Customized Methodology for Flood Risk Assessment in Ungauged Urban Areas: A Case Study of Hurghada City, Red Sea, Egypt

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INTRODUCTION

Context

Flood risk mapping forms the basis for disaster risk management and the associated decision-making systems. The effectiveness of this process is highly dependent on the quality of the input data of both hazard and vulnerability maps and the method utilized.

Problem statement

Flood risk maps are resulted from combining both hazard and vulnerability maps. On the one hand, in ungauged regions, high-quality flood hazard maps are considered a difficult task, especially in urban and suburban areas. On the other hand, vulnerability mapping at the microscale suffers limitations as a result of: (1) the failure to consider vulnerability components, (2) the low spatial resolution of the input data, and (3) the omission of urban planning aspects that have crucial impacts on the resulting quality.

Objectives

(1) enhance the quality of hazard and vulnerability mapping at the urban microscale in ungauged regions and (2) to produce flood risk maps to support decision-makers in (A) determining the impact of urban development planned for 2027 on the existing urban area in Hurghada, (B) evaluating the 2027 CSP from a flood risk perspective, and (C) prioritizing intervention points.

Study Area

Hurghada, Egypt is an important center for tourist and mining activities. The city is one of the most vulnerable cities to flash floods along the Red Sea.

METHODOLOGY

The proposed methodology **(Figure1)** integrates remote sensing data and high-quality city strategic plans (CSPs) using geographic information systems (GIS), a 2D rainfall-runoff-inundation (RRI) simulation model, and multicriteria decision-making analysis (MCDA, i.e., the analytic hierarchy process (AHP)). Current and future physical, social, and economic vulnerability maps were produced based on seven indicators. The total vulnerability maps were combined with the hazard maps based on the Kron equation for three different return periods (REPs; 50, 10, and 5 years) to create the corresponding risk maps.

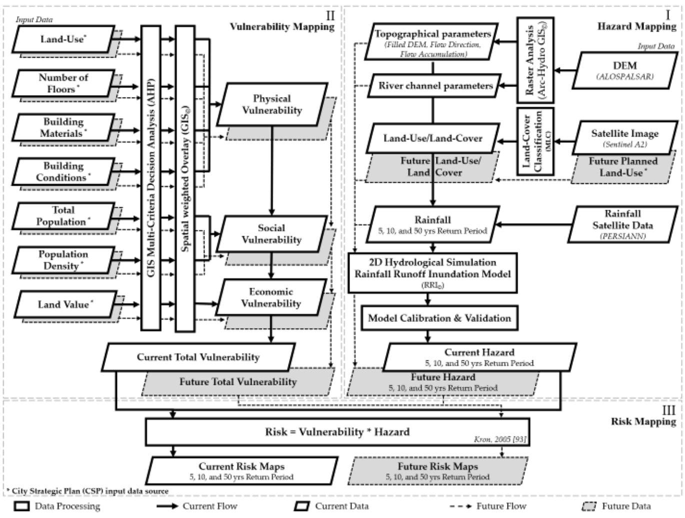
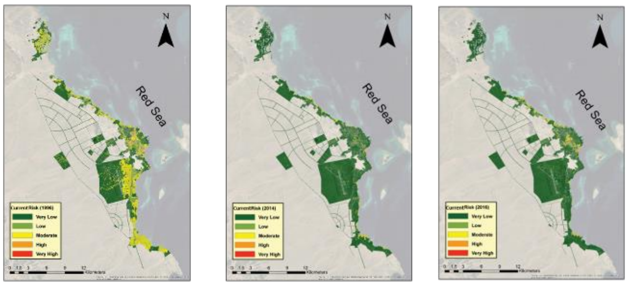


