

Assessment and Modeling of Environmental and Socio-economic Impacts of Urban Development Using RS and GIS for Integrated Coastal Land Use Planning

Ed Carla Mae Tomoling^{1a}, Ariel Blanco^{2a}, Ayin Tamondong^{3a}, Kazuo Nadaoka^{4b}, Kentaro Iwai^{5b}

^aEnvironmental Systems Applications of Geomatics Engineering (EnviSAGE) Research Laboratory, Department of Geodetic Engineering, University of the Philippines, Diliman, Quezon City 1101 Philippines

¹edcarla.tomoling@yahoo.com.ph, ²ayeh75@yahoo.com, ³ayin_t@yahoo.com

^bDepartment of Mechanical and Environmental Informatics, Graduate School of Information Science and Engineering, Tokyo Institute of Technology, Tokyo 152-8552 Japan

⁴nadaoka@mei.titech.ac.jp, ⁵iwai.k.aa@m.titech.ac.jp

Abstract: Urban development planning in coastal regions commonly prioritizes the economic return from ecosystem services without balancing its trade-offs. Marine resource management practices have often been ineffective because planning for the sea and land are usually independent. Based on the UN Atlas of the Oceans, about 44% of the world's populations live in coastal zones. The increasing migration towards coastal areas has caused environmental stresses on natural landscapes and habitats and this is aggravated by global climate change. Boracay Island, world-renowned for its four-kilometer beach with talcum-like white sands, is situated in the northwest tip of Panay Island in the Visayas. It is one of the top tourist destinations in the Philippines where tourism began to flourish in the 1970s. Large influx of visitors started in the late 1980s which led to proliferation of establishments that jeopardized the island's pristine environment. An integrated assessment of the environmental and socio-economic impacts of rapid urban growth in the island was carried out by determining the inter-relationships between the alterations on the island's landscape from 1988 to present, the water quality of the beaches from 1997 to present and the changes in the demographic and socio-economic structure over the last three decades. Land cover and benthic habitat maps, which were derived from Landsat, Quickbird and Worldview-2 satellite images, show a decrease in the vegetation and coral cover. Household, establishment and tourist surveys were conducted which covered the three barangays comprising the island. An offshoot of the exponential increase of tourist arrivals, from fourteen thousand (1984) to more than 1.2 million (2012), is the swelling population which experienced a 900% growth over the last three decades. A geodatabase was developed which contains (1) feature datasets derived from a digital aerial photo, (2) tables storing socio-economic and water quality information and their (3) relationship classes. Historical beach water quality data was obtained from the Environmental Management Bureau (EMB) and water samplings near-shore were conducted in 2012 and 2013. The parameters measured include total nitrogen, total phosphorus, NO₃, NO₂, NH₄, SiO₂, PO₄, salinity, conductivity and radon. Water samples were also taken from thirty-six wells to investigate for possible seawater intrusion caused by excessive extraction of groundwater and to determine radon levels in wells used for drinking water. Poor

water quality is observed in the eastern side of the island where the marine outfall is located and in sitios where dense informal settlements are present. A digital elevation model (DEM), with a 1-m horizontal and 2-m vertical accuracy, and multi-beam echosounder (MBES) bathymetric data, with 0.6-m horizontal and 0.2-m vertical accuracy, were integrated in this study. The enviro-socio-economic parameters derived from the assessment were used to model possible future scenarios using the different components of Community Viz (CommViz) and Integrated Valuation of Ecosystem Services and Trade-offs (InVEST) models which are both in ArcGIS platform. A 3D model of the island was also developed to further understand the geographic patterns of the datasets over time and to support informative decision making for the stakeholders.

Keywords: GIS, Tourism, Urban Development, Coastal Ecosystems, Resource Management