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Coastal Management Using UAS and High-Resolution Satellite Images for Touristic Areas

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ABSTRACT

Coastline change and human activities in shoreline zones are two factors indicating the vulnerability and the quality of a coastal environment. In this article, coastline evolution and spatiotemporal differences on coastal touristic infrastructure are presented as two case studies. Both case studies have increasing interest among scientists monitoring sensitive coastal areas, and for stakeholders evolved in the tourist industry. The study is twofold: monitors the shoreline evolution and examines how the shoreline behavior affects the seasonal anthropogenic touristic infrastructure. Shoreline detection methodology integrates unmanned aerial systems (UAS) or high-resolution satellite images for data acquisition, and geographic object-based image analysis (GEOBIA) for the shoreline recognition and the infrastructure change detection. The methodology used produced robust results in the aspect of mapping and detecting coastline changes, coastal erosion and the human pressure due to specific activities.

KEYWORDS

Coastal Management, Coastal Monitoring, Coastal Touristic Seasonal Infrastructure Mapping, Shoreline Evolution, Touristic Development, UAS, UAS Data Acquisition, UAS-GEOBIA

INTRODUCTION

Coastal zones are among the most populated and the most productive areas in the world. They offer a variety of habitats, connection to the shipping routes and ecosystem services. They are popular settlements, essential business zones and shipping zones. The importance of coastal management is highlighted by the European Commission with the application of the different policies and related activities which was adopted with the joint initiatives of Maritime Spatial Planning and Integrated Coastal Management. The aim is to promote sustainable growth of maritime and coastal activities and to use coastal and marine resources sustainably. Several other environmental policies are included in this initiative, like the Marine Strategy Framework Directive, the Climate Change Adaptation, and the Common fishery policy (Ouellette & Getinet, 2016).

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Two essential threats for coastal areas are beach erosion and the overcrowded use of the beach. The impact of tourism on coastal areas is significant and requires modern techniques for monitoring and controlling. Sustainable tourism is an old issue, since 1992 Earth Summit - Rio de Janeiro, and coastal managers require up-to-date, accurate information on coastal movements and coastal use. Remote sensing plays a significant role in coastal observation since it provides a synoptic view of the coast situation at a specific time. Coastal monitoring requires multi-temporal data, either from satellites or Unmanned Aerial Systems (UAS). The availability of very high-resolution Digital Surface Models (DSM) and orthophotos presents increasing interest (Apostolos Papakonstantinou, Topouzelis, & Pavlogeorgatos, 2016) and shoreline information is fundamental for understanding coastal dynamics and for implementing environmental policy (Su & Gibeaut, 2017). Several studies on numerical models for wave run-up and UAS have shown the need of quality information dedicated to coastal management (Casella et al., 2014, 2016; Drummond, Harley, Turner, Matheen, & Glamore, 2015; Gonçalves & Henriques, 2015).

Also, the increasing demand for monitoring of the coastal area requires automatic algorithms and techniques. Geographic Object-Based Image Analysis (GEOBIA) is an object-based analysis of remote sensing imagery and is trying to bridge GIS and OBIA. It uses automated methods to partition imagery into meaningful image-objects and generate geographic information (in GIS-ready format) from which new knowledge can be obtained (Hay & Castilla, 2008). GEOBIA was used in various coastal applications such as the analysis of Landsat satellite data for worldwide assessment of sea coast changes over time (Urbanski, 2010) or to extract coastline from Quickbird multispectral imagery (Giannini & Parente, 2015). Husson et al demonstrated an automated classification of non-submerged aquatic vegetation using OBIA to true-color UAS images (Husson, Ecke, & Reese, 2016).

Raster-based change analysis was mainly achieved from object-based techniques, where a group of pixels with similar characteristics analyzed forms "meaningful" entities (objects) (Apostolos Papakonstantinou et al., 2016; Qin, 2014). Apart from coastlines, such objects could be Coastal Touristic Seasonal Infrastructures (CTSI), such as water sports, umbrellas, beach cantinas, hotel facilities. Temporal differences define the interconnection of available areas in touristic beaches and coastal erosion. Shoreline information is fundamental for understanding coastal dynamics and for implementing environmental policy (Su & Gibeaut, 2017). Several studies on numerical models for wave run-up and UASs have shown the need for quality information dedicated to coastal management (Casella et al., 2014, 2016; Drummond et al., 2015; Gonçalves & Henriques, 2015).

The present paper aims to present how satellite images and UASs very-high resolution orthophotos can be used for the management of coastal areas, specifically in touristic areas, where the spatial dimension is crucial and specific measures are necessary for the local authorities. Shorelines were detected in satellite and UAS data and GEOBIA analysis was performed for identifying beach usages. Spatiotemporal differences define the interconnection between CTSI area occupation in touristic beaches and coastal erosion in both use cases. The proposed methodology was used to map coastal erosion and the CTSI coastal land use changes over time.

STUDY AREAS

Two study areas located in Greek islands were selected, the first on Santorini and the second on Lesvos island. Both sites present similar geomorphological characteristics as both are sandy coasts and are affected by erosion. These areas were selected due to the continuous and rapid changes in their coastal characteristics, during the last years as last year these changes led to a continuous advance or retreat of shorelines in the affected coastal areas. Furthermore, both study areas are recognized as the most occupied with seasonal touristic infrastructure beaches. Thus, it is crucial that changes in the morphology of the study areas are monitored, as they affect all touristic activities.