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Editorial

Editorial on Geomatic Applications to Coastal Research: Challenges and New Developments

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Abstract: This editorial introduces the Special Issue entitled "Geomatic Applications to Coastal Research: Challenges and New Developments" and succinctly evaluates future trends of the use of geomatics in the field of coastal research. This Special Issue was created to emphasize the importance of using different methodologies to study the very complex and dynamic environment of the coast. The field of geomatics offers various tools and methods that are capable of capturing and understanding coastal systems at different scales (i.e., time and space). This Special Issue therefore features nine articles in which different methodologies and study cases are presented, highlighting what the field of geomatics has to offer to the field of coastal research. The featured articles use a range of methodologies, from GIS to remote sensing, as well as statistical and spatial analysis techniques, to advance the knowledge of coastal areas and improve management and future knowledge of these areas.

Keywords: geoinformation science; coastal dynamics; coastal monitoring; climate change; remote sensing; geographic information systems

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1. Introduction

Coasts are very dynamic areas that naturally present changes at different temporal and spatial scales [1,2]. Nevertheless, humans tend to perceive this complex region as a simple line that separates the land from the water, assuming that the coastal contours (i.e., coastlines) are rigid and immobile. The rich resources and beauty of coastal areas also attract a high concentration of people and allow them to sustain themselves and prosper. Consequently, pressure by human occupancy on the coastal area tends to grow, as more people are interested in moving from inland regions to the coast [1,3].

It is clear from this dichotomy, a high degree of change, and increased use/occupation that the management of coastal areas is a challenging task. Moreover, coasts are particularly sensitive to climate change, which can easily disrupt the natural and unique balance of sensitive habitats. Humans have recently been accelerating the natural rate of change of some ecosystems, which my compromise the coastal socio-economic model, leading to environmental loss and even loss of lives if more extreme climate change scenarios become a reality [3,4]. Unless governments and users of coastal resources take appropriate action, the pressure of the population and the associated levels of economic activity will further exacerbate the over-exploitation of coastal resources and degrade the environment in many coastal zone habitats.

Climate change demands specific monitoring programs and sustainable coastal management plans, and detailed information about the types and magnitude of processes taking place is essential to fulfill this goal. Indeed, two of the cross-cutting mainstreamed issues are focused on research contributing to fighting and adapting to climate change and to conserve the oceans, seas, and marine resources. Researchers and policy managers are now required to use accurate, up-to-date, high-resolution, and multi-temporal information on coastal areas for several applications. However, despite the need to monitor, manage, and protect coastal areas, the broad-scale environmental data available to date are surprisingly incomplete. In addition, the coasts are one of the most dynamic environments on Earth, making them extremely demanding to monitor and study. Thus, to fully grasp the changes and evolution in coastal areas, several tools and methods must be used to understand the system at different scales (time and space) and provide a holistic view [5].

Geomatic instruments and techniques such as Geographic Information Systems (GIS), remote sensing, photogrammetry, and geoinformatics, among others, have long been used in coastal studies, but their recent improvements in ease of use and increased accuracy have exponentially expanded their applications to coastal sciences. In fact, remote sensing and GIS have been widely used to support conventional methods for monitoring coastline change [6], but free access to data from Earth observation satellites has been a game-changer in providing the capability to monitor coastal changes cost-effectively [7,8]. Furthermore, many advanced methodologies have been developed using close-range digital images to detect change or assess environmental parameter variations in more detail [9,10].

This Special Issue, "Geomatic Applications to Coastal Research: Challenges and New Developments", aimed to collect high-quality, innovative research papers dealing with the collection, storage, integration, modeling, analysis, and display of spatially georeferenced information about the highly changeable coastal system. It presents different applications and new case studies on the use of geomatics to increase the knowledge of the coastal environment in diverse areas. The published articles are briefly introduced in the next section. The main contributions of the Special Issue are summarized in the final section, and future directions derived from them are presented.

2. Contributions to the Special Issue

New applications of GIS to coastal dynamics were presented by Xu and Liu [11] and Vieira et al. [12]. The first article [11] introduced a three-level GIS framework coupled with a graph model to better track, represent, and analyze tidal flats' dynamic activities in the southwest tip of the Florida Peninsula from 1984 to 2018. The three-level GIS framework allows one to assemble information on adjacent cells as objects, which are linked on different time steps as lifecycles by tracking predecessor–successor relationships. Coupling the graph model provides a better way to represent the lifecycles, and graph operators are utilized to facilitate the event analysis. Results indicate that the methodology effectively tracks, represents, and analyzes tidal flats' dynamic activities. The second article [12] presents a GIS model used to assess the vulnerability of the estuarine system of Cananéia-Iguape (Brazil). The work applies the evaluation and prediction of vulnerability models for the conservation and preservation of mangroves, showing a homogeneous distribution of vulnerability in the studied estuarine system. The results also revealed the urgent need to regularly monitoring areas where anthropogenic actions are taking place and to assess and predict changes at different times and temporal scales, including future responses.

