## Innovative Tools For Erosion Control And Coastline Management

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Coastal zones around the globe host about two-third of the world population. Besides, their economical and social value, coastal areas have an invaluable ecological importance. Nevertheless, coastal zones are also extremely vulnerable. Erosion and associated loss of land is the most evident sign of this vulnerability. Of the world's coastal areas more than 70% have shown net erosion over the past few decades. Within Europe, the area lost or seriously impacted by erosion is estimated to be about 15 sq. km per year with an average yearly cost of 5,400 million euro per year (results from the Eurosion study). Those figures are likely to become even more drastic in the near future as a consequence of the expected climate change and sea level rise. Adequate solutions require knowledge of the underlying morphodynamics and ecological processes. As a matter of fact, the natural coastal morphology results from a delicate balance between these processes, which provide self organizing capacity and resilience. External interventions disturb this balance and the long-term impact is often hard to predict. The Dutch experience shows that the most effective and sustainable way to deal with coastal erosion is to work with nature. In case of sandy costs, the most appropriate material for restoring, raising or building out sandy coasts is sand. Different concepts and tools have been developed in recent years as design basis to deal with erosion control and management of sandy coast. The use of different approaches is mainly linked to the spatial and temporal scale of the problem under consideration. The present paper describes results from several projects involving Deltares, universities, governments, coastal managers and landscape architects with the aim of defining the most suitable concepts and tools to deal with erosion control and coastline management at those different scales. Whenever the focus is on short-term coastal erosion issues, i.e. time scale of few days (e.g. storm event) and spatial scale of meters, it can be sufficient to restore the sand volume in the dune and beach area. Several process-based models have been developed to assess, design and evaluate possible solutions (e.g. XBeach, Delft3D in 3D mode). For medium-term erosion issues, i.e. time scale of years and spatial scale of kilometers, restoring the sand volumes only on the beach and dune area can not be considered sustainable, as it would involve reviewing the adaptation option against erosion every few weeks. The restoration of the sand volume on a larger stretch of the cross-shore profile is suggested. Ad-hoc tools based on simplified versions of process-based models (e.g. quasi-3D or depth averaged models) have been developed to assess those interventions. Moreover, statistically based models combining information from models and data are also under development. As morphological changes are often linked to long-term processes (e.g. sea level rise), new concepts and tools have also been developed to provide sustainable solutions at time scales of decades to centuries, and spatial scales of tens to hundreds of kilometers. Ad-hoc one dimensional coastline models have been adapted to be able to account for the effects of interventions and sediment losses at this time scale and to be able to predict the long-term effects on a number of morphological and socio-economic indicators. Three implementations of the three conceptual and modeling approaches are described in details in the paper. An intercomparison including applicability, advantages and disadvantages of each approach is also discussed.