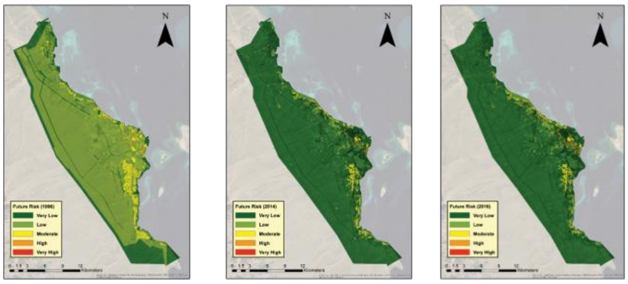
Fig. 1 Flowchart for data processing and methods

RESULTS AND DISCUSSION

The resulting spatial flood risk maps for the 1996, 2014, and 2016 flood events currently and in the future are shown in **Figure2.** The Statistics results regarding hazard, vulnerability and risk are shown in **figures 3,4, and 5,** respectively.



(**a**) (**b**) (**c**)



(**d**) (**e**) (**f**)

Fig. 2 Flood risk maps for Hurghada for the events in 1996 (50-year REP) (a), 2014 (5-year REP) (b), and 2016 (10-year REP) (c) for the current situation and (d, e, f) for the future situation in the 2027 CSP, respectively

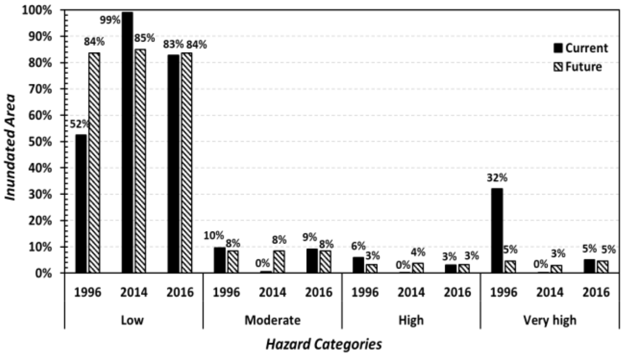


Fig. 3 Flood inundation percentages for the current and future (2027) situations for the events in 1996, 2014 and 2016

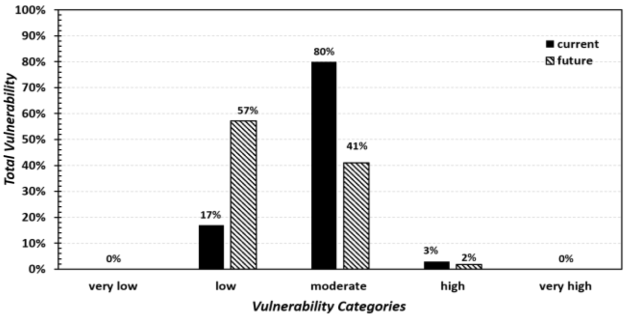


Fig. 4 Current and future total vulnerability in Hurghada

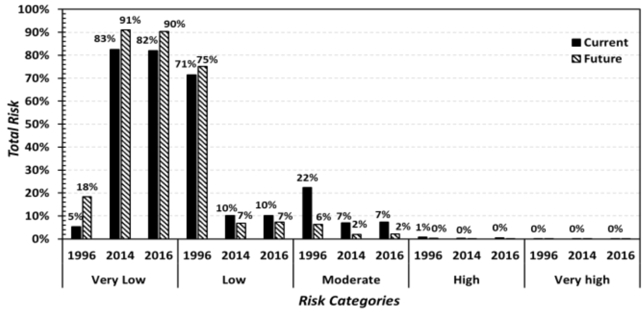


Fig. 5 Current and future total risk in Hurghada

- The results show that: (1) The urban extension is in the range of low and moderate risk, except for new projects along the coast, which are expected to be at high risk. Therefore, Hurghada 2027 CSP needs to be revised based on the risk maps produced, especially for the new projects along the coast.
- (2) The main two intervention points in Hurghada can be highlighted as follows: (A) the coastal areas, which have the most tourism activities, increasing the socioeconomic risks incurred by the city, and (B) slums areas.

CONCLUSION

This integrated methodology proved to be an economical tool to overcome the scarcity of data, to fill the gap between urban planning and flood risk management (FRM), and to produce comprehensive and high-quality flood risk maps that aid decision-making systems.

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