THE ABILITY OF COASTAL ECOSYSTEMS TO REDUCE STORM SURGE AND COASTAL EROSION IN THE CONTEXT OF CLIMATE CHANGE

Elisabeth Mondon, Smith Warner International, elisabeth@smithwarner.com
Philip Warner, Smith Warner International, philip@smithwarner.com
David Smith, Smith Warner International, david@smithwarner.com

OVERVIEW

Global warming and climate change are expected to have a profound influence on weather-related hazards in the Caribbean. Possible effects include more frequent and intense extreme weather events such as tropical storms and hurricanes; increase in the rate of sea level rise; increased coastal erosion; potential destruction of fisheries; drought; and saline intrusion into freshwater lenses. These impacts are exacerbated by inappropriate human interventions that influence and magnify the effects of events such as floods, storm surge, landslides and drought through improper planning and poor execution of mitigation practices.

INTRODUCTION

This study focuses on the contribution of ecosystems to the reduction of risks related to climate variability and change. The aim is to assess in a representative manner, which specific coastal ecosystems in the CARICOM Small Island Developing States (SIDS) are of particular relevance for climate change adaptation, especially with respect to reduced coastal erosion and storm surge. Both Marine and Freshwater types of ecosystems exist, to varying degrees, in the Caribbean. The most abundant types are the benthic bottom substrates (i.e., seagrass), coral reefs and wetlands where mangroves thrive. These ecosystems were chosen for further analysis.

METHODOLOGY

In order to achieve these objectives a numerical model of each representative ecosystem layout and conditions was developed using the MIKE 21 wave/sediment/hydrodynamic-modeling suite for three different representative sites. MIKE 21 (developed by the Danish Hydraulic Institute) is a professional engineering software package for the simulation of flows, waves, sediments and ecology in rivers, lakes, estuaries, bays, coastal areas and seas. The dynamics of the beach and storm surge on each of the selected sites was modeled using three main modules that function together in a coupled mode to simulate the mutual interaction between waves, currents and sediment transport. The coupling of hydrodynamics and waves is an important aspect of storm surge computations, particularly in areas such as the Caribbean Sea where wave set-up is a significant factor. As large waves approach the shoreline or a reef and break, the water level increases, causing localized currents to be generated. These currents and changing water levels affect the waves by carrying them further inland.

Overall, three different ecosystems: (i) coral reefs, (ii) seagrass and (iii) mangrove habitats were considered to be modeled within the MIKE 21 numerical model. In addition, three sites were selected from within the CARICOM region, such that each represented one of the prevailing ecosystems listed above. Climate change impacts were modeled for each ecosystem and the model results evaluated in the context of its efficiency to reduce storm surge and/or coastal erosion. The presence or not of Coral Reef, Seagrass and Mangrove was represented essentially by updating the bed roughness, the layer thickness and elevation of seabed features.

At each of the sites the maximum wave heights, water levels, and beach erosion (when relevant) were calculated throughout the simulation and plotted to show the impact of ecosystem degradation and the potential increases in storm intensity. All were compared to a base case scenario, which identified a supposedly healthy living ecosystem and typical storm occurring in the Caribbean.

RESULTS AND OBSERVATIONS

Overall, the numerical results showed reasonably good correlation with onsite observations. It was found that the three coastal ecosystems had some effect on wave height, storm surge and beach erosion depending on how far away they were located from the nearshore area. The closer to shore the more effects the ecosystem has on the nearshore. Of the three ecosystems identified, the loss of mangrove habitat demonstrated the greatest impact on storm surge reduction at the project site, therefore demonstrating that mangroves can successfully lessen the force of both waves and storm surges. With other ecosystems the wave height, storm surge and beach erosion were found to be more influenced by the increase in storm intensity than the loss of ecosystem itself.