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Application of the Coastal Hazard Wheel methodology for coastal multi-hazard assessment and management in the state of Djibouti

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ABSTRACT

This paper presents the application of a new methodology for coastal multi-hazard assessment and management in a changing global climate on the state of Djibouti. The methodology termed the Coastal Hazard Wheel (CHW) is developed for worldwide application and is based on a specially designed coastal classification system that incorporates the main static and dynamic parameters determining the characteristics of a coastal environment. The methodology provides information on the hazards of ecosystem disruption, gradual inundation, salt water intrusion, erosion and flooding and can be used to support management decisions at local, regional and national level, in areas with limited access to geophysical data. The assessment for Djibouti applies a geographic information system (GIS) to develop a range of national hazard maps along with relevant hazard statistics and is showcasing the procedure for applying the CHW methodology for national hazard assessments. The assessment shows that the coastline of Djibouti is characterized by extensive stretches with high or very high hazards of ecosystem disruption, mainly related to coral reefs and mangrove forests, while large sections along the coastlines of especially northern and southern Djibouti have high hazard levels for gradual inundation. The hazard of salt water intrusion is moderate along most of Djibouti's coastline, although groundwater availability is considered to be very sensitive to human ground water extraction. High or very high erosion hazards are associated with Djibouti's sedimentary plains, estuaries and river mouths, while very high flooding hazards are associated with the dry river mouths.

Introduction

Projected climate change will alter the environmental conditions along most of the world's coastlines and thereby the livelihoods of the local coastal populations (IPCC, 2014). According to the IPCC, the utilization of the coast has increased dramatically during the 20th century and this trend will continue during the 21st century, leading to a growth in the global coastal population from the current 1.2 billion to 1.8–5.2 billion by the 2080s depending on migration assumptions (IPCC, 2007a). Identifying climate-related hazards to coastal regions is therefore essential for managing potential hazards in due course, and this is especially a challenge in developing countries where data, expertise and economic resources are limited and coastal populations are growing rapidly.

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To date, several different methodologies and approaches have been developed to assess and manage coastal climate change vulnerability and coastal climate-related hazards. Generally, one can distinguish between index and indicator based methods, GIS-based decision support systems and dynamic computer models that are developed for different purposes and with different requirements for data and expertise (Ramieri et al., 2011). The index and indicator based methods such as the Coastal Vulnerability Index (CVI) and the Smartline system are to date the most realistic options for use in data-poor regions such as developing countries, but they cannot be directly used to identify a range of sector-specific hazards and management options and require relatively detailed input data (Ramieri et al., 2011; Thieler et al., 2000; Sharples, 2014). The GIS-based decision support systems and dynamic computer models such as the DIVA model are very complex systems that would have to be combined with larger data-collection programs or be applied at very coarse resolution and also require highly specialized expertise (Global Climate Forum, 2013; Ramieri et al., 2011; Mcleod et al., 2010).

The Coastal Hazard Wheel (CHW) framework is developed to address the gap in the current coastal vulnerability/hazard assessment methodologies and to offer a tool that can be used for combined assessment and management of the key climate-related coastal hazards in areas with limited data availability, resources and institutional capacity. The framework is especially designed to facilitate hazard screening and identification of hazard-hotpots at regional and national level but can also be applied as a first-line tool for hazard identification at local level prior to more detailed feasibility studies. The CHW framework makes use of publicly available geo-data and remote sensing information, and, depending on accuracy requirements, different levels of field verification. The system covers the hazards of ecosystem disruption, gradual inundation, salt water intrusion, erosion and flooding and can be used for development of hazard maps and hazard statics and subsequent identification of management options. The system can be applied for multi-hazard-assessments at three different steps depending on the data availability and accuracy requirements, namely:

- Step 1 that is designed for hazard assessments where data availability and accuracy requirements are relatively low. This step can generally be implemented based on remote sensing and publicly available data and is useful for hazard screening and for getting an initial picture of hazard presence in a cost-efficient manner.
- Step 2 that is designed for hazard assessments with moderate accuracy and this step generally requires additional field verification of the data obtained through remote sensing and public data sources.
- Step 3 that is designed for hazard assessments with moderate and locally focused accuracy and this step requires systematic and detailed field assessments at the local level, if possible supplemented with results from other locally focused assessment tools.

Generally, Step 1 and 2 are recommended for larger sub-regional, regional and national assessments, as it would require significant time and resources to implement Step 3 at this scale. Step 1–2 can therefore be used for broader hazard assessments, while Step 3 can be used for coastal stretches of specific interest or for detailed assessment of hazard-hotspots indentified at Step 1–2. Spot-assessments of a single coastal site can be carried out at any step depending on accuracy requirements, but it is important to be aware of the associated uncertainties at local level, unless the assessment is supplemented with more detailed results from other more locally focused assessment tools.

In this paper, the CHW framework is used to carry out a multi-hazard assessment at Step 1 (which can be thought of as a 'First Pass' assessment) for the full coastline of Djibouti and to develop a range of hazard maps along with national hazard statics. For the state of Djibouti, very little information is currently available on future climate-related hazards in coastal areas and it is therefore difficult for national planners and decision-makers to address and mitigate potential hazards. As systematic geophysical data collection until now has been limited and major challenges persist in downscaling regional climate models, this knowledge gap could potentially become a barrier for sound planning decisions. With a growing population and a possible future migration to coastal areas, the need for a robust decision-base for coastal planning becomes even more critical.

Together with developing relevant information for management of coastal climate change hazards in Djibouti, the assessment provides a good example of a CHW application in a data poor location for which the system is designed. The goal of this paper is therefore twofold, namely to showcase the practical procedure for applying the CHW methodology for national hazard assessments in a data poor location, and to provide relevant information on coastal hazards and management options for the coastline of Djibouti.

Since the assessment is carried out as a national hazard assessment at Step 1, it is designed to provide a good overview of where specific hazards are present and at what level the hazards are manifested for the full length of Djibouti's coastline. If a higher level of accuracy is needed, it might be necessary to supplement the assessment with addition field verification. At this stage, however, the assessment provides a good general picture of the coastal hazards for Djibouti. The result of the hazard assessment is presented as a series of five thematic overview maps for Djibouti, and along with this, the assessment has tested the possibility of developing detailed hazard layers for use in Google Earth. Whereas the overview maps are useful for getting a good general picture of the coastal hazards, the hazard layers can be used to support more detailed planning decisions at sub-regional level.

The Coastal Hazard Wheel (CHW) framework

The CHW framework is a hazard assessment and management methodology that can be used in areas with limited geophysical data availability and institutional capacity. The framework is based on a specially designed coastal classification