The use of satellite imagery is paramount to the study of coastal issues, and de Carvalho et al. [13] presented a study where multispectral, high-resolution WorldView-3 satellite imageries are used to inspect small touristic infrastructures. This study highlights the potential of using this type of data to supervise if public lands and property are being misused or exploited for private economic purposes without the proper licensing. This study uses instance segmentation to target the mapping of straw beach umbrellas (SBUs) implemented in public sandy beaches (a very small object to classify in satellite images). An improved Mask-RCNN was used to classify nearly all SBUs correctly and highlight the application of these images as effective for inspecting large coastal areas and providing insightful information for public managers.

Sakti et al. [14] used remote sensing, statistics, and socio-demographic data to model the potential for plastic waste to accumulate in Indonesia. As plastic waste is one of the most significant contributors to the pollution of marine environments, the authors created a model to quantify plastic waste originating from the mainland and possible accumulated in estuaries. The model couples data from marine plastic disposal generated by remote sensing and spatial analysis, using plastic waste generation, land cover, population distribution, and the identification of human activity as model parameters, and creating an index of plastic waste disposal. Results show that 0.6% of Indonesia accounts for the highest generation of plastic waste, including metropolitan cities.

Regarding the applicability of geomatic tools to study coastal processes, this Special Issue focuses on coastline evolution as a major instrument to understand coastal change, presenting new study cases in areas where no information has previously been provided. As such, Ibarra-Marinas et al. [15] have evaluated long-term beach evolution in the southeast of Spain, at Regional Park of Salinas and Arenales of San Pedro del Pinatar. The authors have used old cartography and aerial images datasets to assess changes between 1899 and 2019. The results clearly indicate that anthropogenic actions (port construction) are the primary driver of change for this coastal stretch. Caspel and Vasseur [16] evaluated the drivers of coastline change for a study case at Lake Ontario. The methodology used historical aerial images to assess coastal change and also explore the role of selected climatic and non-climatic drivers in explaining the observed changes. Results identified the main areas where erosion is occurring and which are less prone to change, discussing why this is occurring in more vegetated areas.

Regarding disaster management, the study by Rifat and Liu [17] presented a new composite community disaster resilience index (CCDRI) for the coastal communities of the conterminous US. The new index considers different dimensions of disaster resilience based on ordinary least squares (OLS) and geographically weighted regression (GWR) models to assess which resilience variables are best to use. Results showed that in the conterminous US, northeastern communities are comparatively more resilient than south-eastern communities and that the resilience components selected by the methodology have a statistically significant impact on minimizing disaster losses.

Waiyasusri and Chotpantarat [18] performed spatial evolution of land use change (LUC) in the coastal city of Koh Chang, Thailand, between 1990 and 2020 and estimated its evolution for the next 30 years with logistic regression and the Duna-CLUE model [19] using three scenarios: natural evolution, reserved area protection, and growth in recreational areas. The variables most influencing LUC were topography, slope, population density, and distance from villages. The project's LUC maps are also valuable management tools, as they can help communities establish different pathways of adaptation and evolution.

Fandé et al. [20] also advanced different scenarios of coastal flooding exposure to sea-level rise (SLR), using Guinea-Bissau as a study case. This study analyzes and discusses the application of simple coastal flooding models coupled with high-precision global digital elevation models (TanDEM-X DEM) for areas where no other datasets are available. Results show that the land exposed to coastal flooding hazards increases significantly and progressively with increasing SRL scenarios. The simple methodology effectively provides a first snapshot of the extent of inundation concerning different SLR scenarios and can easily be applied to other areas that lack more specific and in-depth data but are highly vulnerable to climate changes.

3. Summary and Future Directions

The Special Issue "Geomatic Applications to Coastal Research: Challenges and New Developments" features nine articles presenting different methodologies and study cases, drawing attention to what the field of geomatics offers to the field of coastal research. The featured articles use a range of methodologies, from GIS to Remote Sensing, through statistical and spatial analysis techniques, to advance the knowledge of coastal areas and improve management and future changes in these areas. This SI only scratches the surface of geomatic applications in coastal research, but we are confident that the featured articles will advance knowledge on this topic. Geomatics provides a critical set of tools and methodologies to apply in coastal research, and many new and good works are envisioned in the future, particularly regarding remote sensing applications.

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