Digitalization of Coastal Management and Decision Making Supported by Multi-Dimensional Geospatial Information and Analysis

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ABSTRACT

This paper presents the status and outcomes of the fourth year of an NSF-funded Digital Government Program project. During this four-year period, geo-spatial technologies have been investigated and developed to enhance the operational capabilities of federal, state, and local agencies responsible for coastal management and decision making. Successful collaborations have been established among research laboratories and government agencies in the areas of data collection and analysis, hydrodynamic modeling, development of web-based systems, and real-world applications of research results.

Categories and Subject Descriptors:

H.4 [**Information Systems and Applications**]: Spatial information technology

General Terms:

Management, Design, Verification.

Key Words:

GIS, remote sensing, satellite images, 3D visualization.

This paper summaries the status and outcomes of a four-year project supported by the NSF Digital Government Program. The objective of this project is to investigate current status, needs and potential of federal, state and local governmental operations related to geospatial information supported coastal management and decision making. Successful collaborations have been established among research laboratories and government agencies such as NGS/NOAA, COOPS/NOAA, NIMA, ODNR, the Lake County (OH) Planning Commission, and Tampa Bay Estuary Program. These collaborations were initiated in the areas of data collection and analysis, hydrodynamic modeling, development of web-based systems, and applications of research results [1].

The project has made significant progresses. We have completed coastal spatio-temporal data collection, set up a spatial data inventory system, and conducted multi-source spatial data integration. Technologies of space- and airborne and in situ spatial data acquisition, spatio-temporal data modeling and analysis, hydrological modeling and forecasting, and web-based information systems were examined and integrated into a coastal management and decision-making system.

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To facilitate the administrative processes of state and local government agencies, we have developed a web-based system for coastal management and decision making [4, 5]. Wireless technology and mobile communication devices are used in this system to support coastal management and decision-making processes (Fig 1).

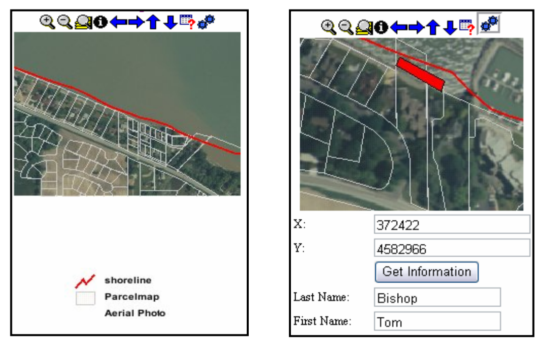

Figure 1. Interface of on-site mobile system

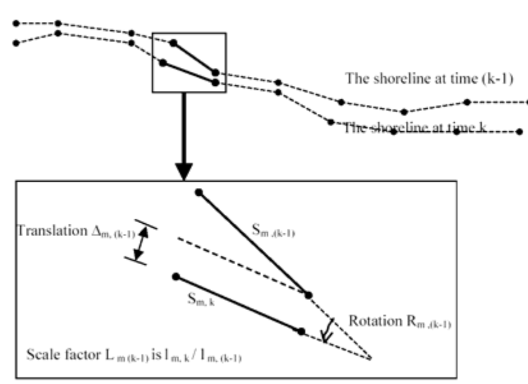

Figure 2. A shoreline prediction model.

A shoreline prediction model has also been designed at The Ohio State University Digital Mapping and GIS Laboratory (Fig 2) [7]. Based on historic shorelines, future shorelines are predicted and published in a shoreline erosion awareness subsystem [4, 5]. This prediction model will help end users, especially coastal residents living in erosion areas, assisting them in making such decisions as building property protection constructions, property purchasing/selling, and small community planning activities.

Based on advanced web service technology, we have implemented a distributed spatial data infrastructure within which spatial data can be effectively and efficiently managed, shared, and integrated in different data servers. At the same time, the requirements for data storage and computation intensity have been significantly reduced.

In multi-source spatial data integration, three-year (1999-2001) satellite altimetric data, water-gauge data, and hydrodynamic model hindcast results are compared with the goal of improving operational lake and coastal circulation nowcast and forecasting capabilities [3]. To provide a good understanding of spatial data integration and uncertainty analysis, three-dimensional visualization technology was used to analyze the three-dimensional relationship between satellite altimetric data, water-gauge data, the hydrodynamic model, and high-resolution DEM. A vertical data conversion system for Lake Erie was developed to facilitate seamless integration of spatial data with different horizontal and vertical datum.

In addition to Lake Erie study area, sub-meter high-resolution QuickBird and IKONOS satellite stereo imagery were also acquired for the southern Tampa Bay area. Applying four different adjustment methods, geo-positioning accuracy of the QuickBird was achieved at a level of 71 cm in the horizontal and 65 cm in the vertical directions. The integration from different satellite sensor imagery, QuickBird and IKONOS, was also studied. 3-D shorelines and high-resolution coastal DEMs were derived for coastal environmental change analysis [2, 6]. A stereo satellite image processing system was also developed.

We performed seagrass distribution pattern and change analysis in Tampa Bay, using seagrass distribution maps from 1988 to 2001. Based on transition matrices derived from these seagrass maps, seagrass variation patterns were classified into four different types: stable zones, degradation zones, restoration zones, and dynamic zones. These variation types are depicted in a seagrass variation map (Fig. 3). From the seagrass variation map, it was found that there are direct relationships between the seagrass variation zones and corresponding locations as well as water depths. Most of the restoration zones were isolated by small islands and thus ocean wave and current energy could be reduced or attenuated. The restoration zones were also located in the regions with shallower water, where seagrass leaves can absorb abundant light used for photosynthesis. The degradation zones were away from the shoreline and exposed to ocean water, where deeper locations with steeper slopes would enhance the influences from wave and current actions. Stable zones and dynamic zones are closer to the shoreline and islands where there is neither deep water nor a steep slope.

Currently, the developed geospatial data acquisition and integration technologies are used to examine the environmental and ecological impacts of shoreline changes, sea level changes, bathymetric changes, sandbar movement, waves and currents, and biochemical influences. A self-adaptive modeling system will be developed to investigate coastal environmental changes, predict ecological variation, and provide critical information for coastal ecosystem monitoring, management, and decision making. The detailed research will be conducted at a small watershed with high spatial resolution, examined at other bay segments, and finally, extended to the whole bay or larger coastal zones.

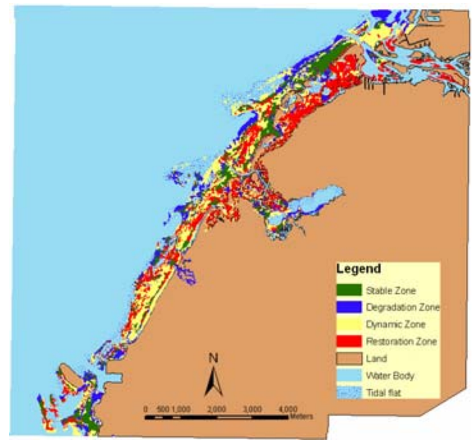

Figure 3. Seagrass variation map

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