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TITLE: Black Sea beaches vulnerability to sea level rise

AUTHOR: ['Karin Allenbach', 'Irene Garonna', 'Christian Herold', 'Isavela Monioudi', 'Grégory Giuliani', 'Anthony Lehmann', 'Adonis Velegrakis']

ABSTRACT:

Integrated Coastal Zone Management (ICZM) aims to promote sustainable management of coastal zones based on ecosystem and holistic management approaches. In this context, policies have to consider the complex interactions that influence the fragile equilibrium of coastal ecosystems. Beaches represent both valuable and vulnerable natural resources because of the various ecosystem services they provide and their sensitivity to climate change and sea level rise. We present the first comprehensive digital record of all Black Sea beaches and provide a rapid assessment of their erosion risk under different scenarios of sea level rise. Through the digitisation of freely available remote-sensed images on the web, we provide broad information on the spatial characteristics and other attributes of all Black Sea beaches (e.g. photo-based visual estimation of the sediment type, presence of coastal defences, urban development). These data have been assembled and stored in full Spatial Data Infrastructure (SDI) ? allowing spatial queries, visualisation and data sharing ? and are therefore particularly interesting to feed/supply web-GIS portals (coastal atlases) for visualisation purpose, spatial queries or spatial indicators calculations. The resulting Black Sea beaches database contains 1228 beaches, with a total coastline length of 2042 km with an area of 224 km². The majority of the Black Sea beaches have been found to have small widths (61% have maximum widths less than 50 m), whereas 47% of all beaches presented coastal defence schemes, suggesting an already serious beach erosion problem. The erosion risk of the Black Sea beaches was assessed through the comparison of their maximum widths with estimations of the sea level rise-induced retreat by an ensemble of six 1-D analytical and numerical morphodynamic models. Following more than 17,000 experiments using different combinations of wave conditions, beach sediment textures and slopes and 11 scenarios of sea level rise (up to 2 m), the means (best fits) of the lowest and highest projections by the model ensemble were estimated; these were then compared to the maximum widths of the Black Sea beaches. The analysis showed that sea level rise will have highly significant impacts on the Black Sea beaches, as for a 0.5 m sea level rise 56% of all beaches are projected to retreat by 50% of their maximum width. For a 0.82 m sea level rise (the high IPCC estimate for the period 2081?2100) about 41% are projected to retreat by their entire maximum width, whereas for 1 m sea level rise about 51% of all Black Sea beaches are projected to retreat by (drowned or shifted landward by) their entire maximum width, if the high mean of the model ensemble projections is used. Results substantiate the risk of beach erosion as a major environmental problem along the Black Sea coast, which therefore needs to be taken into account in any future coastal management plans, as a matter of urgency. As these scenarios consider only sea level rise, they are considered to be conservative. Although the present results cannot replace detailed studies, the database and projections may assist Black Sea coastal managers and policy makers to rapidly identify beaches with increased risk of erosion, value accordingly coastal assets and infrastructure, estimate beach capacity for touristic development purposes, and rapidly assess direct and indirect costs and benefits of beach protection options. They also provide the necessary inputs to advance discussions relevant to the Black Sea ICZM.

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