transects overlaid while the areas the has accreted sediments however experienced erosion in 1996-2004. These areas where a relatively high difference on the shorelines (first 40 transects) can be observed from 1989-1996 is where one big river of Dulag is located. This may have influenced the varying profile of the beach in this area as river runoffs may also influence the formation of the beach. The trend however was not significantly observed in 2004-2010 (Figure 4C) as in the southern part of the municipality only a low rate of erosion is reflected in the graph. It is in this period however that the highest rate of erosion was observed with a rate of 2.42m of erosion per year and 2.13m accretion. In 1989-1996, rate of erosion and accretion are 1.41m/yr and 1.48m/yr respectively. For figure 4D, it can be observed that in this period, the beach is accreting sediments as it can be observed that almost all transects have relatively high accretion. It is also in this period that highest of accretion was recorded at approximately 2.61m/yr accretion with only 0.55 m/yr erosion rate.

Conclusion

This study was conducted on the shorelines of the Municipality of Dulag on the eastern side of Leyte province. It was conducted to determine the current rate of accretion and erosion of the shoreline of Dulag, Leyte. The study was able to answer its objectives using remote-sensing and Geographic Information System. Transect lines were shown to be important in establishing the actual beach profile dynamics of the municipality.

The study shows that using the proper software and data, it is possible to conduct coastal environmental studies through remote sensing. Results showed that over the 25-year time range, the shores of Dulag underwent an erosion rate of 0.9m/year, and with an accretion rate of 1.1m/year, exceeding the rate of erosion. The generated shoreline profile of the 2014 Landsat data showed no unique values, considering that this was the year immediately after the supertyphoon Haiyan hit the Philippines, particularly Eastern Visayas.

Recommendations

Erosion and accretion are just some of the factors that influence the organisms found along the shores of the municipality. Several more studies may be conducted using data with higher resolution to achieve a more detailed beach profile of the municipality. Depending on the availability of the necessary data and software, this study may easily be replicated for several other municipalities. In this study, factors such as the tides and seasons of the years in which the Landsat images were taken, were not interpreted as possible factors affecting the accuracy of the study. It is recommended that for future studies, these things shall be taken into consideration. Future studies may also go one step further and predict the future instances of accretion and erosion of the area of interest.

Acknowledgement

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