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Measuring Shoreline Changes in Rincon Beach Using Remote Sensing Techniques

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Abstract

The rate of coastal erosion can vary considerably in space and in time. Climate conditions can have an immediate response on beach erosion and transport of sediments, making dramatic changes to the shoreline. The activities related to industrial development can be highly relevant to the vulnerability of coastal erosion, as with the extraction of sand for the industry of construction, which generates subsidence and therefore would also be responsible for the decline of coastline. This study was conducted in the western coast of Puerto Rico. One of the most affected coasts in this area is Rincon Beach; where the degradation of land and high erosion levels over decades generates a complex scenario for coastal tourism industry. The coastline has been dramatically changed the land/sea boundary, which is constantly transformed by tides and waves.

The fieldwork for this research was a key to allow a better interpretation of the recognition of historical aerial photos, satellite images and remote sensing techniques for study changes in coastlines. The fieldwork included in-situ observations that were analyzed and compared with aerial photographs/satellite images from a different range of years using Geographic Information Systems (GIS), the new generation interactive tool to study shoreline changes. Even if global warming is a fact, not the only cause of coastal erosion, there are more triggers that generate processes of coastal erosion. This research represents the effort to provide recommendations to coastal community to avoid loss of human life and economic losses.

Keywords: Rincon Beach, erosion, changes, shoreline, remote sensing

Introduction:

This proposed work is part of a comprehensive study that takes place in the coastal area of Rincon, Puerto Rico (figure 1), which is an area with high vulnerability and risk. The main objective of this research is to interpret the recognition of historical aerial photos and satellite using remote sensing techniques to study changes in coastlines in Rincon Beach. This work includes fieldwork observations to be analyzed for a preliminary hypothesis than that obtained by analysis of aerial photographs and satellite images from a different range of years. This research is mainly focused on the usage of latest remote sensing techniques and in-situ observations to measure shoreline changes in the Villa Cofresi Beach in Rincon, Puerto Rico. The Villa Cofresi Hotel, built in the decade of 1960's, had one of the most attractive beaches in the western coast of Puerto Rico (Scott, 2010). Today, this beach has no sufficient sand and recreational facility between hotel's main building and the coastline (Scott, 2010). The hotel administration has tried to stabilize the beach artificially building a rigid wall (Scott, 2010) to protect the building from waves and erosion, especially during bad weather conditions.

The scope of the research and verification of the hypothesis will allow interpreting causes of this problem and possible solutions. There are several ways to study and measure changes in shoreline. Geographic Information Systems (GIS) is the new generation interactive tool to study shoreline changes (Bolstad, 2005). A GIS is a set of procedures on a database or not descriptive graphical real-world objects that have a graphical representation and which are susceptible to measurement with respect to its size and dimension relative to the surface of the Earth (Bolstad, 2005). Aerial images can be georeferenced spatially to compare shoreline changes in this area to estimate rate of erosion (Bolstad, 2005). The specific objectives for this research are:

- To compare aerial photographs and satellite images from a different range of years to measure shoreline changes in Villa Cofresí Beach, Rincón.
- To compare in-situ observations within the range of years selected.
- To apply general remote sensing techniques and GIS to measure shoreline changes.
- To provide recommendations to coastal community to avoid loss of human life and economic losses.

Methodology:

A total of seven (7) GPS points were selected in a 400-meter transect from Punta Ensenada to Playa Corcega north to south respectively to measure shoreline changes supported by the latest remote sensing techniques and in-situ observations (figure2) based in previous studies performed in this zone. Using aerial pictures from years 2007 and 2010 we can determine and compare shoreline changes in Rincon Beach. The integration of these tools can help us to determine a long-term risk to the coastal zone and it contributes to strengthening risk assessment caused by coastal erosion (Gornitz, 1991), affecting a better quality of life and sustainability of the affected area and coastal community.

To get better results this study is conducted using the Geological and Environmental Remote Sensing Laboratory (GERS). This research is widely supported by using ArcGIS Vesrion 10 (figure 3) and its free software extension of Digital Shoreline Analysis System (DSAS) version 4.4 (Thieler et al. 2003) (see figure 4). This extension is a very useful tool to conduct studies of shoreline changes, and generates a series of transects (See Figure 1), with the selected spatial interval to compare different shorelines at a different range of time (Thieler et al. 2003). ENVI software (figure 5) was an excellent tool to determine sharpness and colors for the aerial pictures.

Data and Sampling:

As stated before, for this study a total of seven (7) GPS points were selected in a 400-meter transect from Punta Ensenada to Playa Corcega from north to south respectively to measure shoreline changes. Every point represents the change from the shoreline to the baseline inland. This transect includes turistical zones of this area and in-situ observations to compare changes in shoreline within the proposed range of years. Also, terrestrial and aerial pictures were obtained to compare the shoreline changes in this area.

Results:

After analyzing results of field observations and computer-aided modeling using aerial pictures and satellite images, we can observe that Rincon Beach is suffering degradation of shoreline at a very fast rate (Thieler et al. 2007). DSAS model shows clearly a change in shoreline from 2007 to 2010. This change is realized due to several triggers described in the discussion/interpretation section. Another robust evidence of shoreline change and coast degradation in this area is shown when field observations (pictures from 2007 to 2012) reveal a similar result as DSAS predict. When we observe DSAS projection lines, the 2010 line (blue) is inner (inland) and closer to the coast structures. According to Thieler et. al, 2007, their job is validated and continued with this recent research. A collection of field pictures is provided in the appendix section.

Discussion/Interpretations:

Rincon beach sands are composed by carbonates, quartz, and lithic materials with a low amount of feldspar. Grain size ranges from medium to fine based in the sample collected at the berm at the middle of this transect. The beach is extended from north to south where the shoreline is

composed by rocky material (Thieler et al. 2007). Sampling off this point indicates that much of the sand is moving offshore at Punta Cadena (Thieler et al. 2003). Some of this sand is transported as suspended sediments and then is added to the Añasco beach. So, we can interpret that Rincon Beach is being eroded by natural and man-made changes. 2007 terrestrial pictures show the abundance of sand in the beach. By 2008, Villa Cofresí Hotel administration had to construct a sea wall and redesign their public bar area due to the fast erosional rate of the beach.

Conclusions:

Coastal erosion is one of the several environmental problems that affect the coastal zone of Rincon. These problems have negative effects to the economy, especially for the tourism industry. Some of the problems identified in this region are: Land degradation, coastal erosion, loss of biodiversity and existence of affected private and public properties (Gornitz, 1991).

Rincon Beach erosion is expected for the next couple of years. According to Thieler et al. 2007, there is a direct correlation between land degradation and sea level rising including man-made modification to the ecosystem.

The erosion of the coastal zone has negative effects to the ecosystem .The usage of tools such as GIS and DSAS integration can help to avoid the problem of the erosion of the coastal zone (Thieler et al. 2007).

Another special tool to analyze the shoreline change is comparing aerial pictures from different ranges of years. Triggers such as rising sea level change produces erosion and land degradation globally.

Acknowledgements:

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List of figures:

Figure 1: Transect Location. Rincon, Puerto Rico

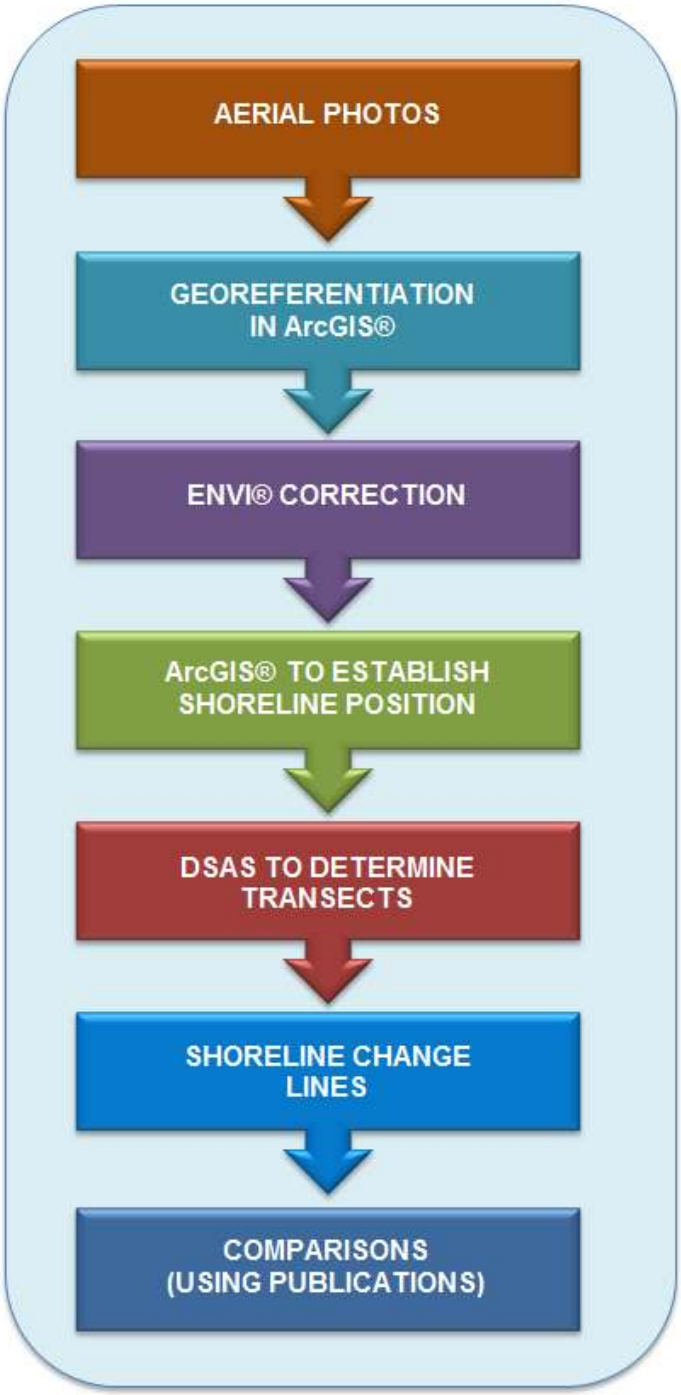

Figure 2: Methodology flow chart. Processes before obtain final results.

Figure 3: Screen shot of ArcGIS Version 10. Photo taken during research work.

Figure 4: DSAS Final results. Shoreline changes can be seen. GERS Laboratory.

Figure 5: Screen example of ENVI software. Used to improve colors and more detailed features.

GERS Laboratory.

Appendix:

A1: Seawall constructed by Villa Cofresi Hotel (2012). Photo: P. Mejías.

A2: Me observing the erosion of the 4 year-old sea wall. Photo: P. Mejías.

A3: Close up detail of the concrete wall. Photo: P. Mejías.

A4: Concrete wall erotion. Photo: P. Mejías.

A5: Recent damage to the concrete wall . Photo: P. Mejías.

A6: Grain size detail. Photo: P. Mejías.

A7: Erosion of sand behind Rincon of the Seas Hotel. Photo: P. Mejías.

A8: Erosion of sand behind Rincon of the Seas Hotel. Photo: P. Mejías.

A9: Erosion of sand behind Rincon of the Seas Hotel. Photo: P. Mejías.

A10: Sea wall rocks to control erosion. Photo: P. Mejías.

Notes: